

Effects of different substrates on growth and development of Globe amaranth (*Gomphrena globosa* L.)

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Abstract

Commercial substrates have the greatest application in the production of ornamental flowers. Depending on the species being produced, there is an adequate substrate for each production. Thanks to a wide range of commercial substrates, they can be completely adapted to the type of plants, and provide everything they need in the most sensitive stage of life, as well as in the later stages.

The research is based on the possibilities and effectiveness of different substrates on growth and development of roots and above ground parts of the Globe amaranth (*Gomphrena globosa* L.), in the seedling phase and in the adult plant phase. The research was conducted in the "Gornja Puharska" Nursery in Prijedor during 2019. The substrates used in the experiment are the mixture of garden soil, Baltic, and peat from Grahovo, Hawitta baltisches UBI 20 Tonsubstrat 2, and Klasmann-Deilmann - TS3 Medium basic substrate. Measurements of morphological parameters of growth and development of plants (the plant height, number of leaves and flowers, and flower diameter) were performed, as well as determination of weight of fresh and dry roots and above ground parts and the number of seeds. Effect of medium basic substrate is reflected in an increase in the average value of vegetative morphological parameters (the plant height and number of leaves) of Globe amaranth seedlings and adult plants. Furthermore, this substrate had a positive effect on both fresh and dry mass of adult plants, as well as the number of obtained seeds, compared to the other two substrates. Efficiency of substrate comprising a mixture of

garden soil, Baltic, and peat from Grahovo, is reflected in an increase in the average values of generative morphological parameters (the number of flowers and flower diameter) of the Globe amaranth - *Gomphrena globosa* L., compared to commercial substrates applied.

Key words: substrate, *Gomphrena globosa* L., morphological parameters

Introduction

Commercial substrates are mostly applied in the production of flowers and ornamental planting material. Depending on the plant, there is an adequate substrate for almost every production. Dedicated substrates for certain flower and ornamental species can be found on the market, such as primrose substrate (with added amount of Mg), surfinia substrate (with added amount of Fe), substrate for rhododendron and azalea (with lower pH value), substrate for orchid, and many other types of substrates. With a wide range of commercial substrates, everything that plants need can be given in the most sensitive phase of life, as well as in the later stages.

Right choice of suitable substrate contributes a lot to the successful ornamental flower production. With the development and expansion of the horticultural industry the availability of suitable substrate is going to be limited and the type and composition of available substrates vary in various countries. Moreover, the available substrates are going to be expensive day by day and the demand may also increase so, greater need is required to evaluate good substrates for plant growth.

Garden soil and peat are the most used growing substrates for the container production of ornamental plants (Tariq et al., 2012). Peat is the most widely used substrate for potted plant production in nurseries, affecting the nutrients, pH, biological stability, absorption capacity, and also the organic matter in dissolved soil (Marfa et al., 2002; Ribeiro et al., 2007; Caballero et al., 2007). These materials also increase microbial activities in soil which are essential for raising and fulfilling the nutritional requirement. They also reduce nitrogen losses. Soil is fine for garden plants, but it is not a good choice for container plants because frequent water demanded by container plants will cause most soil to compact into a tight mass. On the other hand, the high cost and low availability of quality peat limit its use. The combination of garden soil and peat moss is very beneficial for plant growth. The water holding capacity increases by using peat and compost enhances the nutrient holding capacity of the growing media (Chong, 2005). Plants grown on compost-based substrates provide maximum growth and enhance nutritional values. They also improve the chemical, physical and biological properties of a soil due to high organic matter contents, and increase the porosity, water holding capacity, and infiltration rate of a soil (Ostos et al., 2008).

For appropriate growth, a root medium must fulfil 4 functions: 1) continuously supply water; 2) provide nutrients; 3) allow the exchange of gases to and from the roots; and 4) offer support for the plants (Nelson, 1991). The equilibrium of these demands varies, however, depending on the plant being grown and the phase of growth. It is necessary to find alternative growing materials. Researches have suggested that peat can be satisfactorily replaced in container media with some organic waste materials including bark and wood fibre, coconut coir, and compost.

