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OPTIMIZATION OF SOME PARAMETERS FOR ORNAMENTAL PLANTS PRODUCTION IN OFF-SEASON

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Abstract

The present study evaluated the behaviour of three ornamental species through flowers, in off-season cultivation conditions, in order to optimize production parameters. The total time of flowering (Ttf) was described, for each species, by mathematical models, in relation to the temperature and plants height. The biological material was represented by the species: Lathyrus odoratus L.; Antirrhinum majus L., and Matthiola incana (L.) W.T. Aiton., respectively. The variation of the plant height, in the studied ornamental species, in relation to the temperature (T), was described by polynomial equations of degree 3, in safety statistical conditions (R^2=0.975 for Lathyrus; R^2=0.987 for Antirrhinum, and R^2=0.971 for Matthiola, respectively). In relation to the biological specificity and the behavior in the off-season, the three species had different values for the total time of flowering (Ttf); Ttf = 19 days for Lathyrus; Ttf=166 days for Antirrhinum, and Ttf=210 days for Matthiola. Multiple regression analysis led to the obtaining of Ttf estimation models, depending on the temperature (T, °C) and the height of the plants (H, cm), in statistical safety conditions. The Wolfram Alpha software facilitated the obtaining of 3D and isoquant graphic distribution models of Ttf, according to T (°C) and H (cm), for each species studied. The optimal values for H and T were determined, in order to obtain the best total flowering time, in off-season conditions, values that can be ensured by the cultivation technology of the studied species.

Key words: *Antirrhinum, Lathyrus, Matthiola, models, total time of flowering*

INTRODUCTION

Ornamental flowering plants are very numerous and are represented by various species and genotypes, in relation to taxonomic criteria. They are grown for decorative interest, rather than for other purposes.

They are annual plants, biennial or perennial, herbaceous, in the form of shrubs, or trees, of indoor or outdoor [7]. Ornamental plants have a very varied origin, in different centers and areas around the world, depending on the origin of the framing species [7].

Three ornamental species were analyzed in the present study, in out-season conditions: *Lathyrus odoratus* L., *Antirrhinum majus* L., and *Matthiola incana* (L.) W.T. Aiton, respectively.

Lathyrus odoratus L. is an ornamental plant of the genus Lathyrus, a genus that includes about 160 species. Some species are of economic importance and are grown for food resources, as fodder or for ornamental purposes [38], [39], [45].

Although various species of *Lathyrus* have been cultivated since ancient times, cultivation as an ornamental plant is associated with Sicily, England and the Netherlands, around 1699.

These species quickly became cultivated as ornamental plants for smell and various decorative ornaments [29]. Some studies have evaluated the potential of the *Lathyrus* gene pool [38]. The propagation of *Lathyrus odoratus* L. species has been approached both by classical and *in vitro* methods [27].

Antirrhinum majus L. is an ornamental species, and belongs to the genus *Antirrhinum*, Family *Plantaginaceae* [28], [41]. *Antirrhinum majus* has a flower that expresses beauty through specific shape and colors [16]. It is an annual herbaceous plant that predominates in the Mediterranean region.

Antirrhinum majus is widely used as an ornamental plant, and is a model species, extensively studied in genetics [24].

Antirrhinum majus has been extensively studied in relation to genome structure, genetic diversity and evolution [42], [41], [21]. The behavior of some F1 hybrids was studied in relation to post-harvest flowering attributes [18].

Various studies have analyzed *Antirrhinum majus* in relation to seed germination, plant growth and flowering [2]. The flowering and post-harvest performance of the cut flowers were analyzed, in relation to different growing conditions (e.g. temperature) and ethylene treatments [5]. *Antirrhinum majus* has also been studied in relation to flowering and flower pattern, from the perspective of evolution and development [15].

Matthiola incana (L.) W.T. Aiton. belongs to the Brassicaceae family and is frequently cultivated as an ornamental plant, in large areas, in different parts of the world [11], [46].

In some areas (Bolivia, Ecuador, India, Iran, Italy), it is also used as a medicinal plant in traditional medicine and treatments [43]. *Matthiola incana* L. is also of interest for human nutrition, in some areas being eaten flowers (as vegetables in the form of garnishes, desserts, or for tea), pods (freshly cooked) [33], [19], [43].

It is cultivated for ornamental purposes, but is also important for the medical field due to some principles and bioactive compounds [43]. Some studies have evaluated micro propagation in *Matthiola incana* L. [1], [20].

Vegetative growth parameters such as stem elongation, plant height, number of branches, fresh and dry weight of *Matthiola incana* were studied in relation to growth biostimulants [14], [22].

Studies on the influence of foliar fertilization in *Matthiola incana* L., evaluated the behavior of cut flowers [40], in terms of leaf number, leaf area, chlorophyll content, position and size of flowers.

Morphophenological variation of cut flowers and meiotic behaviour were studied at *Matthiola incana* L. [17].

The present study evaluated the behaviour of three ornamental species through flowers, in out-seasons cultivation conditions, and described, by mathematical models, the duration of flowering in relation to some ecological growth parameters and plants physiological indices.

MATERIALS AND METHODS

The aim of the study was to analyze the behavior of three species of ornamental plants through flowers, in off-season, in order to optimize some production parameters in relation to flowering time.

The biological material was represented by the species: *Lathyrus odoratus* L. (Lo); *Antirrhinum majus* L. (Am), and *Matthiola incana* (L.) W.T. Aiton (Mi), respectively; Lo, Am and Mi, are abbreviations used in the article for the species studied.

The species studied are annual, and to obtain flowers in the off-season, they were sown in the third decade of September, in a protected conditions (greenhouse).

