



[DOI: 10.22620/agrisci.2021.30.005](https://doi.org/10.22620/agrisci.2021.30.005)

## THE MORPHOLOGICAL AND BIOLOGICAL CHARACTERISTICS OF THE SPECIMENS FROM *MONARDA DIDYMA*

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### Abstract

The plants of the genus *Monarda* of the family *Lamiaceae* are little known in our country. The species *Monarda didyma* is mainly distributed. It is used in landscaping as a perennial ornamental crop. In addition to its original blossoms, it has a pleasant aroma combining the aromas of bergamot, lemon and mint, due to the essential oils contained in the leaves, blossoms and stems of the plant.

The Institute of Ornamental and Medicinal Plants - Sofia has a perennial species collection in which the genus *Monarda* is represented by 32 genotypes of the *Monarda didyma* species. The plants are characterized by different habit, color and shape of the blossoms. During the phenological observations it was established that in the Sofia field region the *Monarda* vegetation begins in the beginning of March and ends in the beginning of October. The flowering period in almost all samples covers the months of June to August, with mass flowering in the beginning of July. Biometric measurements show differences in the size of the tufts formed, the size of the leaves and the flowers.

After analyzes, genotypes with emphasized decorative qualities were separated, which will be used to diversify the range of seedlings in the *Monarda didyma* type offered on the market.

**Key words:** *Monarda didyma*, habit, blossoms, phenological observations, flowering period

### INTRODUCTION

The production of ornamental plants is expanding every year. Currently the world market for these crops is estimated at about 107 billion dollars a year. Such an assessment emphasizes the importance of the sector for the economy of countries, as well as its important social role related to income and employment (Aguirre, 2007, Botelho et al., 2015, Silva, et al. 2018).

In recent years, the need to diversify the range of ornamental species for the garden is constantly growing and this requires looking for crops with original shape and color, pleasant aroma and resistance to abiotic and biotic environmental conditions.

Ornamental gardening is the sector of modern agriculture responsible for the commercialization of hundreds of species from

many botanical families, including exotic or native landscape and houseplants (Heywood, 2001, Anderson, 2007). The success of new flower products on the market can be increased if the desired qualities are determined by specific criteria such as: the morphological characteristics of the plant in terms of its novelty or aesthetic value.

The decorative value of the plant is no longer the only criteria needed to make it commercially successful. There is a renewed interest in the old ornamental crops that possess drought tolerance and disease resistance, continuous flowering or healing properties (Wilkins and Anderson, 2007; Stumpf, et al. 2012, Tognon and Cuquel, 2016).

The *Monarda* genus is named after the Spanish physician and botanist Nicolaus Minardes (1493-1578), who originally studied it. Species of this genus naturally inhabit North



America from Canada to Mexico. They have been imported and cultivated in Europe since the 18th century. The species *M. citriodora*, *M. didyma*, *Monarda fruticulosa* and *M. fistulosa* are known in agriculture (Davidson, 2007). Most hybrids on the market are derived from intra- and interspecific crosses of *M. didyma* and *M. fistulosa*. Varieties and hybrids vary depending on the color, height of the plant and disease resistance (Davidson, 2007, Korablyova, Lynx, 2013, Feskov and Shevchuk 2017). Powdery mildew (*Erysiphe monardae*) and rust (*Puccinia menthae Pers.*) are the most common diseases observed in landscape crops (Collicutt and Davidson 1999). Powdery mildew that attacks the *Monarda* should be considered a fungal disease of economic significance. The symptoms of the disease consist of powdery mildew which grows spots on the leaf mass, and in some cases when the attack is stronger the spots appear on the stems. The leaves turn yellow and dry out and this leads to a decrease in the decorative qualities of the plants (Dudchenko, et al (2020). In recent years, the *Monarda* selection program has focused on creating varieties or hybrids with compact shape, large flowers, resistance to disease and increased content of essential oils (Collicutt & Davidson, 1999, Dudchenko, et al, 2020). The representatives of the *Monarda* genus of the family *Lamiaceae* are little known in our country, mainly as perennial ornamental plants. The species *Monarda didyma* is widespread (Shtilyanova, 2005). In addition to its decorative flower, which makes it an interesting crop used in flowering gardens, it has a pleasant aroma combining the scent of bergamot, lemon and mint which come from the essential oils contained in the leaves, flowers and stems of the plant.