Gomphrena globosa L. - Globe amaranth is a popular edible plant used as food colourant, in traditional medicine, and it is ideal for public green areas. It is a very heat-tolerant and drought resistant plant, but grows best in full sun and regular moisture, blooms continuously throughout summer and early fall.

The aim of this research is to evaluate the possibilities and effectiveness of different substrates on growth and development of roots and above ground parts of the Globe amaranth (*Gomphrena globosa* L.), in the seedling phase and in the adult plant phase.

Material and Methods

The research was conducted in the "Gornja Puharska" Nursery in Prijedor during 2019. Globe amaranth (*Gomphrena globosa* L.) seeds were sown in April in the Fruhstorfer Erde type Aussaat und Stecklinge substrate (sowing substrate; Hawita Gruppe, Germany). The substrate contained perlite, peat, and volcanic clay for better aeration and friability. Other substrate characteristics were as follows: 5.9 pH, N mg/L=80, P₂O₅ mg/L=60, K₂O mg/L=90, and retention capacity of 700 ml/L. Polystyrene containers were kept in an unheated greenhouse where daily temperatures varied according to the amount of precipitation and the number of cloudy days. In June, when seedlings developed two pairs of true leaves, they were transplanted into polyethylene pots ϕ 17 cm diameter. The experiment was set up in a split-plot design with four replications and three treatments: the mixture of garden soil, Baltic, and peat from Grahovo (A1) - control group, the Hawitta baltisches UBI 20 Tonsubstrat 2 (A2) - treatment, and the Klasmann-Deilmann - TS3 Medium basic substrate (A3) - treatment. The trial consisted of total of 120 plants. The substrate mixture, commonly used in this nursery, for perennials and annual flowers is a mixture of garden soil, Baltic and peat from Grahovo. Baltic Grow substrate contained black peat, clay, and perlite, 4-6 pH, EC 0.02-0.16 dS/m. Peat from Grahovo contained high quality peat with 5.9-6.6 pH, 65% organic matter, high values of phosphorus (P) and potassium (K), and low values of nitrogen (N). In the Laboratory of Soil Science, Faculty of Agriculture, University of Banja Luka the chemical analysis of a mixture of garden soil, Baltic and peat from Grahovo was conducted and its composition is given in Table 1.

Tab. 1. Agrochemical analysis of the mixture of garden soil, Baltic, and peat from Grahovo

garden soil + Baltic peat + peat from Grahovo			
pH	humus	P ₂ O ₅	K ₂ O
H ₂ O	%	mg/100g	mg/100g
6.10	18.7	15.0	21.5

The Hawitta baltisches UBI 20 Tonsubstrat 2 substrate contained white peat with a coarse structure 5-25 mm, 5.8 pH, low values of clay, 50-300 mg/l NH₄-N+NO₃N, 80-300 mg/l P₂O₅, 80-400 mg/l K₂O, > 97 % organic matter. The Klasmann-Deilmann - TS 3 substrate contained 140 mg/l N, 100 mg/l P₂O₅, 180 mg/l K₂O, 100 mg/l Mg, 150 mg/l S, and had 5.5-6.5 pH.

During the seedling phase (by the end of July) measurements of morphological parameters of growth and development of transplants - plant height (cm), number of leaves and flowers, as well as flower diameter (mm) were carried out. After the seedling phase, the plants were moved to an open field, and this phase lasted until the end of October. The following parameters were recorded, namely the plant height (cm), number of leaves, flowers and seeds, flower diameter (mm), fresh and dry mass of parts. In order to examine the growth and development of adult plants under the effect of different substrates, the roots were cleaned from the substrate, washed with distilled water, followed by measuring of the weight of fresh plants. This plant material was packed in separate paper bags and dried to a constant weight at 70°C. The mass of fresh and dry plant material was measured at two decimal place accuracy and expressed in grams (g).

