Scientific Research Publishing

American Journal of Plant Sciences, 2024, 15, 374-386
https://www.scirp.org/journal/ajps
ISSN Online: 2158-2750
ISSN Print: 2158-2742

Some Indicators of the Water Regime in Some Varieties Belonging to the *Monarda didyma L.* Genus in the Conditions of Tashkent (Uzbekistan)

Mamadalieva Vakhobjon Kizi Madina[1*], **Rakhimova Tashkhanim**[2]

[1]Physiology of Plant and Botany Department, Biology Faculty, National University of Uzbekistan named after Mirzo Ulugbek, Tashkent, Uzbekistan
[2]Institute of Botany of the Academy of Sciences of the Republic of Uzbekistan, Tashkent, Uzbekistan
Email: *madinabonu2410@gmail.com

How to cite this paper: Madina, M.V. and Tashkhanim, R. (2024) Some Indicators of the Water Regime in Some Varieties Belonging to the *Monarda didyma L.* Genus in the Conditions of Tashkent (Uzbekistan). *American Journal of Plant Sciences*, 15, 374-386.
https://doi.org/10.4236/ajps.2024.155027

Received: March 2, 2024
Accepted: May 26, 2024
Published: May 29, 2024

Abstract

In this article, the names of 3 varieties of *Monarda didyma L.*, which are considered to be introduced species, some indicators of the water regime in the climatic conditions of Uzbekistan: the amount of water in the leaves, water deficit, water storage capacity were studied in spring and summer, and seasonal changes were determined. According to these indicators of the water regime, the studied varieties belong to the labile water regime, high green mass (centner), seed yield (how many grams), resistance to diseases and pests have been determined, which shows that it is promising for introduction in the conditions of our republic. Therefore, it is recommended to breed these varieties in the foothills and hilly regions of Uzbekistan, where the amount of precipitation is more than 400 - 500 mm.

Keywords

Uzbekistan, Tashkent, *Monarda didyma*, Bergama, Jar-Ptitsa, Cambridge Scarlet, Water Regime, Water Quantity, Water Shortage, Water Storage Capacity, Labile

1. Introduction

Nowadays, the growing population of the world is causing to increase the need for food, clothing, medicine and various sectors of the national economy. It is known that natural resources are great importance in all fields. Among these, it is necessary to emphasize the need for water.

According to the International Food and Agriculture Organization (FAO), more than 50,000 medicinal plants are used for medicinal purposes worldwide. The use of representatives of local flora for the purpose of treatment is high in Southeast Asian countries, this figure is 19% in China and 20% in India. Preparations made on the basis of raw medicinal plants occupy a wide place in the pharmaceuticals of Germany, Japan and other European countries [1].

One of the main current problems is that global climate change is having a negative impact on agriculture worldwide, causing a decrease in productivity. At the same time, as a result of the creation of an unfavorable environment, there is a decrease in the stock of medicinal plants available in the natural flora.

About 4380 tall plants are naturally distributed in the natural flora of Uzbekistan, and about 1200 of them have medicinal properties. Today, more than 100 medicinal plants are allowed to be used in official medicine in our Republic, and 80% of them are naturally growing plants [2].

Medicinal plants contain aromatic essential oil, species containing thymol and carvacrol, terpenoids, and aromatic compounds act. Medicines obtained from natural plants are preferable because the drugs obtained by chemical means sometimes have a negative effect on the human body. Therefore, strengthening medicine for the treatment of diseases is one of the important issues of today.

The main factor determining the growth and development of plants is soil moisture and air temperature. Knowing how each species adapts to drought and different soil conditions makes cultivation a little easier. Plants growing in different environments have different requirements for water. When there is enough water in their bodies, the growth of physiological and biochemical processes accelerates. 70% - 80% of the plant cell consists of water, and water participates in providing all vital functions [3].

