

PhD THESIS

The Influence of some Technological Links on the Growth and Development of *Pelargonium zonale* (L.) L'Hér. ex Aiton Plants

SUMMARY OF THE PH.D. THESIS

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INTRODUCTION

The production of ornamental plants represents a horticultural sector in full development, which enjoys appreciation in national and international profile markets. Being considered the "Queen of the Balcony", geraniums are preferred as room plants, or balcony plants with an ornamental role for buildings, and in addition to their decorative appearance and due to their good resistance to adverse environmental conditions, they are preferred as plants that are included in areas urban greens.

1. General considerations concerning *Pelargonium zonale* (L.) L'Hér. ex Aiton

The genus *Pelargonium* is one of seven genera belonging to the family Geraniaceae, namely *Geranium*, *Pelargonium*, *Erodium*, *Monsonia*, *Hypseocharis*, *Rhynchotheca* and *Sarcocaulon*. This genus contains around 280 species that show great variety. Among the subgenera of the genus *Pelargonium*, *Ciconium* is the most important in the ornamental plant market, mainly due to the species *Pelargonium zonale* (L.) L'Hér. ex Aiton and *Pelargonium inquinans* (L.) L'Hér. ex Aiton, which are part of it (BLEROT ET AL., 2015; JANET JAMES, 2002; DIANA MILLER, 2002).

2. The cultivation and uses of plants that belong to *Pelargonium* L'Hér. ex Aiton genus

According to the **technology of cultivation** (CANTOR MARIA, 2017), propagation of *Pelargonium* L'Hér. ex Aiton plants can be produced both vegetatively by cuttings and by hybrid seeds especially in breeding works (CANTOR MARIA ET AL., 2021).

3. The aim and objectives

The aim of the PhD thesis research "was to perfect the culture technology of *Pelargonium zonale* (L.) L'Hér. ex Aiton under controlled conditions and to deepen the knowledge regarding the behavior of some cultivars under the influence of fertilizers. In order to achieve the proposed goal, the following **objectives** were stable: monitoring the qualitative indicators of growth (for geranium plants under the influence of experimental factors; determining the physical-chemical parameters of the cultivation substrate; the study of quantitative indicators of growth; The effect of fertilization (chemical and unconventional) on growth and plant development; studying the influence of the phytosanitary control method on plant growth and development; comparative analysis of the main quantitative and qualitative characteristics of the two varieties of geraniums.

4. Environmental peculiarities of the experimental site

Experiments on the influence of some technological links on the growth and development of *Pelargonium zonale* (L.) L'Hér plants. ex Aiton were made in the greenhouse of the Horticultural Research Institute of Transylvania – ICHAT (Fig. 4.1), within the University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, located at an altitude of 363 m, 23°36' east longitude and 46° 46' north latitude (Fig. 4.2). The chemical analyzes were carried out in the Environmental Quality Monitoring Laboratory of the Faculty of Agriculture.

5. Material and method

The biological material studied for the realization of the experimental plan is represented by two cultivars of *Pelargonium zonale* (L.) L'Hér. ex Aiton as follows: 'Tango Salmon' (Montevideo) and 'Tango Dark Red'. The conventional fertilizer Peters® Professional 15 - 11 - 29 + TE/N - P - K + Trace Elements (TE), manufactured by ICL Fertilizers was used for foliar fertilization. For non-conventional foliar fertilization, a homeopathic natural product mixture known as Schuessler Salts was used for both geranium cultivars studied. Phytosanitary treatments were carried out with the conventional products Amistar (Syngenta) and Switch (Syngenta). Pindstrup peat was used as soil substrate, from S.C. Blondy România S.R.L. To follow as faithfully as possible the influence of the method of fertilization and phytosanitary control of *Pelargonium zonale* (L.) L'Hér plants. ex Aiton, three series of experiences were organized: the research on the influence of the fertilization method (chemical and unconventional) on the morpho-decorative characters, organized as a bifactorial experience (MOLDOVAN ANDREEA ET AL., 2021a, MOLDOVAN ANDREEA ET AL., 2021b; MOLDOVAN ANDREEA ET AL., 2023; determination of the physico-chemical parameters of the culture substrate consisting of Pindstrup peat and the study of the influence of the phytosanitary control method (chemical and non-conventional) of the pathogens *Botrytis cinerea* Pers. and *Puccinia pelargonii-zonalis* Doidge organized as a bifactorial experience (MOLDOVAN ANDREEA ET AL., 2021c). In order to process the raw data, both statistical and mathematical methods were used. The IBM SPSS Statistics v.20 program for Windows was used to calculate the statistical parameters of interest (ARDELEAN ET AL., 2002).

