



## **COMPARISON OF WATER NEEDS AND PRECIPITATION DEFICIENCY DURING THE GROWING SEASON OF ASPARAGUS IN THE REGION OF BYDGOSZCZ AND WROCLAW**

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### ***Abstract***

The aim of the study was to compare the water requirements and the precipitation deficiencies during cultivation of asparagus in the period from June to August in the regions of Bydgoszcz and Wrocław. The water needs were calculated using the plant coefficient. The reference evapotranspiration was measured by Grabarczyk's method (1976). The coefficients  $k_c$ , determined for the Polish conditions by Rolbiecki (2013), were used to estimate the water requirements considered as the crop evapotranspiration. In the studied period (from June to August, 1996–2015), higher water requirements of asparagus were noted in the Wrocław region (366.1 mm) than in the Bydgoszcz region (288.5 mm). The monthly water needs in June, July and August were 69.8 mm, 128.8 mm and 167.5 mm, respectively, in the Wrocław region, and 55.5 mm, 98.5 mm and 134.5 mm, respectively, in the Bydgoszcz region. In July, the tendency to increase the water requirements in both observed regions was noted. The monthly crop evapotranspiration in July rose in each decade by 12.3 mm in the Bydgoszcz region and by 21.2 mm in the Wrocław region. In the 20-year study, the rainfall deficit in June and July during 11–13 years was noted. In August, the precipitation deficiencies were observed during 16 years in the Bydgoszcz region and during 19 years in the Wrocław

region. A higher rainfall deficit during the 20-year period under study was reported in the Wrocław region (128.5 mm) than in the Bydgoszcz region (87.0 mm). In August, the highest monthly precipitation deficiencies of 100.3 mm (Wrocław region) and 70.3 mm (Bydgoszcz region) were noted.

**Keywords:** *Asparagus officinalis* L., evapotranspiration, plant coefficient, rainfall deficit, water requirements

## INTRODUCTION

*Asparagus* (*Asparagus officinalis* L.) produces deep and strong root system, so it is classified as vegetable with relatively low sensitivity to soil water deficits (Kaniszewski 2005, 2006). On the other hand, asparagus grows well on the light soil that requires irrigation, although this species responds very positively to the irrigation treatment. It was noted that the drip irrigation applied during the post-harvest period (from June to August) significantly increased the marketable yield of asparagus in the next growing season (Rolbiecki 2013). However, in the literature no more information was found on the water requirements of asparagus during cultivation period. The research reported by Rolbiecki (2013) is the only one that, based on field experiments, studied the influence of irrigation on the asparagus growing. In order to evaluate the reference evapotranspiration of asparagus, Rolbiecki (2013) determined the plant coefficients  $k_c$  using Grabarczyk's model (1976). Finally, the plant coefficients  $k_c$  allows for the calculation of the crop evapotranspiration that indicated the water requirements of the asparagus plants.

The objective of the twenty-year period (1996-2015) of the research was to compare the water requirements and the precipitation deficiencies evaluated during growing of the asparagus in the period from June to August in the regions of Bydgoszcz and Wrocław.

## MATERIAL AND METHODS

In the research the mean decade values (periods of ten days for each month) of air temperature (°C), moisture deficiency (hPa) and total precipitation (mm), measured during the period from June to August (VI-VIII) in the years 1996-2015, were used. Meteorological data for the Bydgoszcz region were derived from standard meteorological measurements performed at Mochelek Research Station and analyzed at the Department of Land Melioration and Agrometeorology of University of Science and Technology in Bydgoszcz. Meteorological data for Wrocław region came from the Agro – and Hydrometeorology Observatory of the Wrocław University of Environmental and Life Sciences.

