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EXAMINATION OF BRT® GREENMOSS, BRT® EVERGREEN AND FAINSOIL BIOACTIVATOR (FBA) IN THE PRODUCTION OF *TAGETES PATULA* L. 'CSEMŐ'

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Three kinds of recently developed plant growing media and organic fertilizers were studied separately or in combinations in *Tagetes patula* L. 'Csemő' production at the Szent István University, Budapest in 2014. Plant height and width; fresh weight and fresh/dry weight rate, chlorophyll content and peroxidase enzyme activity were detected. Highest and widest plants were obtained in BRT® GreenMoss, GreenMoss in combination with 10% BRT® Evergreen and in common growing mixture combined with 30% BRT® Evergreen in combination with Fainsoil Bioactivator treatment. All treatments increased fresh weight and chlorophyll content.

Keywords: Tagetes, chlorophyll, peroxidase, BRT

Sustainable development is an important question in recent years. Ornamental plant production uses huge amounts of organic and inorganic growing mixture additives, nutrients, water, plant growth controlling agents, etc. that can be harmful for the environment; they are available in limited volumes or the transport is expensive (Fain et al., 2008). Therefore, the research and study of such products that can lower or eliminate the above mentioned problems are in focus. Intensive study is going on in searching alternative growing mixtures and on the effect of different organic nutrients. Nazari et al. (2008) examined Agrobiosol, a fungal biomass, Alkan, consists of poultry manure, sulphur and *Thiobacillus*, Bavar, 2 phosphate Biofertilizer containing two types of phosphate solubilizing bacteria, vermicomposts originated of animals or plants, different bacterial strains and animal manure. They found that *Tagetes erecta* can be grown successfully in these growing mixtures, in some cases they reached significantly better results compared to the commonly used control medium. Fain et al. (2008) studied the possibility of using *Pinus tedea* bark alone or in different combinations with peat during the production of *Tagetes patula*. They proved that the whole tree substrates especially when combined with peat moss are potential alternatives to conventional greenhouse substrates. Hou et al. (2012) used composted corn stalk alone or in combinations with garden soil for plug production of *Tagetes erecta*. They found that composted corn stalk can be an alternative growing mixture for this species or other bedding plant production. Hou and Yang (2011) examined different growing medium compositions made of vermiculite, perlite, composted chicken manure and hog waste for the production of *Tagetes erecta*. Significantly better results were obtained with growing media containing vermiculite, peat, well-composted chicken manure and perlite at the ratio of 3 : 4 : 2 : 1. Sludges of dairy, wood or paper and malt origin were examined for their potential as peat diluents after co-composting with shredded green materials by NiChualain et al. (2011). They found that plant growth in media containing co-composted materials was comparable to, and in some cases exceeded that of conventional peat-media. Sardoei et al. (2014) compared animal manure originated vermicompost in different concentrations to a traditional basic growing medium in *Tagetes erecta* growing. Vermicompost had significant positive effects on flower numbers, leaf growth and shoot fresh and dry weights compared to the control media. The best results were obtained with 60% vermicompost containing medium. The results indicated that vermicompost had significant effect on photosynthetic pigment level as well. Rather uncommon medium, iron ore tailings were tested for *Tagetes patula* growing by Chaturvedi et al. (2014). They measured increase in growth, chlorophyll content, and metal accumulation capacity with increasing proportion of tailings in the soil. Furthermore, the increase in antioxidant activities in plants grown on tailings as compared to control was observed. Using wetting agents into the growing mixture is offered for tenth of years (Adams and Fonteno, 2003). Yan et al. (2016) examined Geohumus® mixing to the artificial medium for green roof. They observed that the survival rate of the examined plant species (*Mukdenia rossii*, *Dianthus chinensis*, and *Pachysandra terminalis*) differed depending on the amount of Geohumus® mixed. The results of the experiment showed, with some exceptions, that Geohumus® helped to improve soil water content, reduce plant stress, and extend plant survival period. Kapsimalis et al. (2011) examined mineral-polyacrylate substrate amendment in pot Hydrangea production during normal and reduced water supply. They found that this additive could retain water and plants could well grow even in fir bark medium supplemented with 4 kg m^{-3} polyacrylate. Nutrition of the plants with organic fertilizers is an up-to-date question as well. Algae and bacteria containing products are already