After emergence, during the plant growth period, 12 series of measurements were made, at different time intervals, between December 1 and March 23, and the plants height (H, cm) was evaluated until the growth stabilized. Associated with each measurement of plant height, the temperature in the protected area was also recorded (T, °C).

The beginning of flowering (Bf) and end of flowering (Ef) were recorded for each species. The interval between Bf and Ef represented total time of flowering (Ttf) in days, for each of the studied species.

The interdependence relationship between Ttf and plant height (H, cm), respectively temperature (T, °C) of the growing period was evaluated.

The experimental data were analyzed to evaluate the statistical safety, the presence of variance (ANOVA test), the level of correlations and interdependence between the studied parameters. PAST software [13], and Wolfram Alpha software [47] were used for data analysis.

RESULTS AND DISCUSSIONS

The three species of ornamental plants, *Lathyrus odoratus* L., *Antirrhinum majus* L., and *Matthiola incana* (L.) W.T.Aiton, respectively, have been studied in relation to growth and flowering in off-season conditions.

For this, seedlings were produced by sowing them in conditions of protected space, respectively in the greenhouse. This ensured the germination and growth of plants, in protected environment conditions, to obtain flowers in the off-season.

Plant growth was analyzed in relation to temperature (T, °C). The height of the plants in dynamics was determined between December 1 and March 23, during 12 moments of determination, and the values are presented in Table 1.

Table 1. Values of plant height in the studied species, in relation to the time period and temperature

Measured period	Temperature (T)	Plant height (H)		
		Lo	Am	Mi
	(°C)	(cm)		
1 XII	20.1	30.30	23.50	12.10
16 XII	21.2	34.30	25.60	15.10
8 I	22.6	37.20	27.60	17.70
15 I	23.2	40.40	29.50	19.70
22 I	23.5	45.90	31.00	22.70
5 II	23.8	50.50	33.50	25.30
19 II	24.2	53.20	35.50	28.80
26 II	25.3	57.30	40.50	30.80
2 III	25.7	60.40	42.50	35.30
9 III	25.4	63.50	44.10	38.80
16 III	26.4	66.90	46.20	40.80
23 III	27.2	70.10	50.20	46.80
SE		±3.84	±2.53	±3.17

Lo - *Lathyrus odoratus* L.; Am - *Antirrhinum majus* L.
Mi - *Matthiola incana* (L.) W.T. Aiton
Source: original data, obtained under the experimental conditions.

The graphical distribution of plant height, in the three studied species, with the variation interval and the standard errors, is shown in Figure 1.

The variation of plant height in the species *Lathyrus odoratus* L., in relation to the temperature, during the studied vegetation period, was described by a polynomial model of degree 3, equation (1), in statistical safety conditions, according to R^2=0.975, p<<0.001, F=105.52. The graphical distribution is shown in Figure 2.

$$H_{Lo} = -0.1868\,T^3 + 13.54\,T^2 - 319\,T + 2{,}491$$
.... (1)

where: H_{Lo} - *Lathyrus odoratus* plants hight (cm); T – temperature (°C)

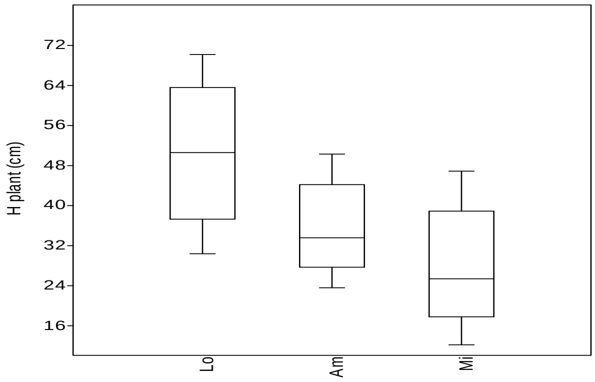

Fig. 1. Graphical distribution of plant height, with variation range and standard error
Source: original graph based on experimental data.

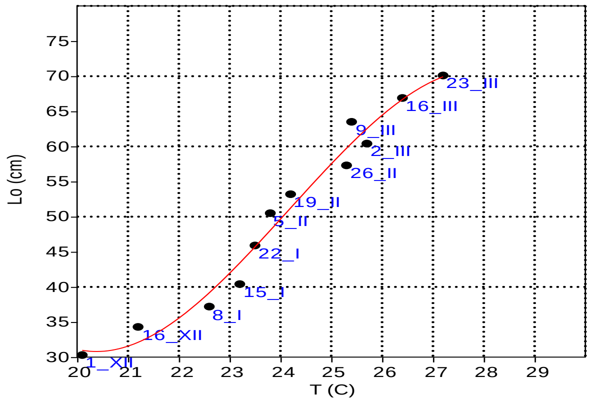

Fig. 2. Graphic distribution of plant height in *Lathyrus odoratus* L., as s function of T (°C)
Source: original graph based on experimental data.

In the case of *Antirrhinum majus* L., the variation of plant height, in relation to the average temperature (T), recorded during the study period, was described by a polynomial model of degree 3, equation (2), in statistical safety conditions according to R^2=0.987, p<<0.001, F=198.16.