In the study, the water requirements of asparagus (*Asparagus officinalis* L.) were calculated using the plant coefficient method. The reference evapotranspiration was evaluated according to Grabarczyk's model (1976). The water needs of asparagus plants considered as the crop evapotranspiration were estimated using the coefficients  $k_c$  that was determined for the Polish conditions by Rolbiecki (2013) on the basis of many years of irrigation experiments. The deficit or surplus of rainfall in the period from June to August was calculated as the difference between the water requirements of asparagus – considered as  $E_{tp}$  for the particular month – and the total rainfall during that month.

The results were statistically estimated by the average, median, maximal and minimal values and the standard deviation (SD) as well the variability coefficient (VC). Furthermore, the calculations were made in order to determine possible trends in the water needs changes of asparagus in both studied regions using linear regression analysis with evaluation of determination coefficients. The relationships between the rainfall and the rainfall deficit or surplus during the asparagus cultivation in the particular month and particular region, were determined. The estimations were performed using Excel software.

## **RESULTS AND DISCUSSION**

In the region of Bydgoszcz, in each of the three studied months, the values of variability coefficient for the water requirements of asparagus plants, considered as the crop evapotranspiration, were higher than in the region of Wrocław (Table 1). The variability calculated for the monthly rainfall was higher than the variability measured for the crop evapotranspiration. The values of variability coefficient observed for the monthly precipitation ranged from 39.1% to 62.8% in the region of Bydgoszcz, and from 52.7% to 56.1% in the region of Wrocław.

In each observed month the rainfall was higher in the region of Wrocław than in the region of Bydgoszcz (Fig. 1). In July, the highest monthly precipitation of 85.2 mm in the region of Bydgoszcz and 100.7 mm in the region of Wrocław was noted. In August, the rainfall, measured as the mean for the years 1996-2015, was similar in both studied regions (64.2 mm in the region of Bydgoszcz and 66.2 mm in the region of Wrocław).

The water needs of asparagus plants increased in the following months (Fig. 2). Higher water requirements in the region of Wrocław than in the region of Bydgoszcz were observed. On average, in the years 1996-2015 the water needs of asparagus in the region of Bydgoszcz were 55.5 mm, 98.5 mm and 134.5 mm, while in the region of Wrocław they amounted to 69.8 mm, 128.8 mm and 167.5 mm, in June, July and August, respectively. Consequently, the total water requirements in the period from June to August were 288.5 mm in the region of Bydgoszcz and 366.1 mm in the region of Wrocław. In the study reported

by Paschold *et al.* (2004) the water consumption of the asparagus plants grown under lysimetric conditions ranged from 266 mm to 292 mm. In turn, according to Pardo *et al.* (1997) the water consumption of the asparagus plants cultivated under lysimetric conditions ranged from 274 mm to 294 mm.

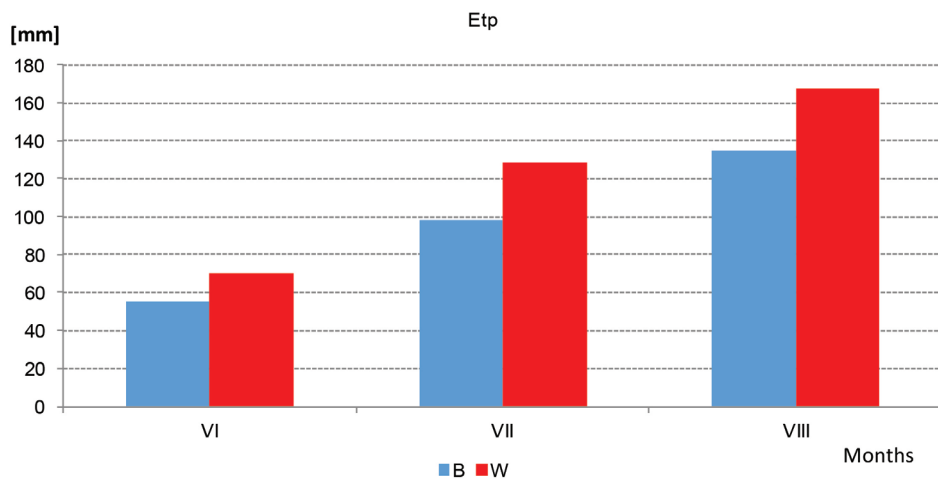
**Table 1.** Water requirements of the asparagus crop and the rainfall in the years 1996-2015

