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COMPARISON OF WATER NEEDS OF TRUE MILLET IN THE REGION OF BYDGOSZCZ AND WROCŁAW

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Summary

The objective of the study was the comparison of optimal precipitation and deficits of atmospheric precipitation in relation to millet cultivated in the region of Bydgoszcz and Wrocław in the period 1975-2014. In the region of Wrocław water needs in millet cultivation were larger than in the region of Bydgoszcz. In the growing season (from May to August) they amounted to 253 mm and 242 mm respectively. July was the month when the largest water needs were observed – 74 and 72 mm respectively. It was also discovered that in the region of Wrocław the optimal amount of precipitation in the millet growing season (from May to August) systematically increased in subsequent decades, from 234 mm in the period 1975-1984 to 266 mm in the period 2005-2014. The correlation and regression analysis showed that the increasing trend of changes of that index in time was significant. Monthly deficits of precipitation in the millet growing season – both maximum and average – were in each case larger in the region of Bydgoszcz. The largest maximum and average insufficiencies of precipitation occurred in July. The frequency of occurrence of years with insufficient precipitation was also larger in each month in the region of Bydgoszcz. The frequency of occurrence of years with extremely dry, very dry and dry millet growing seasons was larger in the region of Bydgoszcz (42.5%) than in the region of Wrocław (37.5%).

Key words: rainfall, millet, deficits of rainfall

INTRODUCTION

What differs millet from other cereals is its economical water balance, even though good yielding requires appropriate water supply in the growing season (Rolbiecki et al. 2007, 2008a,b; Songin 2003). A particularly sensitive period in its development is the stalk shooting and tasselling phase (Songin 2003).

Total area of millet fields in Poland is quite small. At the end of the thirties of the previous century millet was cultivated on the area of around 120,000 ha. Currently, it is grown on around 6,000 ha (Central Statistical Office 2008). However, dietary advantages and chemical composition of the grain have resulted in the increase in interest in growing that long-neglected plant (Babalski et al. 2011). Farmers cultivate two Polish varieties of millet: Gierczyckie (with open panicle) and Jagna (with compact panicle), although currently they do not figure in the national register of varieties. They can be found only in preservation agriculture [Research Centre for Cultivar Testing 2006]. According to the data of the Central Statistical Office, in 2013 millet harvest amounted to 42,000 tons, which is a 27% increase in relation to the previous year. The main reason behind that is the 40% increase in the cultivation area – up to 31,200 ha. The largest millet harvests come from the voivodeships of the central Poland: Lubuskie and Świętokrzyskie – 27% and 21% respectively. Coastal and piedmont regions prove less appropriate. However, it is possible to have a high yield of grain if the soil is optimally moisturized. It can be proved by the results of experiments with the use of overhead irrigation and various nitrogen fertilizations, which were carried out on the Pyrzyce-Stargard Plain (in Lipnik near Stargard Szczeciński) and at the eastern end of the Krajna Lake District (in Kruszyn Krajeński near Bydgoszcz) (Rolbiecki at al. 2007, 2008a,b, 2009). An increase in the interest in millet cultivation for food can be also observed in the Lower Silesia (Senyk 2012). The cultivation area of the plant is increasing especially at ecological farms. In many regions financial incentives of the Rural Development Programmes 2007-2013 and 2015-2020 (Agri-Environmental and Climatic Programme, Package 6 – Preserving Endangered Genetic Resources of Agricultural Plants) prove to be an additional stimulus to invest in greater millet acreage.

The objective of the study was the comparison of optimal precipitation and insufficiencies of atmospheric precipitation in relation to millet cultivated in the region of Bydgoszcz and Wrocław in the period 1975-2014.

