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EFFECT OF PLANTING DATE ON ANEMONE PLANTS, GROWN IN A SUSTAINABLE GARDEN IN BUCHAREST, ROMANIA

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Abstract

Corms of a mixed cultivars of Anemone coronaria ('Mr. Fokker', 'Sylphide', 'Hollandia', 'The Bride', 'Harmony White') were planted in raised beds during the fall, winter and spring. Without applying any maintenance except weed control, plants from the corms planted in November had the most flowers and managed to survive best during the two years of observations. Anemones planted in February and March were able to flower in June and July, when the air temperature was over 30ºC. In conclusion, Anemone coronaria proved to be an excellent species for spring conditions in Bucharest, with an extended flowering period, much more than other species such as tulips, daffodils or hyacinths. Moreover, regardless of the planting date, anemone plants are suitable for sustainable flower plantations.

Key words*: Anemone coronaria; climate changes; flowerbeds; phenology events.*

INTRODUCTION

Flowers are important color components of urban green spaces. Compositions with flowers contribute to the aesthetic quality of streets (Todorova et al., 2004) and significantly attract urban population to visit parks (Mou et al., 2023). Moreover, flowerbeds proved to have important effects on humans' aesthetic experience, being able to link them to particular location (Poje et al, 2013). Also, in urban areas, flowers have a positive effect on both diversity and richness of bees (Tommasi et al., 2004; Gunnarsson & Federsel, 2014; Burr et al., 2016; Lanner et al., 2020; Ayers & Rehan, 2021) and butterflies (Nagase et al., 2011).

Studies conducted in different countries revealed that compositions with higher flower color diversity are more appreciated by people (Todorova et al., 2004; Hoyle et al., 2018; Tomitaka et al., 2021). These can be created by using a mix of flower species and/or cultivars. However, in mixed flowerbeds, the combination of species and cultivars became a changeling issue, in the context of climatic changes. Flower species respond differently to climate change (Miller-Rushing & Primack, 2008; da Silva et al., 2014; Sanczuk et al., 2022). Many of them, have changed their phenology events, especially in temperate climate (Tooke & Battey, 2010) and for mixed flowerbeds it is important to select species with a similar response for maximum design effect.

Early spring-flowering species are more responsive to climate change (Fitter et al., 1995; Fitter & Fitter, 2002; Dunne et al., 2003) and this has an important impact on their cultivation in green spaces.

For spring-flowering geophytes, planting date is essential for plant survival, flowering and dormancy, especially in temperate climate. In Romania, where long, warm and dry autumns are followed by short, but cold winters, the planting time of spring-flowering geophytes is quite difficult to establish.

In the actual context, characterized by climate change and energy crisis, it is crucial for urban green spaces to select species and cultivars with adaptive potential and to cultivate them in a sustainable plantations.

Anemone species are naturally adapted to survive summer drought and high temperatures (Kamenetski, 2004), but in Romania are less popular than tulips, daffodils or hyacinths. Flowers of *Anemone coronaria* L. exhibits various colours including purple-blue, red, white and pink and at least 30 gradual colour variants (Dafni et al., 2020). These characteristics recommend them to sustainable urban gardens. But even if the species or

cultivars are very adaptative, flowering duration depends on planting date. For this reason, in this study, different planting date were tested on a mix of cultivars of *Anemone coronaria* L. Their performance was investigated in a sustainable urban garden in order to evaluate emergence, growth, flowering, dormancy, plants resilience and response in the second year of cultivation.

MATERIALS AND METHODS

Experiences were conducted in a sustainable urban garden at the University of Agronomic Sciences and Veterinary Medicine, in Bucharest (latitude 44°24'49"N and longitude 26°05'48"E), Romania. Anemone tubers (*Anemone coronaria* L. De Caen Group) from different cultivars ('Mr. Fokker', 'Sylphide', 'Hollandia', 'The Bride', 'Harmony White') were planted at four different times, on November 2020, December 2020, February 2021 and March 2021. Until planting, the tubers were stored at 18-22ºC.

Prior planting, the existing soil was improved with leaves compost for a lighter texture.

Tubers were planted without any prior treatment, at a depth of 6 cm, and distances of 20 cm apart within rows and 10 cm apart between rows, in raised flowerbeds, in full sun.