Today, many medicinal plants have been introduced in our country. Including, *Crotolaria alata* L. (Fabaceae) and *Guizotia abyssinica* (L.F) Cass. (Asteraceae) were learned under introduction conditions by N. Rahimova [4], *Valeriana officinalis* L. was acclimatized in the conditions of the Tashkent oasis and its bioecological properties were determined by E.E. Abdunazarov [5]. Sh. Khalimova and T. Rakhimova [6] studied the stages of ontogenesis of some medicinal plants in the soil and climate conditions of Bukhara. D. Fakhriddinova and others learned the anatomical structure of vegetative organs of *Lavandula officinalis* species in the condition of Tashkent Botanical garden [7]. T. Rakhimova, Sh. Halimova introduced *Galega officinalis* L. to the conditions of Bukhara city [8]. F. Dusmuratova, T. Rakhimova and others [9] conducted research on the anatomic structure of the vegetative organs of *Lavandula officinalis* L which is being introduced in the Tashkent Botanical Garden. M.A. Jabbarova [10] introduced some species of Amorha L. in the conditions of Tashkent oasis. The introduction of *Curcuma Longa* L. species in the conditions of Uzbekistan is covered in the works of D.I. Sotiboldieva [11].

In addition to the above scientific research works, additional ones are being carried out to acclimatize many plants with medicinal essential oils that are not found in our natural flora in the climate conditions of Uzbekistan and among the practical works of introduction, several indicators of the water regime are being studied in order to find out the demand and water storage capacity. Experimental works were carried out in the Botanical Garden of the National University of Uzbekistan in order to find out the water demand of varieties of the Monarda family, which is considered a medicinal plant, under the conditions of introduction (year 2023).

The experimental area is located in the city of Tashkent, and the nature of the city largely depends on its geographical location, surrounding and the structure of the earth surface. It is located in the middle part of the Chirchik River valley, which flows from the ridges of Qorjontov, Ugom, Piskom, Koksuv and Chotkal in Western Tianshan, on the low-high foothills on the right side of the river. The natural and geographical conditions of the region are part of the Turon natural geographical province which is subtropical desert zone of the northern hemisphere. The climate is continental, cold in winter and hot and dry in summer.

Tashkent is one of the sunniest cities, with an average of 2870 hours of sunshine per year. During the year, it varies from 110 hours (in December) to 390 hours (in July). On average, there are 36 days without sun in a year. The average annual air temperature is +13.8 celsius. The weather in Tashkent is hot and stable in summer. The hottest month of the year is July, the average air temperature is +27 celsius. The highest summer air temperature is +44.6. Winter weather is relatively unstable and changeable. The coldest period is January, the average temperature is −0.6, and the lowest temperature is −29.5.

The genus Monarda L. belongs to the Lamiaceae family and includes about 20 species. Among the species belonging to this category, there are annual and perennial representatives. Due to the large amount of essential oils stored in the vegetative and generative organs, it is used in medicine, food industry and cosmetology [12] [13].

Monarda essential oil contains thymol, carvacrol, as well as flavonoids, group B vitamins, ascorbic acid and additives [14] [15].

It is used as antiseptic means for colds, diseases of the respiratory organs as well as treatment of diseases such as chronic bronchitis, tuberculosis, *Mycoplasma pneumonia*, harmful fungi in the body, cystitis, psoriasis, hypoxia and anemia. Essential oils have immunity-enhancing properties, and according to the results of research conducted in recent years, they give a positive result when used to prevent the human papilloma virus that causes cervical cancer. It also helps restore body strength after radiation and chemotherapy in patients with oncological diseases [16] [17].

Its main homeland is the American continent, and it grows in places up to 1500 meters above the sea level. In its natural state, it is widespread in Canada, southern Mexico, western parts of Ontario and Minnesota [18] [19].

The Oswego tribe living in North America first used this plant and the leaves of monarda were used as an antiseptic in the treatment of sore throats and oral cavity diseases. Later, settlers from European countries also used monarda leaves as a medicinal tea to treat stomachaches as an antiseptic. After that, this plant became very popular and was called "Oswego", "Oswego bee balm" or "Oswego balm" with the name of the tribe [20] [21] [18].

Representatives of this category are called bergamot because the scent resembles the smell of the fragrant citrus plant "Bergamot", and sometimes they are called by such names as Indian nettle, North American lemon balm, Indian feathers, and lemon mint. By the beginning of the 19th century, this plant began to be called as monarda [22].

After X. Columbus discovered America, this plant was brought to Spain for the first time, from where it spread throughout Europe and Russia. The information about this plant was written in the books of the Spanish doctor Nicholas Monardes "Good News from the New World" (1589), "Medical History of the West India" (1580), and European people learned about Monarda from these books. Two centuries later, Carl Linnaeus included the classification of this group in his book "Plant Species" and named it "Monarda" in honor of Nicholas Monardes [16] [23].