MATERIAL AND METHODS

The researchers used the values of monthly air temperatures and total precipitation in the millet growing season (from May to August) for the surroundings/region of Bydgoszcz (Research Station of the Faculty of Agriculture and

Biotechnology of the University of Science and Technology) and Wrocław ("Samotwór" Research and Didactic Station) in the forty-year period between 1975 and 2014. On the basis of the Klatt's table (Żakowicz et al. 2009), the amount of optimal precipitation in individual months of the growing season of millet was determined for all years of the study. Individual millet growing seasons (from May to August) were divided according to moisture (RPI), on the basis of Kaczorwska's classification (Łabędzki 2006), and then average amounts of optimal precipitation were specified for them. The above-mentioned forty years were divided into decades for which average amounts of optimal precipitation were determined. In addition, a correlation and regression analysis was carried out to show how the amount of optimal precipitation for millet changed in time, taking into consideration individual months of the growing season (relevance for the value $r_{\alpha} = 0.312$ and for $n = 40$, with $\alpha = 0.05$). Insufficient amounts of precipitation were specified and the frequency of their occurrence were calculated.

RESULTS AND DISCUSSION

Millet requires a lot of warmth and light and relatively little moisture (Ruszkowki 1974, 1993; Songin 2003). Thus, it is not cultivated in all regions of Poland (Księżak, Truszkowski 2010). The possibilities of crop substitution are limited by climatic and soil conditions (Leszczyńska 2006). Subsistence and semi-subsistence farms seek for possibilities of harvest increase in non-expenditure production factors. Such factors include pluvio-thermal conditions that are appropriate for the plant.

Average water needs in the millet growing season (from May to August) in the period 1975-2014 – determined as optimal precipitation according to Klatt – amounted to 242 mm in the region of Bydgoszcz and 253 mm in the region of Wrocław (Table 1).

Table 1. Optimal precipitation in the vegetation period of millet vegetation in the region of Bydgoszcz and Wrocław in the period 1975-2014

Period	V		VI		VII		VIII		V-VIII	
	B	W	B	W	B	W	B	W	B	W
1975-1984	45	45	57	56	67	67	67	66	236	234
1985-1994	48	49	55	56	73	74	69	71	245	250
1995-2004	45	52	55	61	70	74	70	74	240	261
2005-2014	45	51	57	63	78	79	68	73	248	266
Mean for 1974-2014	46	49	56	59	72	74	68	71	242	253

B – Bydgoszcz, W– Wrocław

Table 2. Correlation coefficients between optimal precipitation and years

Month	Region of Bydgoszcz	Region of Wrocław
V	0,054	**0,312**
VI	0,014	**0,507**
VII	**0,366**	**0,474**
VIII	0,140	**0,539**
V-VIII	0,255	**0,630**
Value r_α for j = 38 (n = 40), for α =0,05	r_α = 0,312	

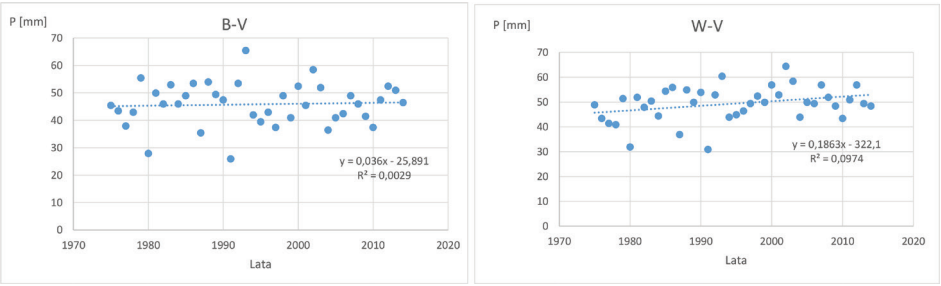

Figure 1. Temporal variability of optimal precipitation in May for millet in 1975-2014 in the region of Bydgoszcz (B-V) and Wrocław (W-V)

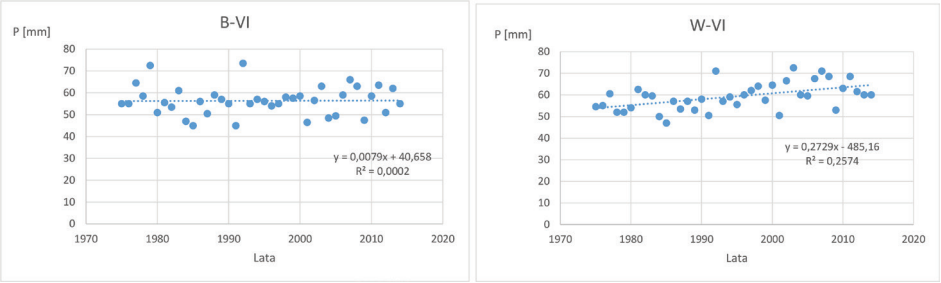

Figure 2. Temporal variability of optimal precipitation in June for millet in 1975-2014 in the region of Bydgoszcz (B-VI) and Wrocław (W-VI)

The analysis of total monthly amounts of optimal precipitation showed that – in average for the discussed four decades – in each month of the growing season they were larger near Wrocław. Monthly water needs were the largest in July – 72 mm in Bydgoszcz and 74 mm in Wrocław.