The graphical distribution is presented in Figure 3.

$$H_{Am} = -0.09542\,T^3 + 7.138\,T^2 - 172\,T + 1{,}385$$
.... (2)

where: H_{Am} - *Antirrhinum majus* plants hight (cm); T – temperature (°C)

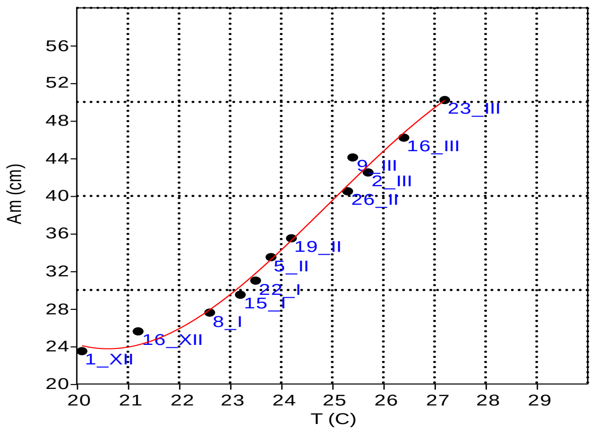

Fig. 3. Graphic distribution of plant height in *Antirrhinum majus* L., in relation to T (°C)
Source: original graph based on experimental data.

Plant height variation in the species *Matthiola incana* (L.) W.T. Aiton, in relation to the average temperature (T), during the vegetation period, was described by a polynomial model of degree 3, equation (3), in statistical safety conditions, according to R^2=0.971, p<<0.001, F=88.7. The graphical distribution is presented in Figure 4.

$$H_{Mi} = -0.06338\,T^3 + 4.951\,T^2 - 122.3T + 984.3$$
.... (3)

where: H_{Mi} - *Matthiola incana* plants hight (cm); T – temperature (°C)

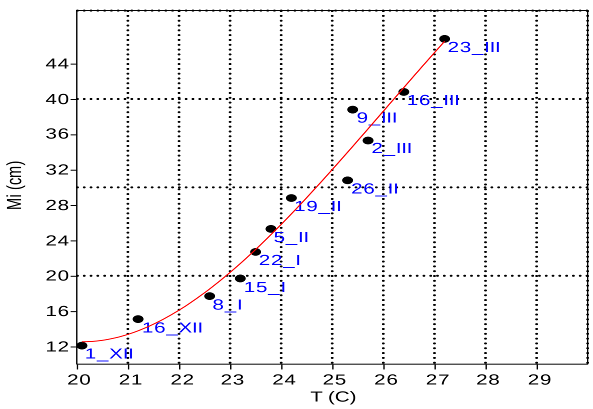

Fig. 4. Graphic distribution of plant height in *Matthiola incana* (L.) W.T. Aiton, depending on T (°C)
Source: original graph based on experimental data.

The three species studied had a different flowering period. *Lathyrus odoratus* L. had the beginning of flowering (Bf) on February 14, and end of flowering (Ef) on March 5, with a total time of flowering Ttf = 19 days. *Antirrhinum majus* L. had the beginning of flowering (Bf) on April 20, and the end of flowering (Ef) on October 3, with a total time of flowering Ttf = 166 days. *Matthiola incana* (L) W.T.Aiton had the beginning of flowering (Bf) on March 2, and the end of flowering (Ef) on September 28, with a total time of flowering Ttf = 210 days. The graphical distribution of Ttf, in the three studied species, is presented in Figure 5.

The variation of the total time of flowering (Ttf) in relation to the temperature (T, °C) and to the height of the plants (H) recorded during the study period, for each species was analyzed.

For the species *Lathyrus odoratus* L. total time of flowering (Ttf) as a function of temperature (T, °C) and plant height (H_{Lo}, cm) was described by equation (4), in statistical safety conditions (R^2=0.998, p<<0.001), with the graphic distribution in Figures 6 and 7.

Based on ANOVA test data, the statistical safety p parameter had values p≤0.001 for all terms of equation (4). 4

Under these conditions, for the species *Lathyrus odoratus* L. the optimal values for x and y in relation to Ttf_{Lo} were calculated and the values were found: x_{opt}=24.86 °C (T), and y_{opt}=56.74 cm (H_{Lo}).

$$Ttf_{Lo} = ax^2 + by^2 + cx + dy + exy + f$$
.... (4)

where:

Ttf_{Lo} – total time of flowering, *Lathyrus odoratus* specie;

x – T (°C), y – H_{Lo} (cm);

a, b, c, d, e, f - the equation (4) coefficients;

a=-0.0690423915208798;
b=-0.00137306729486659;
c=2.30309937489746;
d= -0.339417886897436;
e=0.0199181927841958;
f=0.

The values obtained showed that in off-season growing conditions for the optimization of Ttf in the species *Lathyrus odoratus* L., control of plant temperature and height is necessary, they can be managed, and they can lead to optimizing the time of flowering.

