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# Water Needs of Bird Cherry Trees at the Period over Three Years after Reclamation in Different Regions of Poland

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## 1. Introduction

Bird cherry (*Padus avium* Mill.) is not only a popular ornamental plant, but also a medicinal plant often used in herbal medicine (Podbielkowski 1989, Olszewska & Kwapisz 2011). Different plant tissues, such as fruits, flowers, leaves and bark of bird cherry have been traditionally used as ingredients of mildly diuretic, anodyne, febrifuge, anti-rheumatic, antibiotic, anti-diarrhoeal and sedative ethnomedicines (Launert 1989, Strzelecka & Kowalski 2000, Olszewska & Kwapisz 2011). Bird cherry is also frequently used as a decorative plant; it is planted in parks and along roads, as well as used in landscape and reclamation plantings (Krüssmann 1986, Podbielkowski 1989, Hammatt et al. 1998). Due to decorative advantages of bird cherry flowers and fruits, as well as beautiful yellow and red colors of autumn leaves, and also the plenty of fruits, which are a source of food for birds, it is worth using this species more often in the park and landscape plantings (Karczmarczuk 2012).

The survival rate of plants in the reclaimed areas depends mainly on ensuring optimal water conditions of the soil, which in turn can be effectively controlled by the irrigation treatments (Żakowicz 2010). However, designing and programming an irrigation system requires determination of the water needs, as well as specific requirements of individual plant species. In the case of bird cherry plants, it should also be taken into account that these species prefer soils with mobile and flowable water, and thus does not tolerate habitats with stagnant water (Lasota et al. 2014).

The aim of the present study was to estimate the water needs of bird cherry plants at the period over three years after planting on the reclaimed areas located in five different regions of Poland.

## 2. Material and methods

The water needs of bird cherry (*Padus avium* Mill.) were determined using the plant coefficient method. The plant coefficients for the bird cherry trees over three years after planting on the reclamation area were adapted to the reference evapotranspiration that was calculated using the Blaney-Criddle's formula, modified for Polish conditions by Żakowicz (2010).

The water requirements of bird cherry plants were estimated in the years from 1981 to 2010 for five different agro-climatic regions of Poland with the representative meteorological stations located in Olsztyn, Bydgoszcz, Warsaw, Wroclaw and Krakow (Łabędzki et al. 2013) (Fig. 1). The calculations were performed for the period of two months, including July and August, critical in terms of the amount of water available to the plants.


**Fig. 1.** Agro-climatic regions of Poland with the representative meteorological stations (according to Łabędzki et al. 2013)

The precipitation deficit with the occurrence probability of average dry years ($N_{50\%}$), medium dry years ($N_{25\%}$) and very dry years ($N_{10\%}$) was determined according to the Ostromęcki's method (Żakowicz et al. 2009).

The results of currently presented study are the continuation of research published by Rolbiecki et al. (2018 b) that analyzed the water needs of bird cherry plants during the first three years of growing on the reclaimed areas.

## 3. Results and discussion

The variability of bird cherry water requirements in the period of July-August ranged from 4.2% in the S-E region of Poland to 4.7% in the N-E and C-N-W region of the country (Table 1). In August, the variation coefficient of bird cherry water needs was higher than in the period from July 1 to August 31 and ranged from 4.5% in the C-E region to 5.1% in the C-N-W region of Poland.

**Table 1.** Characteristics of the bird cherry water needs during the growing period

| Specification | Region of Poland | July-August | August |
|---|---|---|---|
| Minimum (mm) | north-east (N-E) | 237.0 | 100.9 |
| | central-north-west (C-N-W) | 249.0 | 106.5 |
| | central-east (C-E) | 249.9 | 106.9 |
| | south-west (S-W) | 221.0 | 99.0 |
| | south-east (S-E) | 230.0 | 100.9 |
| Maximum (mm) | north-east (N-E) | 281.5 | 127.3 |
| | central-north-west (C-N-W) | 292.9 | 133.7 |
| | central-east (C-E) | 294.6 | 138.5 |
| | south-west (S-W) | 261.0 | 126.0 |
| | south-east (S-E) | 273.3 | 130.5 |
| Median (mm) | north-east (N-E) | 258.7 | 114.2 |
| | central-north-west (C-N-W) | 271.7 | 121.8 |
| | central-east (C-E) | 270.0 | 120.2 |
| | south-west (S-W) | 241.1 | 111.8 |
| | south-east (S-E) | 251.7 | 111.4 |