Specification	Water requirements (mm)			Rainfall (mm)		
	VI	VII	VIII	VI	VII	VIII
<b>Bydgoszcz region</b>						
Minimum	33.5	53.6	64.9	15.5	24.2	15.1
Maximum	79.5	137.6	236.5	133.8	146.1	150.7
Median	54.5	93.2	121.5	39.8	93.9	56.9
Mean	55.5	98.5	134.5	52.1	85.2	64.2
SD	11.2	21.3	35.1	32.7	33.3	38.3
VC (%)	20.1	21.6	26.1	62.8	39.1	59.7
<b>Wroclaw region</b>						
Minimum	50.7	91.8	125.7	17.6	12.0	5.6
Maximum	91.0	196.9	259.7	171.7	249.7	182.7
Median	69.6	127.3	165.0	60.5	101.6	57.6
Mean	69.8	128.8	167.5	69.7	100.7	66.2
SD	10.6	24.2	27.7	36.7	55.7	37.2
VC (%)	15.1	18.7	16.6	52.7	55.3	56.1

SD – standard deviation; VC – variability coefficient

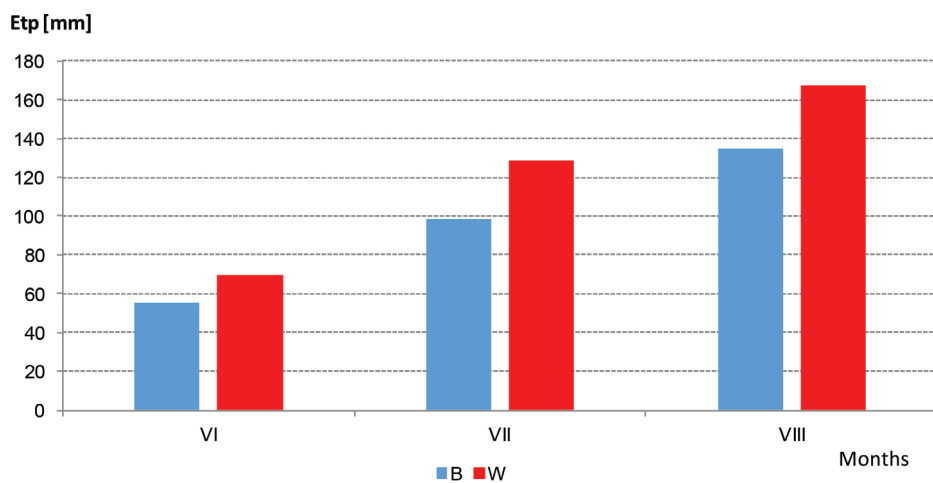
Source: Author's own study

During the twenty-year period of the research (1996-2015), in both studied regions, the water needs of asparagus plants presented the tendency to decrease in June, and at the same time showed the trend to increase in July and August (Figs 3 and 4). In July, the strongest upward development in the case of water requirements was observed in both regions. According to the linear regression estimations, the monthly crop evapotranspiration of the asparagus plants in July increased in each decade by 12.3 mm in the region of Bydgoszcz and by 21.2 mm in the region of Wroclaw.