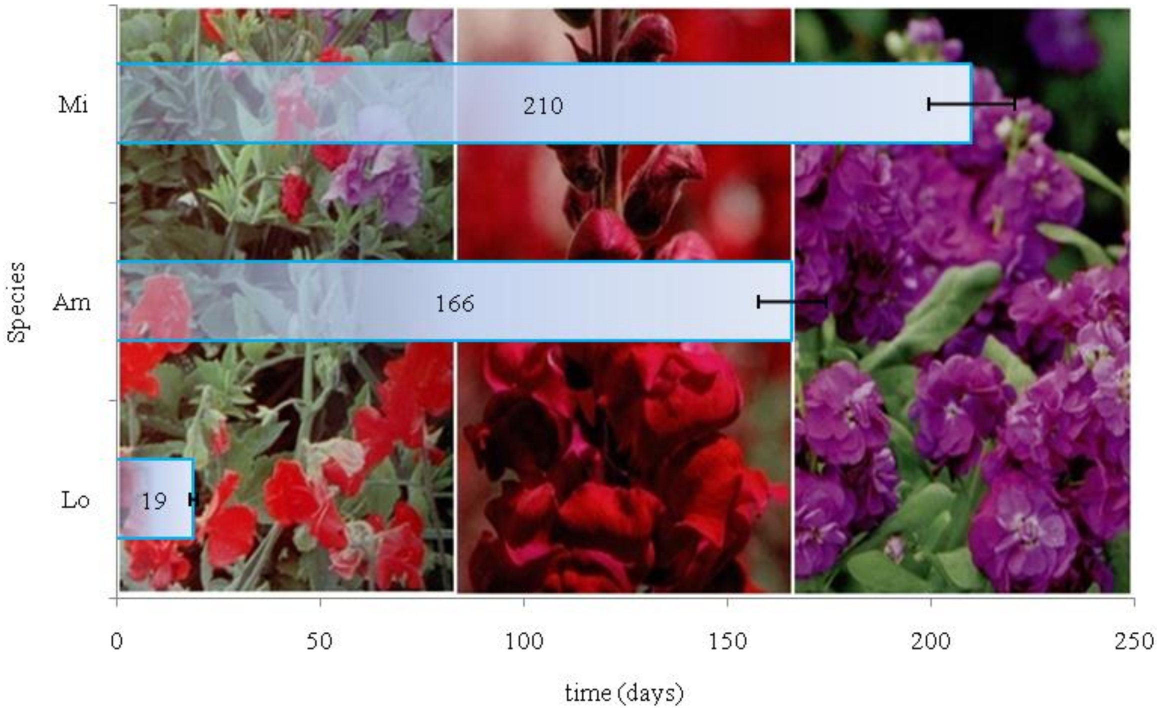

Fig. 5. Graphical representation of Ttf for the studied species; left - *Lathyrus odoratus* L.; middle - *Antirrhinum majus* L.; right - *Matthiola incana* (L.) W.T.Aiton
Source: original graph based on experimental data.

In practical conditions, for the production of flowers in off-season, for the species *Lathyrus odoratus* L., it is recommended to ensure an average growth temperature around 24.86 °C, and plant height of 56.74 cm. Temperature can be controlled in conditions of protected space, respectively greenhouse.

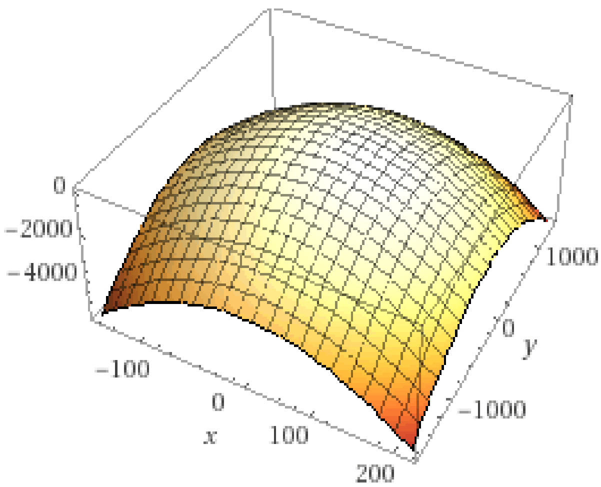

Fig. 6. 3D distribution of Ttf_{Lo} for *Lathyrus odoratus* L. specie, according to T (x-axis) and H_{Lo} (y-axis)
Source: original graph based on equation (4) data.

In order to control the vigor of the plants in terms of height, around the optimal value found in studied conditions (56.74 cm), watering and nutrient supply are recommended, in relation to the soil status, known, classical by soil analysis, or in real-time by sensors [34].

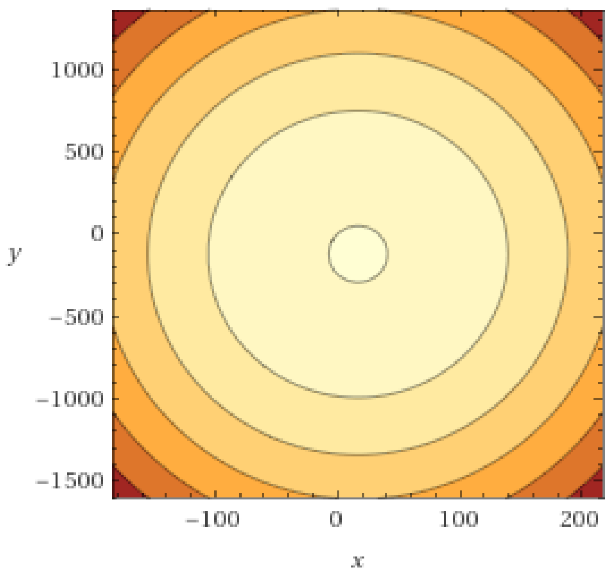

Fig. 7. Isoquants graphic distribution of Ttf_{Lo} in relation to T (x-axis) and H_{Lo} (y-axis) for *Lathyrus odoratus* L.
Source: original graph based on equation (4) data.

For the species *Antirrhinum majus* L., total time of flowering (Ttf) as function of temperature (T, °C) and plant height (H_{Am})

was described by equation (5), in statistical safety conditions (R^2=0.998, p<<0.001). The graphical distribution is shown in Figures 8 and 9.

$$Ttf_{Am} = ax^2 + by^2 + cx + dy + exy + f \quad (5)$$

where:
Ttf_{Am} – total time of flowering, *Antirrhinum majus* L. specie;
x – T (°C), y – H_{Am} (cm);
a, b, c, d, e, f - the equation (5) coefficients;
a= -0.680045822394766;
b= -0.0350370759388762;
c= 21.3384929031298;
d= -4.93089825850534;
e= 0.310930500817678;
f=0.

