Thesis of PhD Dissertation

EVALUATION OF HUNGARIAN BRED POLYANTA AND FLORIBUNDA (BEDDING) ROSES

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The applicant met the requirement of the PhD regulations of the Corvinus University of Budapest and the thesis is accepted for the defence process.

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1. PRELIMINARIES AND OBJECTIVES OF THE DISSERTATION

The garden rose (*Rosa hybrida* hort.) is one of the most intensively used and most diverse flowering ornamental shrubs in the world. One of its subgroups, the so called "bedding rose" is a commercial concept, a product of modern gardening, but its origins can be traced back to 1884, when the variety 'Paquerette' was created. These roses, which can be grown in flower beds, are decorative shrubs and can be in use for up to 20 years, creating a vivid and distinctive patch of colour when in groups and are in flower throughout the whole vegetation period. The number of bedding rose varieties is too large to survey: in the year 2000 the number of registered floribunda varieties was 3908, and that of polyanthas was 762. In the course of planting them out in flower beds large amounts of reproductive material have to be used, which is a relatively costly process, so carrying out an examination of the value that individual rose varieties represent when planted out with the use of scientific methods serves not only aesthetic purposes, but significant economical interests as well.

Outdoor rosegrowing has been significant in Hungary since the XIX. century, as has rosebreeding to a varying extent. Rosegrowing is in an upswing, and the rose stem production in the growing area of Szőreg supplies for export 3 million rose stems again, and the creation of rosegardens is also back in fashion. Recently there have been plans to create rosariums in Kecskemét, Kalocsa, Törökbálint and Budapest.

Among the rosebreeders of the previous century, Gergely Márk is without doubt the most significant, and also the best known one in western Europe. As a result of his roughly 50 years of breeding work, by the year 2009 the number of his varieties and candidates had reached 669, of which the number of bedding roses is 397. Because of his advanced years his present activity consists in the evaluation of species, rather than the creation of new species, in which the Research Institute for Fruitgrowing and Ornamentals also plays a significant role**.**

Considering the fact that more and more Hungarian settlements wish to create rosegardens, and that a growing number of Hungarian species make their way abroad, a scientific evaluation of Hungarian bedding roses has become necessary, so the Research Institute for Fruitgrowing and Ornamentals (Budapest, Hungary) has undertaken the task of presenting a scientific evaluation to the decorative value of the rose varieties created by Gergely Márk. Thanks to the spread of information technology in the last decades, nowadays it is not necessary to judge the aesthetic value of rose varieties on the basis of individual preference. The decorative value of different varieties has become calculable, and new methods are available, like chromatic difference calculation, which is able to give an exact account of the fading and variegation of the flowers, and makes it statistically processible. These methods are especially valuable due to the fact that colour variability and growth

habit diversification of the garden rose make it almost impossible to compare its varieties using traditional methods.

My plan was to work out new and modern methods – exploiting the above mentioned ones – to evaluate the decorativity of bedding roses in an exact way, and according to the expectations of modern gardening, so that with the help of these methods I could assess the aesthetic value of bedding roses bred by Gergely Márk, which are suitable for bedding out in parks.

The objectives of my work

- Working out a method of calculation to enable us to characterise the flowering intensity of the rose using the relative proportion of the flower covered foliage surface.

- Working out indices to describe the yearly flowering dynamics (the yearly change of flowering intensity) of individual varieties.

- Statistical evaluation of the flowering dynamics of the most important Hungarian bred bedding rose varieties, pointing out the special characteristics of individual variety groups, flowercolour and growth habit combinations.

- Evaluating the speed of deflorescence in different varieties.

- Evaluation of the colour and the fading of the rose flower in relation to individual varieties in an exact way.

- Working out a new complex method, with the help of which it is possible to define the decorativity of the rose flower based on measurements, according to the speed of opening, the size and the colour-change of the flower.

- Numerical evaluation of the most important Hungarian bred bedding rose varieties on the basis of the decorativity of their flowers, pointing out the special characteristics of individual variety groups, flower colour and growth habit combinations.

- Making suggestions for garden design, garden building and rose breeding in relation to the use of varieties based on exact numerical results of flower intensity and flower decorativity examinations.