The obtained data was statistically analysed using two-way analysis of variance -ANOVA. The Fisher's LSD test was applied to assess statistical significance of differences between treatments using main values that were considered significantly different when $p < 0.05$. No additional fertilization or pesticide treatments were used in the experiments.

Results and Discussions

Table 2. presents the average values of the morphological parameters of Globe amaranth seedlings. All morphological parameters were under statistically highly significant ($p=0.01$) effects of different substrates. The plant height and number of leaves were increased by a treatment with the Klasmann-Deilmann – TS 3 substrate, while the number of flowers and flower diameter increased by using the control A1- the mixture of garden soil, Baltic, and peat from Grahovo.

The highest plants were observed in A3 – the treatment with the Klasmann-Deilmann - TS 3 substrate (20.58 cm), and lowest in A1 - control (15.45 cm). The number of leaves were highest in A3 (52.81) and lowest in A1 (44.25). The

number of flowers were highest in A1 (3.15) and lowest in A2 – the treatment with the Hawitta baltisches UBI 20 Tonsubstrat 2 (1.29). The largest flower diameter was observed in A1 with 9.39 mm, and smallest in A2 with 6.45 mm.

Tab. 2. Effects of different substrates on morphological parameters of Globe amaranth (*Gomphrena globosa* L.) seedling (A1- control - mixture of garden soil, Baltic and peat from Grahovo; A2- treatment - Hawitta baltisches UBI 20 Tonsubstrat 2; A3- treatment - Klasmann-Deilmann - TS 3 substrate; means marked with different letters ^{a,b,c} significantly differ at $p < 0.05$)

Morphological parameters of seedlings		Plant height (cm)	No. of leaves	No. of flowers	Flower diameter (mm)
Treatment variant (A)	Control (A1)	15.45 ^c	44.25 ^c	3.15 ^a	9.39 ^a
	Treatment (A2)	19.33 ^b	49.49 ^b	1.29 ^c	6.45 ^c
	Treatment (A3)	20.58 ^a	52.81 ^a	2.14 ^b	6.86 ^{b,c}
Average		18.45	48.85	2.19	7.57
LSD	0.05	0.9426	2.4202	0.6417	0.9832
	0.01	1.3543	3.4773	0.9220	1.4126
		Plant height (cm)	No. of leaves	No. of flowers	Flower diameter (mm)
A1xA2		**	**	**	**
A1xA3		**	**	*	**
A2xA3		*	*	*	ns

ns = not significant

In Table 2. it can be seen that different substrates have different statistical effects on morphological parameters of Globe amaranth seedlings. After analysing morphological parameters of growth and development of Globe amaranth seedlings, the measurement of morphological parameters in adult plants was carried out, and the results obtained are presented in Table 3.

Tab. 3. Effects of different substrates on morphological parameters of *Globe amaranth* (*Gomphrena globosa* L.) adult plants (A1- control - mixture of garden soil, Baltic and peat from Grahovo; A2- treatment - Hawitta baltisches UBI 20 Tonsubstrat 2; A3- treatment - Klasmann-Deilmann - TS 3 substrate; means marked with different letters ^{a,b,c} significantly differ at $p < 0.05$)

Morphological parameters of adult plants		Plant height (cm)	No. of leaves	No. of flowers	Flower diameter (mm)
Treatment variant (A)	Control (A1)	21.84 ^a	101.11 ^{a,b}	28.59 ^c	15.93 ^c
	Treatment (A2)	24.81 ^b	103.31 ^{a,c}	19.40 ^a	11.44 ^{a,b}
	Treatment (A3)	26.06 ^c	109.19 ^c	26.77 ^{b,c}	12.35 ^b
Average		24.24	104.54	24.92	13.24
LSD	0.05	1.1536	5.2379	3.4789	0.7957
	0.01	1.6575	ns	4.9984	1.1432
		Plant height (cm)	No. of leaves	No. of flowers	Flower diameter (mm)
A1xA2		**	ns	**	**
A1xA3		**	**	ns	**
A2xA3		*	ns	**	ns