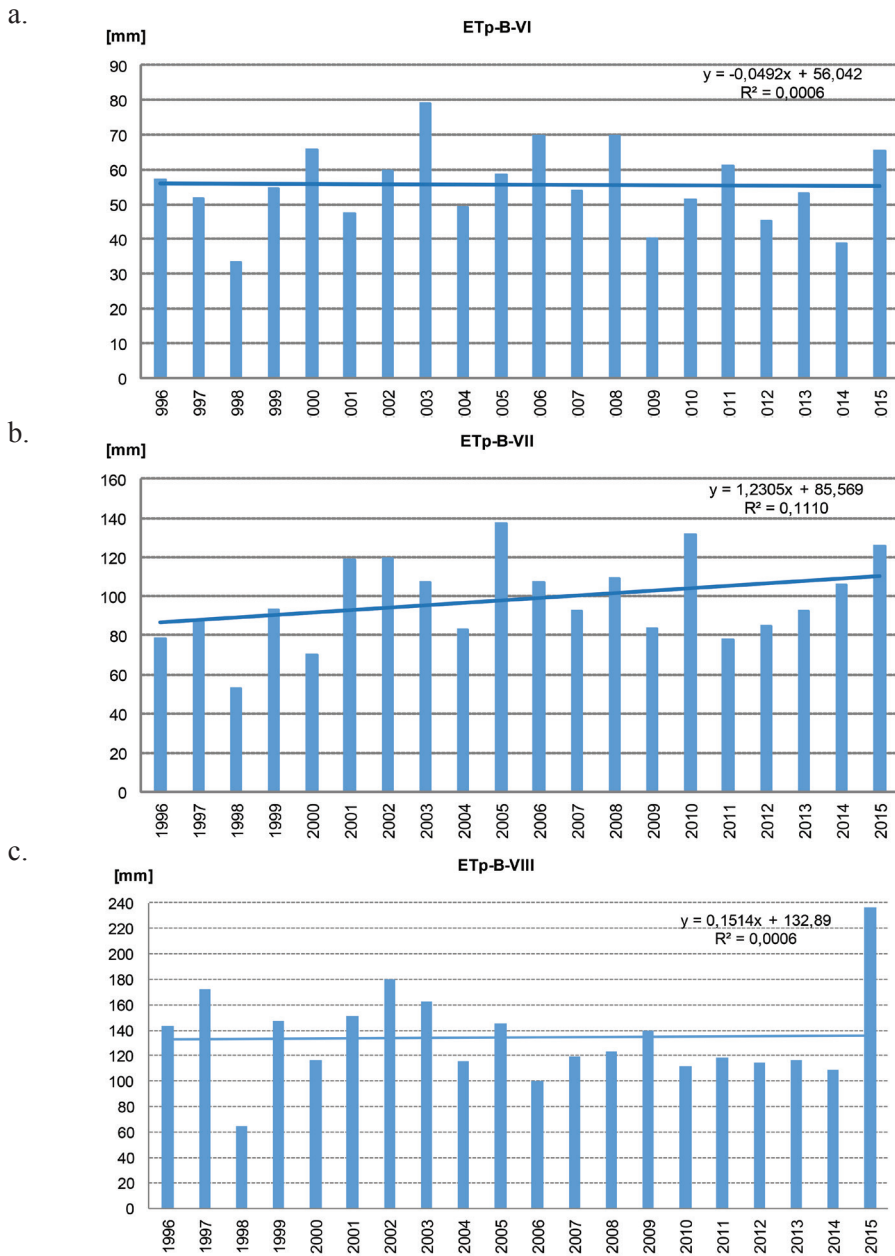
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**Figure 1.** Monthly rainfall (P) in the Bydgoszcz (B) and Wrocław (W) regions in the years 1996-2015



