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Contents

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Studies concerning the sowing period in the arugula (*Eruca sativa* Mill) plants' development

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Abstract. The staged production and supply markets with fresh vegetables is a particular problem because a wide range of vegetables must be assured throughout the year. Arugula is a less-known plant (in our country) and the customers are provisioned with import products. The experiment was conducted in unheated greenhouse at the endowment of Vegetable Growing Department of Agricultural Sciences and Veterinary Medicine Cluj-Napoca in 2010, in spring culture. Three cultivars of arugula were studied: similar in size and growing season (30 and 55 days) but of different origin. Biometric measurements were conducted on plants to determine the capacity for growth. Production data were interpreted statistically by an analysis of the variance method.

Keywords: rocket, leafy vegetables

1 Introduction

Arugula cultivation has recently begun to be expanded in culture in Western and Central Europe. It is an edible plant, generally used in salads and cooked as vegetable sauces.

It is an annual plant with a size between 20 and 100 cm, with deeply pinnate leaves (four to ten lateral lobes, small and large terminal lobe). The flowers are 2-4 cm in diameter, arranged in a corymb: a typical *Brasicacceae* structure. The petals are white or cream with purple veins and yellow stamens. The fruit is 12-35 mm long with many seeds that are edible (1 g contains approximately 700 seeds depending on variety).

As a rustic plant, it has reduced requirements towards the vegetation factors and it is easily adapts to climate changes and different soil types. It is sensitive to soil salinity, suitable for winter cultivation, a little pretentious towards the factors of vegetation. The seeds germinate between 3 and 10 days; they prefer exposed lands to the sun but tolerate semi-shade. To obtain quality and high yields, it requires moist, well-drained and fertile soils, rich in humus.

2 Material and method

Three cultivars of arugula were studied, as follows: **Eruca sativa** cultivar with thinner leaves, lighter colour with less taste, from Intersemillas Company Spai; **Rukkola** cultivar with good productivity, large, rounded leaves, poor taste from Hungary, from Kertimag Company; **Rocket** cultivar with dark green, large, thick foliage, a hard-to-deliver flowering stem, with a high production and peppery flavour, 30–40-days vegetation period, from England, from the Suttons company.

The studied experimental variants were:

Factor A – the Cultivar a_1 = cultivar Eruca sativa
a_2 = cultivar Rocket
a_3 = cultivar Rukkola
Factor B – the Density b_1 = low density (150 plants/lm)
b_2 = high density (300 plants/lm)

During the experiments, various observations were made on the morphological features of the plants. Data were recorded on:

- plant development - average plant height (cm)
  - number of leaves
  - average plant weight (g)
- plant yield (kg/m^2)

3 Results and discussions

Analysing the cultivars from a developmental point of view, the data presented in Table 1 show that the variant Rocket (sown at high density) presents the highest values of plant height and weight after 25 days of emergence.

Plant weights ranged from 5.77 g to 12.41 g, the number of leaves per plant was between 7 and 9, and plant heights were between 8.0 and 14.70 cm.

Table 1: Degree of development of arugula plants at 25 days maturity

Variant		**Plant**	**Number of**	**Plant**
Cultivar	**Density**	**weight(g)**	**leaves/plant**	**height (cm)**
Eruca sativa	high	6.25	8	8.60
Eruca sativa	low	7.15	8	9.45
Rocket	high	10.30	9	12.10
Rocket	low	12.41	8	14.70
Rukkola	high	6.67	8	8.00
Rukkola	low	5.77	7	8.20

The data presented in Table 2 on the degree of development concerning arugula plants after 55 days of emergence show that Rocket cultivar is superior to other variants in plant weight and height. Another feature to note is that the rarely sown variants (150 plants/lm) show lower values than those that were sown densely (300 plants/lm).

Table 2: Degree of development of arugula plants at 55 days maturity

Variant		**Plant**	**Number of**	**Plant**
Cultivar	**Density**	**weight(g)**	**leaves/plant**	**height (cm)**
Eruca sativa	dense	8.25	10	35.40
Eruca sativa	rare	9.12	9	34.58
Rocket	dense	12.40	12	34.72
Rocket	rare	15.65	11	32.03
Rukkola	dense	7.20	8	33.00
Rukkola	rare	8.80	9	31.36

Taking into account the vegetation period of arugula from sowing until harvest, it appears that while the vegetation period is prolonged, there is a decrease in the plant weight of all studied variants (Fig.1).

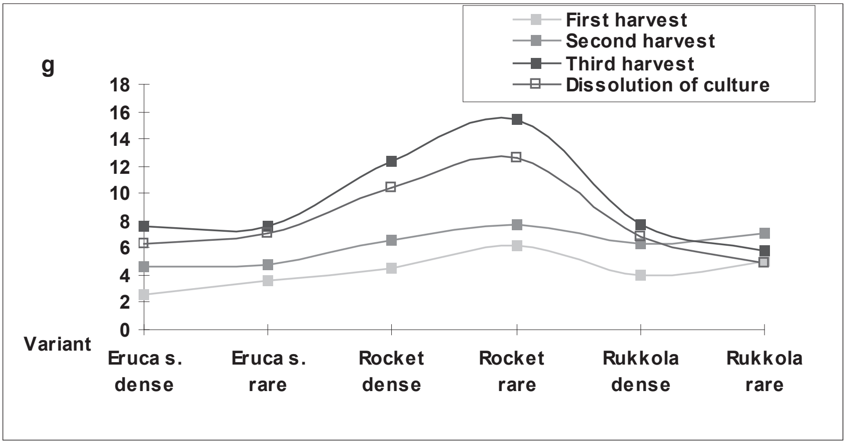

Figure 1: Weight evolution of arugula plants in 2010

It follows that the plants are mature, they lose weight and start to form flower stems; the leaves become older, with more pronounced taste and in fact, commercial quality decreases.

Table 3: Obtained yield with arugula culture (kg/m^2), first sowing period, 24.03.

Variant		2010	
Cultivar	**Density**	**Rep 1**	**Rep 2**
Eruca sativa	high	2.01	2.47
Rukkola	high	1.35	1.25
Rocket	high	2.64	2.76
Eruca sativa	low	1.73	1.50
Rukkola	low	1.05	0.98
Rocket	low	2.43	2.00

In terms of production – when the sowing was performed on 24.03.2010 –, it reached 2.76 kg/m^2 and Eruca sativa stood out from the control of experience variety with its high density and a relatively high production of 2.01 and 2.47 kg/m^2 (Table 3). With regard to the behaviour of variety Eruca sativa and Rukkola cultivars – rarely sowed (150 plants/lm) –, a decrease of production was observed. Rocket cultivar provided a consistent production in both densities, but a lower one than that cited in the literature (2700-6700g/m^2) [2].

Analysing the data presented in Table 4, a decrease was noted in the obtained values as compared to the obtained yield of the first sowing period. The highest values were obtained with variety Eruca sativa (high density), Rocket (both densities), and Rukkola (high density) variants.

Table 4: Obtained yield with arugula culture (kg/m^2), second sowing period, 03.04.

Variant		2010	
Cultivar	**Density**	**Rep 1**	**Rep 2**
Eruca sativa	high	1.44	1.84
Rocket	high	1.74	2.54
Rukkola	high	1.25	1.45
Eruca sativa	low	0.75	0.95
Rocket	low	1.29	1.00
Rukkola	low	0.83	0.99

Taking into account the vegetation period of arugula culture from sowing until harvest, certain differences in the production are noted, which are determined by shortening the growing season with 10-15 days (in the second sowing period) as well as the climatic factor, the temperature (which was *higher*) Figure 2.

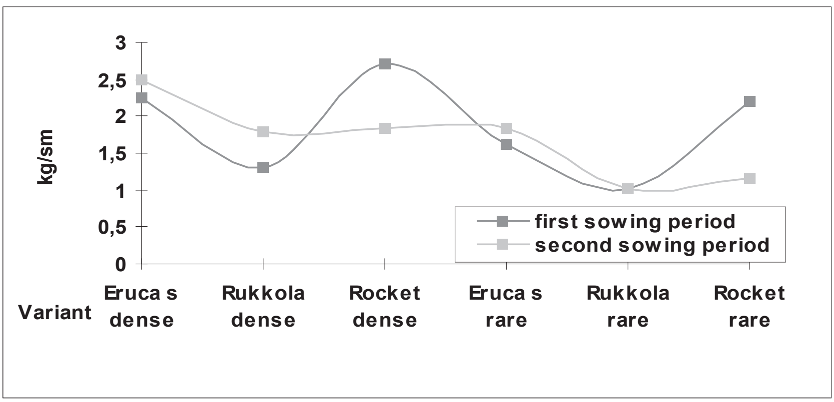

Figure 2: Yield evolution in the two sowing periods

4 Conclusions

The experiments carried out with arugula culture resulted in the following conclusions:

- Arugula plants are less demanding towards the vegetation factors.
- The establishment of arugula culture (in the climatic conditions of the Transylvanian Plateau) in protected culture (unheated greenhouse) is in the third decade of March.
- This culture is suitable for high densities (300 plants/lm).
- Considering the growing period of arugula, from sowing until harvest, there is a substantial decrease in yield in the case of sowing in the month of April.
- Regarding the behaviour of cultivars, Rocket cultivar achieved the highest production in both experiments.

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The influence of planting density upon the obtained yield with corn-salad (*Valerianella olitoria Maench*) culture

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Abstract. The leafy vegetables are consumed raw, in salads, ensuring the full use of vitamins and chlorophyll. This group of vegetables includes corn-salad (*Valerianella olitoria Maench*, sin. *Valerianella locusta* L.), which in our country is used for consumption from spontaneous flora. The experiment was conducted in the unheated greenhouse of the Vegetable Growing Department of University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, in spring culture in 2009 and 2010. The agrobiological behaviour of three varieties of corn-salad was studied such as D'Olanda, Volhart, and Elan. Biometric measurements were conducted to determine growth capacity, increase in the number of leaves, diameter of leaf rosette, plant weight, and obtained yield. The obtained results show that the studied varieties have the same behaviour and the number of leaves decreases at variants with higher density, thereby influencing plant weight.

Keywords: leafy vegetables, lamb's lettuce, corn-salad

1 Introduction

Corn-salad comes from the spontaneous flora. This vegetable is grown in large areas in Western European countries, both in open field culture and in covered crops. In our country, it is less known and cultivated, and for consumption is harvested from spontaneous flora [2].

Corn-salad is an annual herbaceous plant. The root is pivoting and grows in the surface soil, the vast majority of roots penetrating up to 20-25 cm deep. At the surface, it develops a rosette of leaves. The leaves are of light green colour (depends on variety) and there are known two groups of varieties that differ by the shape of the leaf. The leaves are trapped on a short stalk that can be found in axillary bud-shaped side-rosettes of the small leaves that determine the bush aspect of the plant.

The flowering stem forms many branches of 10-20 cm long whose flowers are small, white, or bluish white, and they are grouped in terminal bunches.

Corn-salad has reduced requirements regarding growth factors, it is easily adapting to different variations of soil types and climate conditions [1].

2 Material and method

Three different varieties were studied as follows:

Elan is a variety from the group with large leaves and short growing season, resistant to cold and diseases, especially downy mildew and powdery mildew. Ideal for cultivation in protected areas.

Also part of the previous group is **D'Olanda**. Early variety with large and long leaves, cold resistant, reaches maturity in 65-80 days. This variety has a bitter-sweet flavour and a high productivity. Volhart is the representative of the other group (those with small leaves and compact rosette), it is a frost resistant, bright green coloured variety with a distinctive commercial aspect and better productivity.

The culture of corn-salad may be established by direct sowing; in the case of small areas, seedlings may be produced. The seeds are sowed in cubes or pots, distributing 4-5 seeds in each cell. Corn-salad is a species that lends itself to high density. In the case of each variety, 3, 5, and 7 seeds/pot were sowed. Planting different densities was achieved by assigning a different number of pots:

- 10 pots were planted/lm at each variant
- 15 pots were planted/lm at each variant

During the experiments, various observations were made on the morphological features of plants. Data were recorded on the:

- number of leaves/plant
- average weight (g) of plants

3 Results and discussion

The obtained results show that the studied varieties had a similar behaviour and the number of leaves decreased at higher density, thereby influencing plant weight (Table 1).

Table 1: Development of corn-salad plants at maturity

Variant			**2009**		**2010**	
Variety	Number of seeds/pot	Number of pots/lm	Average number of leaves/plant	Average weight of plants (g)	Average number of leaves/plant	Average weight of plants (g)
V_1 D'Olanda	3	10	30	33.90	30	33.90
V_2 D'Olanda	3	15	30	27.11	26	30.50
V_3 D'Olanda	5	10	26	36.81	28	32.25
V_4 D'Olanda	5	15	20	28.49	24	28.25
V_5 D'Olanda	7	10	22	39.88	24	35.85
V_6 D'Olanda	7	15	18	30.99	20	33.75
V_7 Volhart	3	10	34	25.81	32	26.25
V_8 Volhart	3	15	32	23.59	30	26.60
V_9 Volhart	5	10	30	26.09	30	31.66
V_{10} Volhart	5	15	28	24.64	26	30.00
V_{11} Volhart	7	10	22	24.84	22	31.16
V_{12} Volhart	7	15	20	19.13	18	28.20
V_{13} Elan	3	10	32	32.90	34	28.05
V_{14} Elan	3	15	32	30.22	30	29.63
V_{15} Elan	5	10	30	35.01	28	26.25
V_{16} Elan	5	15	26	32.76	24	29.80
V_{17} Elan	7	10	26	33.81	24	35.00
V_{18} Elan	7	15	22	30.60	20	30.00

Analysing the data presented in Table 1, we can find a slight difference at the concerned varieties in the number of leaves/plant. D'Olanda achieved between 18-30 leaves/plant, Volhart has 20-34 leaves/plant, and Elan reached values between 22-32 leaves/plant.