2. MATERIALS AND METHODS

The examined rose varieties: I examined 28 bedding rose varieties altogether, which were classified by their breeder as either polyanthas (9 varieties) or floribundas (19 varieties). 23 varieties of these were Hungarian bred, all of which were created by Gergely Márk. The most important factors in the selection of the varieties were to be able to find them in at least two of the locations examined, and for them to be measurable against one another, regarding growth habit and flower colour. For controls I chose such varieties from abroad, which have been marketed for twenty years minimum, and correspond in their flowering characteristics and growth habit with the group they are used to control. The varieties are listed in Table 1.

Table 1 Hungarian bred and foreign varieties used as controls in the examinations of flowering dynamics and flower decorativity

Name of variety (breeder, year of registration)
White floribundas **'Bem apó emléke'** (Márk, 2000); **'Szent Margit'** (Márk, 1997) **'Iceberg'** (Kordes, 1958)
Yellow floribundas **'Aranyhíd'** (Márk, 1992); **'Domokos János emléke'** (Márk, 1997) **'Sunsprite'** (Kordes, 1977)
Multi-coloured polyanthas **'Dsida Jenő emléke'** (Márk, 1966); **'Huba'** (Márk, 1996); **'Verecke'** (Márk, -) **'The Fairy'** (Bentall, 1932)
Pink bedding roses **'Bethlen Gábor emléke'** (Márk, 1997); **'Déryné'** (Márk, -); **'Leila'** (Márk, -); **'Max Holder'** (Márk, 2000); **'Millecentenárium'96'** (Márk, 1996); **'Szendrey Júlia emléke'** (Márk, -) **'The Fairy'** (Bentall, 1932)
Short red bedding roses **'Borsod'** (Márk, -); **'Déva'** (Márk, -); **'Domokos Pál Péter emléke'** (Márk, 1998); **'Gül Baba'** (Márk, 2000); **'Lágymányos'** (Márk, 2000); **'Petőfi Sándor emléke'** (Márk, 2006); **'Táncsics Mihály emléke'** (Márk, -) **'Nouvelle Europe'** (Gaujard, 1964)
Tall red bedding roses **'Báthory István emléke'** (Márk, 2004); **'Munkács'** (Márk, 2006); **'Szabó Dezső emléke'** (Márk, 1998) **'La Sevillana'** (Meilland, 1978)

I used some other varieties as well for two complementary examinations, which might provide some information for the evaluation of other types of roses as well, so as to get results from a larger assortment of varieties. To calculate the percentage of the flower-covered foliage I evaluated 33 miniatures, polyanthas, floribundas, grandifloras, hybrid teas, climbing roses, modern climbing roses, and shrub roses in Budatétény, whereas to calculate the visible surface of flowers I measured the flowers of altogether 18 bedding roses that were planted out in large numbers in Budatétény and on Margitsziget.

The locations and dates of the outdoor experiments:

The examinations were carried out between **2002** and **2009** on three locations, which were the following:

- **Budatétény Rose garden** (Research Institute for Fruitgrowing and Ornamentals, Budapest)
- **Margitsziget Rose garden** (FŐKERT Public Company, Budapest)
- **Törökbálint show garden** (Gergely Márk's private garden; Törökbálint)

There are significant differences between the three locations in both climate and soil, and these typify well the variable ecological conditions of the capital and its surroundings (Table 2).

Table 2 The ecological parameters of the three locations examined

Ecological parameters	Budatétény	Margitsziget	Törökbálint
Height above sea level (m)	100-120	105	130-140
Climate USDA zones	7b	8b (mild)	7b
Watering level	none	regular	none
Geographical location, mezo-climate	southern slope	danubial island of river bar origin	almost flat high groundwater level
Plantation medium	slope offal and alluvial soil	soil of Délegyháza + acidy peaty soil + compost	alluvial meadow soil with clay
Soil pH	moderately alka-line	neutral	neutral
Lime content of soil	very high	not evaluated	moderate
Ground hardness	loam soil	not measurable because of high organic content	clay loam
Humus content of soil	medium	not registered	high

Flowering dynamics data collection survey:

Data have been taken in the years 2002 and 2005-2008 in all of the three locations. Measurements have been started with the opening of the first flower, and have been carried out till the first frosts. Measurements have been taken in Budatétény every two days in the summer, and every three days in the autumn, on Margitsziget and Törökbálint every week or every second week. Ranking assessment has been carried out every year on the basis of identical and previously fixed categories of flowering intensity. I worked with 17 categories altogether.

