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Water Requirements of Bird Cherry (*Padus avium* Mill.)

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1. Introduction

In the aspect of human influence on the environment, we usually mean the negative impact of man activity on nature. Post-industrial areas that are heavily degraded particularly threaten people's health and life. Meanwhile, as a result of industrial activity, man unconsciously created new habitats, which often became an enclave for many plant and animal species that are interesting research objects. The side effects of minerals exploitation are heaps and landfills of industrial waste. These areas create the conditions for primary succession, where there is no soil layer rich in nutrients and groundwater, and rainwater quickly penetrates deep into the ground. Poor in minerals and quickly drying soil of dumps and landfills of industrial waste are not conducive to the spontaneous development of vegetation, especially since these areas are also devoid of a natural reser-

voir of seeds. Years ago, heaps and landfills of industrial waste were considered as a "biological deserts", where plants are unable to survive or their growth is very slow. However, it turned out that post-industrial areas, despite difficult conditions, are effectively colonized by plants. The long-term lack of vegetation management on the post-industrial areas favors the succession of plants, which usually after a few years leads to the formation of a strong plant cover.

One of the dominant plant species that spontaneously invades post-industrial areas is bird cherry (*Padus avium* Mill.). Bird cherry, also called hackberry, hagberry or Mayday tree, is a medicinal and ornamental plant. Its flowers, fruits and bark are used in herbal medicine (Podbielkowski 1989). The bird cherry trees are planted in parks and along roads, and also used in landscape or reclamation plantations. The first three years after planting determines the seedling survival rate of the introduced plants (Żakowicz 2010). However, the seedling survival rate during the first period of growth depends mainly on the suitable soil water conditions that should be controlled using a properly designed and operated irrigation system.

The aim of the present research was to assess the water requirements of bird cherry during the first three years after planting.

2. Material and Methods

In the present study, as a measure of the bird cherry (*Padus avium* Mill.) water needs, the potential evapotranspiration (Etp) of the plants was calculated. The formula of Blaney-Criddle, modified by Żakowicz (2010) for Polish conditions, by using the adjusted crop coefficients, was applied. The values of crop coefficients are similar in the first, second and third year after planting and range from 0.70 in April to 0.95 in October. It was assumed that the growing season of bird cherry starts on April 1 and ends on October 31.

The calculations were carried out for five agro-climatic regions of Poland in the years 1981-2010. The borders of studied regions and the corresponding representative meteorological stations were adapted according to Łabędzki et al. (2013) recommendation. The north-eastern region – with the station in Olsztyn – includes the following provinces: Podlaskie, Warmian-Masurian and Pomeranian. The central-northwestern region – with the station in Bydgoszcz – includes the following

provinces: West Pomeranian, Kuyavian-Pomeranian, Łódź, Lubusz and Greater Poland. The central-eastern region – with the station in Warsaw – includes the following provinces: Masovian, Holy Cross and Lublin. The south-western region – with the station in Wrocław – includes the following provinces: Lower Silesian, Opole and Silesian. The south-eastern region – with the station in Krakow – includes the following provinces: Lesser Poland and Subcarpathian (Fig. 1). The rainfall deficiency (or excess) during the period from April to October was calculated based on the difference between the water needs of bird cherry (showed as potential evapotranspiration for this period) and the precipitation totals.

Fig. 1. Agro-climatic regions of Poland with the representative meteorological stations (according to Łabędzki et al. 2013)
Fig. 1. Regiony agro-klimatyczne w Polsce z reprezentatywnymi stacjami meteorologicznymi (według Łabędzki i in. 2013)

The water requirements variability of bird cherry during the first three years of growing in reclamation plantings during the growing period (April-October) was low, because the coefficient of variation ranged from 2.7 to 2.9%. The higher variability of water needs occurred in the period of the highest water requirements (July-August), when the coefficient of variation varied from 4.1 to 4.7% (Table 1).

Table 1. Bird cherry water requirements during the growing period
Tabela 1. Wymagania wodne czeremchy w czasie sezonu wegetacyjnego

Specification	Region of Poland	Water requirements (mm)	
		July-August	April-October
Mean	north-eastern	229	531
	central-north-western	242	566
	central-eastern	241	567
	south-western	230	549
	south-eastern	223	534
Minimum	north-eastern	211	495
	central-north-western	222	531
	central-eastern	223	531
	south-western	212	518
	south-eastern	205	508
Maximum	north-eastern	251	565
	central-north-western	261	599
	central-eastern	263	604
	south-western	251	582
	south-eastern	244	561
Median	north-eastern	231	534
	central-north-western	242	566
	central-eastern	241	566
	south-western	232	550
	south-eastern	225	537

Table 1. cont.
Tabela 1. cd.