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available in markets. Sridhar and Rengasamy (2010a) examined the effect of a liquid fertilizer derived from *Ulva lactuca* seaweed (SLF) on the production of *Tagetes erecta*. SLF in combination with recommended rate of chemical fertilizers gave the best results. The same authors reported results with another seaweed liquid fertilizer derived from *Sargassum wightii*. They found that, similarly to the previous results, the best growth and development was achieved when SLF was combined with the recommended ratio of chemical fertilizer (Sridhar and Rengasamy, 2010b). Singh et al. (2015) compared different organic fertilizers to the commonly used NPK inorganic fertilizers in *Tagetes erecta* growing. Though best results were obtained with the inorganic fertilization, statically, they did not differ and closely followed by the positive effect of vermicompost and poultry manure. Polara et al. (2015) examined the effect and interaction of nitrogen and phosphorus. Increasing N level was in positive correlation with the change of most morphologic parameters. Phosphorus application failed to influence the plant growth. The interaction of N and P had positive effect on plant width and flower diameter. Oppositely Negahban et al. (2014) reported increasing effect of phosphorus fertilization on the production of *Tagetes minuta*. They found that P level is in positive correlation in most examined parameters such as fresh and dry weights, plant height and flower numbers per plant and essential oil content. Rajadurai and Beaulah (2000) combined NPK fertilizers with *Azospirillum* and/or VAM (*Glomus fasciculatum*). Most and heaviest flowers, as well as longest stalks, were produced with the highest fertilizer rate combined with Azospirillum and VAM. Combined treatments were better than single treatments. Organic and inorganic nitrogen sources, such as mustard oil cake, neem oil cake and urea were studied by Ghosh and Pal (2010). Sources of nitrogen significantly influenced the vegetative and reproductive development. The best results were obtained with 50% mustard oil cake as basal and 50% urea as top application in almost all examined parameters.

Material and methods

Tested products

The examination was carried out in the greenhouse of the Department of Floriculture and Dendrology, the Corvinus University, Budapest in Spring 2014. *Tagetes patula* L. 'Csemő' test plant is a Hungarian breeding variety with 30–40 cm in full size, and 30 cm in diameter. The flowers are up to 4.5 cm in diameter, the colour is sulphur-yellow. It tolerates the continental climate, high temperatures (up to 40 °C) and insolation. It tolerates dry conditions, can be used in extensive flower beds without irrigation (www.resinfru.hu).

During the research, three products were examined, developed by the BRT Ltd Oy. and Oy Faintened Ltd., Finland.

BRT® EverGreen, is a hydrophilic product, able to store up to 90% water of its volume and release it slowly to plant root systems. At the same time it can also bind water-based nutrients and fertilizers to the soil. This product also provides roots with extra oxygen needed for growth. BRT® EverGreen is composed of methylene-urea resin. During the manufacturing, highly diluted phosphorous acid is added. EverGreen acts as a soil amendment and also as a slow releasing nitrogen and phosphorous fertilizer. The recommended concentration is between 10% and 30% (www.brt.fi).

BRT® GreenMoss growing medium is produced from the top 20–30 cm layer of *Sphagnum* moss bog. It can be used in all soilless. It is a new environmentally sound, organic and fully recyclable growing medium. The moisture content is about 70% of relative humidity. It has high air capacity which minimizes the risks of oxygen deficiency in plant roots. The structure of moss does not deteriorate as quickly as with blond *sphagnum* peat which makes it suitable for long term growing and even reusable as growing medium (oral information).

FAIN Bioactivator (FBA) is recommended for preventing or eliminating odour problems, quickening composting process in composts and manures etc. The product was prepared with sterile fermenting process from EM-1 microbe mixture, sugar cane molasses and UV-cleansed water. The product contains lactic acid bacteria, yeast and acitonomycene (aerobic and anaerobic), easily and quickly biodegradable patented Fain special tenside and Greenfain product (www.faintend.com).

Plug production

Plug production of *Tagetes patula* 'Csemő' started on 10th March 2014 with seed sowing in the greenhouse of the Department of Floriculture and Dendrology, BCE, the Buda Arboretum, Budapest. Three normal leaf seedlings were transplanted into 7 × 7 × 8 cm black Teku® containers on 6th May 2014 and were placed in the greenhouse of the Experimental Research Farm of the Department of Floriculture and Dendrology, the Corvinus University of Budapest, Soroksár, Péteri-major.