Regarding the average number of leaves/plant, the variants with a reduced number of seeds/pot (3 seeds/pot) presented the highest value (between 30-35 leaves) while the variants with 7 seeds/pot reached the least number of leaves (18-22 and 26, respectively) at all three varieties (Fig. 1).

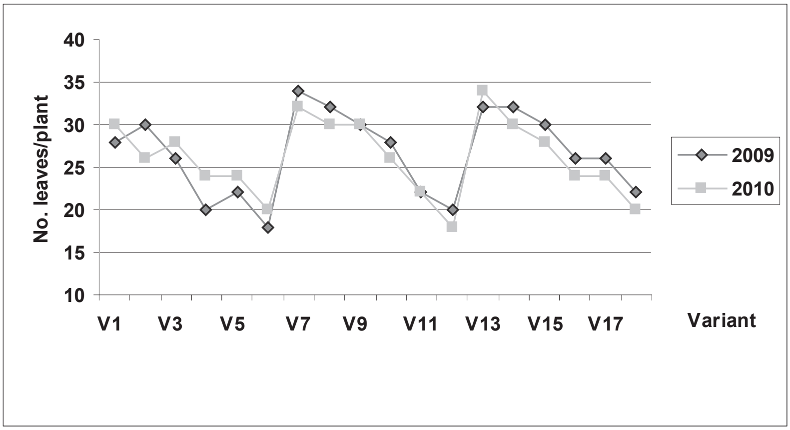

Figure 1: Average number of leaves at corn-salad plants

Concerning the average weight of corn-salad plants and comparing the variants (Fig. 2), D'Olanda shows higher values for variants with 5, 7 seeds/pot at a density of 10 pots/lm as compared to Volhart and Elan varieties. In 2010, the obtained values were lower than in 2009. In the case of variety Volhart, the average weight is lower in 2009 while in 2010, it stands out with relatively high values at variants with 5, 7 seeds/pot at both densities (10 and 15 pots/lm). Elan variety gets higher values in 2009 and the plant weights were lower in 2010.

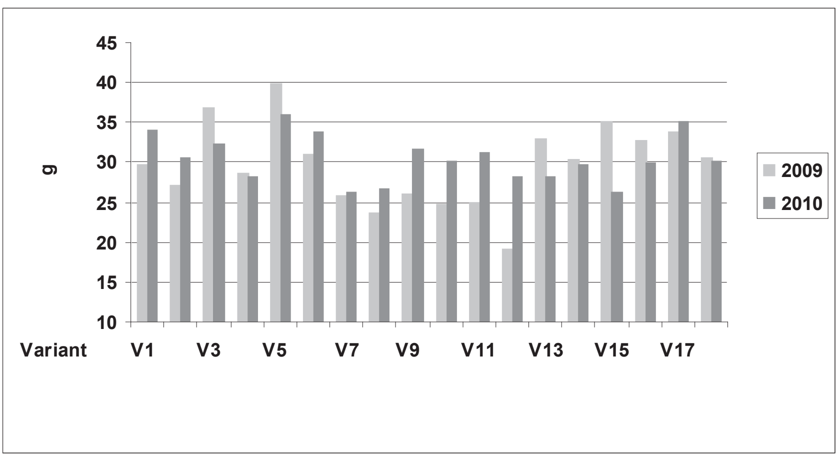

Figure 2: Average weight of corn-salad plants in 2009 and 2010

The achieved yields depend on the variety, developing stage, and harvest time, and they range from 0.8 to 1.5 kg/m^2 [2] or 1.5 to 2 kg/m^2 [3] – after [4] the optimal harvest is realized, when the plants reached 5-7 leaves, depending on how the culture was set up (Fig. 2).

Direct sown crops can produce between 1 and 1.5 kg/m^2 and may reach values from 1.8 to 2 kg/m^2 by planting seedlings.

Table 2: The obtained yield in the experimental years at corn-salad culture (kg/m^2)

		2009		**2010**	
Variant		10 pots/lm	15 pots/lm	10 pots/lm	15 15 pots/lm
D'Olanda	3	1.21	1.62	1.32	1.52
D'Olanda	5	1.56	1.75	1.61	1.93
D'Olanda	7	2.16	2.38	1.94	2.29
Volhart	3	1.61	1.75	1.23	1.44
Volhart	5	2.57	3.04	1.22	1.52
Volhart	7	2.65	3.72	1.44	1.56
Elan	3	1.82	2.24	1.70	1.79
Elan	5	1.89	2.96	1.84	1.97
Elan	7	2.82	3.41	1.76	2.41

As shown in Table 2, production in 2009 ranged from 1.2 to 3.4 kg/m^2, which is considered to be a very good production.

Having the same thickness, Volhart (with 5, 7 seeds/pot, planted with 15 pots/lm) and Elan variety stand out from among the studied variants. It follows that the corn-salad varieties perform well at high density.

Considering the production in 2010 (Table 2), it was a moderate production, without large differences between the studied variants. Considering the obtained yield, D'Olanda and Elan varieties are remarkable.

Considering Volhart variety behaviour, which in 2009 reached the highest values, in 2010, it shows a steady production (yields are almost the same for each density), lower compared to other variants.

Year 2009 is characterized by high yields in both densities. What becomes clear from Fig. 3 is that the variants planted at high density (15 pots/lm) with a large number of seeds/pot generated higher yields than those planted at lower density (10 pots/lm).

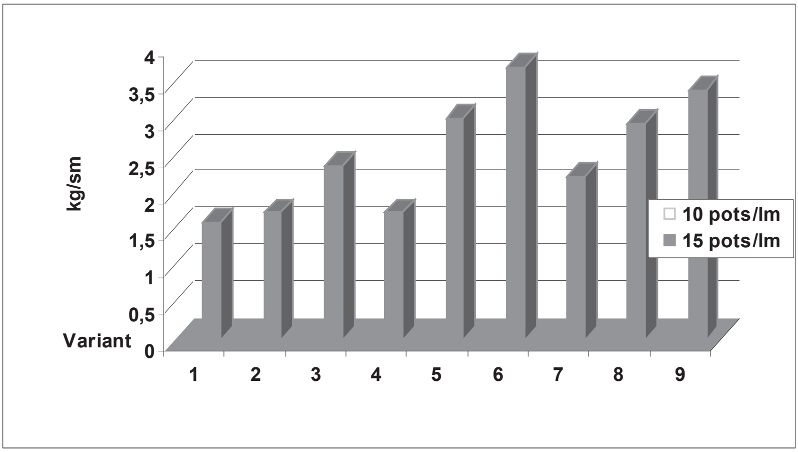

Figure 3: Yield evolution in 2009

In 2010, production values and even the differences between variants (10 pots/lm and 15 pots/lm) were not large. This can be explained by the fact that the location of experience was not changed in 2010 and plant health problems were recorded (Fig. 4.).

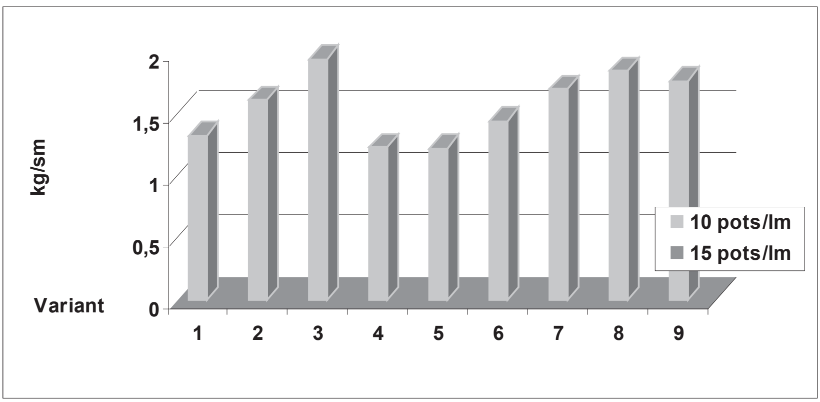

Figure 4: Yield evolution in 2010

Although when planting, the seedlings were selected, there were problems with gray mould (*Botrytis cinerea*) in lettuce crops, and corn-salad culture was also compromised, being in the same protected space. Because it has a short growing season, they did not perform treatments, but it was necessary to remove leaves from the base of the plants; so, there were losses in production.

4 Conclusion

Corn-salad culture is suitable for high density without decreasing the commercial quality.

Through increasing density (from 10 pots/lm to 15 pots/lm), a more efficient use of land can be achieved.

Increasing the number of seeds from 3 seeds/pot to 7 seeds/pot provides a better production without reducing the quality of the obtained product.

Regarding the behaviour of varieties, the behaviour of Elan is remarkable: it ensured the highest production in 2009: 3.40 kg/m^2 at a density of 10 pots/lm and 2.41 kg/m^2 at 15 pots/lm density in 2010.

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Dwarfing of Caryopteris × clandonensis 'Grand Blue': the interaction between growth retardants and the transpiration rate, stomatal conductance, and CO_2 fixation

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Abstract. The effect of growth retardants Alar, Bumper, Cultar, Cycocel, and Mirage was studied on *Caryopteris × clandonensis* 'Grand Blue' young plants in an experiment during May-October, 2011. The young plants were sprayed with the chemicals three times during the summer. The most effective growth retardant was Cultar. The influences of these retardants on stomatal conductance, transpiration rate, and CO_2 fixation on leaves were also measured. The differences between the treatments on the 1st day after the last spraying were the most marked and statistically significant, the differences on the 24th day were still notable but not significant, while on the 43rd day after the last spraying, they decreased to minimum. As a final conclusion, it can be stated that the effect of the different growth retardants faded away after three weeks.

Keywords: plant growth regulators, photosynthetic rate, *Caryopteris × clandonensis* 'Grand Blue'

Introduction

Caryopteris × clandonensis is a summer-flowering semi-shrub reaching a height of 1-1.5 m; it is praised for its late blooming time. The flowering but smaller plant would have a higher market value because the small, compact plants, full of flower are preferred on the market, especially in the autumn season. The aim of the experiment was to decrease the size and the growing time of the plant, and after the dwarfing researches, to measure the photosynthetic activity of the plant.

Review of literature on some growth retardants

There are several chemicals in circulation that have a dwarfing effect on plants.

Many growth regulators continue to be used experimentally, but the transition to approved usage is being delayed for several reasons. On the financial side, a number of mergers, buy-outs, and other dispositions of chemical companies has led to a decrease in the number of commercial compounds available [6].

The most important compounds available on the Hungarian market are as follows: Alar 85 SP, Bumper 25 EC, Cultar, Cycocel, Mirage 45 EC.

Short description of the compounds

Alar 85

Daminozide is the effective ingredient of Alar 85 systemic growth regulator; it is registered for use on ornamental plants, including potted chrysanthemums and poinsettias, and bedding plants in enclosed structures such as greenhouses, shadehouses and interiorscapes [20]. It is widely used in ornamental plant production, for example, in the case of *Dahlia, Fuchsia, Ageratum, Antirrhinum, Petunia, Salvia, Zinnia, Phlox, Nemesia, and Lobelia* genera [4].

Bumper 25 EC

Propiconazole is the effective ingredient of Bumper 25 EC systemic liquid fungicide [20]. Propiconazole is a kind of triazole derivative that has been recommended for use as either fungicide or plant growth regulator. Triazole compounds can also protect plants against various environmental stresses [7]. Banko (2004) used propiconazole for growth control with *Petunia* × *hybrida.* The plants became more compact, the bush diameter decreased. The experiments carried out by Rajalekshmi et al. resulted in decreased plant size and the increase of chlorophyll content with *Plectranthus aromaticus* and *P. vettiveroids.* Hanson et al. (2003) proved that the length of *Amaranthus retroflexus* seedlings retarded significantly if the propiconazole concentration was above 0.36 mg/l.

Cultar

Paclobutrazol, which is the effective ingredient of Cultar, is a very potent, systemic plant growth regulator invented by ICI Plant Protection Division at Jealott's Hill Research Station. As a suspension concentrate it is used for vegetative growth control on fruit trees. The use of Cultar may lead to an increased yield in certain crops [19]. Paclobutrazol is used to reduce vegetative growth and increase fruit bud formation in tree fruit crops and to retard shoot growth in ornamentals and turf grass. It is formulated as a soluble concentrate and applied as a pre-plant dip and/ or foliar spray [17].

Cycocel

Chlormequat (2-chloroethyl) trimethylammonium chloride is the effective ingredient of Cycocel liquid plant growth regulator; it is used on bedding plants and containerized ornamentals in greenhouses, shadehouses, and nurseries. Treated crops are more compact with shorter internodes, stronger stems, and greener leaves [1]. Clormequat is applied as a spray to azaleas after the plants have been pinched for the last time. This checks growth and prompts early flower-bud initiation. Quite often, a large number of flower buds develop. The retardant helps further by reducing the formation of vegetative shoots at the time of flower bud development [19].