Specification	Region of Poland	Water requirements (mm)	
		July-August	April-October
Standard deviation	north-eastern	10.7	15.1
	central-north-western	11.4	15.6
	central-eastern	10.5	15.8
	south-western	10.3	15.6
	south-eastern	9.3	15.4
Variability coefficient (%)	north-eastern	4.6	2.8
	central-north-western	4.7	2.7
	central-eastern	4.4	2.8
	south-western	4.5	2.8
	south-eastern	4.1	2.9

3. Results and Discussion

The water needs of bird cherry in the period July-August estimated as the long-term average from the years 1981-2010 for the five regions of Poland was 233 mm. The highest water requirements were calculated in the central-north-western (242 mm) and central-eastern (241 mm) regions. The lowest water needs were noted in the north-eastern (229 mm) and south-eastern (223 mm) regions (Fig. 2).

The average water requirements of bird cherry, calculated for the period July-August in the years 1981-2010, presented the increasing tendency in all studied regions of Poland; but the values of deretmination coefficients were low. Additionally, the temporal variability of water needs, with the exception of the central-north-western region, was significant for all considered regions. In each subsequent decade of the studied thirty years, the water requirements of bird cherry increased in the period from July 1 to August 31 in the range from 5.2 to 5.7 mm in the south-western and north-eastern regions, respectively. On average, in the years 1981-2010 in all investigated regions of Poland, the water needs of bird cherry increased in the period July-August by 5.1 mm per decade. In the central-north-western region the rising tendency of bird cherry water requirements was not significant and amounted 3.4 mm per decade (Fig. 3).

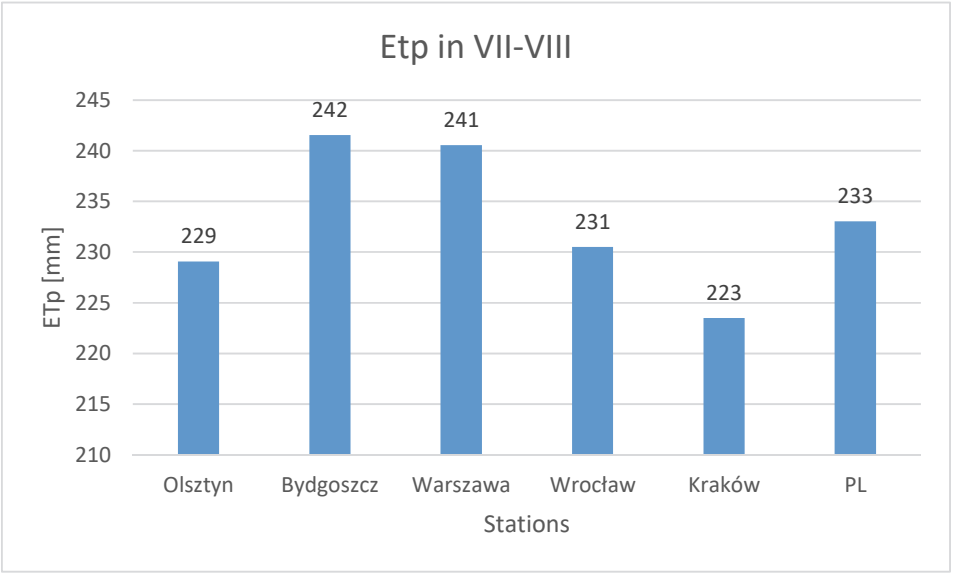

Fig. 2. Water needs (Etp) of bird cherry in the period of the highest water requirements (July-August) in the different regions of Poland
Fig. 2. Potrzeby wodne (Etp) czeremchy zwyczajnej w okresie największego zapotrzebowania na wodę (lipiec-sierpień) w różnych regionach Polski

The relationship between precipitation totals and rainfall deficiency (or excess) in the period July-August are presented in Figure 4. In the north-eastern and central-eastern regions, as well as, on average in Poland, during 29 out of 30 considered years, the precipitation deficit was observed. In the south-eastern region, the rainfall deficiency occurred during 25 years, in the south-western region during 27 years and in the central-north-western region during 28 years.

The long-term (1981-2010) average precipitation deficit for bird cherry in Poland during the period July-August amounted to 87 mm. The highest rainfall deficiency in this period occurred in the central-north-western (103 mm) and central-eastern (102 mm) regions. The lower precipitation deficit was observed in the north-eastern and south-western regions, 90 and 82 mm, respectively. Finally, the lowest rainfall deficiency (58 mm) in the south-eastern region was estimated (Fig. 5).