Even if winters in Romania have become shorter in last decades due to climatic changes, they can be very cold or thermally unstable, with dramatic alternations of warm days and very cold ones, which can destroy the tubers. For that reason, after planting, in November 2020 and December 2020, tubers were covered with a layer of 10 cm of leaves mulch, which was removed on 15th of February 2022, when the temperatures rose.

The plants were cultivated without applying any maintenance, except weed control. Observations and measurements were made daily. After the first growing season, the tubers were left in place for the second year of observations.

Statistical analysis were applied to evaluate the plants parameters. The influence of planting date on plants emergence, growth, flowering and dormancy was analysed using one-way ANOVA test, then statistical differences between means were estimated with the Least Significant Difference (LSD) test at 5% level of significance. Also, in order to establish the relationship between flowering parameters (flower bud initiation, number of flowers, flower diameter, stalk length) and air temperatures, linear regression and Pearson test were performed.

RESULTS AND DISCUSSIONS

Planting date influenced tubers emergence in spring (Table 1). For tubers planted in November and December, non-significant ($P>0.05$) differences in the number of days (on average 6 days) from planting to emergence were noticed. Conversely, planted in February, tubers emerged after significantly more days (on average 20 days) than those in March.

Anemone tubers planted in late fall and early winter (November and December) emerged in spring at 2.5 weeks apart, and those planted in late winter and early spring (February and March), started to emerge in the same time (Table 2).

As other early spring geophytes, *Anemone coronaria* start to grow under particular ecological conditions. Emergence and growth of anemones is controlled by temperatures (Ohkawa, 1986), particularly by soil temperature (Mondoni et al., 2009; Rauter et al., 2022). Therefore, even though the first tubers planted in November emerged in February, most of them (60%) emerged in March, when the soil temperature rose.

The mix of anemone cultivars had a more uniform emergence when planted in the spring, compared with those planted in the fall or winter, where some tubers appeared two months apart from the firsts.

However, the share of emerged tubers was best when planted in November and March, of 82.5% and 80.0%, respectively. Early winter planting (December) and late winter planting (February), when the temperatures frequently varied from abnormally high to extremely cold and freezing, resulted in a lower survival of tubers.

In geophytes, relatively high air temperatures lead to faster growth (Khodorova & Boitel-Conti, 2013), but in our study at temperatures of 18ºC, tubers planted in March, initiated first flowers after 36.96 days, significant much more than those planted in February (Table 1).

Table 1. Phenological response of anemone plants at different planting date

Planting month	Mean number of days from planting to emergence	Mean number of days from emergence to bud initiation	Mean number of days from bud initiation to flowering	Mean number of days from open flower to wilt flower	Mean number of days from last flower to dormancy	Mean number of days from emergence to dormancy
November	123.78 a	42.86 a	7.80 a	7.60 a	41.91 a	104.72 a
December	117.27 a	35.78 a	8.02 a	6.15 b	28.91 b	90.77 b
February	65.38 b	27.18 b	8.07 a	5.57 c	29.21 b	77.29 c
March	44.21 c	36.96 a	7.22 a	5.03 c	25.45 b	79.38 c
LSD	*9.76*	*7.85*	*1.08*	*0.93*	*10.93*	*11.14*

LSD - Least Significant Difference
All data within columns with the same letter are not statistically different at $P \leq 0.05$.

Table 2. Emergence parameters of anemone corms, planted in different months

Planting month	Emergence period (date)	Emergence duration (days)	Share of emerged corms (%)
November	22 Feb. - 13 Apr.	51	82.5
December	10 Mar. - 22 Apr.	44	55.0
February	16 Apr. - 17 May	32	65.0
March	16 Apr. - 19 May	34	80.0

Anemone plants had approximately the same mean number of days from bud initiation to flowering, independent on planting date. Anyway, there were differences among cultivars, some of them ('Sylphide', 'Hollandia') required only 4-5 days from flower initiation to flowering and some others ('Mr. Fokker', 'The Bride'), 10-12 days. These results confirm other studies, which revealed that geophytes cultivars perform differently at flowering (Ahmed & Khurshid, 2004; Addai, 2011; Bock et al., 2015; Mohsin et al., 2018), due to their genetic background.