Mirage 45

EC Procloraze is the effective ingredient of Mirage 45 EC, which is registered primarily as a systemic liquid fungicide [5]. Procloraze belongs to the group of ergosterol-biosynthesis retardants and besides the fungicide effect, it also has a growth retardant effect [4].

1. Studies on growth control of some researchers from Hungary

Kisvarga et al. (2010) used CCC, Caramba, Cultar, Regalis, and Toprex to see the reaction of these growth retardants on *Scabiosa atropurpureai*, *Godetia grandiflora*, and *Coreopsis grandiflora*. Regalis, Toprex, and Cultar showed a very good achievement [14].

Köbli et al. (2010) tested the dwarfing effect of two fungicides, Bumper 25 EC and Mirage 45 EC, comparing them to Alar 85, a traditional growth retardant with the concentration advanced by the producer. The test plant was *Ismelia carinata*. The most effective was Alar 85 [15].

Mohamed's (1997) results indicated that treatments with Daminozide, Chlormequat, and Paclobutrazol were effective in reducing plant height and producing dwarfed plants, especially at high concentrations. Test plants were: *Tagetes*, *Petunia*, *Torenia*, *Rudbeckia*, Buddleja, *Hibiscus*, *Fuchsia*, *Solidago* [19].

2. Studies on plant photosynthetic activity of some researchers from Hungary

It is well known that the photosynthetic characteristics of a broad range of plants are influenced by the light climate in which they are grown. Sun leaves are generally described as requiring a higher light saturation photon flux density and having a higher light-saturated photosynthetic rate and light compensation point than the corresponding shade leaves [18].

The measurements on leaf photosynthetic activity and transpiration rate are used widely in horticultural crops, but they raise methodological questions when applied on urban trees and shrubs. With fruit trees, it has a great significance that as much of the sunlight's energy as possible should be turned into yield on the growing area [13]. In this area, several research results show that there is a close correlation between leaf area index (LAI) and yield [16].

In Hungary, the following studies on photosynthetic activity were made so far: Gyeviki (2011) [10], Gyeviki et al. (2012) [11] measured the transpiration on cherry (*Prunus avium* L.) leaves in field conditions. Forrai et al. (2011, 2012) [8, 9] measured the leaf gas exchange of ornamental woody plant species.

Knowledge about the yield on environmental benefits of trees and shrubs has to be confirmed with on-site instrumental examinations to get actual information. There are little reliable data on LAI values and photosynthetic activity of trees and shrubs exposed to various stress factors (such as air pollution, drought, and human impacts) in different environmental conditions [9].

No literature was found on the dwarfing effect of growth retardants on plant Caryopteris.

Material and methods

The experiment was carried out in 2011 on the Experimental Field of Corvinus University of Budapest, Faculty of Horticultural Science in Soroksár, on young plants, *Caryopteris* × *clandonensis 'Grand Blue'*, propagated by softwood cuttings. The cuttings were taken on 16 May, rooted and planted in 9 × 9 cm pots on 27 June. In growth control treatments, the young plants were sprayed three times (on 28 July, on 18 August, and on 6 September) with growth retardants, each in two concentrations as follows: Alar 85 SP in 0.4%

and 1%; Bumper 25 EC in 0.1% and 1%; Cultar in 1%; Cycocel 0.3% and 1%; Mirage 45 EC 0.2% and 1%. The control cuttings were not sprayed with any growth retardant.

Instrumental measurements of photosynthetic activity were carried out three times on the leaves of the plants with infrared gas analyzer (IRGA): on the 1^{st}, the 24^{th}, and the 43^{rd} day after the last spraying. The first measurement took place on 7 September 2011, the second measurement on 30 September 2011, and the third measurement on 19 October 2011.

Leaf gas exchange was measured using LCi equipment. LCi photosynthesis system is the current portable instrument for differential CO_2 and H_2O gas exchange measurement. Detailed description is given by the producer company [2].

The measurements were made on one leaf per shrub in 6 repetitions, so, in all, we got 6 data for evaluation in every three weeks, which means three times in total.

The data measured were as follows:

- stomatal conductance (mol/m^2/s)
- transpiration rate (mmol/m^2/s)
- photosynthetic rate (μmol/m^2/s)

These values were measured in full sun, between 11:00 am and 14:00 pm, which is the highest radiation period during the day. Only leaves exposed to direct sunlight were measured so far as they played the main role in photosynthesis.

All data were statistically analysed by ANOVA using the statistical package SPSS Statistics programme (SPSS 19.0 for Windows), Guide to Data Analysis. Data were separated by Tukey test at LSD level p=0.05.

Results

Effect of growth retardants on growth and development (Table 1)

Generally, it can be reported that changeable results were obtained with the chemicals used. Cultar 1% showed a very good achievement. Plants treated with this substance had more, shorter internodes, small, thick and fragile leaves, and more compact habit compared to the control plants. Their shoot length was 23.04 cm on average. This was followed by Cycocel 1% and Cycocel 0.3%, Bumper 1%, Mirage 1%, Alar 1% and Alar 0.4%, Mirage 0.2%, and Bumper 0,1%. The control young plants were the longest: their shoots were 39.14 cm long.

The most effective chemical on blossom bud development was Alar 85 used in 1% concentration. The young plants needed only 8.81 nodes to develop the first blossom buds. Similar nodes (8.93) were needed in the case of the untreated control plants. When Alar 0.4%, Bumper 0.1%, Mirage 0.1%, and Mirage 1% was used, the first blossom buds developed after 9-10 nodes except for Bumper and 1% Cultar 1% where the blossom buds developed after 10.11 and 10.29 nodes.

In spite of great differences between the minimum and the maximum size (23.04 cm and 39.14 cm), the number of the nodes showed only slight alternations (9-10). This means that all the chemicals carried out their dwarfing effect by shortening the internodes.

Table 1: The effect of some growth retardants on *Caryopteris* × *clandonensis* 'Grand Bleu' measured on 20-21 September 2011

Growth retardants	Shoot length (cm)	First blossom buds (nodes)	First flowers (nodes)	Last flowers (nodes)	Number of nodes on the average	Blossoming stage	Over-blooming stage
Control	39.14	8.93	9.85	12.57	12.73	4.57	1.38
Cultar 1%	23.04	10.29	10.88	12.15	12.52	3.23	
Alar 1%	38.59	8.81	9.68	12.38	13.27	4.63	1.50
Alar 0,4%	38.50	9.54	10.39	11.95	13.10	4.53	2.15
Cycocel 1%	32.34	9.48	10.30	12.66	13.02	4.19	0.75
Cycocel 0.3%	32.86	9.94	10.73	13.42	13.70	4.34	1.29
Mirage 1%	38.38	9.47	10.57	12.64	13.61	4.04	
Mirage 0.2%	38.71	8.89	9.91	12.41	12.84	4.48	0.25
Bumper 1%	37.52	10.11	11.25	13.54	14.44	4.25	0.75
Bumper 0.1%	38.93	9.20	10.02	12.45	13.18	4.58	1.23

Blossoming stage of flowers
0 - no blossom buds
1 - blossom buds just shown
2 - blossom buds have elongated
3 - colour of flower-buds can be seen
4 - half of the flower-buds blossoming
5 - all flower-buds over-bloom

Over-blooming stage of flowers
1 - 1/3 of the flowers were overblown
2 - half of the flowers were overblown
3 - all flowers were overblown

Effect of growth retardants on the photosynthetic activity (Figs. 1-3)

Stomatal conductance of leaves

At the first measurement, the leaves treated with Alar 0.4% had more opened stomata (0.22 mol/m^2/s). The differences concerning the various treatments were significant. Strong interaction was found between the stomatal conductance and transpiration rate of the investigated leaves. The interaction was varying between the different treatments (Figure 1).

At the second measurement, the untreated leaves had more open stomata (0.32 mol/m^2/s) than those subject to other treatments. Plants treated with Alar 1%, Bumper 1%, Cultar 1%, and Cycocel 0.3% had the same degree of open stomata. The differences concerning the various treatments were not significant.

At the third measurement, the untreated leaves and leaves treated with Mirage 0.2% had more open stomata (0.05 mol/m^2/s) than those subject to other treatments, which had similar effect in the stomatal conductance of leaves. Leaves treated with Cycocel 0.3% and Mirage 1% had the fewest open stomata. The differences were not significant.

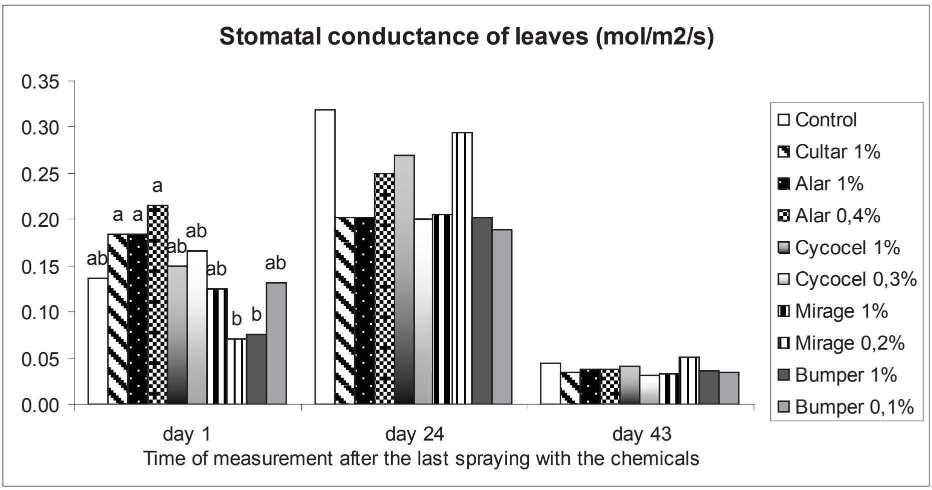

Figure 1: Effect of the growth retardants on stomatal conductance of leaves (mol/m^2/s) on *Caryopteris |times clandonensis* 'Grand Bleu' plants (*Columns marked with different letters differ significantly from each other at level p=0.05%, according to the Tukey LSD test*)

Transpiration rate of leaves

At the first measurement, the results revealed that plants treated with Alar 0.4% and 1%, Cycocel 0.3% and 1%, and Cultar 1% transpired more than the leaves treated with Bumper 1% and Mirage 0.2%.

At the second measurement, plants treated with Alar 1% showed the lowest transpiration rate with 4.82 mmol/m^2/s. Plants treated with Cycocel 1% showed the highest transpiration rate with 6.67 mmol/m^2/s. The difference between the two measurements was 1.85 mmol/m^2/s. Similar results were reached with leaves treated with Alar 1% and with untreated control plants.

At the third measurement, the transpiration rate on the leaves was considerably lower than in earlier measurements. In this case, plants treated with Cycocel 0.3% had the lowest transpiration rate on the leaves and plants treated with Mirage 0.2% showed the highest transpiration rate on the leaves. Similar results were reached with plants treated with Alar and Bumper (Figure 2).

There were no significant differences in transpiration rate between the treatments at all measurements.

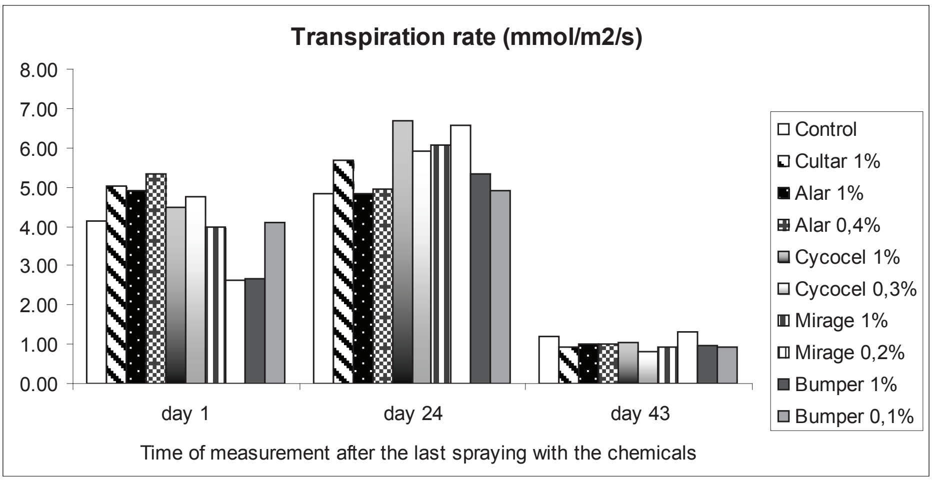

Figure 2: Effect of the growth retardants on transpiration rate (mmol/m^2/s) on *Caryopteris* × *clandonensis* 'Grand Bleu' plants

Photosynthetic rate of leaves

The photosynthetic rate of leaves (measured in net CO_2 assimilation rate of leaves) showed a strong interaction with stomatal conductance.

At the first measurement, the CO_2 assimilation rate of the plants treated with Bumper 1% and Alar 0.4% was very diverse (6.77 and 14.09 μmol/m^2/s), which suggested differences in the CO_2 fixation capacity of the leaves. The difference between the two was 7.32 μmol/m^2/s, which is highly significant. Plants treated with Alar 0.4% and 1%, Cultar 1% and Cycocel 0.3%, and 1% showed the highest net CO_2 assimilation, in contrast with plants treated with Bumper 1% and Mirage 0.2%. The photosynthetic activity of the leaves of control plants represented an average value compared to those subject to other treatments. There were numerous significant differences in the photosynthetic rate of the leaves between the treatments as you can see on Figure 3.