**Table 1.** cont.

| Specification | Region of Poland | July-August | August |
|---|---|---|---|
| Standard Deviation (mm) | north-east (N-E) | 12.1 | 5.7 |
| | central-north-west (C-N-W) | 12.8 | 6.1 |
| | central-east (C-E) | 11.9 | 5.5 |
| | south-west (S-W) | 10.7 | 5.1 |
| | south-east (S-E) | 10.4 | 5.4 |
| Variation Coefficient (%) | north-east (N-E) | 4.7 | 5.0 |
| | central-north-west (C-N-W) | 4.7 | 5.1 |
| | central-east (C-E) | 4.4 | 4.5 |
| | south-west (S-W) | 4.5 | 4.6 |
| | south-east (S-E) | 4.2 | 4.8 |

In each considered region of Poland, during the thirty-year period (1981-2010), a visible tendency to increase the water requirements of bird cherry plants in July and August, were noted (Fig. 2). With the exception of the C-N-W region of Poland, the temporal variability of bird cherry water needs were significant in each considered region of the country. The highest increase of bird cherry water requirements, by 6.7 mm in every ten-year period, in the S-E region of Poland were observed. On average, throughout Poland, during the considered thirty-year period, the water needs of bird cherry in July and August increased in each ten years period by 5.6 mm. In the studies reported by Rolbiecki et al. (2018 b), in each subsequent ten-year period of the considered thirty years, the water requirements of bird cherry plants, calculated for the first three years of growing on the reclaimed areas, increased in the period from July 1 to August 31 in the range from 5.2 to 5.7 mm in the S-W and N-E regions of Poland, respectively. The differences between current results and results presented by Rolbiecki et al. (2018 b) are an effect of the lower values of plant coefficients applied according to Żakowicz (2010) for young plants (first three years after planting) than older plants (over three years after planting).

