BIOSTIMULATORS AND MECHANICAL STRESS ON *MATTHIOLA INCANA* (L.) R. BR. VARSOVIA VARIETIES

Szilvia KISVARGA[1], A. NEMÉNYI[1], Dóra FARKAS[1], L. ORLÓCI[1]

[1]Hungarian University of Agriculture and Life Sciences (MATE), Institute of Landscape Architecture, Urban Planning and Garden Art, Park street, 2, Budapest, Hungary
Corresponding author: Kisvarga.Szilvia@uni-mate.hu

Abstract. *Biostimulators may open new avenues for alternative cultivation technologies for ornamentals. Dwarfing makes it possible to use new species and varieties in public areas. They can also be used as potted ornamental plants. During dwarfing, the habizus is more bushy and the internodes are shortened, which is commercially advantageous. Matthiola incana (L.) R. Br. is an annual ornamental plant, which, although less significant in Hungary, is still bred and marketed by many companies worldwide. The effects of Bistep and thigmomorphogenesis are investigated in different ways with 'Bona', 'Hala' and 'Mela' cultivars of the Varsovia cultivar group. As a result of our measurements in previous years, that mechanical stress are proved by affects the morphological properties of plants, and the Bistep biostimulator strengthens the organ properties of the plant. In summary, in the case of the biostimulator-treated group, it was observed for several cultivars that the vegetative parameters produced significantly higher values than in the case of the control groups. Mechanical stress treatments significantly reduced the size of fresh root mass in all three cultivars compared to the control groups. It can be concluded that mechanical stimulation can be used in a greenhouse environment to change the growth rate and to produce marketable plants.*

Keywords: *annual; biostimulator, mechanical stress, seedling, thigmomorfogenesis*

INTRODUCTION

There are significant climatic differences between the western and eastern parts of Europe. While the main centers for the production and breeding of ornamental plants work under a rainy, humid, more balanced climate, droughts and temperature amplitudes are increasing in central and eastern Europe. The large size of most ornamental plants tolerating the Hungarian climate does not allow this.

In the ornamental plant sector, plant hormones and other growth regulators, mainly retardants, are essential for the production of quality goods, but this is increasingly limited in many countries from an environmental point of view. An everyday technological trick in the cultivation of ornamental plants is the use of physical and chemical reinforcement to produce stocky plants (SÁNCHEZ-BLANCO ET AL., 2019). Dwarfing based on mechanical contact of seedlings can be a new method. Modification of habitus can also be achieved by mediating and reacting to mechanical stimuli. This is what science calls thigmomorphogenesis.

An important question in ornamental plant production is how to grow plants in the least polluting way possible. If the plant has an adequate supply of nutrients, it is more resistant to diseases, pests and adverse environmental effects. Plant stress increases the number of pests in the urban environment (DALE ET AL., 2017).

Biological biostimulators and retardants may also be suitable to support alternative forms of ornamental plant cultivation, including dwarf mechanisms and technologies.

Biostimulators used in the measurements

The primary function of biostimulators is not to introduce nutrients into the soil against fertilizers or to control pests and pathogens as in the case of plant protection products.

Biostimulators bridge the gap between targeted effects and potential benefits in soil and medium (JARDIN ET AL., 2020).

Natural biostimulators can play an important role in reducing the use of key chemicals due to climate change, so they can increase production in a sustainable way at relatively low cost. Their positive effect on the production of horticultural plants is mainly due to bioactive compounds that promote growth and development, such as phytohormones, amino acids and nutrients (ZULFIQAR ET AL., 2019).

Biostimulants consist of one or more bioactive substances and generally have a positive effect on plants. Their use, compared to their effect on fertilizers, is not at the expense of yield and product quality (TOSCANO ET AL., 2018). Their use has been growing rapidly in recent years and decades. Revenue from biostimulators is estimated to increase to $ 2 billion in a few years (VELEZ ET AL., 2014). The European Biostimulants Industry Council (EBIC, 2012) defines plant biostimulants as substances and / or microorganisms that act naturally on plants or root levels in the soil: plant roots and the microorganisms that interact with it.

Ferbanat L (Bistep) (rights: UAB ALJARA)

In recent years, many opportunities have been found to make it more marketable and compact, not only for food plants but also for ornamentals. Pentakeep-V, Kelpak, Radifarm and Ferbanat L are also proving to be extremely effective biostimulators in ornamental crop production.