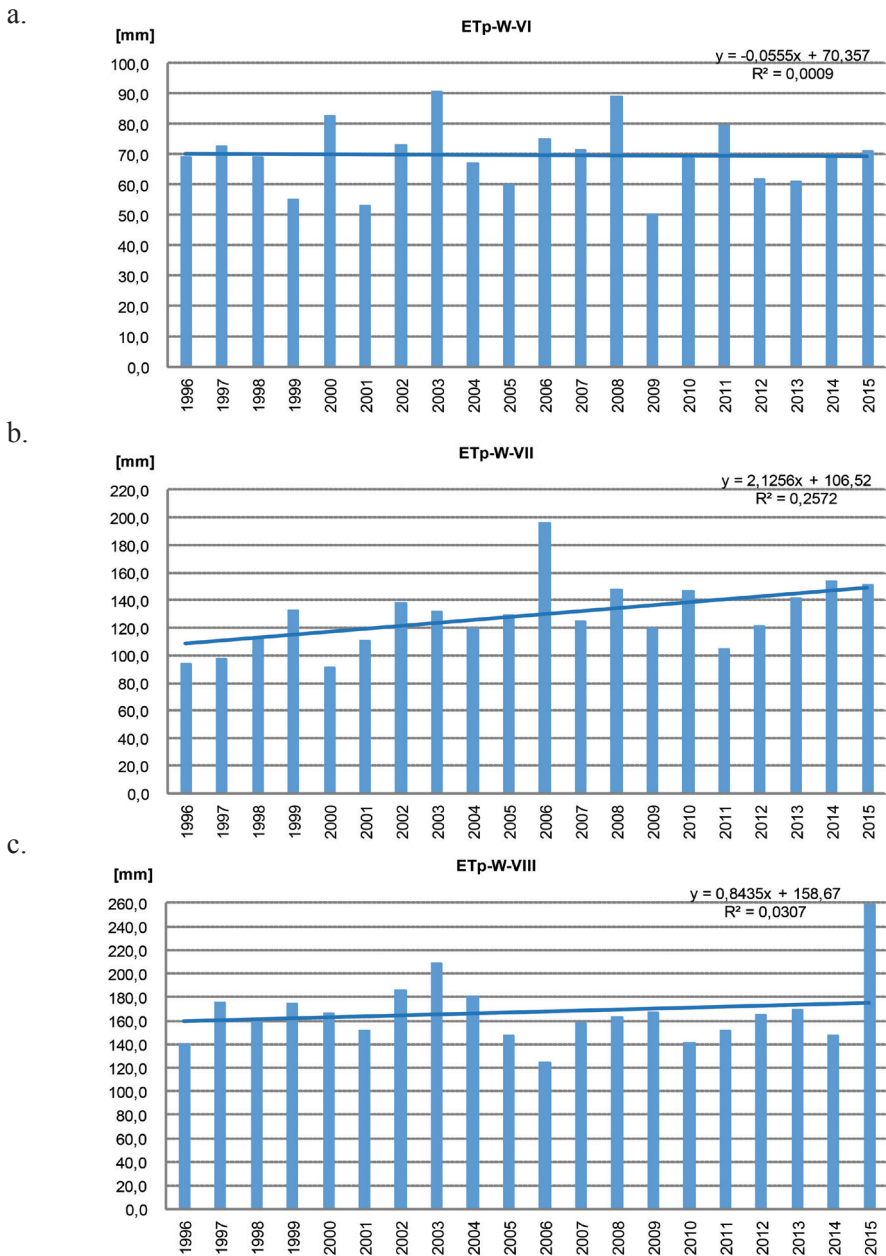
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**Figure 2.** Monthly crop evapotranspiration (Etp) in the Bydgoszcz (B) and Wrocław (W) regions in the years 1996-2015