Treatments

Control: Uni-20 professional growing medium: *Sphagnum* peat based culture mixture (with adding of 2 kg m^{-3} Multicote; 2 kg m^{-3} PG Mix; 1.5 kg m^{-3} Futor ($CaCO_3$)).

MOSS: BRT® GreenMoss as culture mixture supplemented with 2 kg m^{-3} Multicote; 2 kg m^{-3} PG Mix; 1.5 kg m^{-3} Futor ($CaCO_3$).

MOSS + BRT10: 90% BRT® GreenMoss + 10% BRT® Evergreen. Mixture supplemented with the same amount of nutrients as mentioned above.

MOSS + BRT20: 80% BRT® GreenMoss + 20% BRT® Evergreen. Nutrients see above.

BRT10: 90% Uni-20 professional growing medium + 10% BRT® Evergreen.

BRT20: 80% Uni-20 professional growing medium + 20% BRT® Evergreen.

BRT30: 70% Uni-20 professional growing medium + 30% BRT® Evergreen.

BRT10 + FBA: 90% Uni-20 professional growing medium + 10% BRT® Evergreen. Irrigation with 0.1% FainSoil bioactivator solution at the time of potting, two weeks after potting irrigation with 0.05% and 4 weeks after potting irrigation with 0.05% FainSoil solution.

BRT20 + FBA: 80% Uni-20 professional growing medium + 20% BRT® Evergreen. Irrigation method is equal to BRT 10 + FBA.

BRT30 + FBA: 70% Uni-20 professional growing medium + 30% BRT® Evergreen. Irrigation method is equal to BRT 10 + FBA.

Every treatment group contained 30 plants.

Measured and observed parameters

Plant height, plant diameter, leaf width (The values of leaf length were equal with the half of plant width; therefore it was useless to measure leaf length, too. During the experiment the lateral shoots only started to grow, this parameter did not give valuable results; therefore we did not count it as well).

Flowering of the plants: start of the flowering, flowering intensity (number and size of flowers).

Root development (at the end of the experiment, evaluating with quantification): 5 plants from each treatment were separated, root system was evaluated.

Fresh and dry weight of the plants (g): For the determination of fresh and dry weight, 5 characteristic plants were separated from each treatment group. Root system was cut by the root neck; whole green plant body with flowers (if contained) was measured with Mettler Toledo J 1502G scale. Green organs were dried out at room temperature and were measured again (dry weight) with the same scale.

Chlorophyll content, peroxidase enzyme activity (POD). For the determination of chlorophyll content and POD activity 5 leaf samples from different plants were used. Chlorophyll content was determined according to Horváth and Erdei (2003), peroxidase enzyme activity was determined after Blinda et al. (1996).

Data was analysed with the SPSS statistical program group.

Results and discussion

Plant height and diameter

The different treatments had variable effects on plant height (Figure 1). The best results were obtained in the Moss medium alone (17.1 cm), Moss combined with BRT 10 (17.6 cm) and BRT 30 combined with FBA treatment (17.1 cm) compared to the control (15.5 cm). The other treatments did not differ from the control significantly, nor from each other. Nevertheless, all treatments increased more or less the plant height, in practical aspect these results are not mentionable, do not improve the quality.

All treatments had significant effect on plant diameter (and leaf length) compared to the control (20.6 cm). The widest plants were obtained in Moss (25.2 cm) and BRT 30 combined with FBA irrigation (24.6 cm) (Figure 1). Comparing the treatments to each other, the above mentioned treatments resulted in wider plants, but this data did not differ significantly from Moss + BRT 10 (24.6 cm) and BRT 20 + FBA (23.4 cm) treatments as well.

Treatments had no significant effect on leaf width of the plants; nevertheless, all the treatments resulted in wider leaves. FBA treatments combined with BRT lowered leaf width.