Today, about 50 varieties of the Monarda family have been created, and several species have been acclimatized a long time ago in several regions of the CIS, in the regions of Russia with a warm climate, in the Caucasus, Crimea and Volga river. Currently, it is cultivated in Siberia, Stravropol region, Republic of Bashkortostan, Samara region, Ukraine and Moldova [24] [25].

Level of learning: A lot of scientific and research work has been carried out on the study of several species of the Monarda family. In the Russian region, the bioecological features of the genus Monarda are covered in the works of O.V. Gladisheva [19], growth and development in the black soilless lands of the Russian Federation, N.V. Korshachkina [26]. A.N. Kriklivaya [27] studied the ontogeny features of *Monarda didyma L.* in the Omsk region. Essential oils and their pharmacological properties were studied by A.S. Tsibina [16], M.A. Bedulenko [25] and E.V. Krasyuk [14]. Information on the study of the content of flavonoids obtained from *Monarda fistula* can be found in the research works of A.S. Lapina [28]. Z.E. Mashenko [29], S.V. Fedotov [30] and N.S. Ovcharenko [31] conducted scientific research on the chemical composition of some species belonging to the Monarda family. A. S Nikitina and others [32] studied the morphological and anatomic characteristics of *Monarda fistula*, *Monarda didyma* and *Monarda citriodora* in Nikitina Botanical Garden. The scientific works of S.V. Emelyanov [33] covered the agrotechnics of Monarda in the Republic of Mordovia. M.V. Mamadaliyeva [17] studied the bioecological and some physiological characteristics of *Monarda didyma* species and some varieties in the conditions of Uzbekistan.

The connection of the research with the work plans of the scientific research institution where the dissertation was completed. Dissertation research "Protection and enrichment of the diversity of the plant world of Uzbekistan" and "Introduction of promising non-traditional plants and physiological-biochemical properties" (2020-2024 year) within the framework of scientific research.

The purpose of the study: The introduction of some varieties belonging to the *Monarda didyma* L. species in the conditions of Tashkent is considered.

Research object: Bergama, Jar-ptitsa and Cambridge scarlet varieties of *Monarda didyma L.* belonging to the Monarda genus are considered (**Figures 1(a)-(c)**).

Monarda didyma L. - It is one of the most common perennial species belonging to the Monarda L. genus. The length of the stem is 60 - 90 cm, in some places it grows up to 120 cm. The stem is four-sided, hollow. From one rhizome, up to 9 - 10 branches are formed. The number of lateral branches is 12 - 18; the length is 25 - 30 cm. The leaves are ovate, ovate-lanceolate, and oval; the edges are slightly jagged-toothed, opposite on the stem, 7 - 18 cm long. The flowers are located in the inflorescence, consisting of 80 - 200 flowers. The diameter of the flowers reaches 3.5 - 6 cm. The color of the flowers is pink, light purple, red. *Monarda didyma* occurs naturally in Mississippi, Massachusetts, North Carolina, and Ontario. It grows mainly in forests, thickets, rivers and ditches with sufficient moisture. Depending on the climate, it blooms for 30 - 45 days from spring to autumn [17].

In the conditions of Uzbekistan, the flowering process was observed from May to the end of summer. Representatives of this category are of particular importance with their fragrant, beautiful flowers and are cultivated as ornamental and medicinal plants. The scent of essential oil attracts bees, butterflies, and, naturally, insects pollinate flowers.

2. Research Methods

The method of A.A. Ivanov [34] was used to determine the amount of water in plant leaves. Based on the method of I. Catsky [35], the water deficit in the leaf was determined. The method of A.A. Nichiporovich [36] was used to determine

(a) (b) (c)

Figure 1. (a) Bergama; (b) Jar-ptitsa; (c) Cambridge scarlet.

the ability of plants to store water.

In order to determine the amount of water in the leaves of the studied species, experiments were conducted on the leaves of the plants planted in the botanical garden of National University of Uzbekistan. For this purpose, monthly experiments were conducted in the second vegetation year of plants in 2023.

3. The Results Obtained

From the indicators of the water regime: water quantity, water shortage and water storage capacity were determined.