The method of calculating the flower-covered foliage (flower coverage): I made calculations to convert flowering intensity ranking-categories into a natural parameter expressing the biological

production of the variety, and the most suitable one for this purpose is the portion of the foliage covered with flowers, which is a value in percent.

I examined 33 varieties in 2008 between the 29th of May and 12th of June, on 9th and 16th of June, on the 8th and 24th of July and on the 6th of August. I counted the number of flowers in a unit of foliage with every variety, classifying the flowers into 4 categories according to how big a portion of their surface is projected onto the examined surface. I measured the diameter of ten completely open flowers with every variety, and on this basis I counted the surface of an average flower with the help of the $\mathbf{A=r^2\pi}$ circle disk model. This result was multiplied by the counted number of flowers, and by the flower's apparent size category value. This way I was given a flower-surface value for a surface unit, the proportion of which related to the complete foliage gives the value of the flower covered foliage, on the basis of the following formula: $\mathbf{flower\ coverage=A_{flower}/A_{foliage}}$, where $\mathbf{A_{flower}= \Sigma A_a+ \Sigma A_b+ \Sigma A_c+ \Sigma A_d}$. Here $\mathbf{A_{a,\ b,\ c,\ d}= r^2\pi K_{a,\ b,\ c,\ d}}$, where **K** stands for the multiplier of the apparent flower size category ($\mathbf{K_a=0,25;\ K_b=0,5;\ K_c=0,75}$ and $\mathbf{K_d=1}$). The third step was to look for a relationship between the ranked values and the calculated flower coverage using regression analysis.

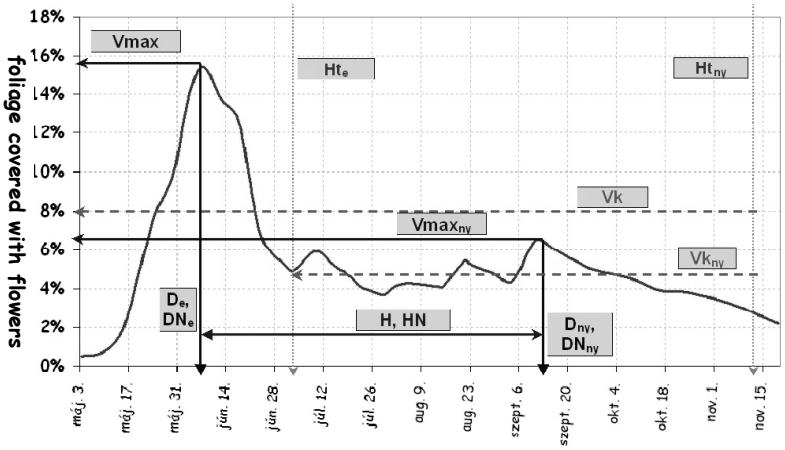

Figure 1 Visual representation of flowering dynamics indices based on the example of the average flowering course of all the varieties in the Budatétény rose garden in 2002

Flowering dynamics indices:

I took altogether 198 yearly data series concerning 28 varieties, based on 6114 pieces of data. I converted every piece of data into flower coverage numbers on the basis of the formula $Y=0.004*2^X$. Every series of yearly data gives a curve covering almost the whole of the vegetation

period, which demonstrates changes in flower intensity in the course of time. I calculated the following indices (see visually as well on Figure 1) to characterise the yearly pattern of flowering dynamics:

Ht_e: The last day of the downward flow of the first flowering wave in the relevant year, measured in days from the 1st of January. It marks out the day for the beginning of the repeat blooming period.

Ht_{ny}: The boundary day of the downward flow of the last flowering wave in late autumn in the given year, measured in days from the 1st of January. It marks out the end of the repeat blooming period.

Vk: The mean value of the flower coverage of the whole vegetation period. It characterises well the average flower production ability of varieties.

Vk_{ny}: The mean value of the flower coverage of the repeat blooming period. It characterises well the repeating abilities of the varieties.

Vmax: Maximal flower coverage in the vegetation period. It characterises well the maximum of the theoretical flower producing ability of the varieties.

$Vmax_{ny}$: Maximal flower coverage in the repeat blooming period. It characterises well the maximum of the theoretical repeating ability of the varieties.

D_e: Earliest incidence of maximal flower coverage during the main flowering period expressed in days from the 1st of January. It shows the earliness of the main flowering period.