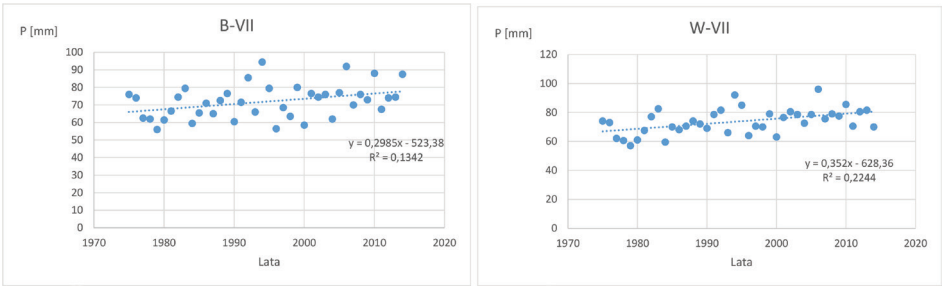

Figure 3. Temporal variability of optimal precipitation in July for millet in 1975-2014 in the region of Bydgoszcz (B-VII) and Wrocław (W-VII)

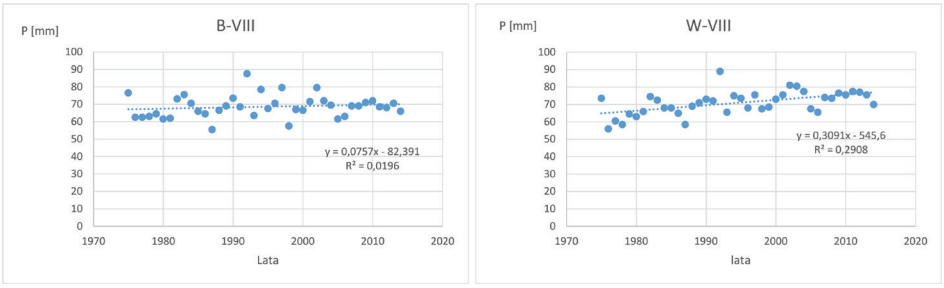

Figure 4. Temporal variability of optimal precipitation in August for millet in 1975-2014 in the region of Bydgoszcz (B-VIII) and Wrocław (W-VIII)

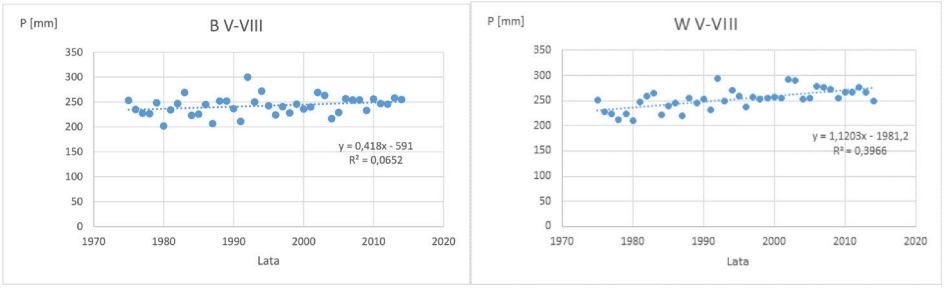

Figure 5. Temporal variability of optimal precipitation in the period May-August for millet in 1975-2014 in the region of Bydgoszcz (B V-VIII) and Wrocław (W V-VIII)

Taking into account the changes of optimal precipitation in the growing season (from May to August) in subsequent decades, a systematic increase from

234 mm in the period 1975-1984 to 266 mm in the period 2005-2014 was observed in the vicinity of Wrocław.