At the second measurement, plants treated with Alar 1% and the untreated control plants showed some differences in the photosynthetic rate of the leaves. Their CO_2 assimilation was diverse (13.14 and 18.59 μmol/m^2/s). The difference between the two was 5.45 μmol/m^2/s. Plants treated with Cycocel 1%, Mirage 0.2%, and the untreated control plants showed the highest net CO_2 assimilation. The differences were not significant.

At the third measurement, plants treated with Mirage 0.2% had the highest photosynthetic rate of the leaves (5.01 μmol/m^2/s). Plants treated with Cycocel 0.3% had the lowest photosynthetic rate of the leaves (3.02 μmol/m^2/s). The difference between the two was 1.99 μmol/m^2/s. There were no significant differences in the photosynthetic rate of the leaves concerning the different treatments.

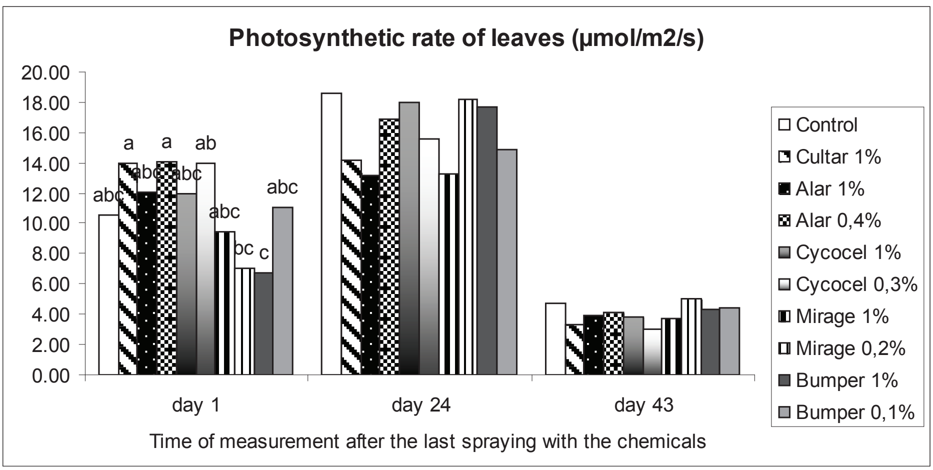

Figure 3: Effect of the growth retardants on the photosynthetic rate of the leaves (μmol/m^2/s) on *Caryopteris* × *clandonensis* 'Grand Bleu' plants (*Columns marked with different letters differ significantly from each other at level p=0.05%, according to the Tukey LSD test*)

Conclusions

At the first measurement, there were considerable differences found in net photosynthetic rate and stomatal conductance of leaves between the different chemical treatments. This suggests a different effect of the five growth retardants. At the second and third measurements, the differences decreased to minimum. This means that the effect of the different growth retardants faded away after three weeks.

As a final **conclusion**, it can be stated that the growth retardants affect not only the growth but also the photosynthetic activities of the treated plants. In the case of *Caryopteris*, this question and the correlation were not yet studied (or, at least, not published) by other researchers. Further measurements are planned to be carried out on *Caryopteris* × *clandonensis* 'Grand Bleu' plants, to affirm these results.

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Analysis of urban air imission and meteorological parameters using mathematical statistical methods

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Abstract. To a certain extent, everybody can perceive the relation between the air imission and the meteorological status. To quantify these ordinary observations is rather complicated, which has more reasons. Among other things, it should be mentioned that fronts cause sudden changes in imission data, in addition there is feedback between the polluting materials emitted in the atmosphere and the meteorological characteristics, that is not only the meteorological conditions affect the transmission of the air pollutions, but also the air polluting materials have an effect on the meteorological parameters. Mathematical statistical methods are suitable to explore such relationships. The study shows the results of a research made on such problems through an urban example.

Keywords: meteorological parameters, air pollution episode, immission, mathematical statistical methods

1 Introduction

Different meteorological parameters affect in a different way the concentration of the various air pollutions, this effect depends on the summer-winter seasons. This contact is stronger in summer and weaker in winter. The windspeed has significant influence on the concentration of every air polluting susbtance, moreover the apropos of nitrogen-dioxide the signal parameters are the sunlight and the atmosphere stability, whereas next to the windspeed, the sulphur-dioxide has significant connection with the temperature relating to heating. The atmospherical dust pollution has more significant connection with precipitation from the meteorological elements (Sándor – Baranka, 1993). The research had to be made on such a settlement, which had meteorological and imission data and it was suitable for this aim taking into consideration its size and geographical location, (distance from other significant sources).

2 Materials and Methods

2.1 The sources of immission data

The Hungarian RIV net began to operate in 1974, and the inland accomodation of the measure points was carried out with taking notice of the World Health Organisation's recommendation, which means in an analized settlement, measuring stations should be located in the centre, in the suburban and in the industrial part of the city if possible (Bozó et al., 2001). Following the WHO's lead in Jászberény, three immission measuring stations were settled, one was located in the yard of the mayor's office representing the city, one was located in the yard of the Szivárvány Nursery representing the suburban environment, one was located in the yard of SZIE ABPK representing the industrial environment (Fig. 1). The measured polluting substances were NO2, SO_2 and settling dust. The scanning of measured data is carried out daily by NO_2 and SO_2 and monthly by settling dust. If we take the characteristics of the settlement into consideration, the location of the stations can be accounted optimal. Unfortunately, the number of the stations and the analyzed components have been reduced, nowadays only one is operating in the city centre, measuring NO_2 (Table 1.). The imission data of the OLM can be freely downloaded from the homepage of the Ministry of Rural Development.

Table 1: The components of the materials measured by the RIV net, and the date of the lapse of the measuring

station	**centre**			**Szivárvány Nursery**			**SZIE ABPK**		
material	NO_2	SO_2	settling dust	NO_2	SO_2	settling dust	NO_2	SO_2	settling dust
the end of the measuring date	—	31.12. 2007	31.12. 2007	30.04 2004	30.04 2004	30.04 2004	30.11. 2006	30.11. 2006	31.12. 2007

Source: own calculation

2.2 The source of the meteorological data

The required meteorological data, which were needed to evaluate the immission data, were procured from different sources. It meant a problem, that the Hungarian Meteorological Service did not have such a measuring station, which was able to provide every meterological parameter the measured parameter was only the daily summarized precipitation. However, this station and the immission measuring station in the SZIE ABPK were at the same place. The nearest meteorological station operated by the OMSZ can be found in Jászapáti, the measured data between 01.07.2006–31.12.2007 are the daily avarage windspeed, daily summarized precipitation (manual, automata). To generate a bigger database own data have been collected. In Jászberény operated by individuals some professional meteorological stations work, which are located suiting the requirements, and the measured data can be found on the www.idokep.hu homepage. Naturally, the operation of these stations depends on the owners, which is not certainly continual. The data of the most relieable WS 2300 station signed by identifier "Felügyelő" have been collected since 01.01.2008 (Figure 1).

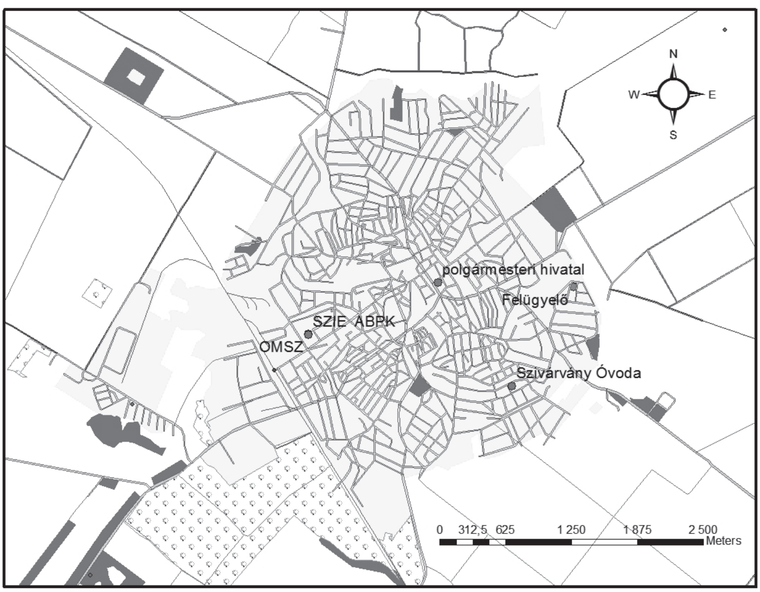

Figure 1: The imission measuring stations and the meteorological stations. Source: own design

The measured daily weather data are: minimum temperature, maximum temperature, minimum atmospheric pressure, maximum atmospheric pressure, minimum relative humidity, maximum relative humidity, sum of precipitation, the most frequent wind direction (night and daytime), average windspeed, average wind direction. Other free data have been downloaded from the OGIMET homepage. This database contains the daily minimum, maximum and average temperature, daily average relative humidity, atmospheric pressure (sea level), clouds, sum of precipitation, average windspeed, average wind direction, sunny hours from the locations of stations are: Eger, Szolnok, Budapest. The time interval is 01.10.1999–11.11.2012. Apart from the listed data from Lakes Environmental according to mixing height, wind direction and wind speed. Comparing the immission and meteorological data was only possible if we had both kinds of data. Measuring of dust and SO_2 immission stopped. It meant that there was no possibility to do certain examinations on these polluting materials.

3 Results

3.1 Connection between the NO_2 immission and meteorological data

The relation between the air quality and the meteorological data was discovered using two aspects. Either of them analyzed the general relationship between the air quality and the meteorological parameters, the other one studied occurent air pollution episodes in extreme conditions. The comparing was performed only in case the immission measuring station had enough immission data. To investigate the effect of the wind to the air quality, we took the daily avarage wind direction and also the daily average wind speed in account to find out whether the different daily average wind direction causes different daily NO_2 immission or not. Figure 2 shows that different average daily immission could be connected to different daily average wind direction, and meeting the requirements, the results of the heating periods usually exceeds the result of the non-heating periods (Figure 2.). Analyzing this variance, corresponding to the different daily wind direction, a test of independence was applied to see if it is stochastic or demonstrable. There was an additional problem. The measured NO_2 concentrations can be regarded a realization of a continuous variate, and the Chi^2-probe can be applied only in discrete case. Wrapping this problem up, the measured results were classified into discrete intervals. The statistic probe, confidence level was 95%, resulted different values, in heating period 0,1, in non-heating period 0,01 proved the independence, so the wind direction does not influence the concentration in the inner city significantly.

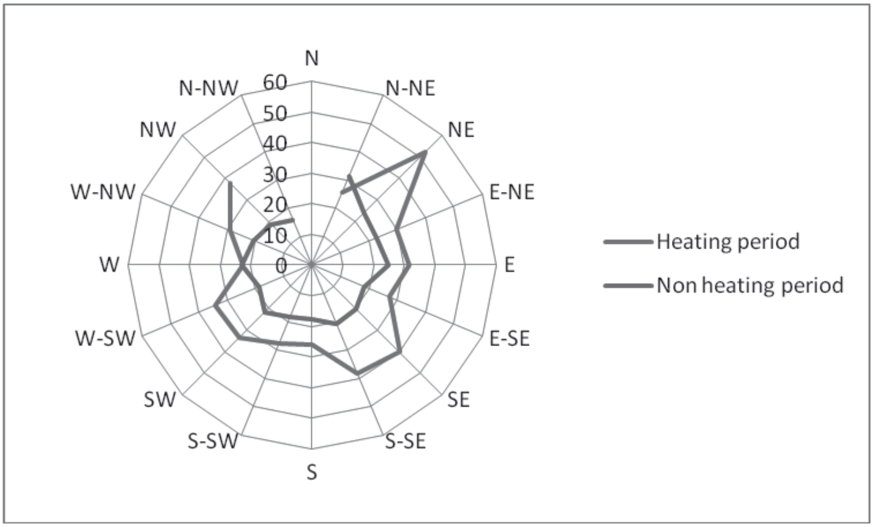

Figure 2: The avarage NO_2 immission per wind directions in heating and non heating period in Jászberény centre. Source: own calculation based on the OLM and Lakes Environmental data in interval 01.01.2011–31.12.2012.

It was very difficult to find any connection between the daily average NO_2 concentration and the meteorological parameters. The rising windspeed develops its beneficial effect primarly in heating periods, medium vehement relation can be supposed by the right of correlation coefficients but in non heating periods some slight connection can be discovered. On the other hand the maximum gust of wind and the immission values can be considered independent (Table 2.). To analyse the relation between the stability of the atmosphere and the NO_2 immission, the hourly Monin-Obukhov length data, made by interpolation technology, were converted into daily average, and these data were compared to the daily average immission. The data transformation was motivated by the temporal resolution of the OLM station's data. There is no doubt that analyzing the hourly data would have been more profitable, but the immission measuring station's data made only the comparison of daily averages possible. On the basis of the results, the data's significant relation can't be demonstrable.

Table 2: The correleation coefficients of the visualised meteorological parameteres and the NO_2 immission

correlation coefficient **NO_2 immission**	**mixing height***	**windspeed ****/***	**Monin-Obukhov length****	**Minimum tempre-ture*****	**Maximum tempre-ture*****	**Maximal gust of wind*****
non hetaing period	-0,04	-0,26 /-0,02	-0,01	-0,11	0,08	0,01
heating period	-0,15	-0,56 /-0,14	0,11	0,02	0,14	0,04

Source: own calculation based on the Lakes Environmental* (01.01.2011–31.12.2011), OMSZ**** (01.07.2006–31.12.2007), "Felügyelő"***(01.09.2008–30.09.2011), OMSZ** (01.01.2011–31.12.2011) and OLM data.