D_{ny}: The latest occurrence of maximal flower coverage in the repeat blooming period. It shows the earliness of the repeating.

DN_e: The normalized value of D_e. It is necessary for the exclusion of the effect of the year of growth. After transformation the mean value is always 0, variance is 1.

DN_{ny}: The normalized value of D_{ny}. It is necessary for the exclusion of the effect of the year of growth. After transformation the mean value is always 0, variance is 1.

H: The period between the first and the last flowering wave measured in days. $H=D_{ny}-D_e$. It expresses the length of the flowering period of the varieties.

HN: The normalized value of H. It is necessary for the exclusion of the effect of the year of growth. After transformation the mean value is always 0, variance is 1.

Ornamental value score of flower, as a new method

In the years 2004-2008 I worked out an original, completely new method in the Budatétény rose garden, especially for the purpose of an exact measurement of the flowering value of the stock of varieties of the rosarium. I express the estimated aesthetic value with ornamental value scores. The governing thought of the method is the following: a variety's flower decorativity can be called ideal

if the flowers are open for a long time, the petals keep their colours for a long time, and the petals die and fall off fast. Figure 2 shows an outlined course of the method. For this I created the following indices:

ΔE_{00f}: the chromatic difference of a petal colour from the petal colour of the flower in the 6th phenological phase considered to be optimal, measured according to the $CIEDE_{2000}$ standard. Its dimension: **ΔE_{00}**.

D_{sz}: ornamental value score of a colour. Calculation: **$D_{sz}= 15- \Delta E_{00f}$.**

D_f: ornamental value score of a phenological phase of reproduction. Calculation: **$D_f= D_{sz}A_l\%$**, where **$A_l\%$** is the visible relative surface of the flower in the given phenophase in the percentage of the flower in the 6th phase.

$D_{ö}$: cumulated ornamental value score of flower: the total decorativity of a flowering period. Calculation: **$D_{ö}= \Sigma(D_f l_f)= \Sigma(A_l\%(15-\Delta E_{00f})l_f)$,** where **$l_f$** stands for the length of the flowering periods expressed in days.

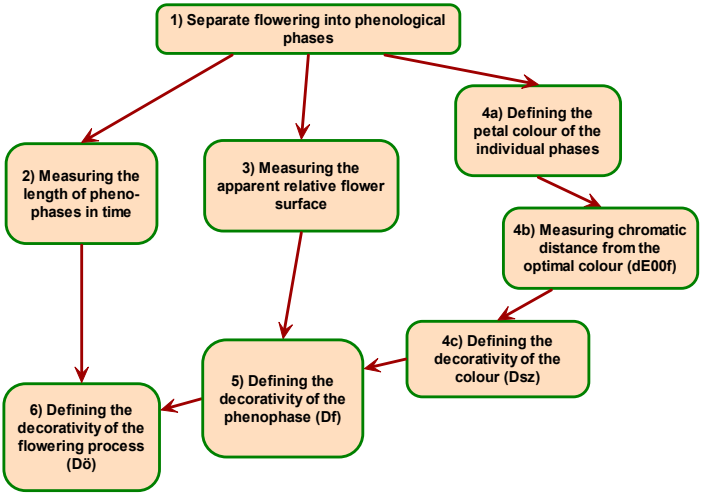

Figure 2 Flowchart for the calculation of the cumulated ornamental value score of flower

Phenological phases of reproduction: I divided the reproductional period (flowering and fruit development) from the state of the palpable bud to the fall of the last petal, or in some cases to that of the hip initiation into 23 stages.

Deflorescence speed of a flower: The examinations were carried out in the Budatétény rose garden between the 2nd of June and the 28th of July in 2005, and between the 7th of May and the 4th of June in 2007 in the first flowering wave of the given year. In 2005 I marked 10 buds per variety, and in 2007 I marked 15 buds per variety. Every 1 to 3 days I kept a record of the phenological stage of the individual flowers, and in this way I was given a varying number of data per flower for evaluation, about 30 pieces of data per year – altogether 8 400 and 13 440 pieces of data respectively, which enabled me to calculate the first day of an individual flower's opening phase, and the average length of the phase afterwards.