Based on the ANOVA test values, the statistical safety parameter p, had values p << 0.001 for all terms of equation (5).
Under these statistical safety conditions, for the species *Antirrhinum majus* L. the optimal values for x and y were calculated to ensure optimal Ttf_{Am}, and the values x_{opt}=27.65 °C (T), and y_{opt}=52.31 cm (H_{Am}) were found.
In practical conditions for producing flowers in off-season for the species *Antirrhinum majus* L. it is recommended to ensure an optimal average plant growth temperature around 27.65 °C and plant height of 52.31 cm.

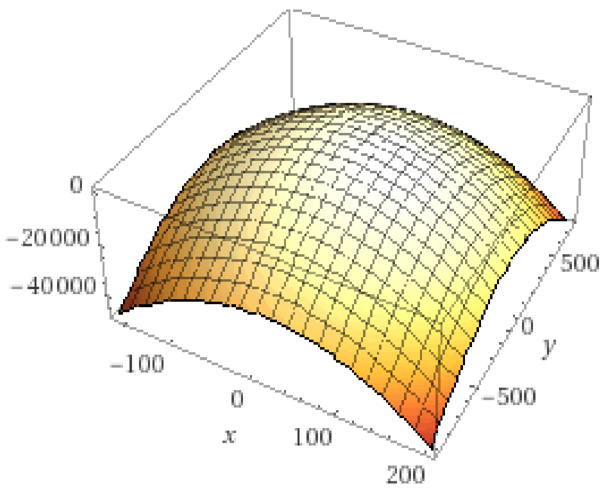

Fig. 8. 3D distribution of Ttf_{Am} for *Antirrhinum majus* L., according to T (x-axis) and H_{Am} (y-axis)
Source: Original graph obtained based on the values of the equation (5).

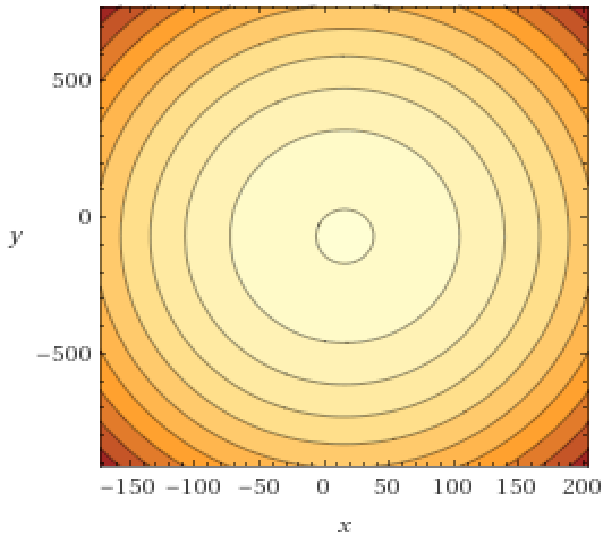

Fig. 9. Graphic distribution in the form of isoquants, of Ttf_{Am} in relation to T (x-axis) and H_{Am} (y-axes) for *Antirrhinum majus* L.
Source: original graph based on the values of the equation (5).

For the species *Matthiola incana* (L.) W.T.Aiton, total time of flowering (Ttf) as a function of temperature (T, °C) and plant height (H_{Mi}) was described by equation (6), in statistical safety conditions (R^2=0.999, p<<0.001). The graphical distribution is presented in Figures 10 and 11. Based on ANOVA test values, the statistical safety parameter p presented values p << 0.001 for all terms of equation (6).

$$Ttf_{Mi} = ax^2 + by^2 + cx + dy + exy + f \quad (6)$$

where:
Ttf_{Mi} – total time of flowering, *Matthiola incana* (L) W.T.Aiton. specie;
x – T (°C), y –H_{Mi} (cm);
a, b, c, d, e, f - the equation (6) coefficients;
a= -0.602135483536352;
b= -0.0214155544573716;
c= 22.5227850256692;
d= -4.31446898999081;
e= 0.229170367365739;
f=0.

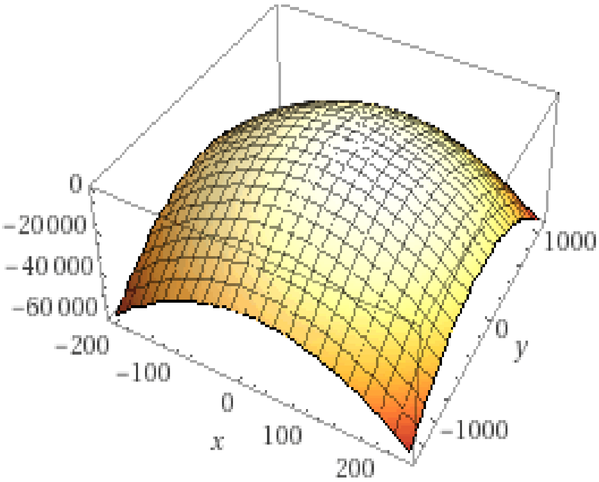

Fig. 10. 3D distribution of Ttf_{Mi} for *Matthiola incana* (L) W.T.Aiton, depending on T (x-axis) and H_{Mi} (y-axis)
Source: original graph, obtained based on the values of the equation (6).

Optimal values for x and y in *Matthiola incana* (L.) W.T.Aiton were found at x_{optMi}= 25.64 °C (T), and y_{optMi}=36.47 cm (H_{Mi}), respectively, values to ensure optimal flowering as total flowering time (Ttf).