The flowering was longer for anemones planted in March, starting from 26th of May to 7th of July, covering a period of 84 days (Figure 1, Table 3). Shorter flowering periods were recorded at those planted in November (56 days) and December (60 days).

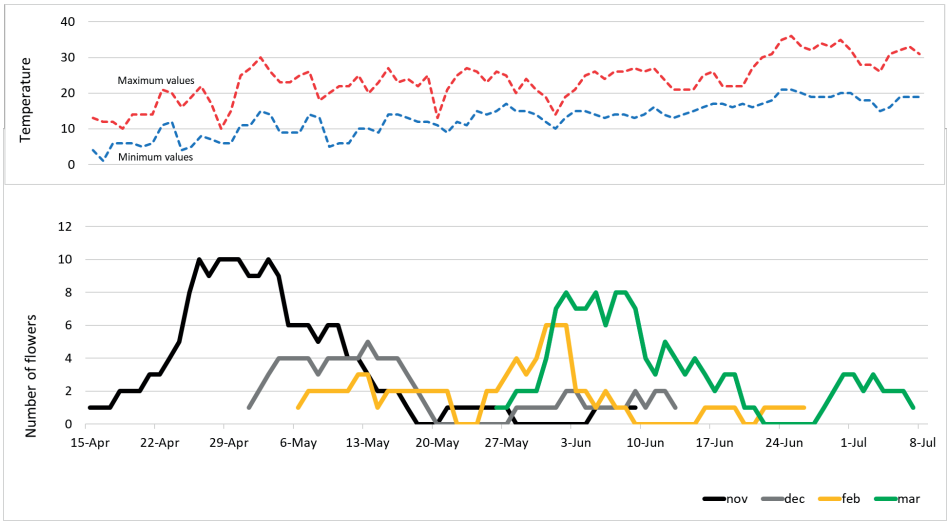

Figure 1. Flowering dynamics of anemones planted at different months

Table 3. Effects of planting date on flowering and flowers parameters

Planting month	Flowering duration (days)	Number of flowers/ plant	Stalk length (cm)	Flower diameter (cm)
November	56	3.26 a	21.56 a	8.11 a
December	60	1.95 b	21.22 a	7.69 a
February	73	1.65 b	19.93 a	6.81 b
March	84	3.13 a	22.72 a	7.50 a
LSD	-	*0.96*	*2.94*	*0.64*

LSD - Least Significant Difference. All data within columns with the same letter are not statistically different at $P \leq 0.05$.

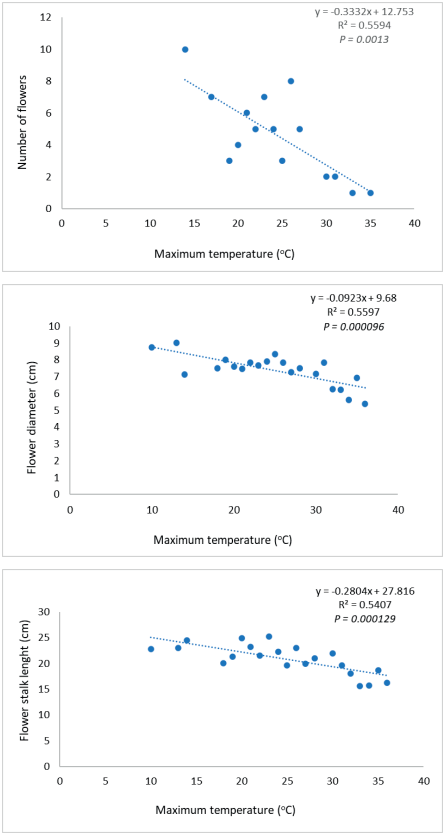

Figure 2. Relationship between flowering parameters and maximum temperature

Comparing these data with those obtained in Romania for other early-flowering geophytes (Manda & Nicu, 2011), it was noted that anemones have a significantly longer flowering (68.2 days) than *Hyacinthus* (10.2 days), *Narcissus* (12.5 days), *Tulipa* (10.4 days), *Crocus* (17.0 days), *Allium* (25.7 days) or *Muscari* (30.2 days).

The length of the flowering period did not influence the number of flowers/plant. Thus, anemones planted in March had almost the same average number of flowers/plant as those planted in November (Table 3).