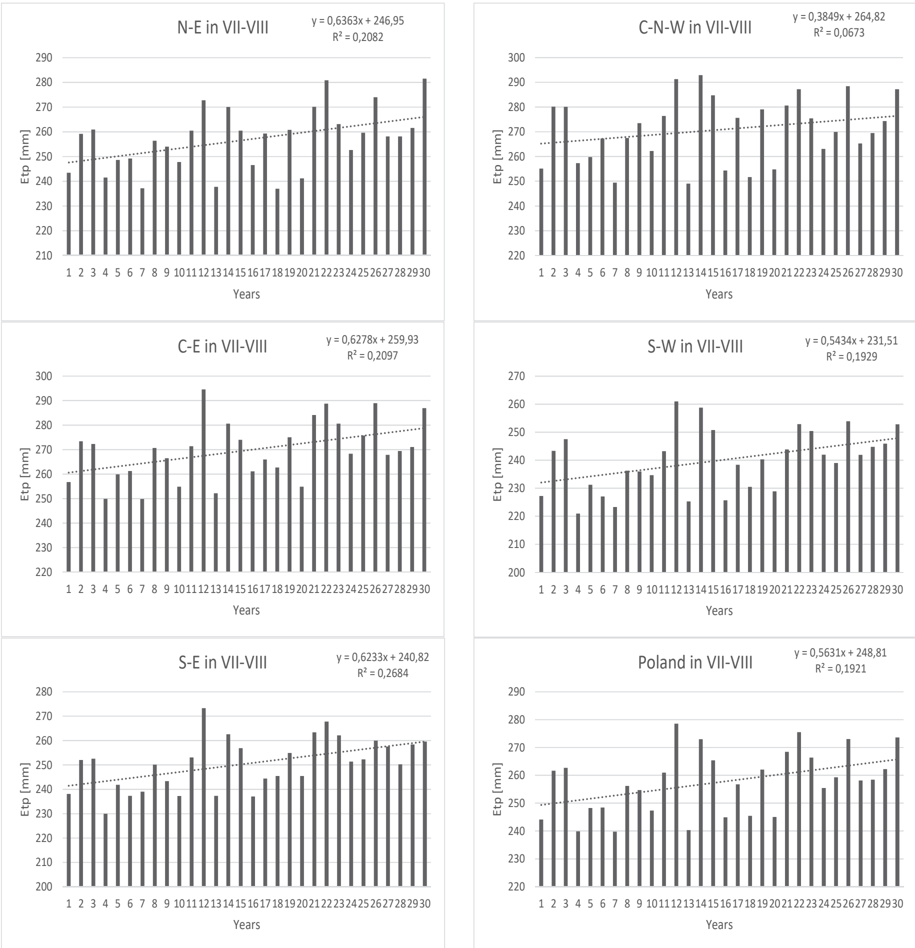
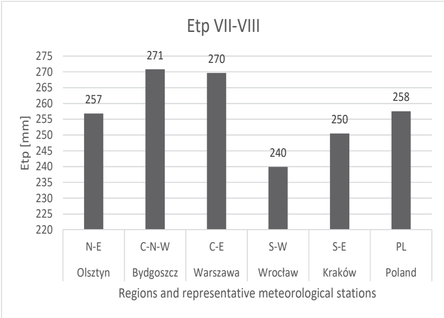



**Fig. 2.** Temporal variability of water needs of bird cherry plants, over three years after planting, in July and August, in the different regions of Poland



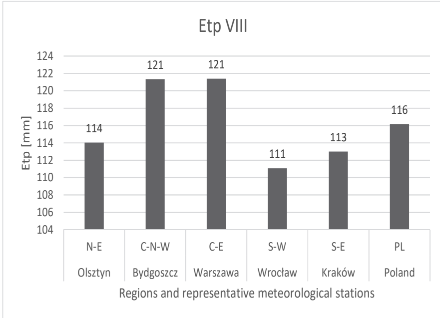




**Fig 3.** Water needs (Etp) of bird cherry, over three years after planting, in the period from July 1 to August 31 and in August in the different regions of Poland

On average, in the years 1981-2010, the highest water needs (Etp) of bird cherry trees, over three years after planting, in the period from July 1 to August 31, was noted in the C-N-W (271 mm) and C-E region (270 mm), while the lowest water requirements (240 mm) in the S-W region of Poland was calculated (Fig. 3). In August, the highest bird cherry water needs (121 mm) also in the C-N-W and C-E region of Poland were estimated, whereas the smallest water requirements (111 mm) in the S-W region of the country was observed. For comparison, the water needs of bird during the first three years after planting in the period of July-August, calculated as the long-term average from the years 1981-2010 for five different regions of Poland, was 233 mm (Rolbiecki et al. 2018 b). The highest water requirements of young bird cherry plants were estimated in the C-N-W (242 mm) and C-E (241 mm) region of Poland, while the lowest water needs were noted in the N-E (229 mm) and S-E (223 mm) region of the country.

Generally, in the present study, throughout Poland, a visible increase in water requirements of bird cherry plants in August were noted (Fig. 4). In every considered region of Poland, except the C-N-W region, the temporal variability of bird cherry water needs was significant. That confirm the results published by Rolbiecki et al. (2018 b).

In the years 1981-2010, the highest increase (by 2.1 mm in each ten-year period) of the bird cherry water requirements in August was noted in the N-E and S-E region of Poland. Non-significant upward trend of the bird cherry water needs in the C-N-W region of the country was only 1.2 mm. On average, in the thirty-year period from 1981 to 2010, throughout Poland, the water requirements of bird cherry plants, over three years after planting, in August increased by 1.8 mm in each subsequent ten-year period.