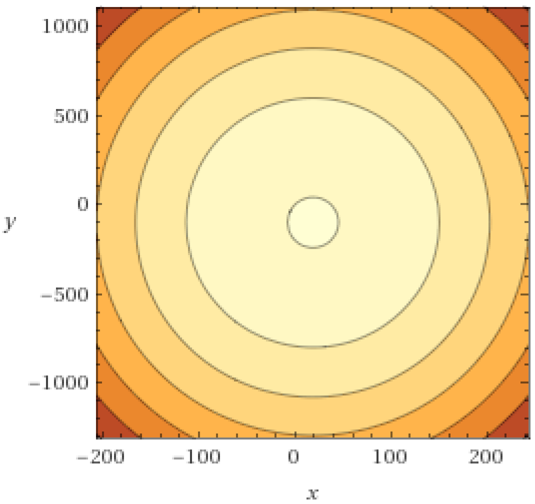

Fig. 11. Graphic distribution in the form of isoquants, of Ttf_{Mi} in relation to T (x-axis) and H_{Am} (y-axis) for *Matthiola incana* (L.) W.T.Aiton.
Source: original graph obtained based on the values of the equation (6).

In order to direct the growth and vigor of the plants, in the species *Matthiola incana*, in terms of plant height, around the optimal value found (56.74 cm) in the experimental studied conditions, and which ensured the optimal flowering time (Ttf), adequate maintenance works are recommended, by watering and fertilizing, in relation to the soil content.

A synthetic presentation of the optimal values for T (°C) and H (cm), in the case of the three ornamental species studied, in off-season conditions, is shown in Figure 12.

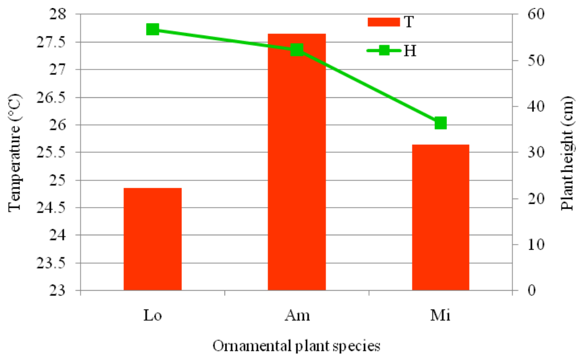

Fig. 12. Graphic representation of optimal values for T (°C) and H (cm) for ornamental plant species studied
Source: original graph obtained based on the x,y optimal values calculated

The highest temperature requirements were recorded for *Antirrhinum majus* L. species, and the smallest to the *Lathyrus odoratus* L. species. This means that they require a differentiated management of growing conditions, in terms of temperature.
In all three species studied, it is important to monitor the health of plants. Imaging tests and analyzes are very effective for early estimation of possible leaf pathogen attacks [9]. This can facilitate decisions for effective treatments.
Ornamental flowering plants have been studied in relation to flower color and influencing factors (internal and external to the plant organism), for the understanding and control of flowers for ornamental purposes and to increase their market value [10], [48]. Some studies have aimed to improve the ornamental and floral attributes of decorative plants [26].
In order to evaluate certain physiological indices at the foliar level of the plants, such as the foliar surface, as an expression of the growing conditions, non-destructive models were promoted [35], [36], or different software applications to estimate the health status of plants [8], [9].
The study of the behavior of some off-season ornamental species is important, in order to obtain ornamental plants of interest, in

relation to market and consumer demand. The product market and consumer demand are very dynamic and require ongoing studies [30], [31], [23].

Sangma et al. [37], analyzed the behavior of 8 genotypes of chrysanthemum (*Dendranthema grandiflora*) by modifying the photoperiod by coating with various materials.

Recent studies have evaluated alternative, soil-free environments for growing ornamental plants, and *Matthiola incana* L. was one of the species studied in relation to paper waste (PW), and olive-stone waste (OSW) in different combinations [6]. There are also many other artificial environments for cultivating horticultural plants, and especially ornamental ones [34]. *Matthiola* has also been studied in response to saline wastewaters with different N contents [12].

Different influencing factors for the growth, development and quality of ornamental plants through flowers were studied: soil or artificial growth media [34], water regime, light, temperatures etc. [44].

In protected areas, such as greenhouses, temperature is an important factor that influences the quality of flowers both directly and in interaction with light. Temperature influences plant growth rate, production time, and in interaction with light (lighting duration and spectrum) influences flower quality attributes, such as plant height, biomass, number of branches, number of flowers, flower size [4], [44]. Therefore, temperature is an important vegetation factor for ornamental crops and is controlled and directed in protected areas, in order to produce ornamental plants for certain events, or certain market-specific data [32], [25], [3].

The present study highlighted the importance and relationship between temperature and total time of flowering in the three species of ornamental plants studied, in off-season conditions, and was in concordance with other studies on the role and importance of temperature in the quality of ornamental species. Also, physiological indices of the plants, such as height, were analyzed in relation to the total time of flowering.

The simultaneous influence of temperature and plant height on the total time of flowering was analyzed, and optimal values for the two parameters of the production process were obtained.

CONCLUSIONS

Ornamental plant species *Lathyrus odoratus* L., *Antirrhinum majus* L., and *Matthiola incana* (L.) W.T.Aiton had specific behaviors under off-season cultivation conditions.

Plant growth was influenced by the temperature in the protected space (greenhouse), and grade 3 polynomial models described variations in plant height relative to temperature.

Total time of flowering (Ttf), as a qualitative aspect, varied in relation to the species, but the influence of growth conditions (temperature) and plant height on Ttf variation was recorded. Regression analysis facilitated the obtaining of models that described the variation of Ttf and the optimal values of T (°C) and plant height (H, cm) for an optimal period of flowering (Ttf).