3.1. Amount of Water

The amount of water in plants is one of the main indicators of the water regime. The amount of water also changes when the types of plants, stage of ontogenesis and growth conditions change.

M. didyma L. - When the amount of water in Bergamot leaves was studied, it had the highest indicator at the end of June and was equal to 76%. At this time, the temperature of the air was +36˚C, and the relative humidity (RH) of the air was 10%. The lowest indicator of water content was 68.7% in August, the air temperature was +39˚C, and the relative air humidity was equal to 10%. Seasonal water amount was 72.5%, seasonal amplitude was 7.3% (**Figure 2(a)**, **Figure 2(d)**).

M. didyma L. - When the amount of water in the Jar-ptitsa variety was studied, the amount of water in the leaves was high in May and June. The highest indicator of the amount of water fell on June 24, and the temperature of the air was +37˚C and the relative humidity of the air was 10%. The lowest water content was observed in July and recorded 69%. At this time, the air temperature was +40˚C and the relative air humidity was equal to 9%. The seasonal average water content of Jar-ptitsa was 74.06%, and the seasonal amplitude was equal to 8% (**Figure 2(b)**, **Figure 2(d)**).

M. didyma L. - When the change of water content of the Cambridge scarlet variety was observed during the season, the highest indicator was observed at the end of May, it was 76%, the temperature of the air was +29˚C, and the relative humidity of the air was 18%. The lowest indicator of water content was 68.7%, corresponding to the month of July. The temperature at this time was 40˚C, and the relative humidity of the air was 9%. The average indicator of the seasonal amount of water was 74.7%, and the seasonal amplitude was 11% (**Figure 2(c)**, **Figure 2(d)**).

As it can be seen from the above results, in the second year of our experiments, when the amount of water in the leaves of several varieties belonging to the genus *Monarda didyma L.* was observed, the vegetation had a high water content during budding and flowering in May and June, decreased in July and reached August and it was observed that it increased again.