The aim of the present study is to analyze the decorative qualities of 32 specimens of *Monarda didyma*, grown under specific conditions in the Sofia field.

## MATERIALS AND METHODS

The study was conducted in IDLR-Sofia in 2019-2020. The seed material from *Monarda didyma* originates from Poland. The seeds were sown in March 2019 in tarins in a mixture of: peat: soil: perlite (2: 1: 0.5). The obtained seeds were dipped at the beginning of May 2019 in pots №9 in the same mixture.

In October 2019, they were transferred only to soil in pots №15. The plants overwintered in an unheated greenhouse. At the beginning of April 2020 they were planted on a permanent place in the collection of perennial species of IDLR-Sofia.

With the onset of vegetation, the following observations were made:

- Phenological - initial, mass and final manifestation of the phenophases budding and flowering. It was assumed that the date a plant enters initial stage is 15% and 80% for the mass stage.

- Biometric - height and width of the plants, number of formed peduncles, total number of flowers, diameter of the flower, color of the flower.

- Resistance to the causative agent of powdery mildew / *Erysiphe monardae* /. The type of reaction of the studied genotypes to the powdery mildew pathogen was tested against a natural background of infection and was assessed by a 4-point system depending on the percentage of leaves with typical symptoms: (1) resistant - leaves are free from powdery mildew, (2) moderately resistant - up to 25% of the leaves have symptoms of the disease, (3) moderately sensitive - up to 50% of the leaves have symptoms, (4) sensitive - over 50% of the leaves have symptoms (Naidenova and Bozhanska, 2014).

## RESULTS AND DISCUSSION

Phenological observations show that in the region of IDLR-Sofia the beginning of



vegetation is considered to be the beginning of March 2020 (Table 1). The plants formed a tuft of many new shoots, some of which in May 2020 were formed into flowering stems.

The beginning of budding in most samples began in early June 2020, and the first flowers were formed 15 days later (Table 1).