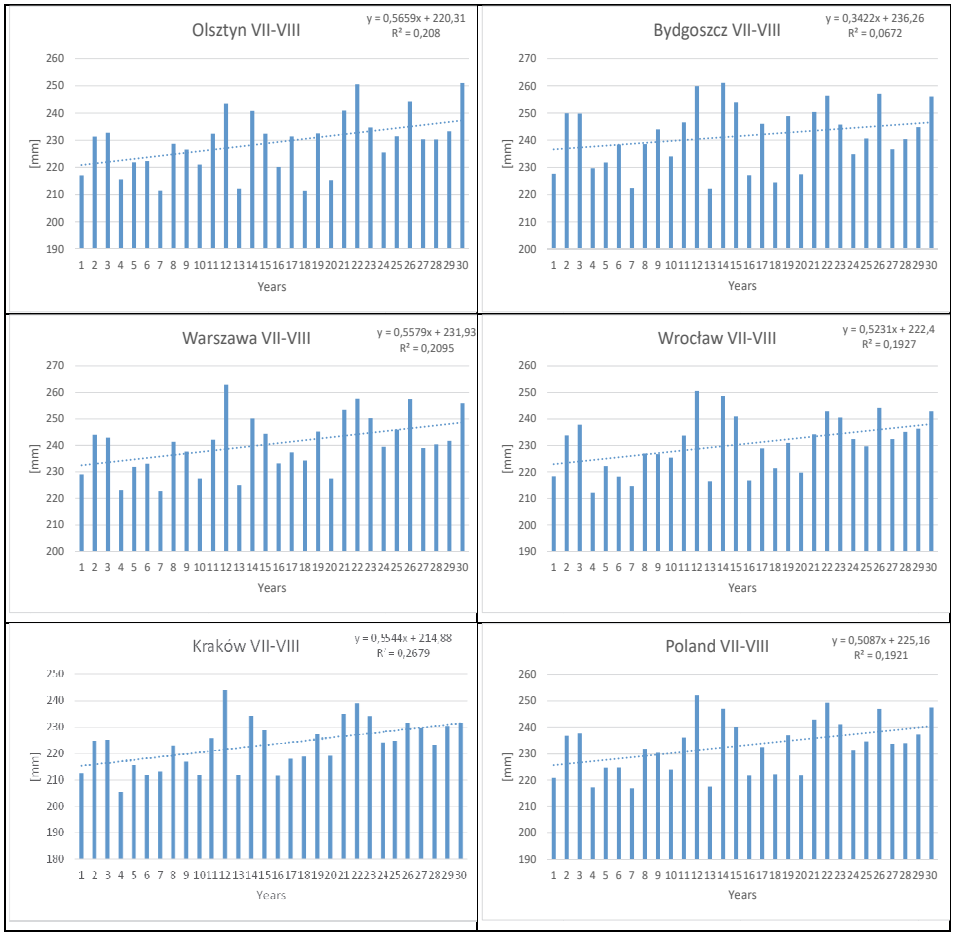

Fig. 3. Temporal variability of bird cherry water needs (Etp) in the period July-August in the different regions of Poland
Fig. 3. Trend czasowy potrzeb wodnych (Etp) czeremchy w lipcu i sierpniu w różnych regionach Polski