6. Results concerning the morpho-decorative traits in the geranium varieties

Applying the least significant difference test at the 5% significance threshold (LSD5%), to both cultivars studied, shows that they are statistically very significant

between the results obtained under conditions of differentiated fertilization, for plant height and for the number of flowers/inflorescence (Tabelul 6.10).

Tabelul 6.10

Dezvoltarea diferitelor părți componente ale *P. zonale* (L.) L'Hér. ex Aiton, cultivarul „Tango Salmon” (Montevideo), 2019-2020

Fertilizare	Treatments			
	H	T	F	I
Fertilization	25.24 ^d	5.70 ^d	16.50 ^d	26.80 ^d
Conventional	30.02 ^d	7.05 ^{da}	20.55 ^{da}	32.60 ^d
Unconventional	33.40 ^d	7.00 ^{da}	21.0 ^{da}	34.75 ^d
Mean	41,93	6,58	19,37	31,38
CV(%)	5,05	11,63	12,88	13,11
LSD _{5%}	2.897	2.188	2.615	3.296
F	49.063***	7.477*	8.674*	51.311***

H –plant heigh; T –number of stems; F –number of leaves; I –number of flowers by inflorescence; CV –variability coefficient; LSD –Least Significant Differences; F –Fisher coefficient.

Tabelul 6.11

Dezvoltarea diferitelor părți componente ale *P. zonale* (L.) L'Hér. ex Aiton, varietatea “Tango Dark Red”, în cazul utilizării unor sisteme de fertilizare diferite, 2019-2020

Fertilizare	Treatments			
	H	T	F	I
Fertilization	15.49a	4.55a	11.80a	28.85a
Conventional	18.90a	5.90a	14.95a	37.55a
Unconventional	18.74a	5.65a	14.15a	34.40a
Mean	17,71	5.37	13.63	33.60
CV(%)	10.86	13.38	12,01	13,10
LSD _{5%}	7.381	1.170	2.990	728.32
F	7.125*	7.291*	12.169**	0.962 ^{ns}

H –plant heigh; T –number of stems; F –number of leaves; I –number of flowers by inflorescence; CV –variability coefficient; LSD –Least Significant Differences; F –Fisher coefficient.

7. Results concerning the determination of the physiochemical parameters of the culture substrate in *Pelargonium zonale* (L.) L'Hér. ex Aiton in greenhouse conditions

The study of how the physico-chemical indicators of peat (pH, temperature, electrical conductivity) influence plant growth and how these interactions are influenced by fertilization conditions revealed a number of peculiarities. All the physico-chemical characteristics of the peat positively influence plant growth, with an intensity expressed by the multiple correlation coefficient (R), whose value differs considerably, depending on the fertilization option (Tabelul 7.4).