Ferbanat L is a complex nanofertilizer and plant conditioning agent based on humic acid and containing microelements, which has a positive effect on physiological processes. Humus and humin compounds have a direct and indirect effect on the plant organism. Their indirect effects are soil structure formation, nutrient supply and utilization, and the uptake of toxins. They have a direct effect on the permeability of the cell membrane, so they require less energy to pass through the membrane. They increase the enzymatic activity of respiration and accelerate oxygen delivery, resulting in increased rates of protein and carbohydrate synthesis (KLESKANOV AND KLESHKANOVA, 2009).

Mechanical dwarfing in horticultural practice

Tigmomorphogenesis is a term used to describe plant growth, which is naturally triggered by abiotic factors in response to a mechanical stimulus, or artificially by simulating adverse agroclimatic events (DRANSKI, 2013). The word thigmomorphogenesis was coined by Jaffe from the Greek words "thigmo," "morpho," and "genesis." The response to the mechanical stress (touch, smoothing) actually affecting the plant was called thigmomorphogenesis (JAFFE, 1973). LATIMER (1991) found that physical disturbance of plants or plant parts results in mechanical stress on the plant. This stimulus also reduces weight and size. The role of ethylene is important in thigmomorphogenesis (YOSHIAKI AND OTA, 1975).

Plants are also able to sense very delicate stimuli. Their roots are extremely sensitive to touch due to their progress in the soil, and so the shoots of runners are also sensitive as they need to feel and recognize the mechanical support during their growth (MISHRA *ET AL.*, 2019).

Some evidence suggests that thigmomorphogenesis may be mediated by ethylene (JAFFE, 1973). In *Epipremnum aureum* plants, individuals running on the retaining wall form larger leaves than the drooping varieties, due to thigmomorphogenesis and gravimorogenesis (BENEDETTO *ET AL.*, 2018), exposure of air roots and shoots to thigmomorphogenetic effects. Height was also reduced when applied to *Solenostemon scutellarioides* plants under vibration stress, and treatment also increased stem mechanical resistance (SAFAEI FAR *ET AL.*, 2019). This can also be observed in nature. Cereals and other herbaceous plants often recover after wind damage, and even woody plants can partially straighten back if adequate access to water and nutrients is available (GARDINER *ET AL.*, 2016). When researching mechanical forces, emphasis is also placed on measuring root fixation in the support medium - finding the point that does not yet damage the plant (STUBBS *ET AL.*, 2019).

Mechanical stress can also be effective from a plant protection point of view. In mechanical stress measurements applied on *Acacia koa* plants, it has been shown that mechanical stress can enhance disease resistance genes (KAUZE *ET AL.*, 2016). LATIMER AND OETTING (1999) found that during twice-daily conditioning, sometimes with 40 mechanical smoothing effects, more perennial ornamental plants' were infected with pests. It was found that mechanical conditioning consistently reduced the number of *Frankliniella occidentalis* and *Tetranychus urticae* on plants. Mechanical disturbances resulting from shaking and baling during balsam pine harvesting induce ethylene biosynthesis and regulation to regulate needle absorption (KORANKYE *ET AL.*, 2018). Bending of the stems of *Pinus taeda* seedlings resulted in dry matter accumulation in the stem and root system, mainly in the lateral roots, to the detriment of the decrease in leaf surface and dry matter content. By bending the plants, the stimulated seedlings showed a higher survival rate and growth rate (DRANSKI, 2013).

MATERIALS AND METHODS

Varieties

Matthiola incana (L.) R. Br. Cultivars were used for our measurements. *Matthiola incana* L. is an annual ornamental plant that is popular and has many good properties. It grows purple, pink, white and purple flowers from a silvery leaf rosette. It is mostly used in flowerbed plantings (HISAMATSU ET AL., 2000). Three members of the Varsovia variety series were used for the measurements. They are all full-bodied, fragrant. Their final height is 50-60 cm, they are usually used as a cut flower. Varsovia 'Bona' is yellow, Varsovia 'Hala' is purple and Varsovia 'Mela' is pink.

Soil

Sowing was carried out in Klasmann-Deilmann TS 3 Fine type 416 medium, then the seedlings were planted in Klasmann-Deilmann TS 3 medium basic medium type 425 and grown in this soil until final evaluation every year.