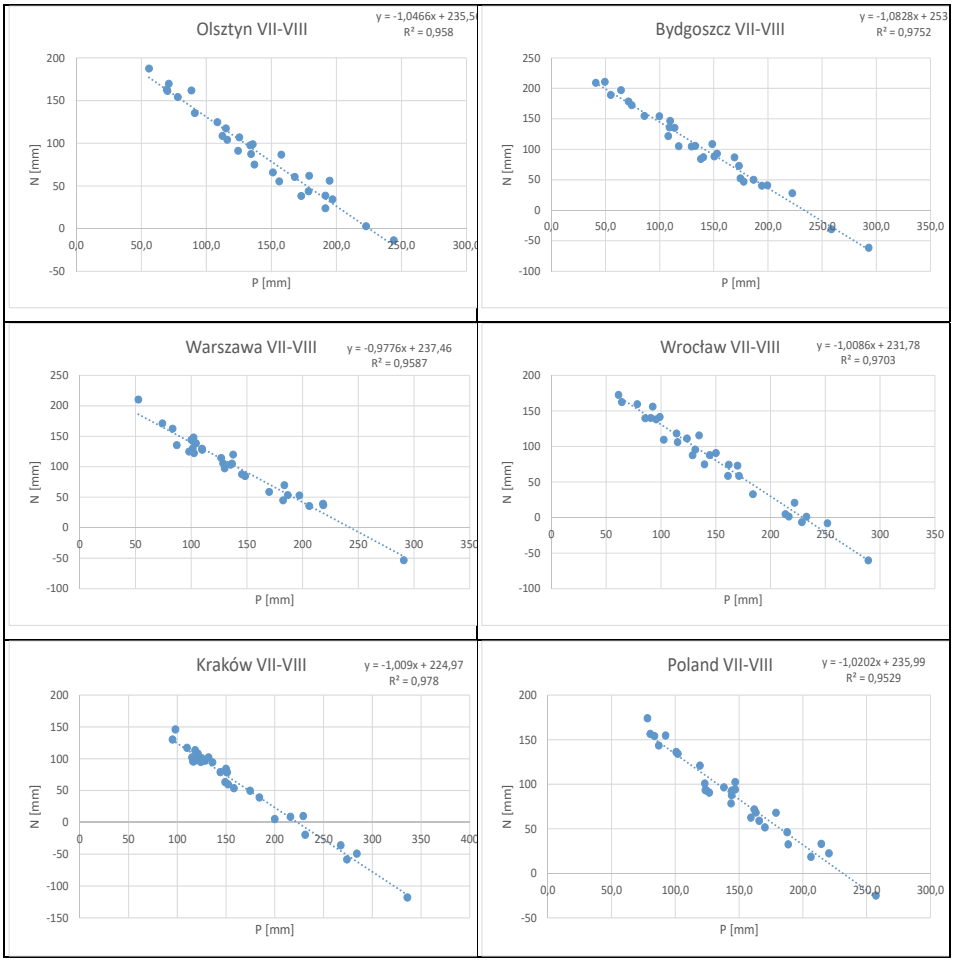

Fig. 4. Relationship between rainfall totals and rainfall deficiency (or excess) for bird cherry in the period July-August in the different regions of Poland
Fig. 4. Zależność pomiędzy sumami opadów a niedoborami (lub nadmiarami) opadów dla czeremchy w lipcu i w sierpniu w różnych regionach Polski

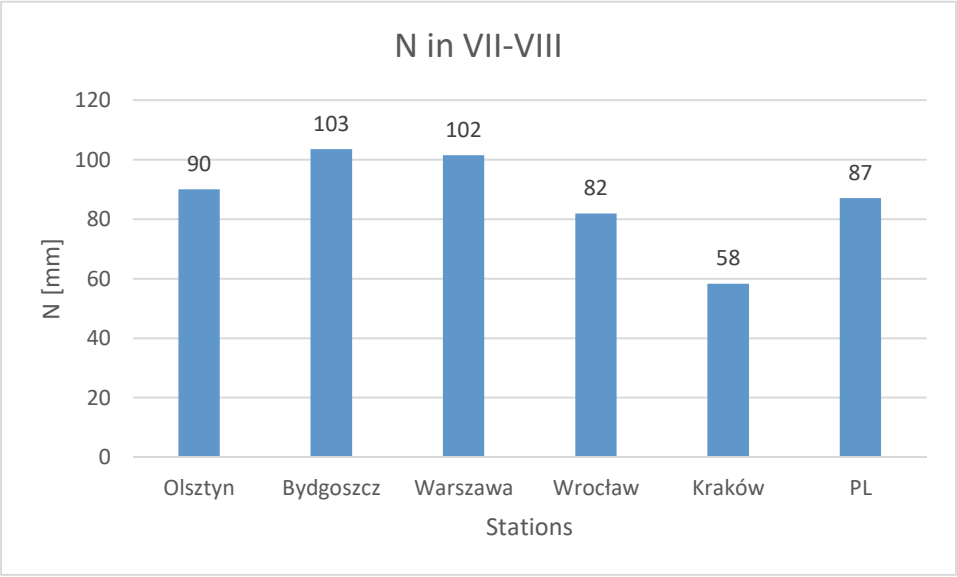

Fig. 5. Long-term (1981-2010) average rainfall deficiency (N) in the growing of bird cherry in the period July-August in the different regions of Poland
Fig. 5. Średnie z wielolecia (1981-2010) niedobory opadów (N) w uprawie czeremchy w okresie od lipca do sierpnia w różnych regionach Polski

In August, the water requirements of bird cherry increased in all studied regions of Poland. The temporal variability of water needs was significant in the north-eastern, south-western and south-eastern regions; however, the values of deretmination coefficients were low. Whereas in the central-north-western and central-eastern regions, non-significant dependencies were noted (Fig. 6).

On average, in the years 1981-2010, the highest water requirements in August (110 mm) were observed in the central-north-western and central-eastern regions. While the lowest water needs (102 mm) were found in the south-eastern region (Fig. 7).

Figure 8 presents the relationship between precipitation totals and rainfall deficiency (or excess) in August. In the central-north-western and central-eastern regions, precipitation deficit occurred in 93% of the studied years, in the north-eastern and south-western regions in 26 years (87%), whilst in the south-eastern region in 24 years (80%).