**Table 1.** Phenological observations of *Monarda didyma* genotypes in 2019/2020

№	Vegetation		Budding		Flowering			
	beginning	closing	beginning	mass	beginning	mass	closing	Duration days
1	01.-10.03	15-30.10	<b>29.05</b>	<b>22.06</b>	<b>26.06</b>	<b>09.07</b>	<b>08.09</b>	75
2	01.-10.03	15-30.10	15.06	22.06	09.07	13.07	20.08	43
3	01.-10.03	15-30.10	08.06	22.06	01.07	06.07	21.09	83
4	01.-10.03	15-30.10	-	-	-	-	-	-
5	01.-10.03	15-30.10	15.06	30.06	06.07	20.07	17.09	74
	01.-10.03	15-30.10	15.06	30.06	13.07	05.08	17.09	67
6	01.-10.03	15-30.10	25.06	06.07	20.07	28.07	14.09	57
7	01.-10.03	15-30.10	<b>04.06</b>	<b>22.06</b>	<b>30.06</b>	<b>06.07</b>	<b>3.10</b>	<b>96</b>
8	01.-10.03	15-30.10	06.07	13.07	25.07	05.08	28.09	66
9	01.-10.03	15-30.10	-	-	-	-	-	-
10	01.-10.03	15-30.10	-	-	-	-	-	-
11	01.-10.03	15-30.10	08.06	30.06	25.06	13.07	09.09	77
12	01.-10.03	15-30.10	17.06	22.06	10.07	13.07	09.09	62
13	01.-10.03	15-30.10	25.06	26.06	13.07	16.07	10.09	60
14	01.-10.03	15-30.10	08.06	25.06	06.07	09.07	17.09	74
15	01.-10.03	15-30.10	22.06	30.06	13.07	20.07	<b>05.10</b>	85
16	01.-10.03	15-30.10	22.06	30.06	13.07	17.07	13.08	32
17	01.-10.03	15-30.10	-	-	-	-	-	-
18	01.-10.03	15-30.10	26.06	06.07	20.07	28.07	27.08	39
19	01.-10.03	15-30.10	22.06	30.06	13.07	20.07	28.09	47
20	01.-10.03	15-30.10	-	-	-	-	-	-
21	01.-10.03	15-30.10	<b>29.05</b>	<b>22.06</b>	<b>30.06</b>	<b>06.07</b>	<b>05.08</b>	68
22	01.-10.03	15-30.10	-	-	-	-	-	-
23	01.-10.03	15-30.10	<b>12.06</b>	<b>30.06</b>	<b>06.07</b>	<b>13.07</b>	<b>03.10</b>	<b>90</b>
24	01.-10.03	15-30.10	08.06	06.07	30.06	28.07	08.09	71
25	01.-10.03	15-30.10	25.06	09.07	13.07	28.07	05.10	85
26	01.-10.03	15-30.10	<b>02.06</b>	12.06	22.06	06.07	<b>03.09</b>	74
27	01.-10.03	15-30.10	22.06	09.07	13.07	20.07	05.08	24
28	01.-10.03	15-30.10	25.06	30.06	20.07	28.07	11.09	54
29	01.-10.03	15-30.10	<b>06.07</b>	<b>20.07</b>	<b>28.07</b>	<b>05.08</b>	<b>05.10</b>	70
30	01.-10.03	15-30.10	25.06	30.06	18.07	20.07	20.08	34
31	01.-10.03	15-30.10	-	-	-	-	-	-
32	01.-10.03	15-30.10	12.06	22.06	06.07	13.07	28.09	85

The mass flowering was in July 2020. The duration of the flowering period was on average about 50-70 days. Genotype 27 was characterized by the shortest flowering period of 24 days, and genotype 7 by the longest - 96 days. No blooms were observed in genotypes 4, 9, 10, 11, 20, 28 and 29, although the plants

bloomed in the second year after sowing.

Later flowering varieties were also created, in which flowering begins in late July and lasts until the end of August, lasting 6-8 weeks (Collicutt and Davidson, 1999). The vegetation period usually lasts for 170-200 days, and its duration depends on the conditions



of the area in which it is grown (Bedulenko, 2013). For the region of the Sofia field, the *Monarda* vegetation ends at the end of October. In the biometric which was made, the examined samples varied in height from 30 to 97 cm and a difference in 40 to 70cm was established. The mass size of the samples was about 70 / 60cm (height / width) (Table 2). Samples 10 and 20 had the most compact form (Table 2).

Many researchers have noted in their observations that the habitat of plants varies from 60 to 120cm depending on the conditions

under which the *Korablyova* culture is grown. (Lynx (2013). Bedulenko, (2013) Feskov, Shevchuk (2017. Dudchenko, et al. (2020).

Varieties have been created for the needs of gardening that have a more compact shape, with a size of 25 / 30cm - such as *Petite Delight* 'Collicutt, Davidson (1999) and *Victoria* variety - 30 / 40cm Can L (1996). The flowers of the *Monarda* are collected in complex apical inflorescences with a spherical shape, and their size varies from 5.5 to 8.5 cm.