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REFERENCES

[1]Behzad, K., Afshin, A., H., Ardashir, K. M., 2011, *In vitro* propagation of *Matthiola incana (Brassicaceae)* - an ornamental plant, Plant Omics, 4(7):435-440.

[2]Bhargava, B., Gupta, Y.C., Dhiman, S.R., Sharma, P., 2015, Effect of seed priming on germination, growth and flowering of snapdragon (*Antirrhinum majus* L.), Nat Acad Sci Lett, 38(1):81-85.

[3]Blanchard, M.G., Runkle, E.S., 2011, Quantifying the thermal flowering rates of eighteen species of annual bedding plants. Sci. Hort., 128:30-37.

[4]Carvalho, S.M.P., Wuillai, S.E., Heuvelink, E., 2006, Combined effects of light and temperature on product quality of *Kalanchoe blossfeldiana*, Acta Hort., 711:121-126.

[5]Çelikel, F.G., Cevallos, J.C., Reid, M.S., 2010, Temperature, ethylene and the postharvest performance of cut snapdragons (*Antirrhinum majus*), Sci. Hortic., 125(3):429-433.

[6]Chrysargyris, A., Antoniou, O., Tzionis, A., Prasad

M., Tzortzakis N., 2018, Alternative soilless media using olive-mill and paper waste for growing ornamental plants, Environ Sci Pollut Res, 25:35915-35927.

[7]De, L.C., 2017, Improvement of ornamental plants - A review, Int. J. Hortic., 7(22):180-204.

[8]Drienovsky, R., Nicolin, A.L., Rujescu, C., Sala, F., 2017a, Scan LeafArea – A software application used in the determination of the foliar surface of plants, Res. J. Agric. Sci., 49(4):215-224.

[9] Drienovsky, R., Nicolin, A.L., Rujescu, C., Sala, F., 2017b, Scan Sick & Healthy Leaf – A software application for the determination of the degree of the leaves attack, Res. J. Agric. Sci., 49(4):225-233.

[10]Fumi, T., Norio, S., Kenjiro, T., Koichi, S., Toshio, H., 2012, Flower colors and their anthocyanins in *Matthiola incana* cultivars (*Brassicaceae*). J. Jpn. Soc. Hortic. Sci., 81:91-100.

[11]Glen, H.F., 2002, Cultivated plants of Southern Africa. Jacana Education: Johannesburg, South Africa, p. 151.

[12]Greive, C.M., Poss, J.A., Shouse, P.J., 2008, Modeling growth of *Matthiola incana* in response to saline wastewaters differing in nitrogen level, HortScience, 43:1787-1793.

[13]Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001, PAST: Paleontological statistics software package for education and data analysis, Palaeontol. Electron., 4(1):1-9.

[14]Hisamatsu, T., Koshioka, M., Kubota, S., King, R.W., Mander, L. N., 2000, Flower promotion of *Matthiola incana* (L.) R. Br. by gibberellin biosynthesis inhibitory Acylcyclohexanediones, Acta Hortic., 515:33-38.

[15]Hudson, A., Critchley, J., Erasmus, Y., 2008, The genus antirrhinum (snapdragon): a flowering plant model for evolution and development. CSH Protoc., 2008:pdb.emo100.

[16]Huxley, A.J, Griffiths, M., 1992, The new royal horticultural society dictionary of gardening, Macmillan Press.

[17]Irani, S.F., Arab, M., 2017, Meiotic behaviour and morpho-phenological variation in cut stock (*Matthiola incana* L.) flower, Folia Hortic., 29(1):51-61.

[18]Jauhari, S., Singh, A. K., 2006, Evaluation of inbreds and their F1s for flowering and postharvest attributes in snapdragon (*Antirrhinum majus* L.), J. Ornam. Hortic, 9(2):91-96.

[19]Jerves-Andrade, L., Leòn-Tamariz, F., Penaherrera, E., Cuzco, N., Tobar, V., Ansaloni, R., Wilches, L.M., 2014, Medicinal plants used in South Ecuador for gastrointestinal problems: An evaluation of their antibacterial potential, J. Med. Plant Res., 8:1310-1320.

[20]Kaviani, B., 2014, Micropropagation of *Matthiola incana* using BA and IBA, Iran J. Plant Physiol., 4(3):1071-1078.

[21]Li, M., Zhang, D., Gao, Q., Luo Y., Zhang H., Ma B., Chen C., Whibley A., Zhang Y., Cao Y., Li Q., Guo H., Li J., Song Y., Zhang Y., Copsey L., Li Y., Li X., Qi M., Wang J., Chen Y., Wang D., Zhao J., Liu G., Wu B., Yu L., Xu C., Li J., Zhao S., Zhang Y., Hu S., Liang C., Yin Y., Coen E., Xue Y., 2019. Genome structure and evolution of *Antirrhinum majus* L., Nature Plants 5:174-183.

[22]Mahgoub, M.H., Abd El Aziz, N.G., Youssef, A.A., 2011, Growth parameters, yield and chemical composition of *Matthiola incana* plants as influenced by foliar spray with Stigmasterol and Diphenylurea, J. Appl. Sci. Res., 7(11):1575-1582.

[23]Marcuta, A., Popescu, A., Tindeche, C., Angelescu, C., Marcuta, L., 2020, Measuring the satisfaction of consumers of apple juice. Case study. Scientific Papers. Series Management, Economic Engineering in Agriculture and rural development, 20(1):321-326.