In the interest of investigating air pollution episodes each summer and winter period was analyzed. In consequence of the basin location and climatic peculiarities the most favourable conditions for the enrichment of airpolluting substances are provided by anticyclone and anticyclone border (Horváth et al, 2003). Researches of the same type have been made in order to analize the extremely high concentration of PM10 and ozone in troposphere (Ferenczi Z. 2009). In summer the air from subtropical area can be typified by extremely high daily maximum temperature, low windspeed, whereas in winter the air stem from Siberia can be characterized by extreme low daily minimum temperature, low windspeed and low mixing height. Considering the features of the city and the disposable data base, the basic research was carried out on the data of 2011. The mentioned data were provided by the daily minimum temperature and the mixing height in heating period and daily maximum temperaure and average wind speed in non-heating period. We compared the immission data of those days when the minimum temperature was not higher than -5 °C and mixing height was not more than 700 m with the data when the daily average temperature was higher than -5 °C and the mixing height was bigger than 700 m. Naturally these two masses of data are not complementary of each other and the analyses of those data which were not suitable was ignored.

In non-heating period we compared data which were characterized by at least 30 °C maximum temperature and not more than 2 m/s average wind speed. Forming the basis of the research the t-probe values showed thesame result. In heating period there is not significant difference between the expected values at 95% reliability level just as in non heating period. It would have been practical to make the research in longer period of time interval, but with the absence of Jászberény data, we could have taken only the data of meteorological stations in surrounding settlements into consideration. Unfortunately, data of Eger, Szolnok and Budapest do not contain values of mixing height, so in heating period, the daily minimum temperature while in non-heating period the daily maximum temperature gave the basis of classification. In the former perod in the case of all stations we compared the daily immission values when the daily minimum temperature was not more than -5 °C with those data which exceeded the mentioned ones. In non-heating periods we put the data of those days when the maximum temperature was at least 30 °C into one group and those days when these data were less were put into the other group. These criteria must have been fulfilled in the case of all three stations. Those data that were not suitable for any of these criteria, were left out of the analysis. The 95% reliability level-probe values which gave the basis of the comparison did not show any differences between the group averages in non-heating periods in the case of none of these stations (Table 3.).

Table 3: Comparsion of NO_2 immission data measured in average and special meteorological conditions

t-probe	**centre****	**centre***	**nursery***	**SZIE ABPK***
heating period	0,86	0,07	0,02	0,46
non heating period	0,86	0,06	0,60	0,60

Source: own calculation based on OLM, Lakes Environmental** (2011) OGIMET* data (from 01.09.1999 to 20.11.2001 in case of centre, otherwise to the date of the lapse of the measuring)

In heating periods we perceived significant difference in expected data of the nursery station. Further examination should be needed to find out the reason of the previously mentioned difference, but we take the results of other stations teherefore it can be stated that it has local origin, so it was not caused by the accummulation of polluting materials in the town or in larger area. As regards the whole settlement the reason of these results is probably offered by the size of the town because the emission in the town does not grow drastically even in winter extreme conditions consequently neither the immission does. In summer the lacking emission of heating origin is probably compensated by the growing traffic but this effect does not cause significant load even in negative meteorological parameters.

3.2 Connection between the SO_2 immission and meteorological data

In the case of SO_2 the analysis was also done separately in heating and non heating periods. In both cases, the corellation coefficients, derived from the daily average temperature and immission data, show weak connection, which can be explained by the finished modernization programme of heating in winter period. In summer the cumulative SO_2 emission caused by the contingently growing electrical energy can't make its effect felt. The correlation coefficients between the daily average windspeed and the SO_2 immission mainly refer to independence (Table 4). These results show that nowadays the local emission has decreased to a negligible level that's why neither the beneficial effect of growing windspeed nor the disadvantageous effect of the decreasing temperature can prevail.

Table 4: The correlation coefficients from the excepted meteorological parameters and the sulphur-dioxide concentration

	heating period		**non heating period**	
	windspeed SO_2 concentration	temperature SO_2 concentration	windspeed SO_2 concentration	temperature SO_2 concentration
correlation coefficient	0,15	-0,27	0,02	-0,18

Source: own calculation based on OLM and OMSZ (01.0.2006–31.12.2007) data.

The analyses of the connection between the wind direction and the immission was not possible because of the breakdown of measuring SO_2 concentration. Selecting those meteorological conditions which are positive for the accumulation of polluting materials was the same as in the case of analyzing NO2. In this case we had no possibility to make calculations with 2011 meteorological data but on the basis of temperatures measured in Eger, Szolnok and Budapest the immission data could be put into groups similar to NO_2 concentration. The calculated average concentrations and the t-probe results which provide the basis of comparison show that meteorological conditions referring to anticyclone in winter period contribute to the growth of SO_2 concentration in the centre of the town. In the case of other stations, the difference is not significant. It also refers to that town emissions cause the growth of immission. In summer we can experience a contrasting effect because between the values of data significant difference can be observed only on the area of SZIE ABPK. It is probably caused by the special location of the station, since well mixed air which is free from effects of the settlement sources arrives at the area because of the most frequent wind direction (Table 5). As opposed to the expectations in this case however, we could measure a lower average immisson in negative conditions. The reason for this is that in colder non-heating periods there is communal immission at minimum scale which affects the nursery and the centre of the city. This effect may appear in the average.

Table 5: Comparsion of SO_2 immission data measured in average and special meteorological conditions

t-probe	**centre**	**nursery**	**SZIE ABPK**
heating period	0,00	0,46	0,21
non heating period	0,00	0,02	0,57

Source: own calculation based on OLM, OGIMET data from 01.09.1999 to 20.11.2001 in case of centre, the date of the lapse of the measuring)

3.3 Connection between the settling dust and meteorological data

The settling dust data are monthly, which made the analyses of the connection between the immission and meteorological data more difficult. The quantity of the precipitation can be significantly variable in space and time, so the interpolation of the measured data is an extremely hard challenge. In consideration of the advantages and the disadvantages of the extant data we used the data which were measured in the yard of SZIE ABK in the interval of 01.01. 2005–31.12.2007. The overlaping of meteorological and immission measurement station made the search reliable. OMSZ wind and temperature data were available only in interval 01.07.2006–31.12.2007, and it was measured in Jászapáti. If the monthly averaging of this database had been made, I would have had very few datapairs, and the OGIMET data could not be representative because of the relatively big distance. So the examination was about only revealing the correlation between the monthly quantity of precipitation and the immission of the settling dust. With the help of the results (Table 6) we can state that in heating period the monthly quantity of precipitation has significant effect of the quantity of settling dust. Suprisingly, in non-heating period only the town centre data indicate the effect on the wet settling while on the area of SZIE ABPK this phenomenon does not appear. The reason for this is probably the different locations of stations and the most frequently occurring wind direction and of course it is because of the monthly amounts and averages.

Table 6: Correlation coefficients of the 30 days settling dust and the indicated meteorological parameter

correlation coefficient	**heating period**		**non heating period**	
	city centre	SZIE ABPK	city centre	SZIE ABPK
30 days precipitation sum	0,09	0,09	0,66	-0,29

Source: own calculation based on OMSZ (01.01.2005–31.12.2007) and OLM data.

4 Conclusions

The executed research indicated fairly various issues. In the case of sulphur dioxide the analyses were made when the heating system was modernized in the settlement and flue gas cleaner in the Mátra Powerplant was installed. This powerplant is about 30 km from Jászberény. Nowadays the sulfur dioxide concentration is controlled by larger scale processes but occasionally local effects can be observed. In the case of NO_2 the effect of wind speed appears in certain occasions. The negative effects on NO_2 immission of those meteorological conditions which refer to anticyclone do not appear, with the exception of nursery station, neither in summer nor in winter. In contrast with this the growing concentration of SO_2 in winter can be seen in the case of the town centre station. In the case of settling dust, the problem was caused by the different timescale of the immission and meteorological data. The correlation coefficients indicated the effect of wet deposition in the city centre in non heating period besides these the data denoted low dust emission from heating.

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Extent of the area and tree-species changes in the forests of Iván

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Abstract. There are no exact data on the extent of the forests of Iván; even the size of the attached fields has changed through the ages. A forest cover test was carried out there by selected permanent points around the village, and we investigated the proportion of forests in this area. The research started with the three military surveys; altogether concluded that the forest cover decreased to 13.5% to the third survey, and started to increase again in the 20th century. This time, experts preferred mainly acacia (*Robinia pseudoacacia*) and Scots pine (*Pinus sylvestris*).

Keywords: forest history, changes of landscape, tree-species distribution

1 Introduction

Our research was made around Iván village, which is situated in Győr-Moson-Sopron County in Hungary, in the south-western part of the county.

The life of the villages around Iván was determined through centuries by the surrounding forests: the Iváni Nagyerdő. The settlements were separated from each other and enclosed by this forest; therefore, the jobs in the forest and forest grazing were the consequent acts. Citizens got field by uprooting; this is the reason why this settlement is called "uprooting villages". Transportation and all kind of traffic were made on paths in the forest, what concluded a very dense road-system, which still exists. Forest rules became decreasing in villagers' life by the decreasing occupied area, we tried to follow these changes on the chosen area researching the changes of the forested areas and tree species.

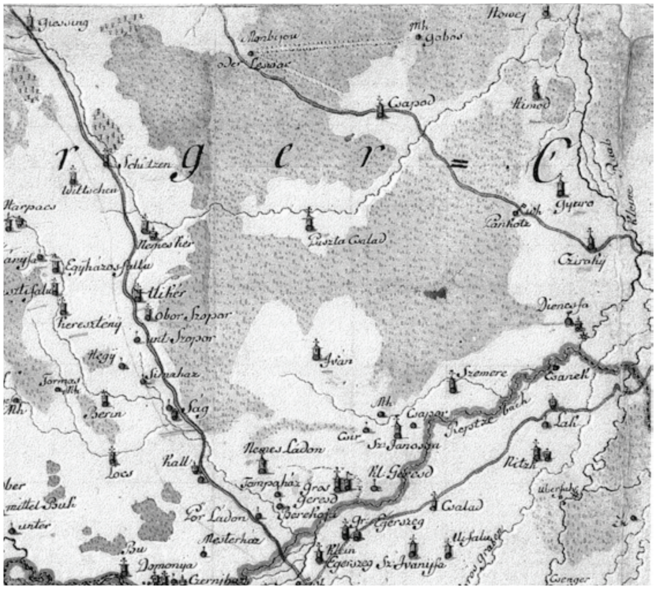
Map 1. The location of Iván in Hungary

2 Materials and methods

There are not exact data about the size of Iván forest from the past, even the so-called forests and fields have changed through the centuries. Therefore, the forest cover test was carried out by selecting permanent points around the village and we investigated the proportion of forests in this area. Before we started the research, we had to find permanent points, which did not change their position in the period under review. We used the following settlements for this kind of permanent points: Sajtoskál, Nick, Gyóró, the line led by Gyóró and Pusztacsalád closed by the line through Sajtoskál in the north-south direction.

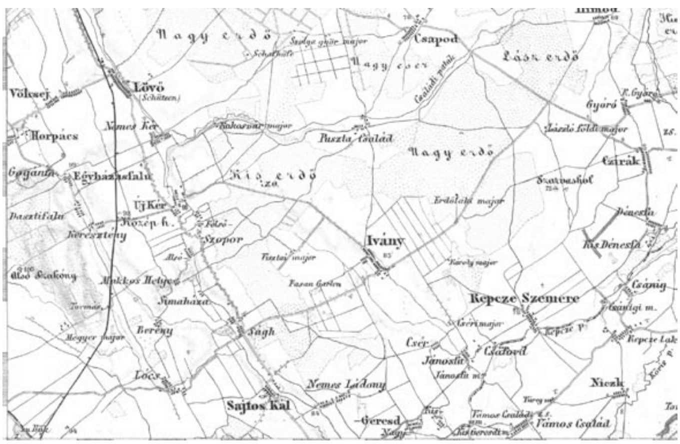
3 Results and discussions

The research was started with the first military survey (Map 2.). On this map, we found that the forest cover of the area was 48%. Considering the monographs of Soproni E. [10] and Firbás O. [3], we concluded that it has taken out even bigger area in the past.



Map 2. Iván and its territory on the first military survey [5].

By the time of the second military survey, the forest cover has decreased to 27.5% (Map 3.). This significant reduction was the result of "soil need of peasantry", which is also reflected in the increased volume of uprooted fields.



Map 3. Iván and its territory on the second military survey [6].

By the time of the third military survey, the forest cover has decreased even more, to 13.5% (Map 4.).

Map 4. Iván and its territory on the third military survey [7].

These facts clearly show that the forest cover decreased to less than 1/3 in the researched area in about 100 years.

In the first part of the 20th century, reforestation began on this bad quality, “cseri” soil, especially after the 2nd world war, when grazing lost its former importance. There was a massive reforestation campaign in the area from the 50s till the end of the 80s. In the 60s and 70s, Scots pine (*Pinus sylvestris*) was preferred, from the end of the 70s and in the 80s, Oak (*Quercus robur*) and Turkey oak (*Quercus cerris*) were rather preferred. Turkey oak (*Quercus cerris*) was planted by seeding.