3.2. Water Shortage

The study of the water deficit in their body is of great importance in knowing

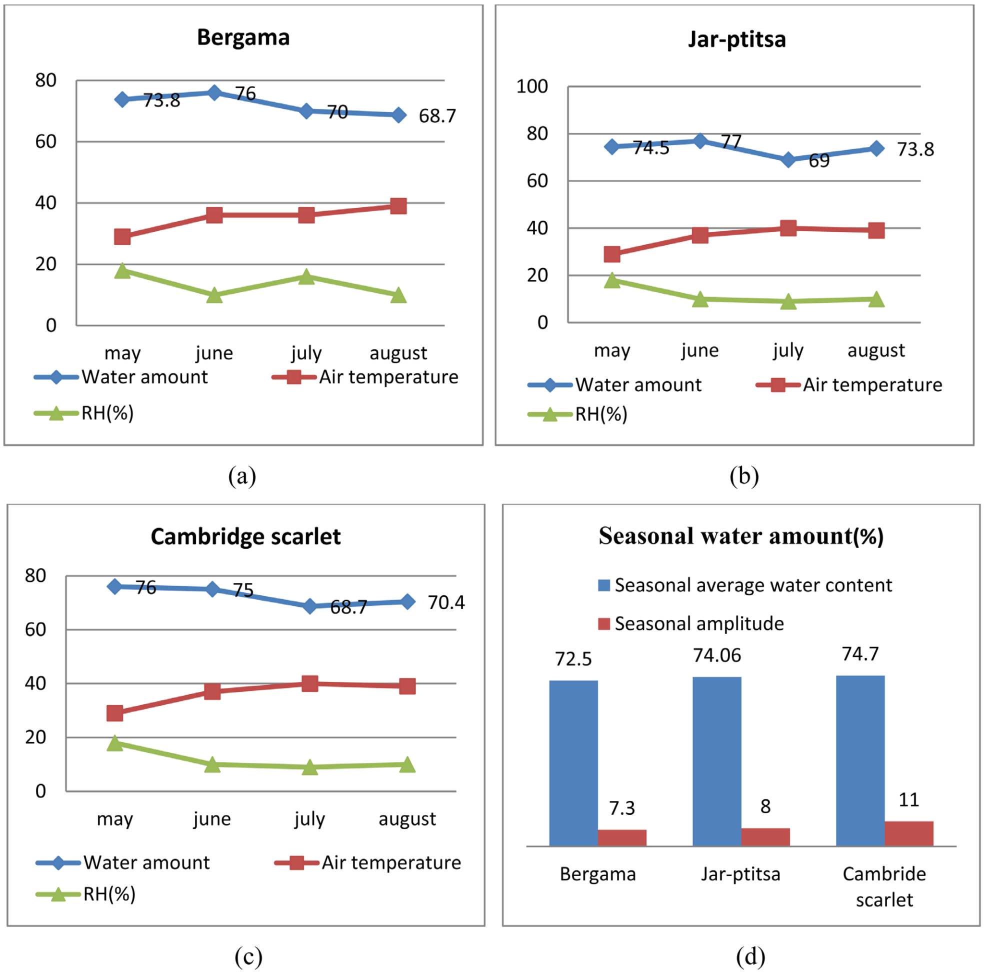

Figure 2. (a)-(c) Monthly water amount for plants. (d) Seasonal average water amount and seasonal amplitude.

the resistance of plants to drought and adapting them to new soil and climate conditions.

In 2023, the daily average value of water deficit in the leaves of *Monarda didyma L.* varieties Bergama, Jar-ptitsa, and Cambridge scarlet was determined every month.

As it can be seen from the table above, the average daily water deficit of the Bergama variety was 24.4% in May, with a daily range of 13%. This month, the average temperature was +29˚C, relative humidity is 18%. In June, the water deficit increased in the middle of the day and was 29%, the average water deficit during the day was 22%, the relative humidity was 10%, and the air temperature was +37˚C, with a daily range of 11%. In July, the daily water deficit was 17.8%, the daily range was 10%, and the air temperature was 40˚C and the relative humidity was 9%. In August, water scarcity increased in the afternoon and averaged 21.7%, with a daily range of 6%. On the day of the experiment, the air temperature was +39˚C, and the relative humidity was 10% (Figure 3(a)).

The daily variation of water deficit in the Jar-ptitsa variety varied from 30% to

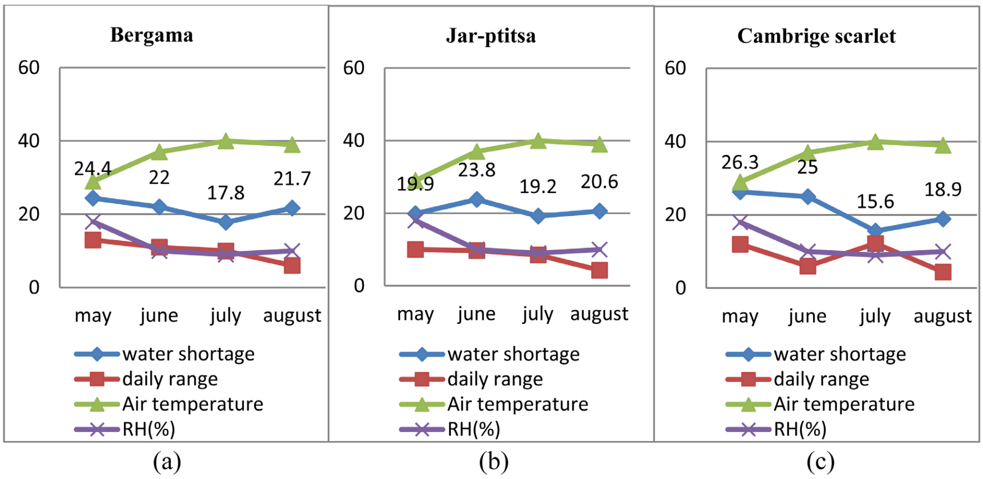

Figure 3. Water shortage of plants during the season.

20% on May 21, and the average water deficit was 19.9% with a daily range of 10%. At this time, the air temperature was +29˚C, and the relative air humidity was 18%. In June, the daily mean water deficit was +23.8% and the daily range returned 9.7%, while the temperature was +37˚C and the relative humidity was 10%. On July 10, the daily water deficit was 19.2%, and the daily range was 8.5%. At this time, the temperature of the air is +40˚C, the relative humidity of the air is 9%. On August 21, the water deficit was found to fluctuate between 18.7% - 23% during the day, and the daily average water deficit was 20.6%, and the daily range was 4.3%. The air temperature was +39˚C, the relative humidity of the air moisture content was found to be 10% (Figure 3(b)).