[24]Mateu-Andres, I., De Paco, L., 2004, Allozymic differentiation of the *Antirrhinum majus* and *A. siculum* species groups, Ann. Bot., 95(3):465-473.

[25]Moccaldi, L.A., Runkle, E.S., 2007, Modeling the effects of temperature and photosynthetic daily light integral on growth and flowering of *Salvia splendens* and *Tagetes patula*. J. Amer. Soc. Hort. Sci., 132:283-288.

[26]Noman. A., Aqeel. M., Deng. J., Khalid. N., Sanaullah. T., Shuilin. H, 2017, Biotechnological advancements for improving floral attributes in ornamental plants, Front. Plant Sci. 8:530.

[27]Ochatt, S.J., Conreux, C., Jacas, L., 2010, In vitro production of sweet peas (*Lathyrus odoratus* L.) via axillary shoots. Methods Mol Biol. 589:293-301.

[28]Oyama, R.K., Baum, D.A., 2004, Phylogenetic relationships of North American Antirrhinum (Veronicaceae). Am. J. Bot., 91(6):918-925.

[29]Parsons, R., Mikić, A., 2011, Conservation and breeding of ornamental lathyrus species, Field Veg. Crop Res., 48:1-6.

[30]Popescu, A., 2019, Changes and trends in wine production and consumption in the world and Romania during the period 2007-2018, Scientific Papers. Series Management, Economic Engineering in Agriculture and rural development, 19(2):345-362.

[31]Popescu, A., Dinu, T.A., Stoian, E., 2019, Changes, trends and relationships between average income and consumption expenditures per household in Romania in the period 2007-2017, Scientific Papers. Series Management, Economic Engineering in Agriculture and Rural Development, 19(2):363-374.

[32]Pramuk, L.A., Runkle, E.S., 2005, Modeling growth and development of Celosia and Impatiens in response to temperature and photosynthetic daily light integral, J. Amer. Soc. Hort. Sci., 130:813-818.

[33]Rasool, N., Afzal, S., Riaz, M., Rashid, U., Rizwan, K., Zubair, M., Ali, S., Shahid, M. 2013, Evaluation of antioxidant activity, cytotoxic studies and GC-MS profiling of *Matthiola incana* (stock flower), Legume Res., 36:21-32.

[34]Sala, F., 2011, Agrochimie (Agrochemistry), Eurobit Publishing House, Timisoara, pp. 148-166.

[35]Sala, F., Arsene, G.-G., Iordanescu, O., Boldea, M., 2015, Leaf area constant model in optimizing foliar area measurement in plants: A case study in apple tree, Sci. Hort. (Amsterdam), 193:218-224.

[36]Sala, F., Iordănescu, O., Dobrei, A., 2017, Fractal analysis as a tool for pomology studies: Case study in apple, AgroLife Sci. J., 6(1):224-233.
[37]Sangma, P.M., Dhiman, S.R., Thakur, P., Gupta, Y.C., 2016, Effect of covering materials on off-season cut flower production in chrysanthemum (*Dendrathema grandiflora*), Indian J. Agric. Sci., 86(4):522-526.
[38]Sarker, A., Robertson, L.D., Abd El Moneim, A.M., Campbell, C.G., 1997, *Lathyrus* species: conserved germplasm resources, priorities for collection and future prospects. In: Proc. Int. Food Legume Res. Conf. III, Adelaide, Australia, 645-654.
[39]Sarker, A., El Moneim, A.A., Maxted, N., 2001, Grasspea and chicklings (*Lathyrus* L.). In: Maxted, N., Bennett, S.J. (Eds), Plant Genetic Resources of Legumes in the Mediterranean. Current Plant Sci. Biotechnol. Agric., 39:159-180.
[40]Sarwar, M., Shoib-ur-Rehman, Ayyub, C.M., Ahmad, W., Shafi, J., Shafique, K., 2013, Modeling growth of cut-flower stock (Matthiola incana R. Br.) in response to differing in nutrient level, Univ. J. Food Nutr. Sci., 1(1):4-10.
[41]Sekerci, A.D., Yetişir, H., Yildirim, Z., Gulsen, O., 2017, Genetic diversity analysis in snapdragon (*Antirrhinum majus* L.) using morphological and molecular methods, Current Trends Nat. Sci., 6(12):68-74.
[42]Singh, A.K., Jauhari, S., Sisodia, A., 2014, Genetic diversity analysis in snapdragon (*Antirrhinum majus*) through RAPD markers, Indian J. Hortic., 71(1):134-137.
[43]Taviano, M.F., Miceli, N., Acquaviva, R., Malfa, G.A., Ragusa, S., Giordano, D., Cásedas, G., Les, F., López, V., 2020, Cytotoxic, antioxidant, and enzyme inhibitory properties of the traditional medicinal plant *Matthiola incana* (L.), R. Br. Biology, 9(7):163.
[44]Vaid, T.M., Runkle, E.S., Frantz, J.M., 2014, Mean daily temperature regulates plant quality attributes of annual ornamental plants, HortScience, 49(5):574-580.
[45]Vaz Patto, M.C., Rubiales, D., 2014, Lathyrus diversity: available resources with relevance to crop improvement- *L. sativus* and *L. cicera* as case studies, Ann. Bot., 113:895-908.
[46]Wiersema, J.H., León, B. 2013, World Economic Plants: A Standard Reference, CRC Press: Boca Raton, FL, USA, pp. 436.
[47]Wolfram, 2020, Research, Inc., Mathematica, Version 12.1, Champaign, IL.
[48]Zhao, D., Tao, J., 2015, Recent advances on the development and regulation of flower color in ornamental plants, Front Plant Sci., 6:261.