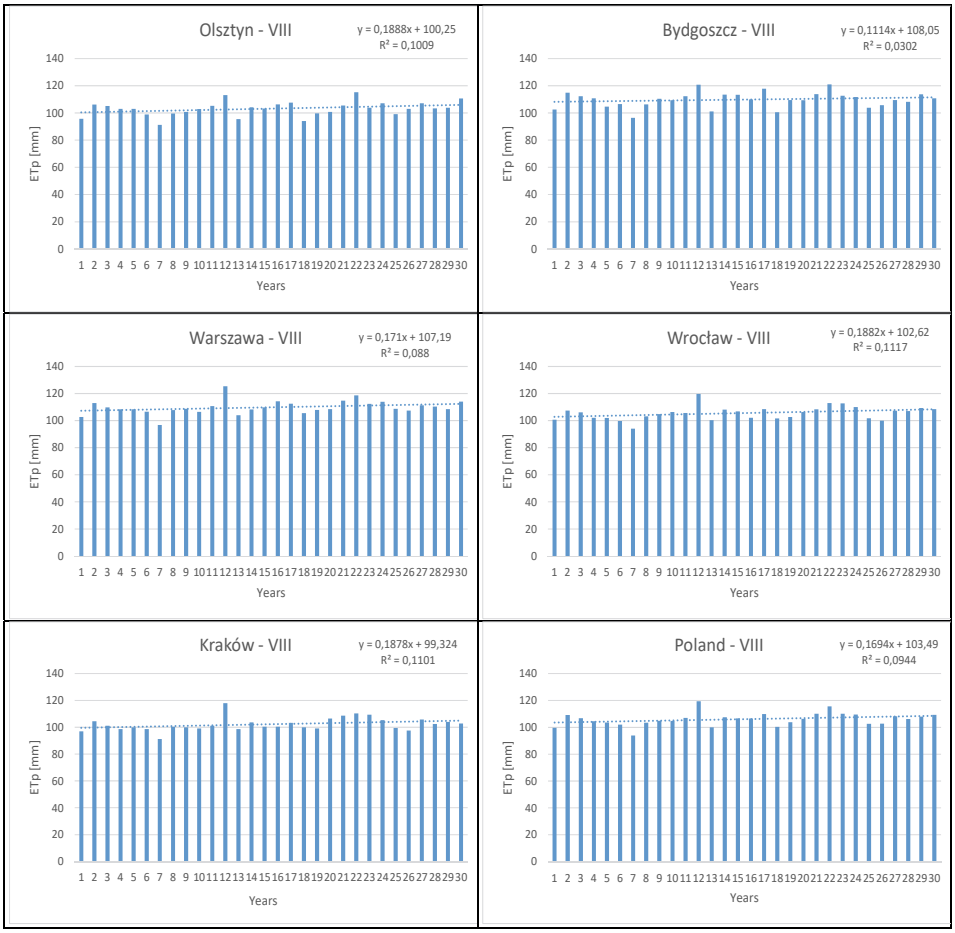

Fig. 6. Temporal variability of bird cherry water needs (Etp) in August in the different regions of Poland
Fig. 6. Trend czasowy potrzeb wodnych (Etp) czeremchy w sierpniu w różnych regionach Polski

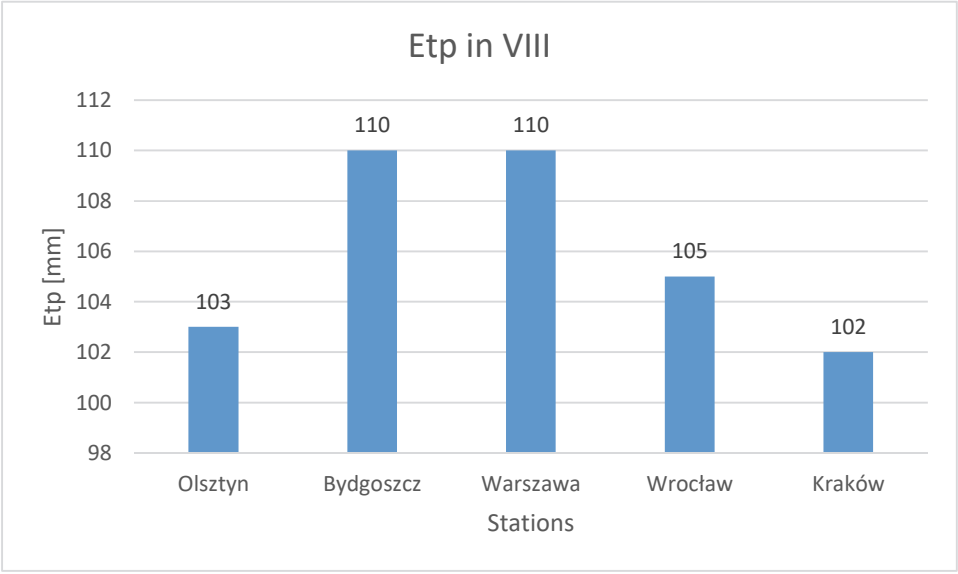

Fig. 7. Long-term (1981-2010) average water needs (Etp) of bird cherry in August in the different regions of Poland
Fig. 7. Średnie z wielolecia (1981-2010) potrzeby wodne czeremchy w sierpniu w poszczególnych regionach Polski