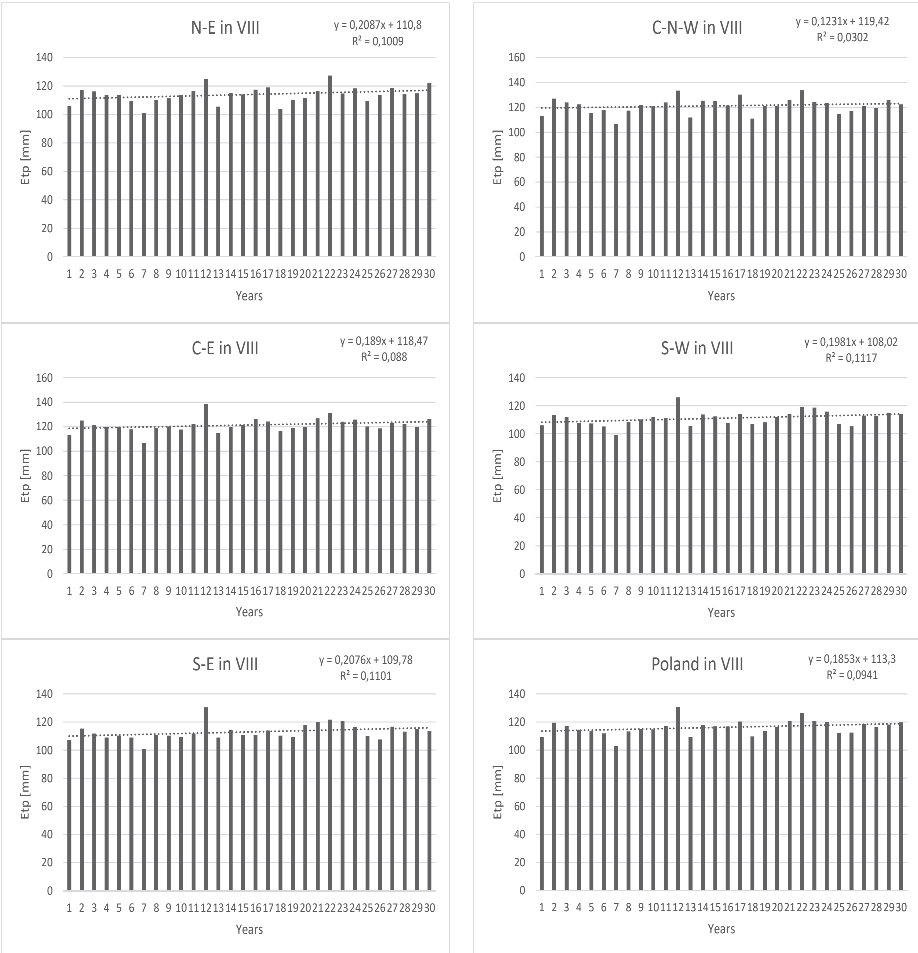



**Fig. 4.** Temporal variability of bird cherry water needs, over three years after planting, in August in the different regions of Poland

In the period from July 1 and August 31, the highest precipitation deficiencies, 131 and 133 mm, in the average dry years ($N_{50\%}$) were noted in the C-E and C-N-W region of Poland, respectively (Table 2). In the N-E, C-N-W and C-E region of the country, the rainfall deficit in the medium dry years ($N_{25\%}$ ranging from 206 to 214 mm) and in the very dry years ($N_{10\%}$ ranging from 269 to 300 mm) was higher than in the S-W and S-E region of Poland ($N_{25\%}$ ranging from 146 to 159 mm and $N_{10\%}$ ranging from 195 to 211 mm). It should be reminded that according to Żakowicz et al. (2009), the value of $N_{10\%}$ covers the water needs of the plants in 90% and thus the value of $N_{50\%}$ covers the plant water needs in 50%.