On 31 December 1983, the Agri-Co-operative of Iván was closed down and its fields were given to forest management, as the surrounding farmers’ co-operatives did not receive these fields from the former one because of the very low quality of soil. Altogether that meant 860 ha, and from this just 60 ha was covered by forest. The forest management was not able to reforest the whole area in one piece; therefore they had to carry on the agricultural production [9]. Thus, forestation was completed in the 80s: almost all of these fields were afforested.

Consequently, the forest cover grew to 28% in 1980, which was equal to the amount of it in the middle of the 18th century. The reforestation wave was continued till the beginning of the 90s.

In the following decades, the size of forest cover continued to increase (Map 5.).

Map 5. Iván and its territory in 1981 [4].

The appearance of forests has changed for more reasons. First of all, because of the originally very low quality of the soil deteriorated by agriculture and grazing use. On the other hand, the wood structure has also gone through great changes. In the 12^{th}–13^{th} centuries, oak, especially turkey oak, was present in a significantly high percentage in the area, which is proven by the naming habits of several surrounding settlements [2].

The grazing in forest and the scion operation method favours the Turkey oak, as it is usually characterized by abundant acorn crop and a good budding ability, unlike other types of oaks. Unfortunately, we have not found accurate data on species distribution from this time.

In the 20^{th} century, there were more tree planting waves; during those times, experts mainly preferred acacia (*Robinia pseudoacacia*) and Scots pine (*Pinus sylvestris*). In the 50s, these two species populated more than a third of the forests of Iván [Oak (*Quercus robur*) and more than a quarter: Turkey oak (*Quercus cerris*) Fig. 1]. By the end of the century, acacia (*Robinia pseudoacacia*) and Scots pine (*Pinus sylvestris*) have equally reached 20% due to repeated plantations and species shift; meanwhile, the rate of Turkey oak (*Quercus cerris*) decreased to 14%. The rate of Oak (*Quercus robur*) increased only by a few percents.

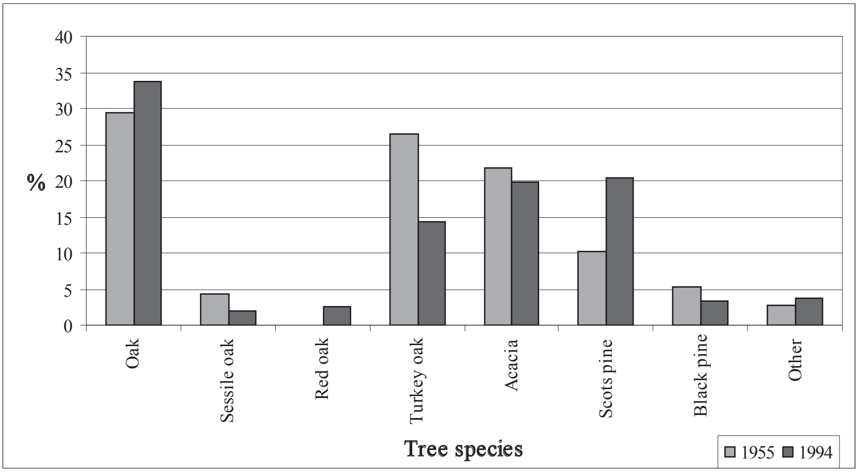


Figure 1: Species distribution of the forests of Iván between 1955 and 1994 LÁSZLÓ [1] based on data [8]

A minor forestation is still going on because of the low quality and inefficiently cultivated soil. The main tree might still remain acacia (*Robinia pseudoacacia*) for easy plantation, versatile use, and short harvesting period. As for Scots pine (*Pinus sylvestris*), its rate will decrease because of the low prices of choice of wood shavings.

4 Conclusion

In this research, we surveyed the changes of the forests' extension in the chosen area from the 18th to the 20th century. The forested field from the initial 48% has decreased to 1/3 by the beginning of the 20th century (13,5%). Owing to the mass reforestation wave of the 50s and the impact of expiry of Iván Agri-Co-operative (1983), the forest area extended to 28%. The species distribution has changed because of reforestation; the rate of acacia (Robinia pseudoacacia) and Scots pine (Pinus sylvestris) have immensely increased in the last decades.

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The quality of life as an aspect of environmental assessment

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Abstract. Our environmental assessing model is subordinated to the value of quality of life of an exact community; in this case, Sopron city's community. The real quality of life is influenced by economical, natural, and human relationship. Human behaviour is based on objective changes in the subjective response. These reactions, which are conscious and unconscious judgments of tangible expression, are typical of the local society. We presume that the relation between objective and subjective elements is correlate and expressible in a multi-variable model. This model can be characterized by the local society's and community's attitudes towards environment.

Keywords: environmental quality, -load, -awareness, green-field system, welfare

1 Introduction

The real quality of life is influenced by economic, natural, and human relationships, as well as, their perceptions by the individual and society.

Human behaviour is based on subjective response given on objective changes. These reactions are typical for a local society and are conscious and unconscious judgments of tangible expression. We assume that the relations between objective and subjective elements are correlate and expressible in a multi-variable model. This model can be characterized by the attitudes of the local society and community towards environment.

2 Materials and methods

Our environmental assessing model is subordinated to the value of quality of the life of a given community; in this case, the community of Sopron city. We considered Allardt's quality of life model [12] to be complex enough for the study.

Table 1: *Allardt*: Having, Loving, Being - An alternative to the Swedish Model of Welfare Research [12]

	Objective indicators	Subjective indicators
Having		
Tangible and non-personal needs	1. The standard of living and environmental conditions in the objective measurement	4. Subjective feelings: the living conditions of satisfaction/dissatisfaction
Loving		
Social needs	2. The objective measurement of relations with others	5. Satisfaction/dissatisfaction of relationships
Being		
Needs of personal development	3. The objective measurement of relations with society and the nature	6. Of alienation or the subjective feeling of personal fulfilment

Assumptions of the research:

Human behaviour is based on a subjective response to objective changes; same inputs in this case induce a similar output.

Applying Allardt's quality of life model to the environmental factors, a functional relation is to be assumed between the objective - subjective factor pairs.

The relationship between man and his environment is measurable using a multi-variable model that is characterized by a well-positioned local society and the surveyed community attitudes to the environment.

Community responses are characterized by the local society's judgments, so, the changes and correlations between the responses are assumed.

The environment is greatly dependent on the inhabitants of a town; the personal ties are fundamentally influenced by the need to improve their environment, which then forms a direct reflection of the urban environment.

A development is characterized by the response of the community's tolerance level in environmental load, satisfaction, and level of environmental awareness.

We used Allardt's model of quality of life in the wider environment as follows:

Table 2: Environmental-related quality of life model (KVÉM model)

	Objective indicators	Subjective indicators
Having		
Tangible and non-personal needs	1. Environmental quality (projection of material wealth)	4. Satisfaction with the environment - a subjective degree of ownership
Loving		
Social needs – role of society	2. The social impact of the environment – environmental load	Tolerating the load of the environment – attachment to the residential environment
Being		
Needs of personal development – role of ego	3. Physiological needs – Environment determines the maximum welfare	6. A personal level of alienation from the environment – environmental awareness

Objective indicators:

In the course of the objective assessment of the environment, all elements that make up the environment should be measured, and their qualitative and quantitative indicators will be placed in a regional system in order to gain a truly objective picture of the environmental values. The value of the environmental components and elements should be explored in the course of nature, landscape, and built elements of the environment as a function of available maximum and optimum load. The measurement of environmental impact must take into account the degradation of certain elements of the highly loaded nodes and their negative and positive effects on the environmental systems. The determination of the maximum available wealth allows the levelling out of the differences in the model.

Subjective indicators:

The subjective assessment of the environment is based on a value of the community's judgment by measuring reactions induced by the changes. In order to ensure adequate visibility, the environmental development efforts, opportunities, and social trends should be explored by grasping the forward direction of changes. These social trends can best measured with questionnaires and through personal interviews.

When transforming the model of Allardt to environmental factors, we assumed three objective-subjective indicator pairs that together are able to express their own perception of a community environment.

3 Results and discussions

The interactions between indicator pairs assumed in the model as follows:

1. "Having" function (H) - Quality of environment

To determine the immediate value of the environment, the quality and the quantity of every environmental component was taken into account in order to obtain as much information as possible of the offered benefits regarding the surrounding environment. This way, we defined the quality in an exact moment, and furthermore, its improvement through an investment. As a result of the investment, we presumed a positive change on the subjective axis, which depends on the exposure of the investment.

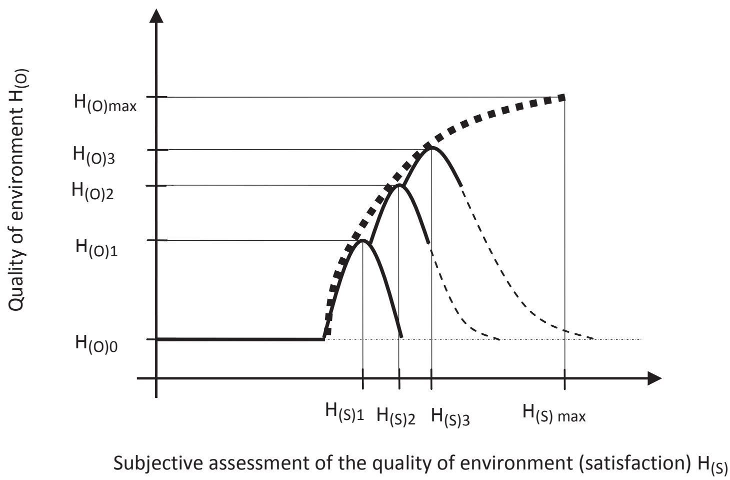

Figure 1: The "Having" function relation (H)

We defined two limits of the function: the top limit on the subjective axis is the maximum effect of the environment on the life of the individual or the community; the lowest limit on the objective axis is the level of environment without any development, which we considered as stable.

We assumed that there are environmental development programmes constantly running as a usual practice of Hungarian local governments, and citizens are informed about them. This way, the effects of the improvements can be built on one another, but without further development, the impact may fall back even to the base level. Therefore, this variable of this function is defined as a variable to be measured over time. We proposed that the sequential developments reach an ever smaller maximum, which is depicted in typical bell-shaped curves leading to an overall logarithmic curve issue. This way, the maximum level of actions achieved during the first few actions determines the maximum available saturation level, assuming a similar intensity of development.

2. "Loving" function (L) - Load of the environment

We identified the load of the environment as the main social need towards it. We examined the pressure of the physical elements and the amount of overuse of green-field elements in order to define the objective load. The subjective degree of the function is the toleration level of the population.

We defined two limits of the function: the top limit on the objective axis is the highest value of the pressure of environment that is still convenient for human life; the lowest value on the objective axis is the level of pressure that is still possibly perceived.

The typical deceleration of the function's curve is distorted by the attitude of long-term residents, which increases the toleration because of their binding to the actual living environment.

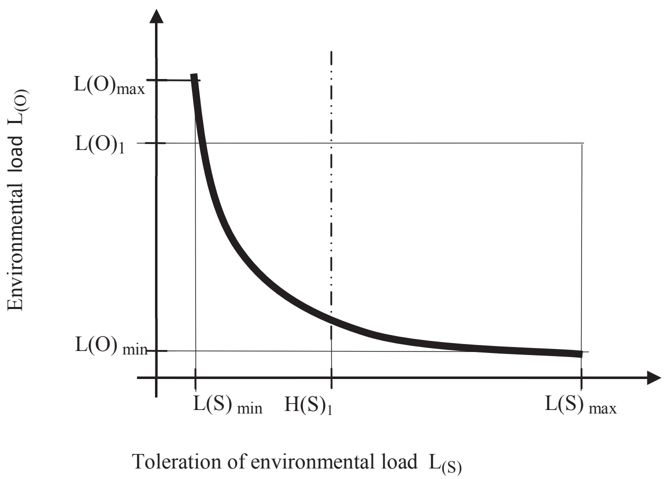

Figure 2: The "Loving" function relation (L)

3. "Being" function (B) - Environmental awareness

We determined the available maximum prosperity as the highest physiological need, which depends on local economy while the environmental value-adding effect is dependent on economy and property, as well. We noted the environmental awareness as the subjective side of personal needs.

We defined two limits of the function: the top limit of the subjective axis is determined by the actual knowledge from environment and the level of exposition regarding the topic; the lower limit of the saturation curve expresses that environmental awareness always has a minimal level, which is higher than zero, and therefore, this level is independent form locality.

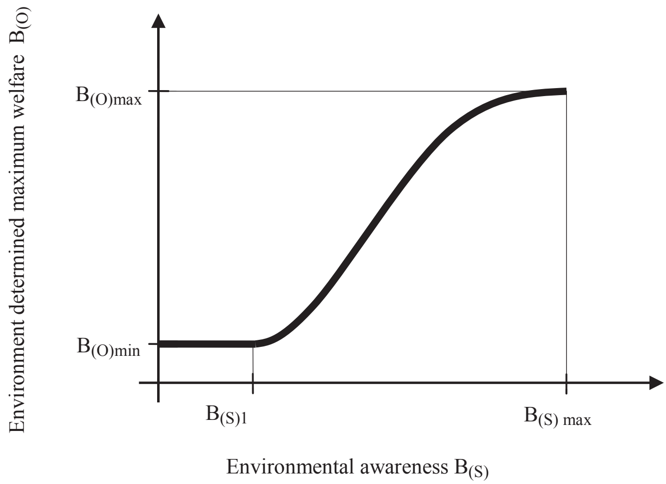

Figure 3: The "Being" function relation (B)

The evaluation of objective and subjective indicators is relatively supported by Maslow's Hierarchy of Needs [8].