Place of experiment

Our experiment was carried out between March 2021 and May 2021 under greenhouse conditions in Budatétény. The average greenhouse temperature was 20 °C during sowing and seedling growing. The plants were not given extra light. They were irrigated once a day from sowing to final evaluation.

The seeds were sown in TS 3 Fine medium on March 3, 2021 in propagation trays. On March 29, 2021, the seedlings were transferred to plastic 7 x 7 x 8 plastic containers. In the two weeks following containerization, the seedling were waited for to acclimate to the new environment and then began treatments on April 12, 2021.

The treatments

Plants were divided into treatment groups. 25 plants from each of the three marked varieties were included in each group. The following groups were made:

1. Control group - only irrigation water was given
2. Bistep 0.2% - A 0.2% solution of Bistep was received at the following times:
    - April 12, 2021
    - April 22, 2021

- May 3, 2021
- May 13, 2021

The biostimulator was applied by spraying. Each group received 150 ml of Bistep solution during the treatments.

Manual mechanical stress

Plants so treated using a brush were described by Latimer *et al.* (1991, 1999) twice daily until final evaluation. Treatments were performed with a brush for 10 seconds per treatment. During the treatments, mechanical stress was applied to the shoot apex of the plants.

Machine mechanical stress

Based on the plans of Prof. Miklós Gábor Fári, he made a prototype of the mechanical dwarf machine we used in 2009.

RESULTS AND DISCUSSION

The effect of Bistep in the studied cultivars was significantly detectable in the treatments. The treated plants became stronger and more stocky compared to the control group. The difference in height can be statistically confirmed, although this shows only a small difference for each variety compared to the results of the control group. Leaf surface was significantly higher for 'Bona' and 'Hala' cultivars. The results of the decrease in green weight and leaf weight showed that the percentage of water loss in the individuals treated with Bistep was statistically higher than in the control plants. In this context, however, root length values differ significantly for varieties. In the case of 'Bona' cultivar, the cultivar treated with Bistep biostimulator had the lowest root length (9.17 cm), while in the case of 'Mela' the average root length was 16.95 cm, which is significantly higher than the root length measured in the control group (13, 20 cm).

In summary, although the Bistep biostimulator has apparently made the treated individuals of *Matthiola incana* more potent and vital, this is not statistically or only weakly detectable. The effect of the biostimulator was not the same for the varieties, but the variety effect and the genome effect must be taken into account. Adverse effects of Bistep were detected in several measured parameters. Root mass and leaf size also increased in the treated plants, as found by Kovács *et al.* (2017).

Effect of mechanical stress

The effect of brush treatment was detectable in terms of the parameters of the treated varieties compared to the results of the control group. The plants treated in this way remained significantly lower, their leaves became denser, and the habit of the plant became wider and more spacious (Figure 1.) In the case of the group treated with mechanical mechanics, the height also became lower, the apex of the leaves became bent back.

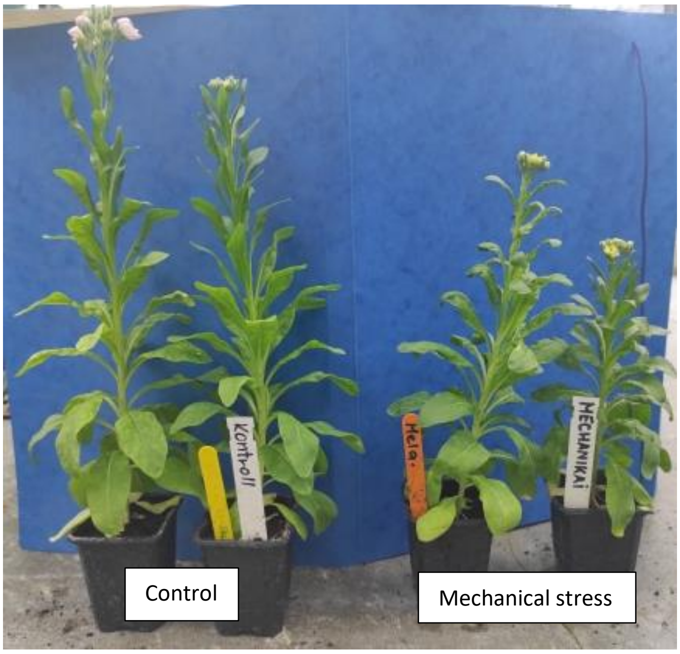

Fig. 1. Effect of mechanical stress on the 'Mela' variety (2021)

Height was significantly reduced in all three treated varieties compared to the control group (Figure 2.). While the mean height of the control group was between 28.19 cm and 35.01 cm, in the brush-treated groups this value was between 24.04 cm and 29.93 cm. In the groups treated with mechanical mechanics, the mean height values were between 19.6 cm and 22.92 cm.