ns = not significant

The plant height, number of flowers, and flower diameter were under statistically highly significant ($p=0.01$) effects of different substrates, while the number of leaves was under statistically significant ($p=0.05$) effects. Also, the plant height and number of leaves were increased by the treatment with A3 – the Klasmann-Deilmann - TS 3 substrate, while the number of flowers and flower diameter were increased by using control A1- the mixture of garden soil, Baltic, and peat from Grahovo.

The highest plants were observed in A3 – the treatment with the Klasmann-Deilmann - TS 3 substrate (26.06 cm), and lowest in A1 - control (21.84 cm). The number of leaves was highest in A3 (109.19) and lowest in A1 (101.11). The number of flowers was highest in A1 (28.59) and lowest in A2 – the treatment with the Hawitta baltisches UBI 20 Tonsubstrat 2 (19.40). The largest flower diameter was observed in A1 with 15.93 mm, and smallest in A2 with 11.44 mm. Different substrates have different statistical effects of morphological parameters of *Globe amaranth* adult plants, as well as in seedlings.

The reason for better development of plant height and number of leaves in treatment A3 and in treatment A2 is that commercial substrates are enriched with macro and micro nutrients. In addition, these substrates have a favourable water-air regime that provides easier transport and absorption of nutrients, but also better development of the root system, which has a favourable effect on the development of the above ground part.

Better development of number of flowers and flower diameter were in the control variant – the mixture of garden soil, Baltic, and peat from Grahovo. Chemical analysis of this substrate mixture showed a high amount of humus (18.7%), P₂O₅ (15 mg /100 g) and K₂O (21,5 mg/100 g), which have great effects on the development of generative morphological parameters. In the presence of a high concentration of nitrate in the substrate, young plants absorb and translocate potassium more intensively than other elements (Zsoldos et al., 1990; Kastori sar., 2013). This substrate mixture had a lot of organic matter, which has slow decomposition, and then in the reproductive phase plants receive maximum quantities of necessary elements. This resulted in an increase in the average values of the number of flowers and their diameter, as the main decorative element of ornamental plants.

After analysing the morphological parameters of growth and development of Globe amaranth adult plants (*Gomphrena globosa* L.), the measurement of the number of seeds and weight of fresh and dry plants was carried out and the results obtained are presented in Table 4.

Tab. 4. Effects of different substrates on fresh weight (FW) and dry weight (DW) of plants, and number of seeds of Globe amaranth (*Gomphrena globosa* L.) (A1- control - mixture of garden soil, Baltic and peat from Grahovo; A2- treatment - Hawitta baltisches UBI 20 Tonsubstrat 2; A3- treatment - Klasmann-Deilmann - TS 3 substrate; means marked with different letters ^{a,b,c} significantly differ at $p < 0.05$)

Morphological parameters of adult plants		Fresh weight FW (g)	Dry weight DW (g)	No. of seeds
Treatment variant (A)	Control (A1)	131.06 ^b	27.84 ^b	32.64 ^b
	Treatment (A2)	122.27 ^{b,c}	24.61 ^c	23.40 ^c
	Treatment (A3)	151.37 ^a	34.75 ^a	41.20 ^a
	Average	134.90	29.07	32.46
LSD		0.05	2.8324	0.8765
		0.01	4.0695	1.1836
		Fresh weight FW (g)	Dry weight DW (g)	No. of seeds
A1xA2		ns	*	**
A1xA3		**	**	**
A2xA3		**	**	**

ns = not significant

Table 4. shows that the fresh and dry plant weight and number of seeds were under statistically highly significant ($p=0.01$) effects of different substrates. The treatment A3 – the Klasmann-Deilmann - TS 3 substrate increased fresh and dry weight of plants, as well as the number of seeds. The highest fresh and dry

weight was recorded in A3 (151.37 g and 34.75 g) and lowest in A2 – the treatment with the Hawitta baltisches UBI 20 Tonsubstrat 2 (122.27 g and 24.61 g). Also, there were most seeds in A3 (41.20) and least in A2 (23.40). Similar to morphological parameters, there was significant interaction between different substrates as regards the mass of fresh and dry plants and number of seeds.