The direct correlation between the optimal precipitation and individual years can be proved by intrinsic values of the correlation coefficient, which, in this case, amounted to 0.63 (Table 2). Such significant correlations were determined for the vicinity of Wrocław in all four months of the millet growing season and for the region of Bydgoszcz – only in July.

Trendlines of the optimal precipitation variability in the images 1-5 show an increasing tendency, which suggests small, gradual increase in water needs in millet cultivation. What is more – as it has been already pointed out – a significant increasing trend was determined for the changes of that index in time in the region of Wrocław.

The largest maximal insufficiencies of precipitation were determined in July and the smallest ones – in May (Table 3). It should be remembered that in each month larger water deficits occurred in the region of Bydgoszcz. Average precipitation insufficiencies for the forty years of study, also in the case of each analysed month of the growing season, were larger in the region of Bydgoszcz. Similarly, the frequency of years with insufficient precipitation was each time larger for the region of Bydgoszcz.

Table 3. Rainfall deficits and the frequency of years with rainfall deficits in the vegetation period of millet

Specification	V		VI		VII		VIII	
	B	W	B	W	B	W	B	W
Maximum rainfall deficits [mm]	-47	-41	-52	-50	-87	-81	-75	-54
Mean rainfall deficits [mm]	-23	-22	-27	-24	-35	-29	-28	-27
Frequency of occurrence of deficits (%)	55	47	60	40	47	45	75	62

Explanations see table 1

Extremely dry – according to the RPI index – growing seasons (from May to August) of millet cultivated on sand and clay soil occurred in the region of Bydgoszcz in 7.5% of years of the analysed four decades, while no such periods were noticed in the vicinity of Wrocław (Table 4). The precipitation deficit in the region of Bydgoszcz was very large. It amounted to -161 mm. On the other hand, very dry growing seasons occurred more frequently (25%) in the region of Wrocław, while dry growing seasons – in the region of Bydgoszcz. The total frequency of years with extremely dry, very dry and dry millet growing seasons was 42.5% in the region of Bydgoszcz, while the frequency of very dry and dry millet growing seasons in the region of Wrocław was 37.5%. It should be also mentioned that humid, very humid and extremely humid millet growing seasons

occurred in total in 32.5% of years in the region of Bydgoszcz and 35% of years in the region of Wrocław. The research conducted near Wrocław showed a clear correlation between yielding of millet varieties, the agrotechnology applied and the weather. In the case of good wheat soils, weather was more favourable in the first year of the experiment, when temperature and precipitation were higher in the growing season (Chrzanowska-Drożdż, Kaczmarek 2007).

Table 4. Amount and frequency of occurrence of deficits in the vegetation period of millet as dependent on RPI

Classification of millet growing seasons acc. Kaczorowska (RPI)	Mean rainfall deficits in the vegetation period of millet (V-VIII)			
	Amount of deficit [mm]		Frequency (%)	
	B	W	B	W
Extremely dry	-161	-	7,5	0
Very dry	-106	-79	17,5	25
Dry	-71	-76	17,5	12,5
Average	-60	-34	25	27,5
Wet	-33	-53	10	12,5
Very wet	-21	-35	15	20
Extremely wet	-28	0	7,5	2,5

Explanations see table 1

CONCLUSIONS

1. In the region of Wrocław water needs in millet cultivation were larger than in the region of Bydgoszcz. In the growing season (from May to August) they amounted to 253 mm and 242 mm respectively. July was the month when the largest water needs were observed – 74 and 72 mm respectively.
2. It was also discovered that in the region of Wrocław the optimal amount of precipitation in the millet growing season (from May to August) systematically increased in subsequent decades, from 234 mm in the period 1975-1984 to 266 mm in the period 2005-2014. The correlation and regression analysis showed that the increasing trend of changes of that index in time was significant.
3. Monthly deficits of precipitation in the millet growing season – both maximum and average – were in each case larger in the region of Bydgoszcz. The largest maximum and average insufficiencies of precipitation occurred in July. The frequency of occurrence of years with

insufficient precipitation was also larger in each month in the region of Bydgoszcz.

4. The frequency of occurrence of years with extremely dry, very dry and dry millet growing seasons was larger in the region of Bydgoszcz (42.5%) than in the region of Wrocław (37.5%).

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