In August, the average rainfall deficiency in Poland during the years 1981-2010 amounted to 40 mm. The precipitation deficits, higher than the long-term average, were noted in the central-north-western (50 mm) and central-eastern (47 mm) regions. Comparing to the long-term average from the years 1981-2010, lower rainfall deficiency (25 mm) was found in the south-eastern region (Fig. 9).

The results of the present research confirm the reports published by Łabędzki (2009), Stachowski (2009), Stachowski & Markiewicz (2011), Żarski et al. (2013) and Rolbiecki et al. (2018), noted the highest irrigation requirements to supplement the precipitation deficit just in the central Poland, so in the region where the rainfall deficiency is the highest.

The presented observations may be useful in the irrigation arrangement of bird cherry during the first three years after planting. The plants introduction to on the reclamation area requires, on the one hand, the properly selected species; on the other hand, the adequate amount of water replenished by irrigation system. The effectiveness of the irrigation treatments during the introduction of bird cherry to on the reclamation areas has been reported by Żakowicz (2010) and Żakowicz & Hewelke (2012).

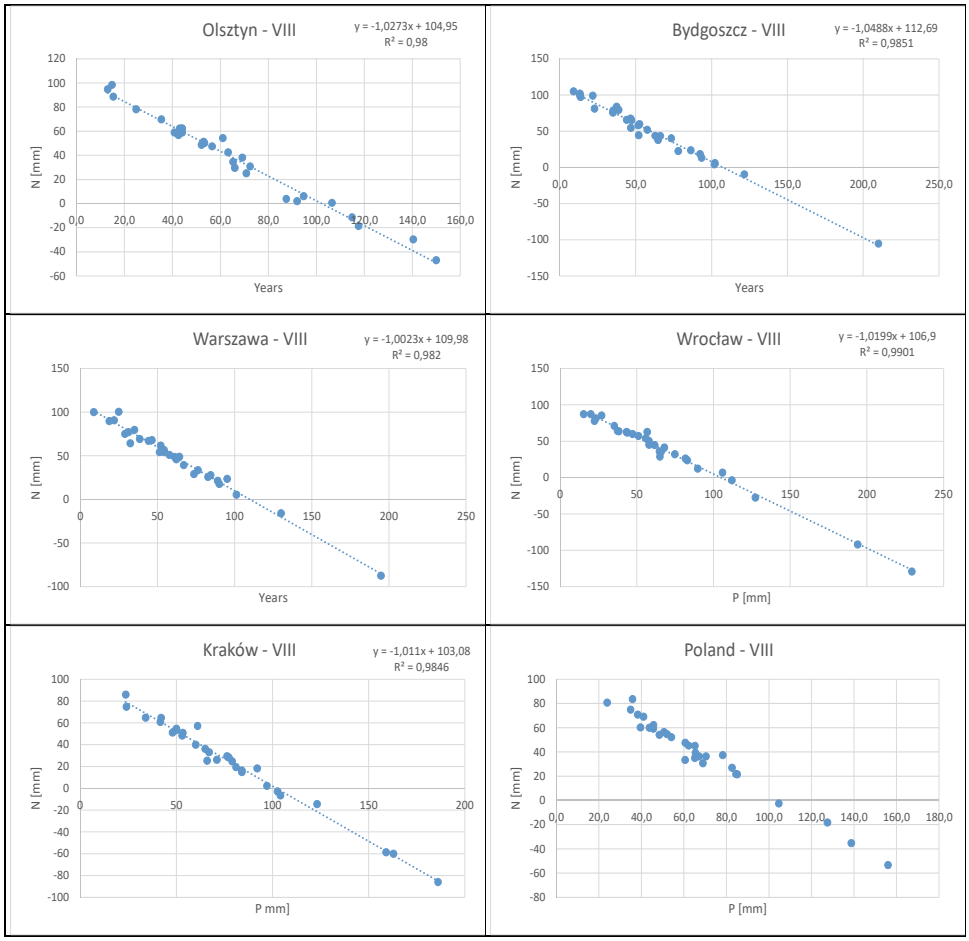

Fig. 8. Relationship between precipitation totals and rainfall deficiency (or excess) for bird cherry in August in the different regions of Poland
Fig. 8. Zależność pomiędzy sumami opadów a niedoborami (lub nadmiarami) opadów w sierpniu dla czeremchy w różnych regionach Polski