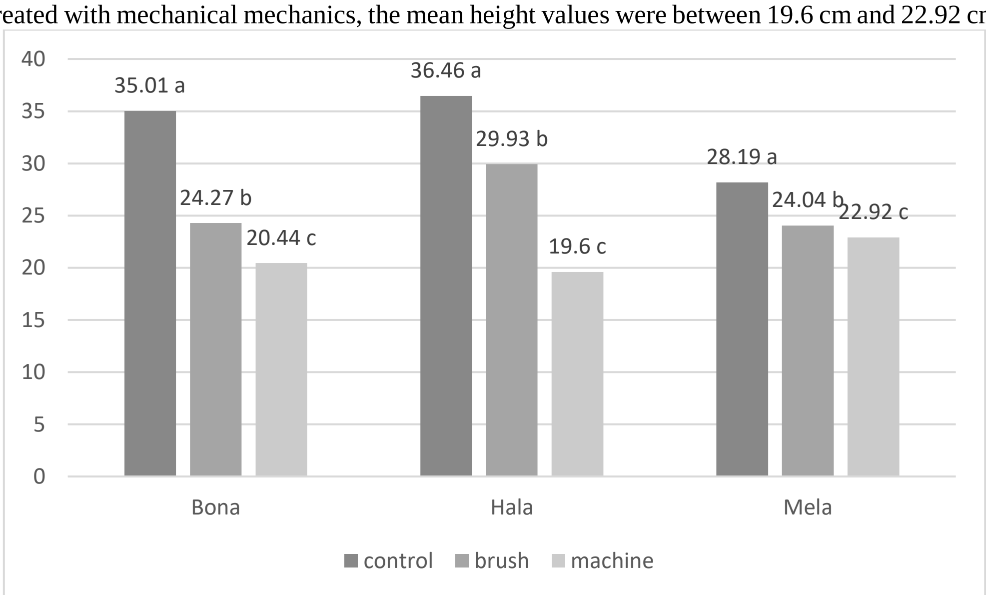

Fig. 2. Mechanical stress effects of plant height (Values of $P < 0.05$ were considered statistically significant)

In the case of leaf number, the average leaf number of the control group in terms of ‘Bona’ variety is not statistically different from the leaf number values of the groups treated with mechanical stress treatment (Figure 3.). The average number of leaves in the brush-treated groups also reached statistically higher values for ‘Hala’ (45.27) and ‘Mela’ (52.27) varieties than in the control group (34.6–39). Regarding mechanical mechanical stress treatments, the number of leaves reached lower values (33.87 pcs) for ‘Hala’ and higher (38.2 pcs) values for ‘Mela’ than for the control groups.

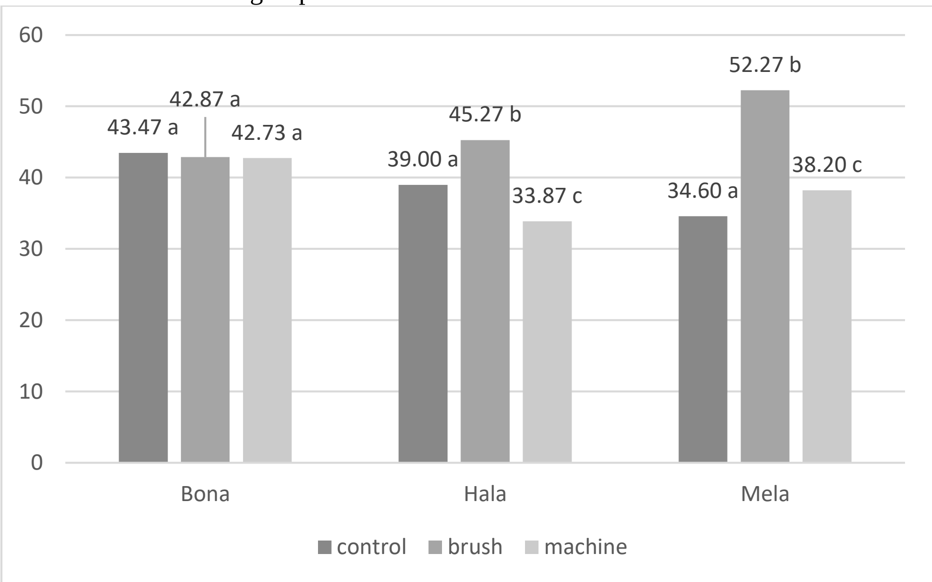

Fig. 3. Mechanical stress effects of number of leaves (Values of $P < 0.05$ were considered statistically significant)