Numerous researchers have confirmed that different materials can be used as substrates for successful cultivation of many crops (Vukobratović, 2008; Polat et al., 2009; Gonani et al., 2011). Spent mushroom substrates are good sources of biofertilizer as they influence the growth of *Capsicum annuum* positively (Roy et al., 2015). According to Zeljković et al. (2015), the application of spent mushroom compost can be used in the production of *Pelargonium peltatum* L. and *Petunia hybrida* Juss. transplants because of a positive impact on the growth and development of roots and above-ground parts. Biochar could replace pine bark or commercial peat moss and perlite-based substrate by 5-30% without negative impact on plant growth of *Gomphrena* ‘Fireworks’ (Gu et al., 2013).

Conclusions

Commercial substrates are enriched with macro and micro nutrients which are sufficient for the initial plant growth. In addition, these substrates have a favourable water-air regime that provides easier transport and absorption of nutrients, but also better development of the root system. The mixture of garden soil, Baltic, and opeat from Grahovo had a lot of organic matter, which has slow decomposition, and then in the reproductive phase plants receive the maximum quantity of necessary elements.

From the above results, it can be concluded that the commercial substrate Klasmann-Deilmann - TS 3 medium basic and mixture of garden soil, Baltic, and peat from Grahovo are favourable in Globe amaranth production. In these substrates plants have better development of all examined morphological parameters, especially an increase in the average values of the number of flowers and their diameters, as the main decorative elements of ornamental plants. Also, in these substrates the plant produces a huge number of seeds, which is very important because this plant is propagated by seeds.

References

- Caballero, R., Ordovas, J., Pajuelo, P., Carmona, E., Delgado, A. (2007). Iron chlorosis in gerbera as related to properties of various types of compost used as growing media. *Communications in Soil Science and Plant Analysis*, 38: 2357-2369.