Table 7.4

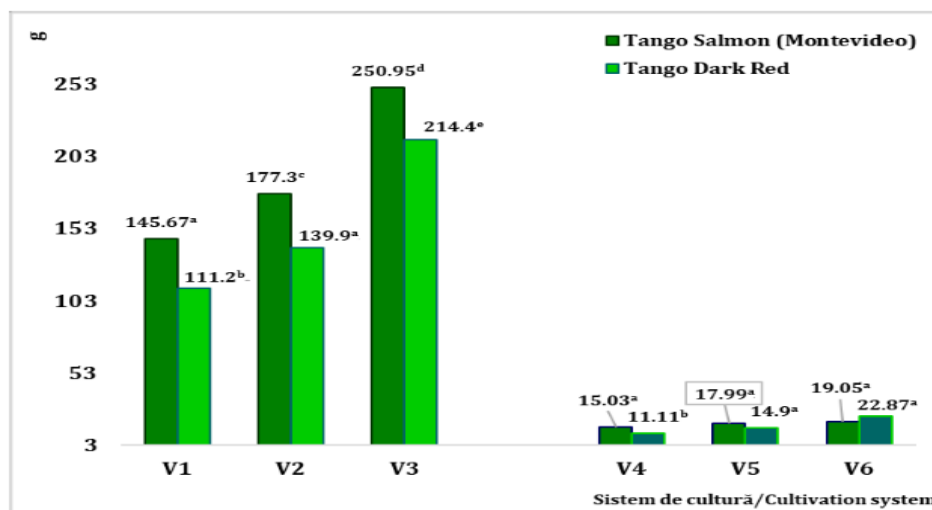
The influence of the temperature, pH, and conductivity of the cultivation substrate on plant height in different fertilization solutions applied in *P. zonale* (L.) L'Hér. ex Aiton, 2019 – 2020

Experimental variant	Regression line	R	R ²
V ₁ - Control	$Y = 1.480 + 0,148X_1 + 0,538X_2 + 0,239X_3$	0,519	0,270
V ₂ - Conventional fertilization	$Y = 9,309 + 0,405X_1 + 0,119X_2 + 0,198X_3$	0,509	0,259
V ₃ - Unconventional fertilization	$Y = 1.352 + 0,241X_1 + 0,151X_2 + 0,067X_3$	0,247	0,061
V ₄ - Control	$Y = 0.281 + 0,751X_1 + 0,309X_2 + 0,318X_3$	0,779	0,606
V ₅ - Fertilizare convențională	$Y = 7.065 + 0,383X_1 + 0,197X_2 + 0,316X_3$	0,399	0,159
V ₆ - Unconventional fertilization	$Y = 14.991 + 0,054X_1 + 0,152X_2 + 0,599X_3$	0,634	0,403

V₁, V₂, V₃ –variety „Tango Salmon Montevideo”; V₄, V₅, V₆ – „Tango Dark Red”; Y –plant height; X₁ –soil temperature (C); X₂ –soil pH; X₃ –soil electric conductivity (S/m); R –coefficient of multiple correlation; R² –coefficient of determination.

8. Results concerning the study of the growing quantitative indices in *Pelargonium zonale* (L.) L'Hér. ex Aiton plants

Regarding the fresh mass averages of the two varieties of *Pelargonium zonale* L. taken in the study, superior values are reported for all the experimental variants for the cultivar "Tango Salmon" (Montevideo). In all cases the differences are statistically significant (Fig. 8.7).