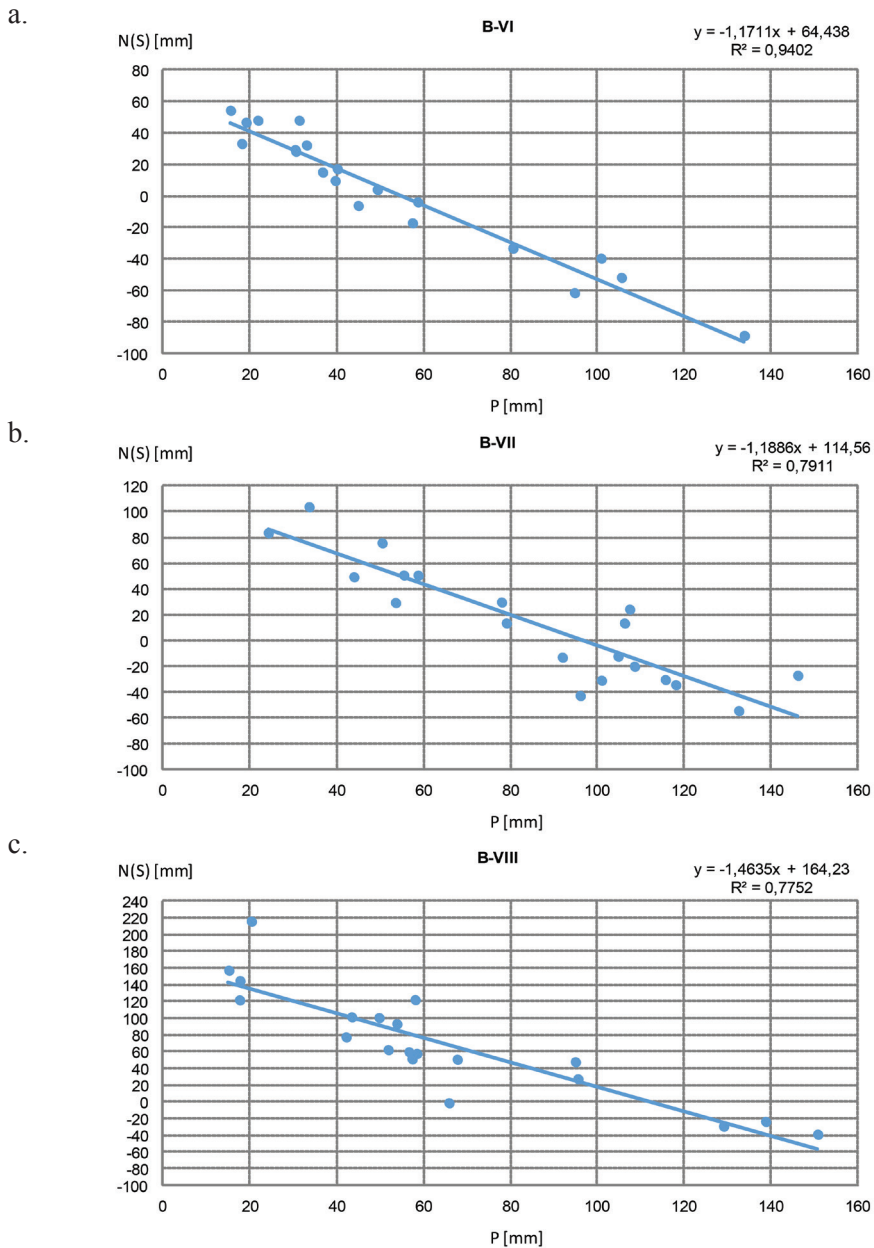
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**Figure 3.** Variability of the water requirements (Etp) of the asparagus crop in June, July and August in the region of Bydgoszcz in the years 1996-2015