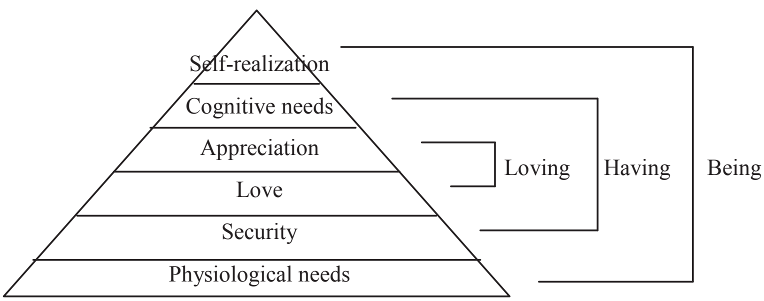

Figure 4: Application of Maslow's Hierarchy of Needs in the KVÉM model

The Hierarchy of Needs assumes that the relativity of the needs to one another is decreasing, what is counterbalanced in our system.

The combined total of the three indicator pairs is what follows:

$$\mathrm{KV\acute{E}M} = \mathrm{H} + \mathrm{L} + \mathrm{B} = \mathrm{H}(\mathrm{h}_{(\mathrm{O})}, \mathrm{h}_{(\mathrm{S})}) + \mathrm{L}(\mathrm{l}_{(\mathrm{O})}, \mathrm{l}_{(\mathrm{S})}) + \mathrm{B}(\mathrm{b}_{(\mathrm{O})}, \mathrm{b}_{(\mathrm{S})}) \quad (1)$$

The objective of our research was to create a quality of life index, which is based on a complex system of environmental evaluation.

The model is a simultaneously identifiable system, where all functional relationships between the variables are assumed. The validity of assumptions is a function of the standard deviations of subjective variables.

4 Conclusion

The noosphere as a lining environment of human beings depends on the people and their personal attachment to the place of residence and has a fundamental influence on the need for environmental development, which reflects back on the urban environment.

A possible way of use of the model is measuring the success of local action programmes. The price-value analysis is well characterized by the previous campaigns, and based on the results, the level of the next investments can be optimized.

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The effect of rootstocks on the development of fruit quality parameters of some sweet cherry (*Prunus avium* L.) cultivars, 'Regina' and 'Kordia', during the ripening process

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Abstract. Combinations of 5 rootstocks ('GiSelA 5', 'GiSelA 6', 'Piku 1', 'PHL-C', and 'Weiroot 158') and 2 scions ('Regina' and 'Kordia') were studied with regards to properties affecting consumer value, fruit appearance, and flavour. Rootstock effect is clearly identifiable in the development of fruit firmness, fruit weight, and sugar and acid content. Based on these properties, 'PHL-C' is recommended for 'Kordia' scion. For 'Regina', there is no obvious "best choice"; other factors must also be considered.

Keywords: scion-rootstock interaction, consumer value, flavour, fruit quality, total soluble solids, titratable acidity

1 Introduction

Owing to its early ripening, eye-appealing outward appearance and internal values, sweet cherry is one of the most popular summer fruits in Europe, as well as, some other parts of the globe. The world's sweet cherry production is about 1.2-1.4 megatons per year, of which Europe's participation is 60-70%. Cherry growers might be interested in knowing how their choice of rootstock influences fruit quality. Our work was meant to help them in their decision.

The performance of a fruit on the market depends primarily on appearance. Fruit size is an important factor in consumer liking and acceptance, as bigger fruits are generally considered to be more attractive to the eye and therefore sell more easily, and usually at a higher price per gram; therefore, varieties yielding larger fruits will be preferred commercially. Similarly to that of size, colour has an essential role in appearance, as consumers - regardless of their age, gender, or ethnicity - prefer darker coloured varieties [1].

The other key attribute is fruit firmness. Growers/exporters/outlets find much easier to handle, store, and transport firm fruits, which also tend to have a longer shelf-life than softer varieties. That does not mean that there is no place for softer varieties, it is just that their market resides locally to the region in which they are grown as they do not travel very well [2].

Whatever the appearance and firmness, a fruit cannot achieve lasting success if the values of the inner content are poor, for the final judgment given by the consumer is based on flavour. Flavour is a combination of taste and smell, influenced by certain chemical compounds like sugars, organic acids, phenolics, and more specialized flavour compounds, including an extensive range of aroma volatiles. The taste of the fruit depends primarily on sugar and acid content, more precisely, on their balanced development. Table 1 demonstrates this balance [2].

Table 1: Acid – sugar balance in sweet cherry fruit

		Sugars	
		High	Low
Acids	Moderate to high	Best flavour combination	Sour, tart
	Low	Sweet	Tasteless

All these attributes are, basically, characteristics of the scion; however, rootstock genotype can also have a great impact on them. By controlling the transport of water and other vital substances, rootstock determines many aspects of tree physiology and fruiting. The Tareen brothers [3] found significant differences between rootstocks with regards to yield, skin colour, and total soluble solids. Gonçalves et al. [4] investigated scion-rootstock interaction by measuring, among others, fruit mass, firmness, total soluble solids, and titratable acids. They demonstrated that any rootstock species found to be the best choice for a particular scion cultivar can also be the worst choice for another cultivar. Spinardi et al. [5] reported that rootstock influences the accumulation of sugars, acids, polyphenols, anthocyanins, and vitamins in cherry fruit.

2 Materials and methods

We studied the effect of 5 distinct sweet cherry rootstocks ('GiSelA 5', 'GiSelA 6', 'Piku 1', 'PHL-C', and 'Weiroot 158') on the fruit quality of 2 scion species ('Regina' and 'Kordia'). The sampling location was in the research centre of BOKU in Jedlersdorf, the testing location was the Laboratory of Horticulture and Viticulture Department, at the University of BOKU, in Vienna.

All measurements were taken with randomly selected fresh sweet cherry fruits. From each of the 10 scion-rootstock combinations, fruit samples were taken at 3 different stages of ripening: at the beginning of fruit coloration (Term 1), at 80% ripeness (Term 2), and at full ripeness (Term 3).

The studied physical parameters were: fruit removal force, fruit diameters (length, width, height), weight of fruit and stone, colour of surfaces, and fruit firmness. The studied chemical parameters were: total soluble solids (TSS), titratable acidity (TA), and electrochemical parameters: pH, rH, redoxpotential, conductivity, electric resistance, P-Value.

Fruit removal force:

By definition, this is the force required to remove the cherry fruit from the stem. It was determined by a Pesola spring scale (max. capacity: 1000 g).

Measurement of fruit diameters:

Fruit diameters were determined by a vernier calliper. 3 types of diameters were measured: height (h), length (l), and width (w). Height is the distance from the stem cavity to the blossom end while length and width are two horizontal diameters in right angle to each other, as shown in Fig. 1. From these 3 diameters was calculated the Fruitformindex (FFI), which shows the fruit shape, with the following formula:

$$FFI = h^2/(l * w)$$

Measurement of fruit and stone weight:

Fruit and stone weights were determined by a precision electronic weight scale (FA-2000S, Sartorius Mechatronics Austria GmbH).

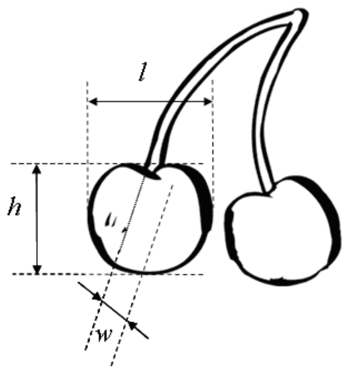

Figure 1: Diameters of a cherry fruit: height, length, and width

Fruit firmness measurement:

Fruit firmness is defined as the force required to rupture the exocarp. It was measured by a Penetrometer Microprocessor force gauge M 1000 E (Mecmesin, Austria) with a 0.5 cm^2 pressure seal. The penetrometer shows the force in g/0.5 cm^2 unit. The point of measurements was the same on each tested fruit: the centre of a randomly selected cheek, around halfway from the blossom end.

Colour measurement:

Fruit colour was determined by direct reading using chroma meter (MINOLTA model: CR-200). The following colour values were obtained: L* (brightness/darkness), a* (redness/greenness), and b* (yellowness/blueness). The measurements were taken with randomly selected fresh fruits at the same fruit parts: the opposite side of the suture, around halfway from the blossom end.

Extraction from and analysis of fresh fruits:

Cherry fruit juice for each cultivar was prepared using a juice extractor (Model: BRAUN-MP80). Each sample was made out of 20 randomly selected cherry fruits of the same tree, and for each scion-rootstock combination there were 8 trees. Juiced samples were filtered using filter paper (grade 3, 20-25 μm, Whatman GmbH, D-37586 Dassel) to obtain pure supernatant for TSS (total soluble solids) and TA (titratable acidity) measurements. TSS content was measured using a digital hand refractometer (Model: PT-32) and expressed in °brix at 20°C [6]. Five cm^3 of supernatant was diluted in 15 cm^3 of distilled water to measure TA using a TitroLine alpha plus automatic titrator (Model: SCHOTT TA20 plus). The sample was titrated to pH 8.1 using 0.1mol/dm^3 NaOH [7]. TA was expressed in cm^3 consumption/dm^3 sample.

Electrochemical properties:

Cherry fruit juice for each cultivar was prepared using juice extractor (model BRAUN-MP80; Braun, Kronberg, Germany). Eight juiced samples from each cultivar were prepared, as described above. Samples were filtered using filter papers (grade 4, 20-25 μm, D-37586 Dassel, Whatman GmbH) to obtain pure supernatant for pH, rH, and R measurement. Then, fruit pH (0-14 scale), rH (mV), and R (Ω) were measured using BE-T-Analyse n. Prof. Vincent (model; MT 732-Fa MED-Tronik, Friesenheim, Germany), as indicated in [8] and [9]. The P-value, an integrating value of these three parameters expressed in micro watts (μW), was calculated using the formula below, considering a specific temperature during the measurement [10], [11]:

$$P = (30 * (rH - 2pH))^2/R$$

3 Results and discussions

Physical attributes:

The fruit removal force, though important from the point of view of storage and transportation, is not dealt with in this publication. Most of the tested cherries were out of specification for the spring scale, i.e. their fruit removal force was above the maximum measurable value. The few values we got were not enough to lead to any conclusion.

The other most important factor affecting storage stability is fruit firmness. Fig. 2 shows the average firmness values for all scion-rootstock combinations in Term 3. Apparently, 'Regina' cherries have generally better firmness than cv. 'Kordia's. Rootstock effect is also evident. 'GiSelA' rootstocks have the most conspicuous behaviour, producing the firmest fruits with 'Regina', but the softest ones with 'Kordia'.

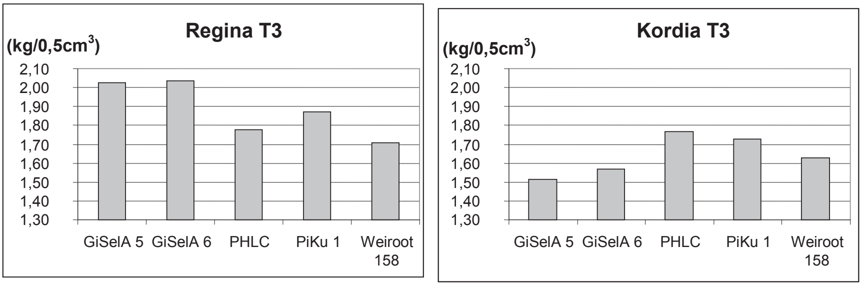

Figure 2: Fruit firmness of ‘Regina’ and ’Kordia’ cherries on different rootstocks in T3

When it comes to marketing, the size of a cherry is a substantial factor. Fig. 3 shows the average diameters for all scion-rootstock combinations in Term 3. Regina’s average size is very stable and reliably constant, regardless of the rootstock. ‘Kordia’, on the other hand, is more susceptible to rootstock effect.

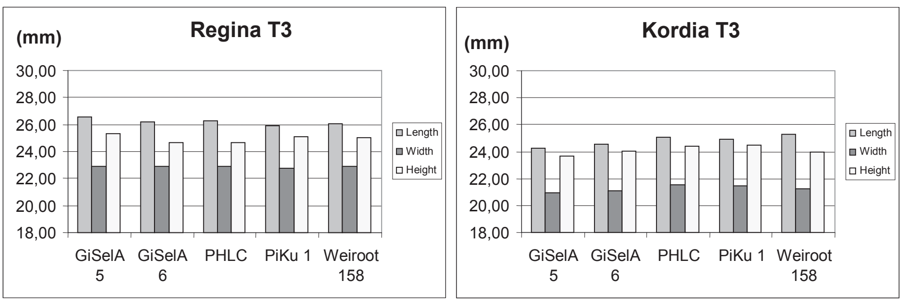

Figure 3: Fruit diameters of ‘Regina’ and ‘Kordia’ cherries on different rootstocks in T3

Simple diameter values are not adequate to describe fruit size. More conspicuous is the development of fruit mass. Fig. 4 shows the average cumulative fruit mass of 8 cherries. ‘Regina’ cherries are obviously much bigger, and a rootstock effect is well apparent. ‘GiSelA 5’ and ‘PHL-C’ display again that the best rootstock for one scion can be the worst one for another scion.