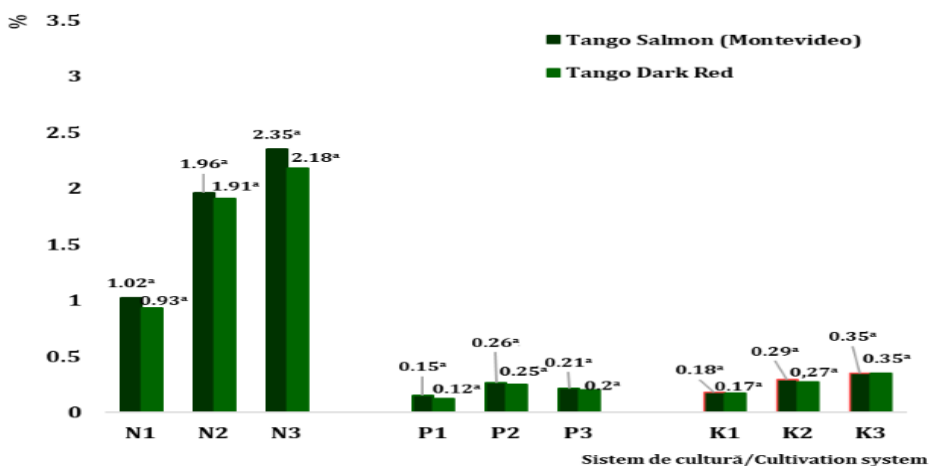
V₁ – V₃ –stems; V₄ – V₆ –leaves; 1 –control; 2 –conventional fertilization; 3 – unconventional fertilization; DS values 5% = 1,12 – 1,54; 4 –control; 5 – conventional fertilization; 6 – unconventional fertilization; the differences between any two variants, considered at quantitative indicator level, are significant if their values are followed by different letters or group of letters; DS values 5% = 1,16 – 1,63.

Fig. 8.7. The means of the fresh and dry mass in geranium plants, "Tango Salmon" (Montevideo), and "Tango Dark Red" varieties, 2019 – 2020

These results suggest that both under fertilization conditions and without it, the utilization of fresh mass into dry mass is achieved in similar proportions (Fig. 8.7).

9. Results concerning the study of the content in macronutrients and chlorophyll in *Pelargonium zonale* (L.) L'Hér. ex Aiton

The comparative study of the evolution of the nutrient content (nitrogen, phosphorus, potassium) of the two cultivars of *Pelargonium zonale* (L.) L'Hér. ex Aiton studied, it is also superior for the variety "Tango Salmon" (Montevideo), but the differences are not statistically significant (Fig. 9.1).



1 - control; 2 - conventional fertilization; 3 - unconventional fertilization; DS values 5% = 1,34 - 2,19; the differences between any two variants, considered at nutrient level, are significant if their values are followed by different letters or group of letters; DS values 5% = 1,52 - 2,47.

Fig. 9.1. The means of the content in nutritional elements (N, P, K) in leaves of the "Tango Salmon" (Montevideo) and „Tango Dark Red” varieties, 2019 - 2020

From the analysis of the data presented in Table 9.5, it can be seen that the administration of non-conventional fertilization (V3) also led to the intensification of the chlorophyll synthesis process.

Tabelul 9.5

The SPAD values reported in leaves of "Tango Salmon" (Montevideo) variety, 2019 - 2020

Tipul de fertilizare/	N	X	Min.	Max.	s	CV (%)
V ₁ - Control	60	35.24 ^a	32.10	37.80	1.85	5.25
V ₂ - Conventional fertilization	60	42.20 ^b	40.00	44.00	1.09	2.57
V ₃ - Unconventional fertilization	60	48.34 ^c	47.60	50.00	0.79	1.63
V ₄ - Control	60	34.28 ^b	60.00	37.80	2.80	8.18
V ₅ - Fertilizare convențională	60	41.35 ^b	39.00	43.00	1.29	3.12
V ₆ - Unconventional fertilization	60	47.08 ^c	45.00	49.00	1.38	2.92
DS values 5%		1,11 - 1,45				

V₁, V₂, V₃ -variety „Tango Salmon Montevideo”; V₄, V₅, V₆ -variety „Tango Dark Red”; N -number of plants; X -mean; s - standard deviation; CV -coefficient of variation; the differences between any two variants are significant if their values are followed by different letters or group of letters, valori DS/DS values 5% = 1,11 - 1,45.

According to the data presented in Table 9.4, over the entire experimental period 2019 - 2020, the nitrogen use efficiency index (NUE) for the two cultivations taken in the study presents specific particularities.