A similar tendency was observed in August, when also the highest rainfall deficit ($N_{50\%}$ ranging from 49 to 61 mm, $N_{25\%}$ ranging from 74 to 87 mm and $N_{10\%}$ ranging from 94 to 133 mm) in N-E, C-N-W and C-E region of Poland was noted, while much lower precipitation deficiencies ($N_{50\%}$ ranging from 36 to 42 mm, $N_{25\%}$ ranging from 56 to 58 mm and $N_{10\%}$ ranging from 65 to 75 mm) occurred in the S-E and S-E region of the country.

**Table 2.** Rainfall deficit of bird cherry plants, over three years after planting, in the period of the highest water needs (July-August) in the different regions of Poland (mm)

| Rainfall deficit | Region of Poland | | | | |
|---|---|---|---|---|---|
| | N-E | C-N-W | C-E | S-W | S-E |
| July-August | | | | | |
| $N_{50\%}$ | 118 | 133 | 131 | 91 | 85 |
| $N_{25\%}$ | 206 | 208 | 214 | 146 | 159 |
| $N_{10\%}$ | 274 | 269 | 300 | 211 | 195 |
| August | | | | | |
| $N_{50\%}$ | 49 | 61 | 59 | 42 | 36 |
| $N_{25\%}$ | 82 | 74 | 87 | 58 | 56 |
| $N_{10\%}$ | 126 | 94 | 133 | 75 | 65 |

According to the study reported by Rolbiecki et al. (2018 b), throughout Poland, during the period from July 1 to August 31, in the years 1981-2010, the average rainfall deficit in the growing of bird cherry plants during the first three years after planting was 87 mm. Additionally, the highest precipitation deficiencies in the C-N-W (103 mm) and C-E (102 mm) region of Poland, was calculated.

In the present study, a visible increase in bird cherry water requirements calculated for the period from July 1 to August 31, in the years 1981-2010, was noted in all considered regions of Poland. Similar observations have already been published by Łabędzki (2009) and Rolbiecki et al. (2018 b). Researchers involved in studying the water needs of the plants consider that the observed climatic changes will result, in the near future, in an increase of the water requirements of most plant species, including also reclamation plantings. Therefore, it is necessary to undertake some adaptation activities, such as developing a program of irrigation techniques, the meaning of which will grow with the intensification of climate changes (Łabędzki 2009, Stachowski 2009, Stachowski & Markiewicz 2011, Kuchar & Iwanski 2011, 2013, Żarski et al. 2013, Kuchar at al. 2015, 2017, Rolbiecki et al. 2018 a).

The survival rate of the plants introduced to the reclaimed areas depends, on the one hand, on the selection of suitable species of trees and shrubs, and on the other hand, on the ensuring suitable soil moisture by applying the irrigation treatments (Żakowicz 2010). Irrigation is considered as one of the most important melioration techniques that guarantee the proper growth of the trees and shrubs seedlings in the plantings and cultivations carried out, among others, in the different plantings and forest nurseries (Rzekanowski & Pierzgalski 2006, Ptach et al. 2018). The results of the present study may be helpful in planning and programming of the bird cherry plants irrigation treatments. The usefulness of the micro-irrigation system in the bird cherry nest reclamation plantings have been confirmed also by Żakowicz (2010), as well as Żakowicz & Hewelke (2012).

The bird cherry plants, on the one hand belong to the species that tolerate the wide types of the soil (Houston Durrant & Caudullo 2016), on the other hand, bird cherry is not drought and shade tolerant plant (USDA 2002). The bird cherry trees especially often inhabit the soils with mobile water, as well as the marshy meadows (Lasota et al. 2014). The results of some experiments carried out in the region of Bydgoszcz indicate a positive effect of irrigation – often also in interaction with other irrigation treatments i.e. revitalization – on the growth of seedlings of many trees species, among others such as: Scots pine (Klimek et al. 2008), white birch (Klimek et al. 2009), European larch (Klimek et al. 2011), littleleaf linden (Klimek et al. 2013) and paulownia (Ptach et al. 2018).