Evaluation based on the colour of the petal: Measuring the colour of the petal was carried out in all of the three locations between 2003 and 2008 *in situ*. I registered the colours of the following phenological stages: 2; 4; 6; 6.5; 7; 7.5; 8; 8.5 reproductional phase. For the purpose of data collection I used typographically produced standardized colour cards, the PANTONE Color Formula Guide 2002-2003 Printer Edition „Coated Paper" series and the 3rd edition of the Royal Horticulture Society Colour Chart. I defined the colours of the colour cards, and on the basis of this, the colours of the rose flowers in the phenological phases in the perceptually uniform CIE LCh D65 10° colour system. The colours of the un-measured phases were calculated on the basis of the neighbouring phases.

Calculation of the visible petal-surface of a flower: To measure the visible surface of the flowers I measured the spatial size of 520 flowers of 18 rose varieties on the 7th, the 12th, and 13th of June and on the 5th of July, and on the 2nd of August. I measured the diameter and the height of the flower, determined its shape, and with the buds I calculated the percentage of the surface covered by the sepal. I calculated the flower's surface on the basis of either the superficies of a cylinder ($\mathbf{A_l= r^2\pi+2rm\pi}$) or a cone ($\mathbf{A_l= r\pi(m^2+r^2)^{1/2}}$) model, omitting the base disc. I calculated the relative value of the flower's surface in the individual phenological phase with every variety, in the percentage of the value measured in the 6th phase of the variety.

Ornamental value score of flower: With the evaluation of the flower colour I used the chromatic difference according to the $CIEDE_{2000}$ standard as my base, for the calculation of which I prepared my own program. Ornamental value score of flower was created as the product of the chromatic difference measured between the petal colour of the consecutive reproductional phases and the 6th phase – in the dimension of $CIEDE_{2000}$ ΔE_{00} -, its visible relative petal surface and its length in days, which I calculated on the basis of the formula $\mathbf{D_ö= \Sigma(A_l\%(15-\Delta E_{00f})l_f)}$, and cumulated for the 2-9; 2-7.5; and the 5.5-7 reproductional phenological stage ranges.

3. RESULTS

Flowering dynamics:

Calculation of flower-covered foliage: I carried out 171 calculations to estimate the flower-covered foliage of 33 varieties, flower diameters were measured in 891 cases. I tried to find the relationship between the ranked flower intensity data and flower coverage expressed in percent with the help of a regressive examination. The correlation is best described both mathematically and professionally by using an exponential function. The generalised formula of the function is $Y= ab^x$, where a=0.0041955, b=1.9768. I also examined a regressional function with the rounded up parameters a=0.004, and b=2. As the relative difference between the Y values of the two models remained under 5%, I chose the simpler model to estimate the biological production of flowering. Henceforward, I converted every piece of data taken by way of ranking, and for further evaluation I used this estimated flower coverage.

Flowering dynamics indices: The evaluation of 198 flowering curves enabled us to estimate the flowering-dynamic characteristics of the rose varieties, and also the circumstances that influence them. On the basis of the variance checks and ANOVA analyses of variance, the quantitative values of flowering were in most cases significantly influenced by the location and the actual year but the earliness-lateness factor was only influenced by the actual year. This latter one, as one of the variety-characteristics is difficult to evaluate, the difference between varieties being - even after the normalization of data - usually only around the 5% significance level. As opposed to this the other parameters of flowering dynamics without doubt are able to characterise varieties well, which can be demonstrated statistically: the difference between varieties was always significant.

I was able to classify the varieties according to the indices in the following dynamic groups:

- VARIETIES WITH A BALANCED PATTERN OF FLOWERING DURING THE YEAR**:**
  - Weak flowering maximums: **'Déva', 'Munkács', La Sevillana'**.
  - Varieties with average flowering course: **'Aranyhíd', 'Báthory István emléke', 'Dsida Jenő emléke', 'Iceberg', 'Petőfi Sándor emléke', 'Max Holder', 'Millecentenárium'96', 'Sunsprite', 'Szabó Dezső emléke'.**
- VARIETIES THAT REPEAT WELL
  - Repeating is of more value than main flowering: **'Bethlen Gábor emléke', 'Szendrey Júlia emléke', 'Szent Margit', 'Táncsics Mihály emléke', 'The Fairy'.**
  - Varieties with a high summer flowering peak: **'Bem apó emléke', 'Gül Baba', 'Lágymányos', 'Leila'.**