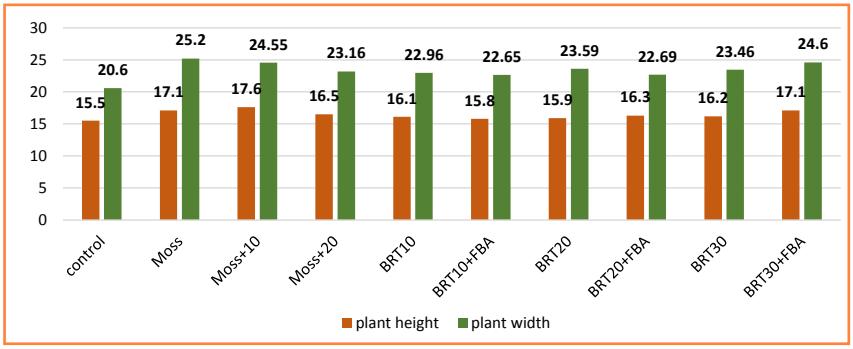

Figure 1 Plant height and width (diameter) of *Tagetes patula* 'Csemő' (cm) at the end of the experiment, 06.06.2014. Letters above the columns mean significant difference

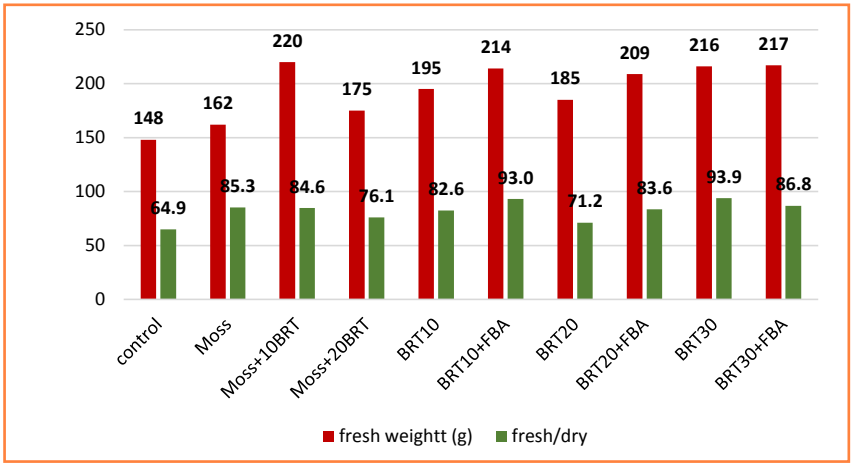

Figure 2 Trends of fresh weight (g) and fresh/dry weight rate affected by different treatments in *Tagetes patula* 'Csemő' production

Fresh and dry weight

As Figure 2 demonstrates that all treatments had positive effect on plant fresh weight compared to the control except of Moss. The FBA treatments increased the fresh weight comparing to the BRT alone. Moss medium combined with 10% BRT had positive result as well; it increased the fresh weight by approximately 30%.

In the case of dry weight we obtained the best results on Moss + BRT 10 medium and growing medium containing 20% BRT (both value was 2,6 g), compared to the control (2,28 g). But, if examining the rate of fresh and dry weight, the lowest rate was observed in the control group. It means that control plants contained the lowest amount of water and highest amount of the solidifying tissue.

Chlorophyll content and POD activity

All treatments increased the chlorophyll content in the leaves of *Tagetes patula* 'Csemő' (Figure 3.). Moss medium alone had very low effect, the chlorophyll level increased in positive correlation with the BRT content in the medium. When BRT was mixed to

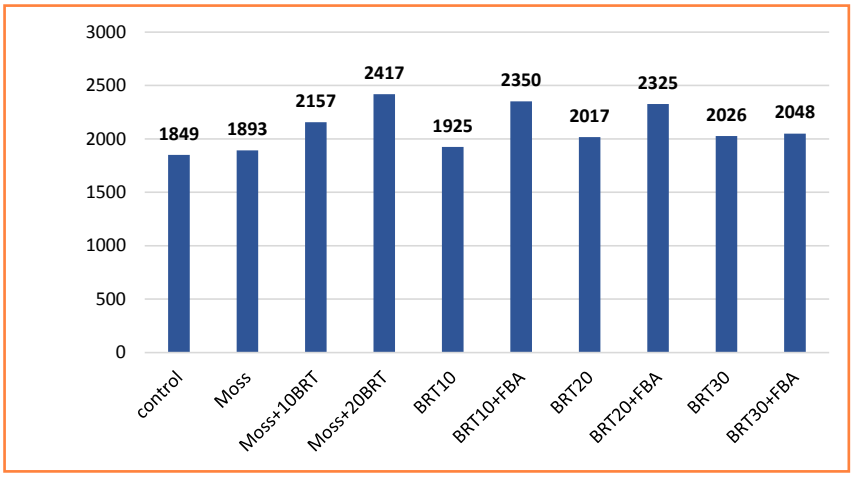

Figure 3 Chlorophyll content in the leaves of *Tagetes patula* 'Csemő'