## 4. Conclusions

1. In the years 1981-2010, in the period from July 1 to August 31, the highest water needs of bird cherry trees over three years after planting, grown on the reclaimed areas, were estimated in the central-north-west (271 mm) and central-east (270 mm) region of Poland, while the lowest (240 mm) – in the south-east region of the country.
2 In August, the highest bird cherry plants water requirements (121 mm) were calculated in the central-north-west and central-east region of Poland, while the lowest (111 mm) – in the south-east region of the country.
3. A visible increase in bird cherry water needs in the period of the highest water requirements (July-August), in the years 1981-2010, was noted in all considered regions of Poland. With the exception of the central-north-west region of the country, the temporal variability of bird cherry water requirements was significant throughout Poland. The highest increase of the bird cherry water needs (by 6.7 mm per every ten years) was found in the south-east region of Poland.
4. In the period of July and August, the highest rainfall deficit, 131 and 133 mm, in the average dry years ($N_{50\%}$) was noted in the central-east and central-north-west region of Poland, respectively. In the north-east, central-north-west and

central-east region of the country, the precipitation deficiencies in the medium dry years ($N_{25\%}$ ranging from 206 to 214 mm) and in the very dry years ($N_{10\%}$ ranging from 269 to 300 mm) was higher than in the south-west and south-east region of Poland ($N_{25\%}$ ranging from 146 to 159 mm and $N_{10\%}$ ranging from 195 to 211 mm).

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**Abstract**

The purpose of the present study was to determine the water needs of bird cherry (*Padus avium* Mill.) over three years after planting on the reclaimed areas. The estimations were performed for the period of two months, including July and August, which are critical in terms of the amount of water available to the plants. The water requirements of bird cherry plants were calculated in the years 1981-2010 for five agro-climatic regions of Poland with the representative meteorological stations located in Olsztyn, Bydgoszcz, Warsaw, Wrocław and Krakow. The bird cherry water needs were determined using the plant coefficient method. The plant coefficients for bird cherry trees over three years after planting were adapted to the reference evapotranspiration that was calculated using the Blaney-Criddle's formula, modified for Polish conditions by Żakowicz. The rainfall deficit with the probability of occurrence of average dry years ($N_{50\%}$), medium dry years ($N_{25\%}$) and very dry years ($N_{10\%}$) was determined according to the Ostromęcki's method. On average, in the years 1981-2010, in July and August, the highest water needs of bird cherry trees, grown on the reclaimed areas over three years, were estimated in the central-north-west (271 mm) and central-east (270 mm) region of Poland. While, the lowest water requirements of bird cherry (240 mm) in the south-east region of the country was calculated. In August, the highest bird cherry water needs (121 mm) were estimated also in the central-north-west and central-east region of Poland, whereas the lowest water requirements (111 mm) occurred in the south-east region of the country. In each considered region of Poland, in the years 1981-2010, a visible increase in bird cherry water needs in the period of the highest water requirements, was noted. With the exception of the central-north-west region of the country, the temporal variability of bird cherry water needs was significant throughout Poland. The highest increase of the water requirements (by 6.7 mm per every ten-year period) in the south-east region of Poland was found. In the period covering July and August, the highest rainfall deficit, 131 and 133 mm, in the average dry years ($N_{50\%}$) was noted in the central-east and central-north-west region of Poland, respectively. In the north-east, central-north-west and central-east region of the country, the rainfall deficit in the medium dry years ($N_{25\%}$ ranging from 206 to 214 mm) and very dry years ($N_{10\%}$ ranging from 269 to 300 mm) was higher than in the south-west and south-east region of Poland ($N_{25\%}$ ranging from 146 to 159 mm and $N_{10\%}$ ranging from 195 to 211 mm).