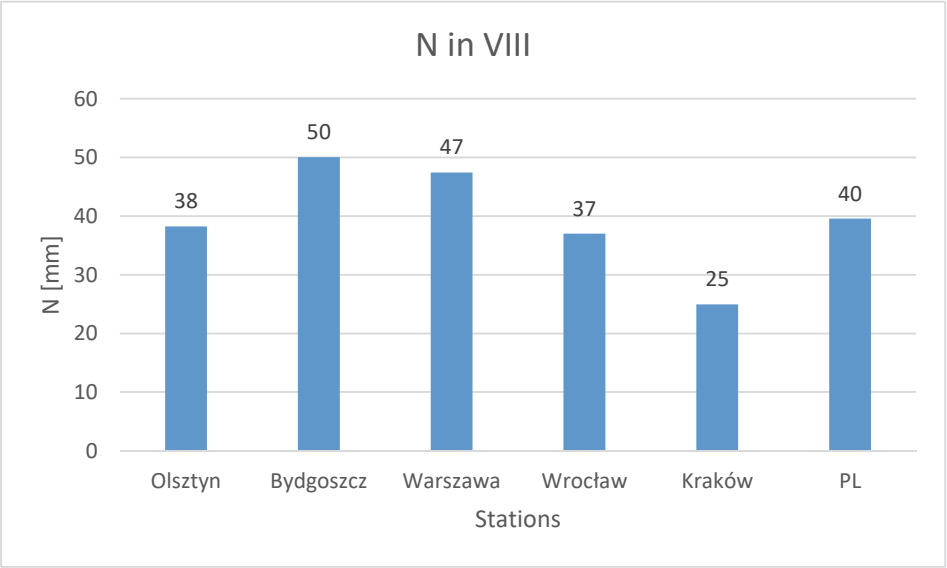

Fig. 9. Long-term (1981-2010) average rainfall deficiency (N) in the growing of bird cherry in August in the different regions of Poland
Fig. 9. Średnie z wielolecia (1981-2010) niedobory opadów (N) w uprawie czeremchy w sierpniu w różnych regionach Polski

The irrigation techniques are considered one of the most important melioration treatments that ensure the proper development and growth of trees and shrubs seedlings in the forest nurseries and other plantings (Rzekanowski & Pierzgalski 2006, Ptach et al. 2018). The results of the experiments performed in the region of Bydgoszcz, also confirmed a positive effect of micro-irrigation, as well other melioration revitalizing techniques, on the development of seedlings of many tree species, including Scots pine (Klimek et al. 2008), white birch (Klimek et al. 2009), European larch (Klimek et al. 2011) and littleleaf linden (Klimek et al. 2013).

Summarizing, the predicted climate changes indicate the increase of plant water requirements, including the reclamation plantings. Consequently, the adaptation activities will have to be undertaken; one of them is irrigation, the importance of which will gradually increase with the progress of climate changes (Kuchar & Iwanski 2011, Kuchar & Iwański 2013, Żarski et al. 2013, Kuchar et al. 2015, Kuchar et al. 2017, Łabędzki 2009).

4. Conclusions

1. The bird cherry water needs in the period of the highest water requirements (July-August) calculated as the long-term average from the years 1981-2010 for the five regions of Poland was 233 mm. The highest water needs (around 242 mm) in the period July-August occurred in the central-north-western and central-eastern regions. The lowest water requirements (227 mm) were noted in the north-eastern and south-eastern regions. In each subsequent decade of the studied long-term, a significant increasing tendency of the water needs in the period July-August by 5 mm was revealed.
2. The raise of the bird cherry water requirements in August was recorded in all studied regions of Poland. On average, in the studied long-term, the highest water requirements in August (110 mm) occurred in the central-north-western and central-eastern regions, while the lowest (102 mm) in the south-eastern region.
3. The highest rainfall deficiency in the period July-August was noted in the central-north-western (103 mm) and central-eastern (102 mm) regions, lower in the north-eastern (90 mm) and south-western (82 mm) regions, and the lowest (58 mm) in the south-eastern region.
4. During the studied long-term, the precipitation deficits in July-August were observed in 29 years in the north-eastern and central-eastern regions, in 28 years in the central-north-western region, in 27 years in the south-western region and in 25 years in the south-eastern region.
5. In August, the rainfall deficiency was noted in 93% of studied years in the central-north-western and central-eastern regions, in 87% of considered years in the north-eastern and south-western regions and in 80% of analyzed years in the south-eastern region.

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Potrzeby wodne czeremchy zwyczajnej (*Padus avium* Mill.)