Tabelul 9.4

The indices of nitrogen using efficiency (NUE), conventional and unconventional fertilization, in *P. zonale* (L.) L'Hér. ex Aiton, 2019 - 2020

Fertilization type		Dosis of N, g/L	Period	NUE
V ₂	Conventional fertilization	0,006	2019	0,19 ^a
			2020	0,22 ^a
			2019-2020	0,19 ^a
V ₃	Unconventional fertilization	1.46·10 ⁻⁶	2019	0,13 ^b
			2020	0,24 ^a
			2019-2020	0,26 ^a
V ₅	Conventional fertilization	0,006	2019	0,32 ^c
			2020	0,36 ^c
			2019-2020	0,34 ^c
V ₆	Unconventional fertilization	1.46·10 ⁻⁶ g	2019	0,92 ^a
			2020	1,21 ^d
			2019-2020	1,05 ^d
Values DS 5%		1,62 - 2,37		

V₂, V₃ - „Tango Salmon” (Montevideo); V₅, V₆ - c „Tango Dark Red”; the differences between any two variants are not significant if their values are followed by identical letters or group of letters, DS values 5% = 1,62 - 2.37.

10. Results concerning the esthetic assessment of *Pelargonium zonale* (L.) L'Hér. ex Aiton, plants, for commercialization

The best scores are reported for non-conventionally fertilized plants V3, in both cultivars (Tabelul 10.1).

Tabelul 10.1

The aesthetic assessment of *P. zonale* (L.) L'Hér. ex Aiton plants, for commercialization

Fertilization type		Vegetative growth	Foliage compactness	General aspect
V ₁	Control	2,7 ^a	3,6 ^a	3,5 ^a
V ₂	Conventional fertilization	4,1 ^b	4,4 ^b	4,2 ^b
V ₃	Unconventional fertilization	4,3 ^b	4,8 ^b	4,7 ^b
V ₄	Control	2,5 ^a	3,5 ^a	3,2 ^a
V ₅	Conventional fertilization	3,9 ^b	4,3 ^b	4,1 ^b
V ₆	Unconventional fertilization	4,2 ^b	4,6 ^b	4,5 ^b
DS values 5%		1,38 - 1,84		

The differences between any two variants are significant if their values are followed by different letters or group of letters, DS values 5% = 1,42 - 18.82.

11. Results concerning the influence of the method of phytosanitary fight on *Pelargonium zonale* (L.) L'Hér. ex Aiton plants health

Applying the least significant difference test at the 5% significance level (LSD5%), for both geranium cultivars, led to characteristic results (Tabelul 11.10.).

Tabelul 11.10

The attack degrees of the *Puccinia pelargonii-zonalis* Doidge și *Botrytis cinerea* Pers. pathogens, in *P. zonale* (L.) L'Hér. ex Aiton, "Tango Salmon" (Montevideo) variety, in different conditions of fertilization and phytosanitary treatments, 2021-2022

Fertilization	Treatments			
	C	N1	N2	N3
Fertilization	13.78 ^c	15.03 ^{ca}	15.65 ^b	15.80 ^a
Conventional	11.80 ^{cb}	13.58 ^{ca}	14.33 ^{ba}	14.68 ^a
Unconventional	12.88 ^b	14.08 ^a	14.75 ^{ba}	15.20 ^a
Mean	12,82	14,23	14,91	15,23
CV(%)	7,73	5,18	4,52	3,68
LSD _{5%}	4.361	4.925	4.168	0.789
F	2.557**	2.797**	2.177*	10.665 ^{ns}

C - control, V₁; C - conventional treatment, V₂; N1 - conventional treatment, V₃; N2 - conventional treatment, V₄; N3 - unconventional treatment, V₅; N - number of cases; X - mean; s - standard deviation; CV - variation coefficient; LSD -Least Significant Differences; F -Fisher coefficient; a - p > 0,05; b - p < 0,05; p < 0,01.