Significantly lower number of flowers/plant were observed in case of anemones planted in December and February. Data indicate that the number of flowers/plant is rather controlled by environmental factors than length of flowering period or cultivar. In geophytes, temperature was found by many researches the most important factor controlling their flowering (Khodorova & Boitel-Conti, 2013).

In fact, significant relationships (Figure 2) were found among maximum temperature and number of flowers ($R = 0.7479$; $R^2 = 0.5594$; $P = 0.001344$), flowers diameter ($R = 0.5596$; $R^2 = 0.5597$; $P = 0.000096$) and flower stalk length ($R = -0.7393$; $R^2 = 0.5407$; $P = 0.000129$). Anemone cultivars formed more flowers when the daytime temperature was between 14-26°C. Also, temperatures lower than 19°C in April and May, and also, higher than 25°C in June and July, had a significant impact on flowers diameter and stalk length. Thus, at these temperatures, the flowers were smaller in height and diameter. Even if the flowers were initiated in short days of April or long days of June, their size appears to be controlled only by temperature. This confirms the results of other researchers that in anemones, photoperiod does not control flowers quality (Kadman-Zahavi et al., 1984; Ohkawa, 1986; Ben-Hod et al., 1988; Rauter et al., 2022).

Anemone plants continues to initiate flowers even the temperatures exceed 28°C and succeed to bloom at 36°C in July.

Flower lasted significantly longer in anemones planted in November (on average 7.60 days) and December (on average 6.15 days), than those in February or March (Table 1). For some of the cultivars, such as 'Mr. Fokker' and 'Hollandia', flowers wilt after 10-11 days. Anyway, in the summer, even these cultivars had their flowers withered after 6-7 days.

Plants dormancy was observed at different dates for each planting month (Table 4). This was extended with each subsequent planting month. Consequently, March plants entered dormancy

last. However, due to high temperatures and long days (Ben-Hod et al., 1988), these plants recorded the shortest period from the last flower to dormancy, of 25.45 days (Table 1).
November plants started their dormancy 41.91 days after the last flower, at a significantly longest period compared to the other plants. Also, they had a significantly longer growing season (on average 104.72 days), than the others (Table 1).
Dormancy length was significantly longer in November plants than the others (Table 4).

Table 4. Effects of planting date on flowering and flowers parameters

Planting month	Starting of dormancy (date)	Dormancy duration (days)	Survival (%)
November	22 June	110.15 a	63.64 a
December	25 June	103.13 b	68.18 a
February	1 July	105.30 b	38.46 b
March	14 July	99.80 b	15.62 c
LSD	-	*6.93*	*4.76*

LSD - Least Significant Difference
All data within columns with the same letter are not statistically different at $P \leq 0.05$.

After only 99.80 days, March plants exit dormancy and at the beginning of October, they started to emerge.
November and December plants survived better after the hot and dry summer (Table 4). Most of the March plants were lost because their pre-dormancy period was extremely short, insufficient for complete carbohydrate storage. Poor tubers survival for late planting anemones was reported also by other authors (Armitage & Laushman, 1990). In geophytes, dormant buds require energy to promote they growth. Therefore, plants depend on sugars, and its storage is essential to maintain their dormancy and promote sprouting (Sheikh et al., 2022). Furthermore, due to a suboptimal level of sugars, March plants emerged in October were lost until spring, although the winter was warm.
In the second year of growth, the tubers started to emerge almost at the same time, independent of the previous year's planting date (Table 5). Also, plants emerged in a significantly shorter period (P = 0.00679) of 20-24 days, than in the first year, of 32-51 days.
During winter 2021/2022 all plants maintained their vegetative growth and in mid-February they already initiated flower buds (Table 5).

Table 5. Phenological response of anemone plants at different planting date, during the second year

Planting month	Emergence period (date)	Mean number of days from emergence to bud initiation	Mean number of days from bud initiation to flowering	Mean number of days from open flower to wilt flower	Mean number of days from last flower to dormancy
November	11 Oct. – 1 Nov.	163.46 a	8.19 a	8.42 a	56.66 a
December	17 Oct. - 5 Nov.	160.50 a	7.74 a	7.37 a	65.50 a
February	13 Oct. – 5 Nov.	125.00 b	8.25 a	8.00 a	66.16 a
March	14 Oct. – 4 Nov.	-	-	-	-
LSD	-	*39.38*	*2.41*	*1.61*	*16.79*

LSD - Least Significant Difference
All data within columns with the same letter are not statistically different at $P \leq 0.05$.