Streszczenie

Czeremcha zwyczajna (*Padus avium* Mill.), nazywana również czeremchą pospolitą, jest rośliną leczniczą i ozdobną. Jej kwiaty, owoce i kora są wykorzystywane w ziołolecznictwie. Bywa sadzona w parkach i przy drogach, a także stosowana w zadrzewieniach krajobrazowych i rekultywacyjnych. Decydującym o wysokiej udatności nasadzeń jest zwłaszcza okres pierwszych trzech lat po nasadzeniu roślin wprowadzanych na dany teren. Wymaga to zapewnienia wystarczającej ilości wody poprzez dobrze zaprogramowane nawodnienia. Celem podjętych badań była próba oszacowania potrzeb wodnych czeremchy zwyczajnej w pierwszych trzech latach po nasadzeniu. Jako miarę zapotrzebowania wody przez rośliny przyjęto ewapotranspirację potencjalną. Wykorzystano do tego celu, zmodyfikowany dla warunków Polski przez Żakowicza (2010), wzór Blaney-Criddle'a, z użyciem dostosowanych do niego współczynników roślinnych. Przyjęto, że sezon wegetacyjny czeremchy zwyczajnej rozpoczyna się 1 kwietnia a kończy 31 października. Obliczenia przeprowadzono dla różnych regionów agro-klimatycznych Polski w latach 1981-2010. Niedobory (lub nadmiary) opadów w okresie kwiecień-październik obliczono z różnicy pomiędzy potrzebami wodnymi czeremchy, wyrażonymi, jako Etp dla tego okresu, a sumą opadów atmosferycznych. Potrzeby wodne czeremchy w okresie jej największego zapotrzebowania na wodę (lipiec-sierpień) w 5 regionach Polski wyniosły 233 mm. Największe potrzeby wodne w lipcu i w sierpniu, wystąpiły w dwóch regionach Polaki: środkowo-północno-zachodnim i środkowo-

wschodnim (około 242 mm). Najmniejsze potrzeby wodne (średnio 227 mm), stwierdzono w północno-wschodnim i południowo-wschodnim regionie Polski. W każdej dekadzie analizowanego wielolecia zaznaczyła się istotna tendencja wzrostu zapotrzebowania na wodę o 5 mm w okresie lipca i sierpnia. W badanym trzydziestoleciu, niedobory opadów w okresie lipiec-sierpień wystąpiły w 29 latach w regionach północno-wschodnim i środkowo-wschodnim, w regionie środkowo-północno-zachodnim w 28 latach, w południowo-zachodnim w 27 latach, a w południowo-wschodnim niedobory opadów wystąpiły w 25 latach. We wszystkich badanych regionach rozpatrywanego trzydziestolecia, zaznaczyła się tendencja do zwiększenia się potrzeb wodnych czeremchy w okresie wegetacji. Trend zmienności czasowej potrzeb wodnych był, z wyjątkiem regionu środkowo-północno-zachodniego, istotny w przypadku każdego regionu.

Abstract

Bird cherry (*Padus avium* Mill.) is a medicinal and ornamental plant. Its flowers, fruits and bark are used in herbal medicine. Bird cherry is planted in parks, along roads and also used in the landscape and reclamation plantations. The first three years after planting determines the seedling survival rate of introduced plants. During this period, the plants should have adequate soil moisture, which can be provided by the properly designed and operated irrigation system. The aim of the research was to assess the bird cherry water needs during the first three years after planting. As a measure of water requirements, the potential evapotranspiration (Etp) of the plants was applied. The modified for Polish conditions by Żakowicz (2010) Blaney-Criddle's formula using the adjusted crop coefficients was applied. It was assumed that the growing season of plants starts on April 1 and ends on October 31. The estimates were carried out for five agro-climatic regions of Poland during the years 1981-2010. The rainfall deficiency (or excess) in the period from April to October was calculated based on the difference between the plants water needs (showed as Etp) and the precipitation totals. The average water requirements of bird cherry in all studied regions during the period of the highest water needs (July-August) were 233 mm. The highest water requirements (around 242 mm) in the period July-August occurred in the central-north-western and central-eastern regions. The lowest water requirements (227 mm) were noted in the north-eastern and south-eastern regions. In each decade of the long-term, a significant rising tendency of water needs in the period July-August by 5 mm was noted. During the years 1981-2010, the rainfall deficiency in the period July-August occurred in 29 years in the north-eastern and central-eastern regions, in 28 years in the central-north-western region, in 27 years in the south-western region and in 25 years in

the south-eastern region. In all studied regions during the long-term, the increasing tendency of bird cherry water requirements during the growing season was noted. The temporal variability of bird cherry water needs, with the exception of the central-north-western region, was important for each region.

Słowa kluczowe:
hałdy, nawadnianie, poprzemysłowe tereny, rekultywacja, udatność nasadzeń

Keywords:
heaps, irrigation, post-industrial areas, reclamation, seedling survival rate