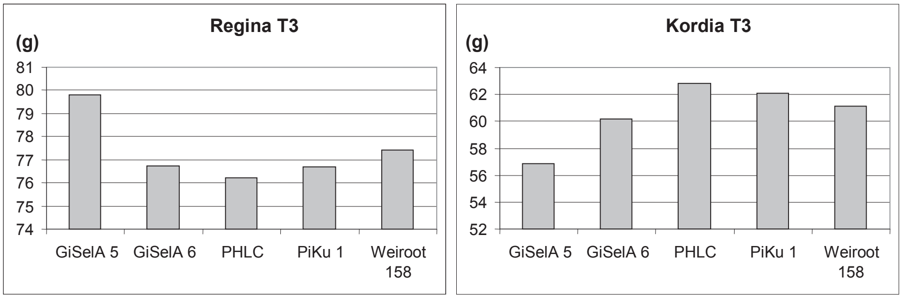

Figure 4: Fruit masses of 'Regina' and 'Kordia' cherries on different rootstocks in T3

Chemical attributes:

One would expect the sugar content of any fruit to increase with time, during the ripening process. 'Regina' cherries met these expectations as their sugar content showed a very strong (cca. 30%) increase. Fruits of 'Kordia', on the other hand, seemed to lose some of their sugar content between Term 2 and Term 3. Sugar contents of 'Regina' fruits were found to be significantly higher than those of 'Kordia', regardless of rootstock (Fig. 5).

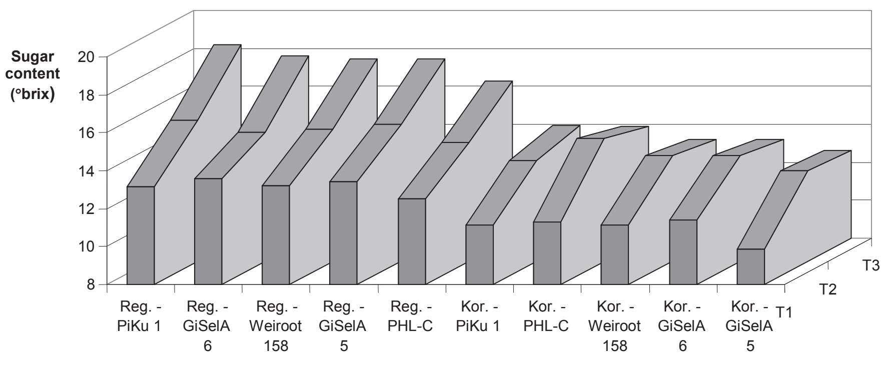

Figure 5: Development of sugar content

Within both scion species, rootstock effect is also well recognizable. Between the lowest and highest sugar content of fruits harvested in Term 3, a difference of 10-12% was observed. The order of rootstocks also showed some variance. Fruits on 'Piku 1' were found to be the sweetest of all, while 'GiSelA 6' and

'Weiroot 158' were reliably of middle sugar level, with both scions. However, 'GiSelA 5' and 'PHL-C' rootstocks behave totally differently when grafted with 'Regina' and 'Kordia'. (Fig. 5)

With regard to total acids (Fig. 6.), again, there was a huge difference between 'Regina' and 'Kordia'. The acid content of 'Regina' fruits showed a monotonous rise with time, and also quite similar results for all rootstocks, except for 'GiSelA 5', which had notably lower acid contents than the rest. On the other hand, cherries taken from 'Kordia' showed a different behaviour. Acid content, in general, decreased substantially during ripening. The variance between rootstocks was about 15%. The decrease was not always monotonous, but it was very rapid in the later stages of ripening.

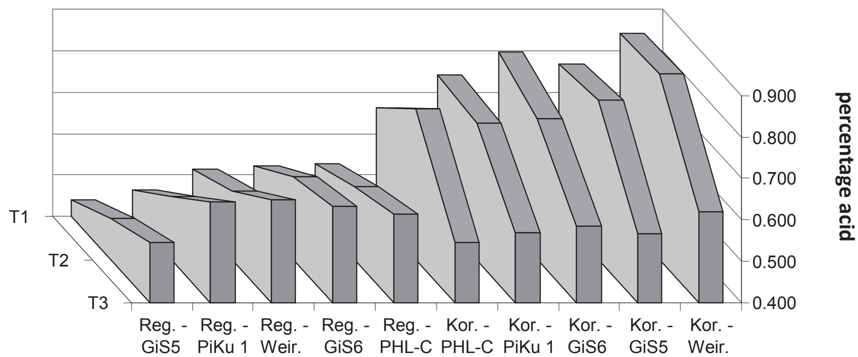

Figure 6: Development of acid content

The conductivity (Fig. 7) of the cherry fruit is important, primarily, for the processability in food industry. For 'Kordia' cherries, a general impression is that conductivity decreases sharply with ripening. However, 'PiKu 1' rootstock is a special case as it shows a sharp conductivity increase between Terms 2 and 3. For 'Regina' cherries, on the other hand, it is quite difficult to find any regularity. Conductivity always decreases during the ripening process, but the actual values as well as the shapes of the diagrams show a wide variety.

Sugar - acid relations: Sugar/acid ratios can be calculated from their parent values. However, this ratio does not characterize fruit flavour adequately. It is equally important, as described in the introduction, that the acquisition of both sugar and acid is balanced. Cherries accumulate sugar and acid from the plant during ripening. If harvested too early, they are unable to accumulate enough quantities to enhance their taste to the levels desired by consumers, and will be, therefore, considered commercially unacceptable.

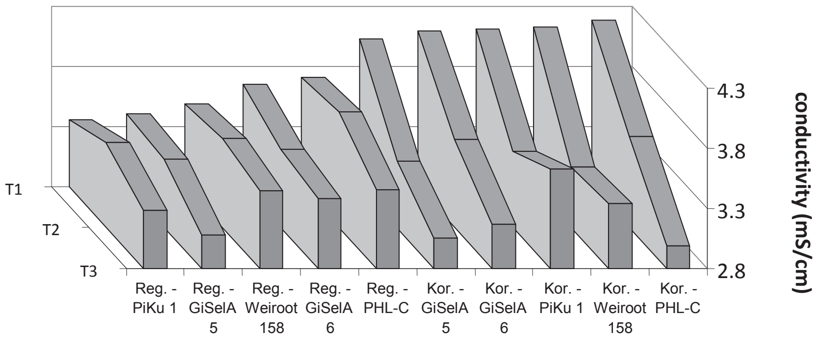

Figure 7: Development of conductivity

Fig.8 shows the sugar-acid distribution of each analysed cherry sample. The black arrow across represents a constant sugar/acid ratio, with the arrow's direction indicating a better fruit flavour. The upper area is relatively rich in acids while the lower one is relatively rich in sugars.

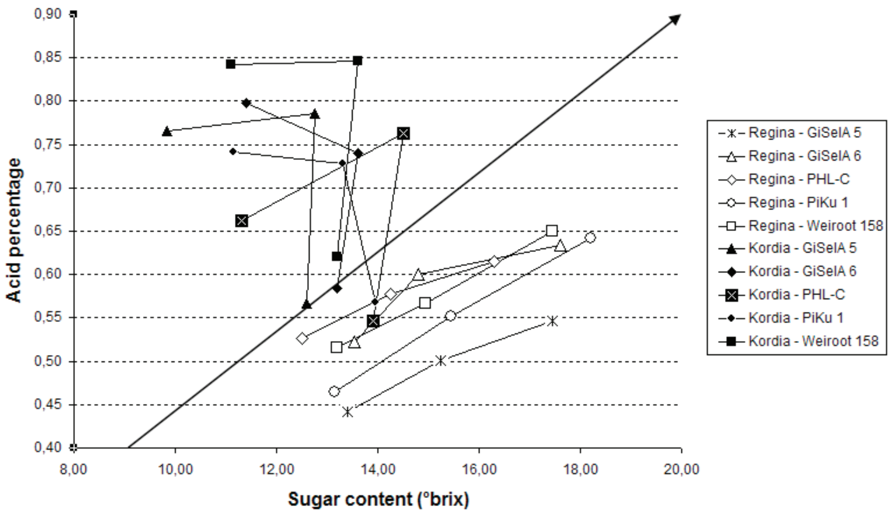

Figure 8: Sugar/acid distribution

'Regina' fruits are located in the lower region, indicated by more or less linear graphs. It is well apparent that the taste quality of 'Regina' cherries monotonously improved during ripening. Best taste quality was observed in-side the big circle, i.e. when ‘Regina’ was grafted on ‘Weiroot 158’, ‘GiSelA 6’, and ‘PiKu 1’.

Graphs of ‘Kordia’ fruits are located in the upper region of the chart. The graphs are broken lines. In all but one case, both sugar and acid content was observed to decrease during the last stage of ripening. It all means that the taste quality of ‘Kordia’ cherries had actually declined. This unexpected result forecasts that direct sensory observation of fruits may not be the most accurate method to determine the stage of ripeness.

In any case, the best flavour quality was associated with the 80% ripe fruit of ‘Kordia’ grafted on ‘PHL-C’, because while all ‘Kordia’ cherries showed relatively high acid content; only this particular combination, indicated by the small circle, had reached a sugar content of 14°brix.

Averages of test results can be found below, in Table 2.

Table 2: Acid – sugar balance in sweet cherry fruit

		Fruit Weight (g, 8 pcs)			Stone Weight (g, 8 pcs)			Fruit Form Index			Fruit Firmness (kg/0.5 cm^2)		
Scion	Rootstock	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Kordia	GiSelA 5	30.270	40.890	56.890	3.275	3.160	2.970	1.305	1.179	1.107	2.67	1.97	1.51
	GiSelA 6	30.720	44.720	60.200	3.080	3.350	3.230	1.309	1.179	1.123	2.83	2.25	1.57
	PHLC	35.195	44.780	62.830	3.675	3.175	2.945	1.200	1.154	1.110	2.75	2.08	1.77
	PiKu 1	31.230	47.500	62.120	3.150	3.445	2.955	1.266	1.175	1.126	2.69	1.83	1.73
	Weiroot 158	31.265	46.520	61.095	3.095	3.520	2.780	1.224	1.119	1.072	2.38	1.97	1.63
Regina	GiSelA 5	61.310	71.340	79.810	3.990	4.820	5.135	1.010	1.027	1.052	3.07	2.43	2.02
	GiSelA 6	60.155	69.545	76.715	4.050	4.950	4.825	1.000	0.997	1.014	2.66	2.35	2.04
	PHLC	67.075	66.970	76.235	4.115	4.730	5.065	1.020	1.033	1.014	2.47	2.17	1.78
	PiKu 1	61.820	67.535	76.690	3.985	4.790	5.135	1.057	1.012	1.075	2.62	2.36	1.87
	Weiroot 158	64.870	70.440	77.415	4.065	4.865	4.955	1.008	1.001	1.049	2.34	2.20	1.71
		TSS (°Brix)			Acid (cm^3)			Percentage acid			Conductivity (mS/cm)		
Scion	Rootstock	T1	T2	T3	T1	T2	T3	T1	T2	T3	T1	T2	T3
Kordia	GiSelA 5	9.85	12.75	12.60	5.72	5.86	4.23	0.766	0.785	0.567	2.67	1.97	1.51
	GiSelA 6	11.40	13.60	13.20	5.95	5.52	4.36	0.798	0.740	0.585	2.83	2.25	1.57
	PHLC	11.30	14.50	13.90	4.94	5.69	4.08	0.662	0.763	0.546	2.75	2.08	1.77
	PiKu 1	11.15	13.30	13.95	5.54	5.43	4.24	0.742	0.728	0.568	2.69	1.83	1.73
	Weiroot 158	11.10	13.60	13.20	6.28	6.32	4.63	0.842	0.847	0.621	2.38	1.97	1.63
Regina	GiSelA 5	13.40	15.25	17.45	3.30	3.74	4.08	0.442	0.501	0.546	3.07	2.43	2.02
	GiSelA 6	13.55	14.80	17.60	3.90	4.48	4.73	0.522	0.600	0.633	2.66	2.35	2.04
	PHLC	12.50	14.25	16.30	3.93	4.31	4.59	0.526	0.577	0.615	2.47	2.17	1.78
	PiKu 1	13.15	15.45	18.20	3.47	4.12	4.79	0.465	0.552	0.642	2.62	2.36	1.87
	Weiroot 158	13.20	14.95	17.45	3.85	4.23	4.85	0.515	0.567	0.650	2.34	2.20	1.71

4 Conclusion

Fruit quality is clearly affected by rootstock species. For ‘Kordia’ scion, based on fruit taste, weight, and firmness, ‘PHL-C’ seems to be the best rootstock choice. With ‘Regina’, the choice is more difficult. ‘Weiroot 158’, 'GiSelA 6', and 'PiKu 1' can equally compete for the title. Even 'GiSelA 5' should not be ruled out because its slightly lower taste quality is compensated by an outstanding fruit size. 'PHL-C' is the least recommended.

It should also be noted that the quality properties of 'Kordia' variants change very rapidly in the later stages of ripening. Thus, growers should consider very carefully timing the harvest of 'Kordia' cherries because the quality of the fruit will change significantly in just a few days. Growers of 'Regina' have more freedom in this regard.

Moreover, the final decision should consider other parameters, which we have not touched upon, such as fruit yields, plant resistance to diseases, etc.

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