Seasonal water deficit of Cambrige scarlet was studied, ranging from 26.3% to 18.9% from May to August. On May 21, the average indicator of the daily amount of water was 26.3%, and the daily range was 12%. In June, the lower indicator of daily water deficit was 22%, the upper value was 28%, the average daily water deficit was equal to 25%, and the temperature of the air was +36˚C, the relative humidity of the air was 10%. In July, the daily variation of water content was around 8% - 20.2%, the average daily water deficit was 15.6%, and the temperature in mid-August was +39˚C and the relative humidity was 10% daily water deficit was 18.9% and the daily range was found to be 4.4% (Figure 3(c)).

3.3. Water Storage Capacity of Plants

The inverse rate of water loss is the ability of leaves to store water. This indicator of the water regime indicates the ability of the plant to withstand this or that level of dehydration.

It was found that the ability of plants grown in the conditions of Tashkent city to store water during the season is high in the Bergama and Jar-ptitsa varieties, while in the Cambridge scarlet variety it decreases from May to August.

In May, water retention was high in the Bergama variety and made up 71%. At the end of June, at the beginning of July, the water storage capacity decreased by 58% and increased in August. The seasonal average water retention capacity of this variety was 63.7%, and the seasonal range was 13% (**Figure 4(a)**, **Figure 4(d)**).

Seasonal variation of water storage capacity in the leaves of Jar-ptitsa plant was also high in spring months, equaling 69% in May and decreasing to 59% in June. The average temperature this month was 36˚C, relative humidity was 10%. The highest water storage capacity was observed in August, reaching 73%, and the seasonal average water storage capacity was 65.5% and the seasonal amplitude was 16%. The lowest indicator of water storage capacity was observed in July and reached 57%. The average air temperature in these months is 36˚C, the relative air humidity was 8% - 16% (**Figure 4(b)**, **Figure 4(d)**).

The ability to store water during the season in the Cambridge scarlet variety had a low index in the warm months due to its morphological characteristics, *i.e.*, its leaves were thinner and more narrow compared to the other varieties. In May, water storage capacity was high, 71%, and low water storage fell to 36% in early July. Seasonal average water retention in this plant was 51.3%, seasonal range was 35% (**Figure 4(c)**, **Figure 4(d)**).

Since the above-ground part of the studied cultivars is medicinal, that ground part was collected during the flowering period, because the amount of essential oils and other chemicals in the flowers and leaves of monarda is high during this