**Keywords:**
crop evapotranspiration, *Padus avium* Mill., precipitation deficit,
reference evapotranspiration, water requirements

# Potrzeby wodne czeremchy zwyczajnej w okresie powyżej trzech lat po nasadzeniach rekultywacyjnych w różnych regionach Polski


## Streszczenie

Celem przedstawionych badań było oszacowanie zapotrzebowania na wodę czeremchy zwyczajnej (*Padus avium* Mill.) w okresie powyżej trzech lat po wykonaniu nasadzeń na obszarach objętych rekultywacją. Obliczenia przeprowadzono dla okresu obejmującego dwa miesiące, lipiec i sierpień, które są krytyczne pod względem ilości wody dostępnej dla roślin. Wymagania wodne roślin czeremchy zwyczajnej zostały oszacowane w latach 1981-2010 dla pięciu agro-klimatycznych regionów Polski wraz z reprezentatywnymi stacjami meteorologicznymi zlokalizowanymi w Olsztynie, Bydgoszczy, Warszawie, Wrocławiu i Krakowie. Potrzeby wodne drzew czeremchy zwyczajnej zostały określone za pomocą metody współczynników roślinnych. Współczynniki roślinne dla drzew czeremchy zwyczajnej w okresie powyżej trzech lat po wykonaniu nasadzeń na obszarach objętych rekultywacją dostosowano do ewapotranspiracji wskaźnikowej, którą obliczono za pomocą wzoru Blaneya-Criddle'a, zmodyfikowanego dla warunków polskich przez Żakowicza. Niedobory opadów atmosferycznych z prawdopodobieństwem wystąpienia roku przeciętnie suchego (N50%), roku średnio suchego (N25%) oraz roku bardzo suchego (N10%) oznaczono za pomocą metody Ostromęckiego. Średnio, w latach 1981-2010, w okresie od 1 lipca do 31 sierpnia, najwyższe zapotrzebowanie na wodę drzew czeremchy zwyczajnej w okresie powyżej trzech lat po wysadzeniu na obszarach zrekultywowanych obliczono w centralno-północno-zachodnim (271 mm) oraz centralno-wschodnim regionie Polski (270 mm). Z kolei najniższe zapotrzebowanie na wodę czeremchy zwyczajnej (240 mm) wystąpiło w południowo-wschodnim regionie kraju. W sierpniu najwyższe zapotrzebowanie na wodę drzew czeremchy zwyczajnej (121 mm) obliczono również w centralno-północno-zachodnim oraz centralno wschodnim regionie Polski, natomiast najniższe zapotrzebowanie na wodę (111 mm) wystąpiło w południowo-wschodnim regionie kraju. We wszystkich rozpatrywanych regionach Polski, w okresie od 1981 do 2010, odnotowano tendencję do zwiększania się potrzeb wodnych czeremchy zwyczajnej w czasie największego zapotrzebowania na wodę, czyli w lipcu i w sierpniu. Z wyjątkiem centralno-północno-zachodnim regionu Polski, trend zmienności czasowej potrzeb wodnych czeremchy zwyczajnej był istotny we wszystkich pozostałych regionach kraju. Najwyższy wzrost zapotrzebowania na wodę (o 6,7 mm w każdym kolejnym dziesięcioleciu) wystąpił w południowo-wschodnim regionie Polski. W okresie od 1 lipca do 31 sierpnia największe niedobory opadów atmosferycznych, 131 i 133 mm, w przeciętnie suchym roku (N50%) odnotowano odpowiednio w środkowo-wschodnim oraz środkowo północno-zachodnim regionie Polski. W północno-wschodnim, środkowo-północno-zachodnim i środkowo-wschodnim regionie kraju niedobory opadów atmosferycznych w średnio suchym roku (N25% w zakresie od 206 do 214 mm) i w bardzo suchym roku (N10% w przedziale od 269 do 300 mm) był wyższy niż w południowo-zachodnim i południowo-wschodnim regionie Polski (N25% od 146 do 159 mm i N10% od 195 do 211 mm).



**Słowa kluczowe:**
niedobory opadów, *Padus avium* Mill., potencjalna ewapotranspiracja, potrzeby wodne, wskaźnikowa evapotranspiracja