Leaf area was also significantly increased for ‘Bona’ (24.6 cm^2) and ‘Hala’ (27.19 cm^2) compared to the mean leaf area values of the control group (18.13 cm2 and 24.43 cm2) (Figure 4.). For ‘Mela’, leaf area sizes did not differ significantly between the control and mechanically treated groups. In the case of the mechanically treated individuals, the leaf area was significantly reduced in all three treated cultivars compared to the values of the brush-treated and control groups.

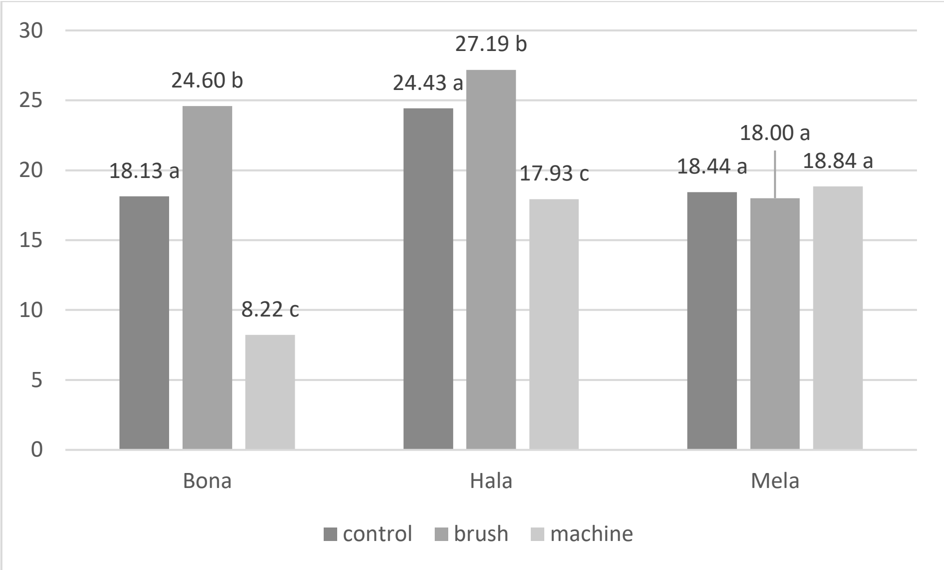

Fig. 4. Mechanical stress effects of leaf area (Values of P < 0.05 were considered statistically significant)

Fresh green mass values also differ significantly from the control group results for all three treated cultivars. In the 'Bona' variety, the 22.24 g achieved in the control group was significantly higher than in the brush-treated group (14.05 g) and the mechanically mechanical stress-treated group (14.39 g). The mean fresh green weight of the control group of the 'Hala' group was 23.06 g, a value that was also significantly higher than the mean fresh green weight of the brush-treated group (19.69 g) and the mechanically treated group (12.17 g). For the 'Mela' groups, the mean fresh green weight of the control group was 19.97 g, while for the treated groups, the parameter values were also statistically different (12.27 g – 14.96 g).

Fresh root mass values yielded similar results compared to the previous ones (Figure 5.). For all three treated cultivars, individuals in the control group resulted in significantly higher fresh root mass than the treated groups. Brush-treated individuals produced significantly higher average fresh root masses in all three cultivars than in the case of mechanically treated herds.

Fig. 5. Root length as a result of treatments (1.: control, 2.: mechanical stress 3.: brush 4.: Bistep)

Flowering data also correlate with vegetative measurement data. At the most advanced stage (May 19, 2021) were individuals in the control group and inflorescences in the groups treated with the Bistep biostimulator. In the case of groups exposed to mechanical stress, flowering was delayed. It has a positive effect on flower size, as found by KISVARGA ET AL. (2014) AND TAKÁCS ET AL. (2015).

CONCLUSIONS

In summary, in the case of the biostimulator-treated group, it was observed for several cultivars that the vegetative parameters produced significantly higher values than in the case of the control groups. Ferbanat L strengthened the root system, as found by TILLY-MÁNDY *ET AL.* (2011).