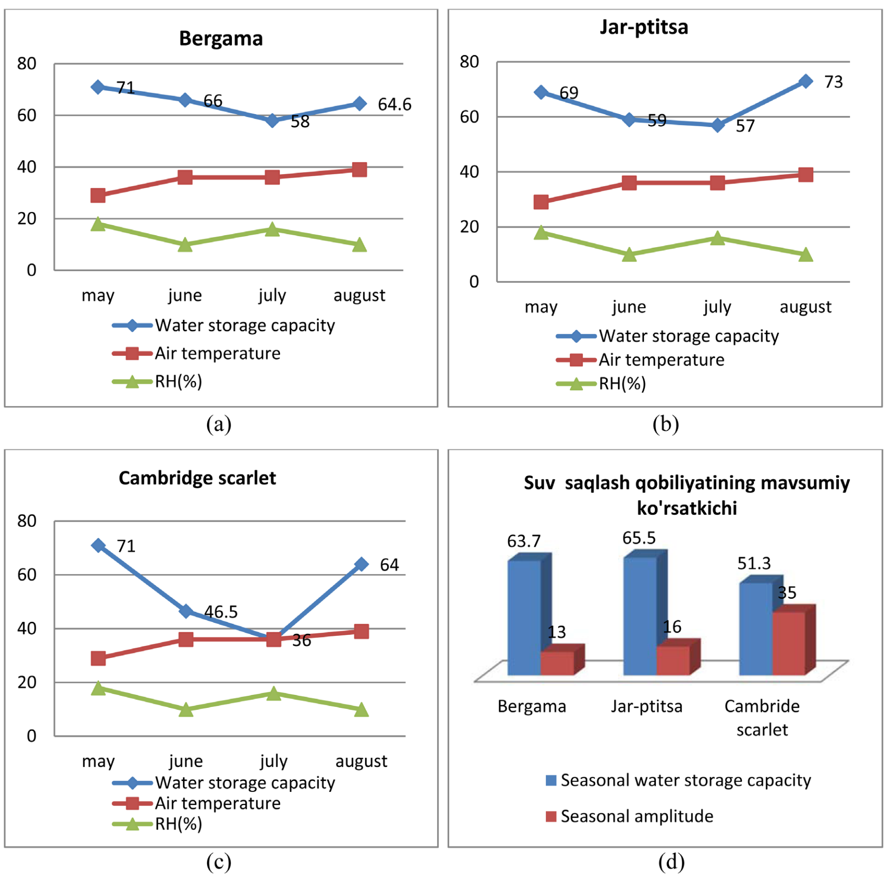

Figure 4. (a)-(c) Water storage capacity of plant varieties; (d) Seasonal water storage capacity and amplitude of plants.

phase. During the flowering of the plants, the upper part of the earth was harvested and dried in a place not exposed to direct sunlight. The dry weight of one bush of a large seedling was 9.7 - 10 g, and the weight of a small bush was 7 - 8.6 g.

In our experiments, the budding of the studied plants was observed at the end of May and the beginning of June. At the end of July, at the beginning of August, the seeds began to ripen and were fully ripe in September. The seeds of varieties belonging to the *Monarda didyma* species are small, have four nuts, are oval-oblong in shape, and have a dark-brown color. In the conditions of the city of Tashkent, the length of the seeds of the Bergama and Jar-ptitsa varieties is 1.6 - 1.9 mm, the width is 0.7 - 0.9 mm, and the weight of 1000 seeds is 0.30 - 0. It was 40 gr. Cambridge scarlet seeds are 1.5 - 1.6 mm long and 0.76 - 0.85 mm wide. The weight of 1000 seeds is 0.39 - 0.45 g. When the seed productivity was determined, the number of flowers in one inflorescence of *Monarda didyma L* - Bergama variety was 248, the seed productivity was 81%, the number of flowers in one inflorescence of Jar-ptitsa was 384, the seed productivity was 86%, one of the Sambridge scarlet variety was There were 300 - 340 flowers in the inflorescence, and the seed productivity was 63% (**Figure 5**).

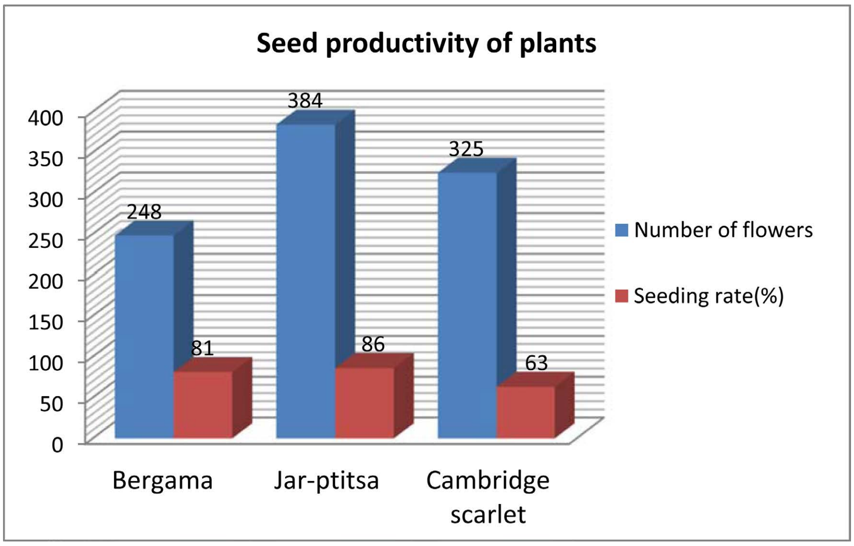

Figure 5. Seed yield of Bergama, Jar-ptitsa and Cambridge scarlet varieties.

4. Conclusion

In conclusion, these studied varieties are mesophytes according to the characteristics of the water regime. It is characterized by the high amount of water in the leaves of plant varieties during the vegetation period, and the low water deficit, which increases only in the summer months. This indicates the lability (variability) of the studied varieties of the water regime, high green mass, seed yield, free from diseases and pests, and their introduction in the conditions of our republic is promising. The local climatic conditions had a good effect on the growth and development of these plants.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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