- Chong, C. (2005). Experiences with waste and composts in nursery substrates. *Hort Technology*, 15: 739-747.
- Gonani, Z., Riahi, H., Sharifi, K. (2011). Impact of using leached spent mushroom compost as a partial growing media for horticultural plants. *Journal of Plant Nutrition*, 34(3), 337-344.
- Gu, M., Li, Q., Steele, P.H., Niu, G., Yu, F. (2013). Growth of 'Fireworks' gomphrena grown in substrates amended with biochar. *Journal of Food Agriculture and Environment*, 11(1), 819-821.
- Kastori, R., Ilin, Ž., Maksimović, I., Putnik-Delić, M. (2013). Kalijum u ishrani biljaka - kalijum i povrće. Poljoprivredni fakultet, Novi Sad. str: 309.
- Marfa, O., Lemarie, F., Caceres, R., Giuff Rida, F., Guerin, V. (2002). Relationships between growing media fertility percolate composition and fertigation strategy in peat-substitute. *Scientia Horticulturae*, 94: 309-321.
- Ostos, J.C., Garrido, R.L., Murillo, J.M., Lopez, R. (2008). Substitution of peat for municipal solid-based composts in nursery growing media: Effect on growth and nutrition of the native shrub *Pistacia lentiscus*. *Bioresource Technology*, 99: 1793-1800.
- Polat, E., Uzun, I.H., Topçuoğlu, B., Önal, K., Onus, N.A., Karaca, M. (2009). Effects of spent mushroom compost on quality and productivity of cucumber (*Cucumis sativus* L.) grown in greenhouses. *African Journal of Biotechnology*, 8(2), 176-180.
- Ribeiro, H.M., Romero, A.M., Pereira, H., Borges, P., Cabral, F., Vaconcelos, E. (2007). Evaluation of a compost obtained from forestry wastes and solid phase of pig slurry as a substrate for seedlings production. *Bioresource Technology*, 98: 3294-3297.
- Roy, S., Barman, S., Chakraborty, U., Chakraborty, B. (2015). Evaluation of spent mushroom substrate as biofertilizer for growth improvement of *Capsicum annum* L. *Journal of Applied Biology & Biotechnology*, 3(03), 022-027.
- Tariq, U., Rehman, S.U., Khan, M.A., Younis, A., Yaseen, M., Ahsan, M. (2012). Agricultural and municipal waste as potting media components for the growth and flowering of *Dahlia hortensis* 'Figaro'. *Turkish Journal of Botany*, 36: 378-385.
- Vukobratović, M. (2008). Proizvodnja i ocjena kvalitete kompostiranih stajskih gnojiva. *Doktorska disertacija*. Poljoprivredni fakultet u Osijeku.
- Zeljковиć, S., Parađiković, N., Šušak, U., Tkalec, M. (2015). Use of spent mushroom substrate for growing geranium (*Pelargonium peltatum* L.) and surfinia (*Petunia hybrida* Juss.) seedlings. *Book of proceedings*. Sixth International Scientific Agricultural Symposium "Agrosym 2015", Jahorina: 109-114.
- Zsoldos, F., Haunold, E., Herger, P., Vasfagyai, P. (1990). Effects of sulfate and nitrate; K⁺ uptake and growth of wheat and cucumber. *Physiologia Plantarum*, 80: 425-430.

Утицај различитих супстрата на раст и развој кугластог шћира (*Gomphrena globosa* L.)

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Сажетак

Највећа примјена комерцијалних супстрата је у цвјећарској производњи и производњи укрсаног садног материјала. Зависно од врсте која се производи, могу се користити супстрати тачно намјењени за одређену биљну врсту. Захваљујући широком спектру, комерцијални супстрати се могу прилагодити биљној врсти тако да јој се обезбиједи све што је потребно у најосјетљивијој фази развоја, као и у даљим фазама раста и развоја.

Истраживање овог рада заснива се на испитивању ефикасности примјене различитих супстрата на раст и развој кугластог шћира (*Gomphrena globosa* L.), у фази расада и у фази одраслих биљака. Истраживање је проведено у Расаднику „Горња Пухарска“ Приједор током 2019 године. Супстрати који су кориштени у огледу су мјешавина баштенске земље, балтичког и граховског тресета, и два комерцијална супстрата Hawitta baltisches UBI 20 Tonsubstrat 2 и Klasmann-Deilmann - TS 3 Medium basic substrat.

Током огледа вршено је мјерење морфолошких параметара раста и развоја биљака (висина биљке, број листова по биљци, број цвјетова по биљци, пречник цвјетова по биљци). Такође, извршено је мјерење свјеже и суве масе одрасле биљке, као и број сјеменки по биљци.

Комерцијални супстрат Klasmann-Deilmann - TS 3 Medium basic, своју ефикасност показао је кроз повећање просјечних вриједности вегетативних морфолошких параметара (висину биљка и број листова) расада и одраслих биљака кугластог шћира, такође имао је позитивног утицаја и на свјежу и суву масу одраслих биљака, као и на бројност добијених сјеменки по биљци, у поређењу са остала два супстрата.

Супстрат који је сачињен од мјешавине баштенске земље, балтичког и граховског тресета, своју ефикасност показао је кроз повећање просјечних вриједности генеративних морфолошких параметара (број цвјетова и пречник цвијета) расада и одраслих биљака кугластог шћира у поређењу са примјењеним комерцијалним супстратима.

Кључне ријечи: супстрат, *Gomphrena globosa* L., морфолошки параметри.

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