the professional growing medium, the content was increased in correlation with the concentration but in a rather lower extent. The FBA treatment resulted in more chlorophyll in the leaves compared to the effect of BRT alone in any concentration.

The use of Moss as a growing medium reduced the peroxidase enzyme activity in the plants (Fig 4. left). The value increased in the plants grown in the mixture of Moss and 10% BRT till the level of the control and reduced again when the concentration was changed to 20%. When BRT was mixed with growing medium, a very small rate of rise could be measured (Figure 4. right). The only salient value was observed in the case of BRT 20. Despite of the fact that small differences could be pointed out between the treatments, all the values were very low.

Conclusion

Summarising the results, Moss can be the suitable growing medium for *Tagetes patula* 'Csemő'. It increased plant height and width, and decreased the stress-enzyme activity in the plant. When BRT® EverGreen was mixed to it, fresh weight and chlorophyll content increased as well. It should be noted that the rate of fresh and dry weight was higher, the tissues contained more water compared to the control. Mixing BRT® Evergreen to the professional growing medium plant height increased too, but only the highest concentration combined with the FBA treatment enhanced the plant width. This result is equal to the observations of Polara et al. (2015). BRT® Evergreen had positive effect on chlorophyll content, the FBA treatment resulted in even higher rate that is in harmony with the results of Rajadurai and Beaulah (2000). The treatments had also positive effect on fresh weight but the best fresh/dry weight rate was observed if plants grew in 20% BRT® Evergreen containing medium without the FBA treatment. Regarding the results, we offer 20% BRT® Evergreen as a growing mixture additive. FBA did not bring the waited positive results. Though 20% BRT® Evergreen increased the POD activity, values are low even in this case.

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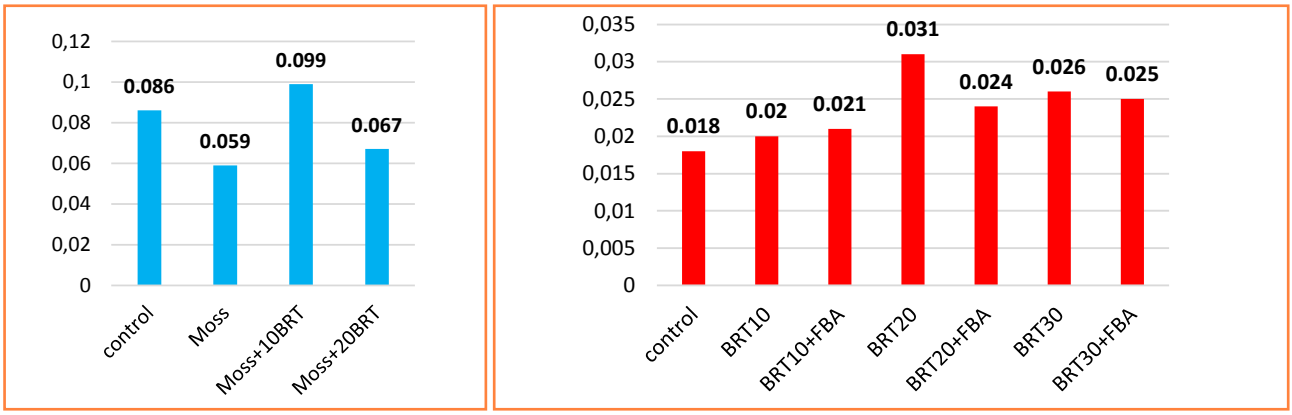

Figure 4 POD activity in the leaves of *Tagetes patula* 'Csemő'. Values were determined in two parts: Left figure: results of Moss and BRT combinations. Right figure: results of BRT and FBA treatmentsn

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