At that time, maximum temperatures were between 13-18ºC. The weather suddenly changed at the end of February, when late spring frost and episodes of snow persisted until the end of March. As a result, the cold weather caused the loss of flower buds.
The first flowers were observed in April for all planting dates. Thus, the flowering period did not differ significantly as in the first year (Table 6). However, in the second year, the number of flowers/plant was higher for all planting dates (Figure 3). More flowers were also obtained in the second year on other geophytes (Cardone et al., 2019).
Mean values of flower diameter and stalk length were quite similar for all planting dates, but lower than in first year.
No significant differences were noticed for flowers duration (Table 5).
All plants entered dormancy in June, when temperatures exceeded 30ºC. Comparing with the first year, the plants had a longer period from

the last flower to dormancy, of 56-66 days. This may be explained by the hot and dry weather in May 2022. Year 2022 was the hottest European summer (van Daalen et al., 2022). In this particular year, temperatures above 30ºC were recorded in Bucharest, starting on May 13, quite unusual for early summer.

Table 6. Flowering and flowers parameters during the second year

Planting month	Flowering duration (days)	Number of flowers/ plant	Stalk length (cm)	Flower diameter (cm)
November	50	7.71 a	17.93 a	6.03 a
December	46	6.72 a	18.27 a	6.67 a
February	48	4.14 b	14.80 b	7.15 a
LSD	-	*3.19*	*3.40*	*0.71*

LSD – Least Significant Difference
All data within columns with the same letter are not statistically different at $P \leq 0.05$.

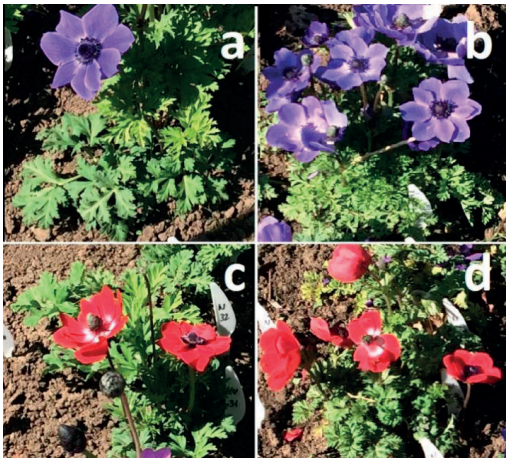

Figure 3. Flowering in the first and second year of some cultivars (a - 'Mr. Fokker' in 2021; b - 'Mr. Fokker' in 2022; c - 'Hollandia' in 2021; d - 'Hollandia' in 2022). More flowers were observed in May, on the same plant in the second year compared to the first

Anemones plants were cultivated without irrigation, in order to test their behaviour in the extreme climate of Bucharest. As a result, in May, the heatwave and lack of precipitation over an extended period, stopped earlier the anemones from flowering. However, in these conditions, the plants continued their vegetative growth and entered in dormancy in June, as in the first year.

CONCLUSIONS

Climate changes creates unpredictable weather conditions every year and the seasons vary widely. Some early spring geophytes are more adaptable than others. *Anemone coronaria* proved an exceptional adaptability, facing temperatures above 30ºC and continuing to flower much longer than other geophytes. Also, anemones can survive for many years if left undisturbed, in sustainable plantations.

Our results showed that planting date should be considered for anemones flowering and plants survival over the years. Tubers planted in late fall (November) had a shorter flowering period but with a high number of flowers, in all cultivars. Also, these plants survived and flowered best in the second year as well. Spring planting (March) increased the flowering period, but not the number of flowers and the plants did not survive in the second year.

Planting date may have implications for flowerbeds design effect and should be considered when anemones are associated with other flower species in sustainable plantations. Also, considering the last European summer weather conditions (the hottest and driest), we recommend autumn planting, which ensure not only an earlier flowering, but also enough time for sugars storage and plants survival.

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