Source: Author's own study

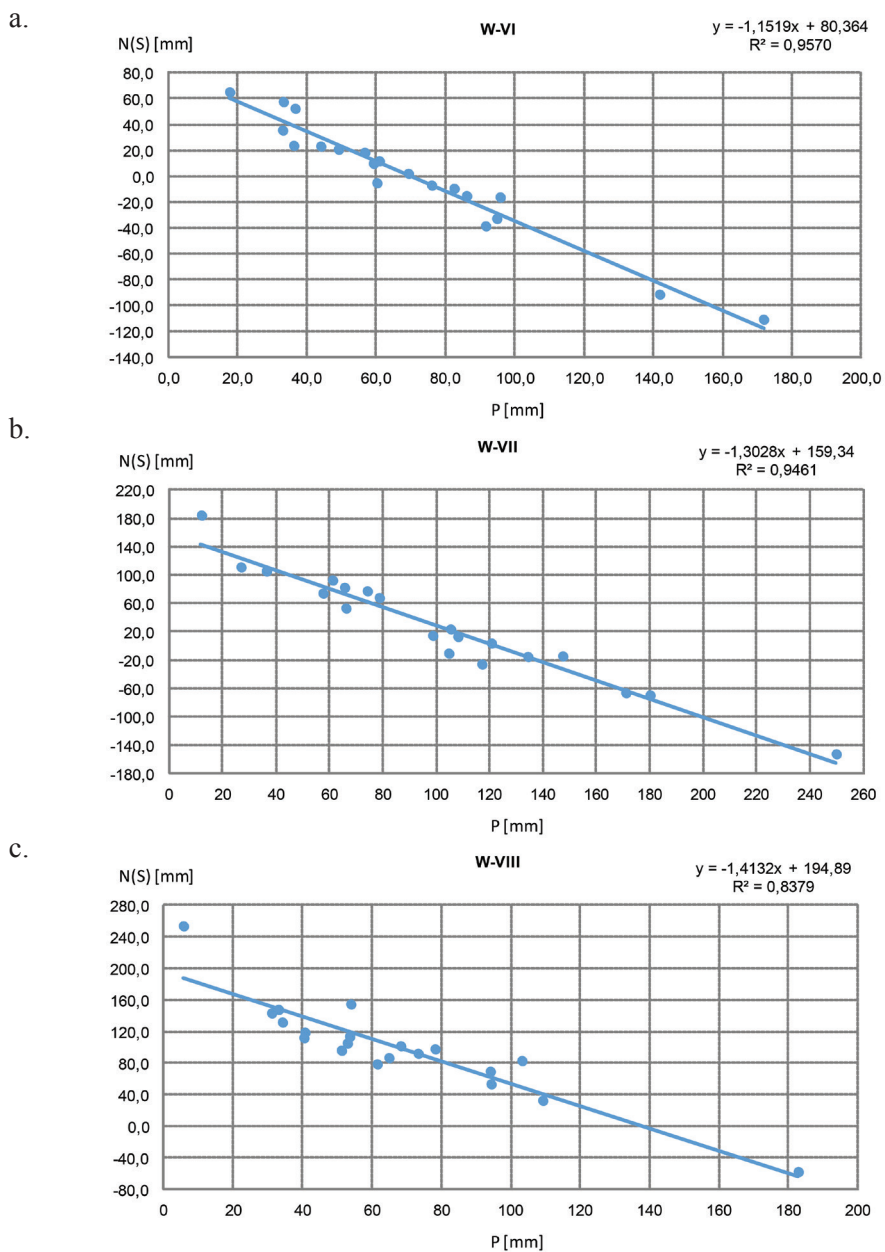
**Figure 4.** Variability of the water requirements (Etp) of the asparagus crop in June, July and August in the region of Wroclaw in the years 1996-2015



Source: Author's own study

**Figure 5.** Relationship between the rainfall (P) and the rainfall deficit (N) or surplus (S) in June, July and August in the region of Bydgoszcz in the years 1996-2015





Source: Author's own study

**Figure 6.** Relationship between the rainfall (P) and the rainfall deficit (N) or surplus (S) in June, July and August in the region of Wrocław in the years 1996-2015

The relationships between the monthly rainfall and rainfall deficit (or surplus) are presented in Figures 5 and 6. In both studied regions, the rainfall deficit in the asparagus cultivation occurred more frequently than rainfall surplus. Over the twenty-year period under study, the rainfall deficit in asparagus growing in June and July was noted during 11-13 years of the research, while in August it occurred during 16 years in the region of Bydgoszcz and during 19 years in the region of Wrocław.

**Table 2.** Precipitation deficiencies (mm) during asparagus cultivation in the years 1996-2015

Region	Months			Total precipitation deficiencies
	VI	VII	VIII	
Bydgoszcz	3.4	13.3	70.3	87.0
Wrocław	0.1	28.1	100.3	128.5

Source: Author's own study

In the period from July to August, higher precipitation deficiencies were noted in the region of Wrocław (128.5 mm) than in the region of Bydgoszcz (87.0 mm) as specified in Table 2. In both studied regions, the rainfall deficit increased in the following months of the experiment, so in August the precipitation deficiencies for the asparagus cultivation were the highest (100.3 mm in the region of Wrocław and 70.3 mm in the region of Bydgoszcz).