**Table 2.** Biometric observations of the qualitative indicators of *Monarda didyma* genotypes in 2019/2020

№	Height cm	Width cm	Flowering stems	Flowers	Diameter flower		Color flower
					single	double	
1	74,5	55	9	13	7,1	-	light pink
2	81,2	59	8	10	7	-	cyclamen-purple
3	97,9	58,2	2	12	7,1	5,2	cyclamen purple
4	52,2	49,6	-	-	-	-	-
5	81	70,3	7	7	7,2	-	light cyclamen
6	82,1	43,3	6	7	6,4	5,1	light pink
7	85,6	69,8	5	-	-	-	-
8	80,1	60,1	7	17	7,6	4,5	light cyclamen
9	48,1	39,5	-	-	-	-	-
10	<b>31,1</b>	<b>40,1</b>	-	-	-	-	-
11	58,2	55,2	-	-	-	-	-
12	90,3	67,6	3	10	7,4	-	dark cyclamen
13	82,3	51,1	5	20	7,2	3,3	pink
<b>14</b>	<b>95,2</b>	<b>46,4</b>	<b>1</b>	<b>2</b>	<b>6,5</b>	-	dark purple
15	<b>70,9</b>	<b>59,4</b>	<b>7</b>	<b>13</b>	<b>8,5</b>	<b>6,6</b>	pink
16	80,6	55,7	6	10	6,3	4,1	light violet
17	70,3	50,3	2	3	5,3	-	pink
18	90,7	55,3	-	-	-	-	-
<b>19</b>	<b>88,9</b>	<b>57,4</b>	<b>3</b>	<b>5</b>	<b>6,7</b>	<b>1,9</b>	crimson pink
20	<b>30,1</b>	<b>45,2</b>	-	-	-	-	-
21	46,9	47,9	3	9	6,9	-	light pink
22	37,3	32,1	-	-	-	-	-
23	65,3	60,2	8	7	7,8	4,2	light cyclamen
24	59,6	60,1	1	9	7,4	-	light cyclamen
<b>25</b>	<b>56,4</b>	<b>40,3</b>	<b>2</b>	<b>5</b>	<b>6,3</b>	-	<b>dark purple</b>
<b>26</b>	<b>61,3</b>	<b>57,5</b>	<b>5</b>	<b>12</b>	<b>8,2</b>	-	<b>dark purple</b>
27	71,9	57,2	1	5	5,9	-	pink cyclamen
28	78,6	63,6	-	-	-	-	-
29	66,2	61,3	-	-	-	-	-
30	95,7	45,6	6	10	6,3	-	pink
31	61,3	41,3	-	-	-	-	-
32	92,1	50	6	15	7,2	-	<b>pale pink</b>



Samples with the size of the flowers in diameter 6-7 cm predominated in the collection of IDLR-Sofia (Table 2). Some of the plants had double, triple and quadruple flowers. They formed on stems coming from the original color, forming cymose inflorescences. The size of the

additionally shaped colors decreased compared to the original, as their size was from 1.9 to 6.6 cm. Sample №15 in the IDLR collection with the largest colors had a size of 8.5 / 6.6 cm (Table 2).

**Table 3.** Biometric observations of the leaves of *Monarda didyma* genotypes in 2019/2020

№	Height cm	Width cm	Form	Hair formation
1	<b>6,4</b>	<b>3,0</b>	<b>broadly lanceolate</b>	-
2	5,3	3,0	broadly lanceolate	yes-weak
3	5,4	2,5	broadly lanceolate	-
4	5	2,3	broadly lanceolate	-
5	<b>6,4</b>	<b>2,9</b>	<b>broadly lanceolate</b>	-
6	5,8	2,9	broadly lanceolate	yes
7	<b>4,0</b>	<b>1,7</b>	<b>broadly lanceolate</b>	yes
8	6,1	2,8	broadly lanceolate	yes
9	5,6	2,3	broadly lanceolate	-
10	5,7	2,6	broadly lanceolate	-
11	4,3	2,0	broadly lanceolate	-
12	5,4	2,7	broadly lanceolate	-
13	5,9	2,7	broadly lanceolate	yes-weak
14	5,3	3,0	broadly lanceolate	yes
15	5,9	2,1	broadly lanceolate	yes-weak
16	5,8	2,9	broadly lanceolate	yes-weak
17	5,6	3,4	broadly lanceolate	-
18	5,6	2,8	broadly lanceolate	-
19	5,7	2,6	broadly lanceolate	-
20	4,4	2,1	broadly lanceolate	yes
21	5,4	3,1	broadly lanceolate	yes-weak
22	5,7	3,8	broadly lanceolate	-
23	5,9	3,0	broadly lanceolate	-
24	5,0	3,0	broadly lanceolate	yes-weak
25	5,7	3,0	broadly lanceolate	yes
26	5,9	2,9	broadly lanceolate	-
27	5,4	3,3	broadly lanceolate	yes-weak
28	<b>6,4</b>	<b>2,9</b>	<b>broadly lanceolate</b>	-
29	4,5	3,0	broadly lanceolate	-
30	5,0	3,8	broadly lanceolate	yes-weak
31	5,7	3,1	broadly lanceolate	yes
32	5,7	3,0	broadly lanceolate	-
33	6,3	2,9	broadly lanceolate	-
34	5,8	2,7	broadly lanceolate	yes
35	6,2	2,4	broadly lanceolate	-
36	5,9	3,7	broadly lanceolate	yes-weak