- VARIETIES THAT ARE MORE VALUABLE IN EARLY SUMMER
  - Balanced early summer flowering: **'Huba'**
  - Outstanding early flowering wave: **'Borsod', 'Déryné', 'Domokos János emléke', 'Domokos Pál Péter emléke', Nouvelle Europe', Verecke.**

Taking the yearly mass of flower into consideration as well, the following can be stated about the examined varieties:

The Hungarian bred white floribunda varieties were not able to surpass the controls, but **'Szent Margit'** was a close approach, only falling behind with the summit value of flowering, and was later flowering. The yellow floribunda varieties differ from every other rose in their weak flowering dynamics values, but **'Domokos János emléke'** overtook its control with a larger flower mass. Among multicoloured polyanthas the **'Verecke'** proved to be the most valuable one, and although its flowering summit was stronger, and the length of flowering time was better than those of the control, on the whole it did not surpass its control. The heterogeneity of the pink varieties is striking, the most valuable one of which is **'Max Holder'** owing to its balanced flowering dynamics and long flowering time. Several of the red Hungarian varieties can be classified as excellent though. Amongst the shorter bedding roses **'Déva'** has significantly surpassed its control regarding its yearly average flower mass, strength of repeating, and the length of its flowering time as well. Amongst the taller varieties '**Munkács**' proved to be more valuable than its control, as it had a high flower-yield in the summer as well, and **'Báthory István emléke'** was also stronger in its flowering peak values.

Flower decorativity:

Length of flowering phenophases: There were significant differences in the length of flowering time with the individual varieties. The average length of the reproductional process from bud to complete deflorescence spread from 13.6 to 38.8 days**.** The earliest ones to lose their flowers were **'Bem apó emléke', 'Bethlen Gábor emléke'** and **'Sunsprite'**, which are yellow and semi-double varieties, whereas **'Domokos Pál Péter emléke'** and **'Szabó Dezső emléke'** had the longest flowering periods**.**

The most decorative period in the life of rose flowers is the period between the phenological stages 5.5 and 6.5. The examination of this period demonstrated a significant difference between the individual varieties, and the most long-lasting ones were the compact and double flower varieties **('Petőfi Sándor emléke', 'Borsod', 'The Fairy', 'Max Holder'),** and the varieties that passed their decorative period the fastest were the yellow and semi-double ones (**'Bem apó emléke', 'Sunsprite', 'Domokos János emléke', 'Aranyhíd' 'Bethlen Gábor emléke'**).

Visible average relative surface of the flower: Table 3 shows the changing of the average relative flower surface during the life of the flower on the basis of measuring 520 flowers. The values were calculated between the 2nd and the 7th phases of flowering, as before the 2nd stage the petal can not be seen, whilst over the 7th the visible flower surface does not change any more practically. The period of petal falling, when change of flower surface is very difficult to measure, I took as half of the maximum value, which is 64%.

Table 3 Changing of visible flower surface expressed in the percentage of the 6th repoductional phase on the basis of measuring 520 flowers.

Repoductional phase	2	2.5	3	3.5	4	4.5	5	5.5	6	6.5	7
Average surface (%)	0.7	1.7	4.3	9.4	14	32	77	79	100	119	127

Ornamental value score of flower: I found three ranges for which it was worth to sum the ornamental value score ($D_ö$). With extensive maintenance the full flowering period (stages 2-9) is informative, with intensive maintenance, including the removal of the dying flower, it is worth to examine a narrower range (stages 2-7.5), and examined as cut flower the suitable range is between stages 5.5 and 7. Both in the course of the full flowering period, and until the start of flower shedding the decorativity value of the Hungarian red varieties is very high: they are very decorative under both extensive and intensive maintenance. The exceptions are only the varieties **'Szabó Dezső emléke'** and **'Domokos Pál Péter emléke'**, the dying flowers of which have to be removed. As to the whole of the flowering period **'Petőfi Sándor emléke'**, **'Munkács'**, **'Borsod'**, and – examined only to the start of shedding their flowers **'Domokos Pál Péter emléke'** also. The ornamental value score of Hungarian pink varieties is lower, the most decorative among them being **'Memory of Julia Szendrey'** and **'Bethlen Gábor emléke'**. With the exception of the latter they can only be recommended for such beddings, where the removal of the withered parts can be assured, this is what the low or negative ornamental value score of the whole of the flowering period refers to. Among the white varieties **'Szent Margit'** stands out by far. The yellow varieties have low aesthetic values in general. Their three cumulative ornamental value scores are near identical, which means their self-cleaning is excellent, so they are homogeneously suitable even under extensive maintenance. With multicoloured varieties the ability to provide a uniform colour patch is not a requirement, so ornamental value score of flower is not expressive.