According to Kaufmann (1977) the water requirements (i.e. irrigation needs), during cultivation of the asparagus under climatic conditions of central Europe, range from 20 mm to 160 mm, depending on the location of the crop. In turn, Paschold *et al.* (2001), based on many years of study conducted at the Horticultural Institute in Geisenheim, Germany, pointed that the irrigation needs of the asparagus grown on the sandy soil depends on the amount as well as distribution of precipitation in the range from 48 mm to 153 mm.

## CONCLUSION

Higher water needs of asparagus plants were noted in the region of Wrocław than in the region of Bydgoszcz. In the period from June to August, the water requirements were 366.1 mm in the Wrocław region and 288.5 mm in the Bydgoszcz region. The monthly water needs in June, July and August were 69.8mm, 128.8 mm and 167.5 mm, respectively, in the region of Wrocław, and 55.5 mm, 98.5 mm and 134.5 mm, respectively, in the region of Bydgoszcz.

In both studied regions, in July the tendency to increase the water requirements of asparagus plants was noted. The monthly crop evapotranspiration

in July increased in each decade by 12.3 mm in the Bydgoszcz region and by 21.2 mm in the Wrocław region.

During the twenty-year study (1996-2015), the precipitation deficiencies in asparagus cultivation in June and July was noted in both observed regions during 11-13 years of the study. In August, the rainfall deficit occurred during 16 years of the study in the region of Bydgoszcz and during 19 years in the region of Wrocław.

Higher precipitation deficiencies in asparagus cultivation were noted in the Wrocław region than in the Bydgoszcz region. On average, during twenty years of the study, in the period from June to August, the rainfall deficits were 128.5 mm and 87.0 mm in the Wrocław and Bydgoszcz regions, respectively. In August, the highest precipitation deficiencies (100.3 mm and 70.3 mm in the Wrocław and Bydgoszcz regions, respectively) were observed.

## REFERENCES

- Grabarczyk S. (1976). *Polowe zużycie wody a czynniki meteorologiczne*. Zeszyty Problemowe Postępów Nauk Rolniczych. 181: 495-511.
- Kaniszewski S. (2005). *Nawadnianie warzyw gruntowych*. Kraków: Plantpress. 1-85.
- Kaniszewski S. (2006). *Nawadnianie warzyw*. In: Karczmarczyk S. and Nowak L. (eds): *Nawadnianie roślin*. Warszawa: Państwowe Wydawnictwo Rolnicze i Leśne. 295-332.
- Kaufmann F. (1977). *Intensivierung der Spargelproduktion durch Bewasserrung*. Gartenbau. 24(3): 73-74.
- Pardo A., Arbizou J., Suso M.L. (1997). *Evapotranspiration and crop coefficients in white asparagus*. Acta Horticulturae. 449(1): 187-192.
- Paschold P.J., Eckes U., Löbmeier F.J., Hoppmann D. (2001). *Untersuchungen zur Ermittlung des langjährigen Wasser und Berednungsbedarfs bei ausgewählten Gemüsearten*, unveröff. Arbeitsbericht, Forschungsanstalt Geisenheim.
- Paschold P.J., Artelt B., Hermann G. (2004). *The water need of asparagus (*Asparagus officinalis* L.) determined in a lysimeter station*. Acta Horticulturae. 664: 529-536.
- Rolbiecki R. (2013). *Ocena potrzeb i efektów mikronawodnień szparaga (*Asparagus officinalis* L.) na obszarze szczególnie deficytowym w wodę*. Wydawnictwo Uniwersytetu Technologiczno-Przyrodniczego w Bydgoszczy. Rozprawy. 162: 1-103.

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