In the collections of different botanical gardens in Russia and Ukraine, the size of the inflorescences varies on average about 5-7 cm

(Feskov, Shevchuk, 2017, Dudchenko, et al 2020). There are hybrids and varieties with smaller flowers 2.5-4 cm (Can L, 1996). The



predominant color of the *Monarda* specimens in IDLR-Sofia was pink cyclamen. Interest was provoked by the wine color of №14, 25 and 26 and the raspberry pink color of №19. Specimens in red and white were not found in the IDLR collection. The world collections are dominated by pink, pink-violet and purple (Davidson, 2007, Feskov, Shevchuk, 2017, Dudchenko, et al 2020).

The leaf mass of the *Monarda* genotypes in IDLR-Sofia was dark green. The shape of the leaves did not differ from one number to another. In all genotypes it was broadly lanceolate. The largest size - 6.4 / 3 cm (length / width) was characterized by the numbers: 1, 5 and 28, and the smallest was the number 7 - 4 /

1.7 cm (length / width) (Table 3). The formation of pappus was observed on the leaf blade, but the amount of plant hairs may be strong or less pronounced. In the collection the number with and without plant hairs on the leaf blade was equal to the samples (Table 3).

The attack of powdery mildew against a natural background of infection was observed mainly in May, June and July. Table 5 presents the distribution of samples using the four-point system depending on the percentage of leaves with typical symptoms. The results show that the majority of the *Monarda* specimens belonged to the group of moderately resistant, in which pathogen damage covers 25% of the leaf mass.

**Table 4.** Reaction to powdery mildew of *Monarda didyma* genotypes in 2019/2020

Reaction	Number of samples	№
1 - resistant	1	25
2 - moderately resistant	21	4,5,6,7,9,10,14,15,16,17,20,21,22,23,24,26,27,29,30,31
3 - moderately sensitive	6	1,11,12,19,28,32
4 - sensitive	4	2,3,8,13

## CONCLUSIONS

After the evaluation of 32 specimens of *Monarda didyma*, plants with potential decorative qualities were found, which would find a place in the landscape planting. These specimens have a more compact shape, as the specimens №10 and 20 have larger colors the same as № 15 and 26. They have spectacular color dye as № 14,19,25 and 26, a longer flowering period as № 7 and 23 and resistance to powdery mildew pathogen such as № 25. Concerning the future production of the planting material the following samples present an interest:

Sample №25 characterized by a compact shape 56.4 / 40.3 cm (height / width), wine color, the formation of double colors and resistance to powdery mildew. Sample №21 had a weak growth - up to 47 cm in height, its flowers were large with a diameter of 6.9 cm and

was characterized by medium resistance to powdery mildew. Sample №15 formed large flowers 8.5 cm (single and double), with a deep pink color and medium resistance to powdery mildew.

In order to preserve the valuable decorative qualities, the samples will be multiplied vegetatively in the laboratory complex of IDLR-Sofia.

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