The highest point values were given to **'Szent Margit'** with $D_ö$= 197 points, with its aesthetic value cumulated onto the whole of the flowering period. The smallest values were given to the light colour shades of '**Verecke'** in the same range. This value was $D_ö$= -72, but in the case of this variety this refers to high colour variety.

4. CONCLUSIONS AND SUGGESTIONS

With the help of the methods I worked out I managed to define and calculate the flowering intensity and the flower decorativity of the rose in a complex way. The acquired values are well-defined, and can be interpreted well. With the help of flowering dynamics indices we can estimate the complex yearly flowering course and flower mass of individual varieties and ornamental value scores of flower demonstrate well the aesthetic values of the flowers of the individual varieties. This latter method also shows the maintenance needs of individual varieties for practical horticulture. On the basis of the above we can say, that a methodology has been worked out to give a well defined evaluation for the decorativity of rose varieties, and this methodology, with certain adaptations, might be suitable for the calculation of the aesthetic values of other flowering shrubs as well.

Table 4 The aesthetic value of the examined rose varieties on the basis of the normalized values of their flowering intensity and flower decorativity

Variety	Flowering intensity	Flower decorativity	Flowering intens. normal.	Flower decorativity normal.	Average of normalized values
Aranyhíd	-2.27	34.29	-2.92	-0.97	**-1.95**
Báthory István e.	0.83	106.36	1.10	0.56	**0.83**
Bem apó e.	-0.18	71.04	-0.21	-0.19	**-0.20**
Bethlen Gábor e.	-0.53	43.49	-0.66	-0.78	**-0.72**
Borsod	-0.24	135.20	-0.28	1.18	**0.45**
Déryné	-0.04	41.91	-0.02	-0.81	**-0.42**
Déva	0.99	119.75	1.30	0.85	**1.08**
Domokos János e.	-0.89	23.27	-1.13	-1.21	**-1.17**
Domokos Pál P. e.	0.65	87.47	0.86	0.16	**0.51**
Dsida Jenő e.	-0.52	52.04	-0.65	-0.60	**-0.63**
Gül Baba	0.09	105.73	0.14	0.55	**0.35**
Huba	0.09	41.13	0.14	-0.83	**-0.35**
Iceberg	1.08	123.43	1.42	0.93	**1.18**
La Sevillana	0.75	139.80	1.00	1.28	**1.14**
Lágymányos	-0.99	82.05	-1.25	0.04	**-0.61**
Max Holder	0.38	8.82	0.52	-1.52	**-0.50**
Millecenten.'96	-0.10	31.77	-0.11	-1.03	**-0.57**
Munkács	0.67	135.30	0.89	1.18	**1.04**
Nouvelle Europe	0.19	101.78	0.27	0.46	**0.37**
Petőfi Sándor e.	-0.19	147.46	-0.22	1.44	**0.61**
Sunsprite	-1.24	29.78	-1.58	-1.07	**-1.33**
Szabó Dezső e.	0.42	101.02	0.57	0.45	**0.51**
Szendrey Júlia e.	-0.75	62.21	-0.94	-0.38	**-0.66**
Szent Margit	0,50	174,20	0,68	2,01	**1,35**
The Fairy	0,51	73,55	0,69	-0,14	**0,28**
Verecke	0,29	6,99	0,40	-1,56	**-0,58**

The decorativity of the bedding rose varieties I examined proved to be significantly different. Table 4 shows the complex aesthetic value of their flowering, which I formed with the help of the mean value of flowering dynamics indices after normalization and the mean value of the cumulated ornamental value scores on the basis of the average given after the normalization of the two values.

Among the Hungarian bred varieties I examined the ones that are most suitable for bedding out in parks are the red bedding roses. According to the evaluations the polyantha **'Déva'** is the most valuable one among them, but the robust red floribundas are very similar to them in their flowering values, among which the most valuable one was '**Munkács'**. So we can say that in the creation of large quantity beddings it is advisable for garden designers to choose red bedding roses first of all. This is the group that carries the biggest amount of good characteristics: - long-lasting and abundant flowering, moderate fading of petals – so they are ideal as raw material for breeding as well. Attention has to be paid to the fact that with some varieties in this category the faded petals do not fall off easily, e.g. **'Domokos Pál Péter emléke'**.