Both manual and machine stress effects had significant verifiable effects.

Plant height was significantly lower in all three cultivars than in the control group. The number of leaves in the case of individuals receiving manual mechanical treatment was significantly increased in the cultivars ‘Hala’ and ‘Mela’. This result is also related to the findings of LATIMER AND THOMAS (1991) AND KOCH ET AL. (2011).

Leaf surface size was significantly increased in the ‘Bona’ and ‘Hala’ cultivars in the brush-treated groups, while no significant difference was detected in the ‘Mela’ cultivars. Under the effect of mechanically mechanical stress, significantly lower leaf area was observed in the treated individuals. The apex of the leaves treated in this way curved downwards.

Fresh green mass was highest in the three treated groups in the control groups, while fresh green mass values were lowest in the individuals treated with mechanical mechanical stress treatment. In the brush-treated groups, the fresh green mass values were significantly lower in all three cultivars than in the control groups. However, these values can also be related to lower heights.

In summary, mechanical stress treatments significantly reduced the size of fresh root mass in all three cultivars compared to the control groups. It can be concluded that mechanical stimulation can be used in a greenhouse environment to change the growth rate and to produce marketable plants, as found by Börnke *et al.* (2018).

BIBLIOGRAPHY

BENEDETTO, A.D, GALMARINI, C, TOGNETTI, J. 2018 - New insight into how thigmomorphogenesis affects Epipremnum aureum plant development. Horticultura Brasileira 36(3):330–340. *http://dx.doi.org/10.1590/S0102-053620180308*

BÖRNKE, F, ROCKSCH, T. 2018 - Thigmomorphogenesis–control of plant growth by mechanical stimulation. Scientia Horticulturae 234:344–353. *https://doi.org/10.1016/j.scienta.2018.02.059*

DALE, A.G, FRANK, S.D. 2017 - Warming and drought combine to increase pest insect fitness on urban trees. PLOS ONE, 12(3):e0173844. *https://doi.org/10.1371/journal.pone.0173844*

DRANSKI, J.A.L. 2013 - Tigmomorfogênese na rustificação e sobrevivência em mudas de Pinus taeda L. Tese (Doutorado em Agronomia). Universidade Estadual do Oeste do Paraná, Marechal Cândido Rondon 107. f. *http://dx.doi.org/10.5902/1980509833047*

EBIC, 2012 - About biostimulants and the benefits of using them | European Biostimulants Industry Council. http://www.biostimulants.eu/about/what-are-biostimulants-benefits/.

GARDINER, B., BERRY, P., MOULIA, B. 2016 - Review: Wind impacts on plant growth, mechanics and damage. Plant Science, 245:94–118. *https://doi.org/10.1016/j.plantsci.2016.01.006*

HISAMATSU, T., KOSHIOKA M., KUBOTA S., FUJIME Y., W.R. KING AND L.N. MANDER. 2000 - The role of gibberellin biosynthesis in the control of growth and flowering in Matthiola incana. Physiologia Plantarum 109:97-105.

JAFFE, M.J. 1973 - Thigmomorphogenesis: The response of plant growth and development to mechanical stimulation: With special reference to *Bryonia dioica*. Planta 114(2):143–157.

https://doi.org/10.1007/BF00387472

JARDIN, P, XU, L, GEELEN, D. 2020 - Agricultural Functions and Action Mechanisms of Plant Biostimulants (PBs). In the chemical biology of plant biostimulants, John Wiley & Sons Ltd. 1-30. https://doi.org/10.1002/9781119357254.ch1

KAUZE, L., ISHIHARA, E., LEE, K. W., BORTHAKUR, D. 2016 - Thigmomorphogenesis: changes in morphology, biochemistry, and levels of transcription in response to mechanical stress in Acacia koa. Canadian Journal of Forest Research. http://agris.fao.org/agris-search/search.do?recordID=US201700195110.

KISVARGA, SZ., KEREZSI, R., KOHUT, I., TILLY-MÁNDY, A. 2014 - The effect of Ferbanat L nano-fertilizer on the growing of *Petunia x grandiflora* 'Musica Blue'. International Journal of Horticultural Science and Technology 20(3-4.):107-109. https://doi.org/10.31421/IJHS/20/3-4/1144

KLESKANOV, V.I., KLESHKANOVA, E.V. 2009. - A FERBANAT L komplex bioorganikus nano-trágya hatása a szőlő vegetatív fejlődésére [The effect of Ferbanat L complex bioorganic nanofertilizer on the vegetative development of grape]. Borászati Füzetek 19(4):6–11.