12. Conclusions and recommendations

In both cultivars, regardless of the fertilization option, the increase in the number of stems positively influences the increase in plant height, and the increase in the number of leaves and flowers/inflorescence tends to decrease the increase in plant height. The physico-chemical characteristics of the culture substrate positively influence plant growth, with an average intensity, in the absence of fertilization and in the case of conventional fertilization in both cultivars studied. For the means of fresh mass and dry mass corresponding to the two cultivars of geraniums studied, superior values are reported for all experimental variants for the cultivar "Tango Salmon" (Montevideo), which is also superior in terms of aesthetic characteristics, from vegetative growth and to the degree of leaf sheath compaction and overall appearance.

The comparative study of the effectiveness of phytosanitary treatments shows that, both in the absence and in the presence of fertilization, higher total attack degrees of pathogens are registered in the cultivar "Tango Salmon" (Montevideo), compared to "Tango Dark Red", but these are not statistically assured at the 5% significance level.

It is recommended to adopt organic solutions in the cultivation of geraniums, due to the fact that the best quantitative performances expressed by the fresh mass

and dry mass of the component parts of the plants, as well as the degree of utilization of nitrogen and phosphorus, were obtained under the conditions of non-conventional fertilization.

In greenhouse conditions, it is recommended to combat pathogens, regardless of the geranium cultivar, to resort to the application of conventional phytosanitary treatments, with synthetic products, and if non-conventional treatments are resorted to, to use treatments with extract of *Allium sativum* L.

SELECTIVE REFERENCES

1. BLEROT B., F. DEMARNE, S. BAUDINO, C. PRUNIER, B. TOULEMONDE, J.-C. CAISSARD, 2015, Botany, agronomy and biotechnology of *Pelargonium* used for essential oil production, *Phytochemistry Reviews*, DOI 10.1007/s11101-015-9441-1.
2. CANTOR MARIA, ERZSEBET BUTA, TIMEA BURU, 2021, Cultura plantelor ornamentale în climat controlat, *Editura AcademicPres. Cluj-Napoca*.
3. CANTOR MARIA, 2017, Plante ornamentale de interior – manual didactic, *Editura AcademicPres. Cluj-Napoca*.
4. JAMES JANET, 2002, Cultivation and sales of *Pelargonium* plants for ornamental use in the UK and worldwide, In: LIS-BALCHIN MARIA Eds., *Geranium and Pelargonium, Medicinal and aromatic plants—industrial profiles, vol. 27, Taylor & Francis, London*.
5. MILLER DIANA, 1996, *Pelargoniums: a gardener's guide to the species and their cultivars and hybrids, London, UK: B.T. Batsford Ltd*.
6. MOLDOVAN ANDREEA, V. MITRE, ANTONIA ODAGIU, 2021a, Study concerning the qualitative indices in "Tango Salmon" (Montevideo) variety of *Pelargonium zonale* (L.) L'Hér., cultivated in greenhouse conditions, *ProEnvironment*, 14(45), 25-30.
7. MOLDOVAN ANDREEA, V. MITRE, ANTONIA ODAGIU, 2021b, Monitoring the quantitative indices in "Tango Dark Red" variety of *Pelargonium zonale* (L.) L'Hér., cultivated in greenhouses, *ProEnvironment*, 14(46), 62-65.
8. MOLDOVAN ANDREEA, V. MITRE, ANTONIA ODAGIU, 2021c, Testing solutions to fight against *Puccinia pelargonii-zonalis* Doidge și *Botrytis cinerea* Pers. pathogens attack in "Tango Dark Red" variety of *Pelargonium zonale* (L.) L'Hér., cultivated in greenhouses, *ProEnvironment*, 14(47), 66-70.
9. MOLDOVAN ANDREEA, ANTONIA ODAGIU, IOANA MOLDOVAN, CĂTĂLINA DAN, MARIA CANTOR, 2023, Morpho-decorative characteristics of two geraniums (*Pelargonium zonale* L'Hér. ex Aiton) cultivars influenced by fertilization, *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*, 51(2).