Among the white floribundas **'Szent Margit'** was definitely the most abundantly flowering and most decorative one, and this is the variety I found most valuable of all the Hungarian bred roses I examined. Thanks to its good everblooming abilities of the variety it is ideal for bedding out in parks, and combines well with the taller red bedding roses.

Yellow floribundas together with their controls fall behind the other examined varieties in almost every feature. The flowering abilities of the yellow varieties even today, 110 years after *Rosa foetida* Herm. was involved in breeding, are still markedly weaker, than those of the other varieties. It can be considered as a success for Hungarian rosebreeding, that **'Domokos János emléke'** is more decorative than its control, probably as a result of its hybrid origin. According to my data garden designers have to live with and comply with their smaller flower mass and weaker colour patch-creating ability.

Among the pink Hungarian varieties, taking all the parameters into consideration '**Déryné'** can be considered the most valuable one. A common characteristic of these varieties is their very significant heterogeneity. They differ from each other in their growth habit, in their flowering characteristics and petal colours, and this needs attention from the part of breeders and garden designers as well. As most pink varieties have some good characteristics, they can not be omitted from park beddings, but a completely balanced variety as to colour and flowering dynamics is still awaiting to be created.

In the case of multi-coloured polyantha roses lesser flower decorativity is paired with a bigger variation in colour, and in this case this is a factor increasing the aesthetic value. On this basis **'Verecke'** is the most decorative, considering its abundance in flowers as well.

On the basis of my data it can be stated, that Gergely Márk's rose varieties are proved to be exceptionally suitable for bedding out in public parks or private gardens, and are decorative and can be associated well with each other under variable climatic or soil effects.

5. NEW SCIENTIFIC ACHIEVEMENTS

1. I worked out a conversion method between the ranking categories of the rose's flowering intensity and its flower-covered foliage. I found a definite and non-linear correlation. The exact numerical result of the conversion is $\mathbf{Y= 0{,}0041955*1{,}9768^X}$, that is rounded up to $\mathbf{Y= 0{,}004*2^X}$.

2. I created 12 indices, with the help of which the yearly flowering dynamics of rose varieties can be described statistically. Among these indices I found, that in the case of the indices describing the daily mean values of the proportion of the flower covered foliage ($\mathbf{Vk, VK_{ny}}$), their maximal values ($\mathbf{Vmax, Vmax_{ny}}$), and its dates transformed by normalization ($\mathbf{DN_e}$, $\mathbf{D_{ny}}$,) I found significant differences between the varieties.

3. I evaluated the yearly course of the flowering intensity of 23 Hungarian bred bedding rose varieties in a complex way, with the help of which I was able to differentiate **6 distinct types in flowering dynamics**, and I demonstrated that the flowering dynamics of rose varieties correlates with their colour and their growth habit as well.

4. I was the first one to employ the $\mathbf{CIEDE_{2000}}$ **chromatic difference standard** to evaluate the fading of flowers, with the help of which of an aesthetic parameter – only possible to assess subjectively before –can be measured in an exact way.

5. I worked out a completely novel complex method for the exact numerical evaluation of the aesthetic value of the rose flower. I created an index under the name of **cumulated ornamental value score of flower** based on the chromatic value of the fading of the flower, the visible flower surface, and the speed of withering, the calculation formula of which is: $\mathbf{D_ö= \Sigma(A_l\%(15-\Delta E_{00f})l_f)}$.

6. With the help of the cumulated ornamental value scores I was able to give a **numerical proof** to the differing aesthetic values of Hungarian rose varieties, the weaker flowering abilities of the yellow varieties, and that different varieties have different demands as to deadheading.

7. 7. I was able to define numerically the aesthetic value of the flowering of rose varieties on the basis of an exact evaluation of flowering intensity and flower decorativity, and in this way I found, that the best Hungarian bedding rose varieties are the following: 1) '**Szent Margit**', 2) '**Déva**', 3) '**Munkács**', 4) '**Báthory István emléke**', 5) '**Petőfi Sándor emléke**'.

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