KOCH, R., SAUER, H., RUTTENSPERGER, U. 2011 - Einfluss von mechanischen Berührungsreizen auf das Wachstum von Küchenkräutern im Topf. Gesunde Pflanzen 63(4):199–204. https://doi.org/10.1007/s10343-011-0266-6

KORANKYE, E.A., LADA, R.R., ASIEDU, S.K., CALDWELL, C. 2018 - Mechanical shaking and baling of balsam fir trees influence postharvest needle senescence and abscission. American Journal of Plant Sciences 9(3):339–352. https://doi.org/10.4236/ajps.2018.93027

KOVÁCS, D., MAGYAR, L., SÜTÖRINÉ DIÓSZEGI, M., HROTKÓ, K. 2017 - Treatments affecting the growth of *Forsythia x intermedia* Zabel. 'Beatrix Farrand' container grown shrubs. Gradus 4(2):284-289. http://gradus.kefo.hu/archive/2017-2/2017_AGR_027_Kovacs.pdf

LATIMER, J.G., OETTING, R.D. 1999 - Conditioning treatments affect insect and mite populations on bedding plants in the greenhouse. HortScience 34(2):235–238. https://doi.org/10.21273/HORTSCI.34.2.235

LATIMER, J.G., THOMAS, P.A. 1991 - Application of brushing for growth control of tomato transplants in a commercial setting. HortTechnology 1(1):109–110. https://doi.org/10.21273/HORTTECH.1.1.109

MISHRA, R.C., BAE, H. 2019 - Plant Cognition: ability to perceive 'Touch' and 'Sound.' In S. Sopory (Ed.), Sensory Biology of Plants, Springer 137-162. https://doi.org/10.1007/978-981-13-8922-1_6

SAFAEI FAR, A., REZAEI NEJAD, A., SHAHBAZI, F., MOUSAVI-FARD, S. 2019 - The effects of simulated vibration stress on plant height and some physical and mechanical properties of *Coleus blumei* Benth. International Journal of Horticultural Science and Technology 6(2):273–282. https://doi.org/10.22059/ijhst.2019.282693.298

SÁNCHEZ-BLANCO, M.J., ORTUÑO, M.F., BAÑON, S., ÁLVAREZ, S. 2019 - Deficit irrigation as a strategy to control growth in ornamental plants and enhance their ability to adapt to drought conditions. The Journal of Horticultural Science and Biotechnology 94(2):137–150. https://doi.org/10.1080/14620316.2019.1570353

STUBBS, C.J., COOK, D.D., NIKLAS, K.J. 2019 - A general review of the biomechanics of root anchorage. Journal of Experimental Botany 70(14):3439–3451. https://doi.org/10.1093/jxb/ery451

TAKÁCS, A., KÖBLI, V., HONFI, P. 2015 - Biostimulátorok alkalmazása a vágottliliom-termesztésben. Application of biostimulators in the cultivation of cut lilies. Kertgazdaság 47(1):40-47. https://matarka.hu/cikk_list.php?fusz=128573

TILLY-MÁNDY, A., HONFI, P., KONCZ, L., HROTKÓ, K. 2011 - The effect of Bistep ont he root formation of Pelargonium 'Robert's Lemon'. Transilvanian Horticulture and Landscape Studies Conference, Tîrgu-Mures. 71.

TOSCANO, S., ROMANO, D., MASSA, D., BULGARI, R., FRANZONI, G., FERRANTE, A. 2018 - Biostimulant applications in low input horticultural cultivation systems. Italus Hortus 35:27–36. https://doi.org/10.26353/j.itahort/2018.1.2736

YOSHIAKI, H., OTA, Y. 1975 - Relation between growth inhibition and ethylene production by mechanical stimulation in Lilium longiflorum 16(1):185–189.

https://doi.org/10.1093/oxfordjournals.pcp.a075120

ZULFIQAR, F., CASADESÚS, A., BROCKMAN, H., MUNNÉ-BOSCH, S. 2019 - An overview of plant-based natural biostimulants for sustainable horticulture with a particular focus on moringa leaf extracts. Plant Science 110194. *https://doi.org/10.1016/j.plantsci.2019.110194*