DOI: 10.21005/AAPZ2016.40.4.17

FOLIA POMERANAE UNIVERSITATIS TECHNOLOGIAE STETINENSIS
Folia Pomer. Univ. Technol. Stetin., Agric., Aliment., Pisc., Zootech. 2016, 330(40)4, 157–170

Kacper RAWICKI, Agnieszka MĄKOSZA[1]

ASSESSMENT OF AGRO-METEOROLOGICAL CONDITIONS OF THE VEGETATION PERIOD IN 2015 IN THE SZCZECIN LOWLAND

OCENA WARUNKÓW AGROMETEOROLOGICZNYCH W OKRESIE WEGETACYJNYM W 2015 ROKU NA NIZINIE SZCZECIŃSKIEJ

Institute of Technology and Life Sciences, West Pomeranian Research Centre in Szczecin, Poland
[1]Department of Meteorology and Green Areas Management, West Pomeranian University of Technology, Szczecin, Poland

Streszczenie. W pracy przedstawiono analizę warunków termicznych i pluwiometrycznych na podstawie wybranych wskaźników agrometeorologicznych w okresie wegetacyjnym (IV–X) w 2015 roku na obszarze Niziny Szczecińskiej w odniesieniu do wielolecia 1961–2014. Na podstawie wyników pomiarów temperatury powietrza wyznaczono początek i koniec oraz długość termicznego okresu wegetacyjnego, a także sumy wartości temperatur efektywnych powyżej progu 5°C. Ponadto przeprowadzono termiczną klasyfikację miesięcy według Lorenc (2000) oraz oceniono warunki pluwiometryczne za pomocą wskaźnika standaryzowanego opadu SPI. Stwierdzono, że w 2015 roku na Nizinie Szczecińskiej termiczny okres wegetacyjny trwał 257 dni – od 19 marca do 30 listopada. Okres ten był zatem o 26 dni dłuższy od przeciętnego i czwarty pod względem długości w porównaniu z analizowanym wieloleciem. Rozpatrywany okres wegetacyjny odznaczał się stosunkowo dużymi zasobami cieplnymi w porównaniu z warunkami termicznymi panującymi do połowy lat 90 ubiegłego wieku i z przeciętnymi zasobami na tle ostatnich kilkunastu lat. Na tle klasyfikacji termicznej był to jednak okres charakteryzujący się przeciętnymi warunkami termicznymi, przy czym deficyt opadów atmosferycznych spowodował wystąpienie silnej suszy atmosferycznej określonej według wskaźnika SPI. Najbardziej niesprzyjające warunki pogodowe wystąpiły w sierpniu, który wyróżniał się anomalnie ciepłymi warunkami termicznymi oraz ekstremalną suszą atmosferyczną.

Key words: agroclimate, air temperature, precipitation, SPI index.
Słowa kluczowe: agroklimat, opady atmosferyczne, temperatura powietrza, wskaźnik SPI.

INTRODUCTION

The climate of Poland is characterised by great variability of weather and meteorological conditions affecting the vegetation period of crops. This is due to the transitional character of the climate, i.e. between the maritime climate of Western Europe and the continental climate of Eastern Europe (Ziernicka-Wojtaszek and Zawora 2008). In the recent years, more and more reports have been published on the estimated increase in variability of air temperature and precipitation and more frequent occurrence of natural disasters (Smolik 2013). The

Corresponding author – Adres do korespondencji: Kacper Rawicki, Institute of Technology and Life Sciences, West Pomeranian Research Centre in Szczecin, Czesława 9, 71-504 Szczecin, Poland, e-mail: k.rawicki@itp.edu.pl

recently observed increase in thermal contrasts in Poland under the conditions of increasing thermal resources may have a negative effect on agriculture, i.e. decreasing productivity of some crops due to heat stress, the spread of thermophilic weeds and pest, and the emergence of new plant diseases (Żmudzka 2012). Short-term precipitation of great intensity may in turn lead to soil erosion and flooding, whereas extended periods of precipitation shortage may be the underlying factor of atmospheric (meteorological) drought and influences on the size and quality of the crops (Nidzgorska-Lencewicz 2006; Biniak-Pieróg et al. 2008). Therefore, it is of significant importance to conduct measurements and analysis of the course of thermal and pluviometric conditions, especially in view of the presumed tendencies and region-specific differences between them (Bartoszek and Banasiewicz 2007; Radzka 2014). According to Woś (1999), the Szczecin Lowland belongs to the West Pomeranian climatic region (Region VI) marked by frequent days with frosty, moderately cold weather with slight cloudiness and lack of precipitation. This area, both in summer as well as in the winter period, is characterised by great variability in thermal conditions. Moreover, it is distinguished by the occurrence of drought in the first half of spring and humid second half of autumn (Koźmiński and Michalska 2000).

According to the Institute of Meteorology and Water Management (IMGW), the year 2015 was characterised by unfavorable thermal and pluviometric conditions recorded over most area of Poland, and was classified as dry with abnormally high air temperatures (Biuletyn… 2015). The study by Łabędzki and Bąk (2015) shows that the drought of 2015 occurred in many regions of Poland as early as in the summer period due to significant shortage of winter and early spring precipitation. Furthermore, the authors claim that the intensity of drought was aggravated not only by lack of precipitation, but also by air temperature which was higher than the mean from the multiannual period. According to IMGW, deviation from the multiannual standard air temperature recorded in 2015 in Poland was from 0.6ºC (Elbląg) to 2.5ºC (Wrocław), and below 1.7ºC in Pomeranian and West Pomeranian voivodeships (Biuletyn… 2015).

Therefore, it seems relevant to address the issue of assessment of weather conditions in the vegetation period of 2015 in the Szczecin Lowland, particularly thermal and pluviometric conditions, on the grounds of selected agrometeorological indices and comparison of the values with the multiannual period of 1961–2014.

MATERIAL AND METHODS

The basis for the analysis were daily air temperature and precipitation measurements from 2015 obtained from the automatic meteorological station located in Reńsko, in the central part of the Szczecin Lowland (latitude 53°14’, longitude 14°57’, altitude above sea level 23m). The station was established within the framework of monitoring, projection and prevention of shortage and excessive amount of ground and surface waters in rural areas conducted by the Institute of Technology and Life Sciences. The results of the analyses conducted for this study were compared with the multi-year values (1961–2014) obtained from agro-meteorological station with the closest location, i.e. Lipnik (latitude 53°21’, longitude 14°58’ altitude above sea level 30 m) – owned by the Department of Meteorology and Green Areas Management of the West Pomeranian University of Technology in Szczecin. Due to central location of this station in the Szczecin Lowland, the results of the measurements are representative for this region (Koźmiński and Michalska 2000).

From the perspective of climatology, vegetation period is defined on the grounds of mean 24-hour air temperature higher or equal to 5.0ºC – the thermal vegetation period (Górski 2006; Żmudzka 2012; Nieróbca et al. 2013). Accordingly, considering the monthly data it is usually assumed that mean 24-hour air temperature higher or equal to 5ºC, as recorded per individual month, occurs from April to October (Bartoszek and Banasiewicz 2007; Ziernicka-Wojtaszek and Zawora 2008; Radzka 2014). There are studies which identify vegetation period to be present in different time spans (Łabędzki and Bąk 2004; Kalbarczyk and Kalbarczyk 2006; Michalska and Kalbarczyk 2007). In the north-west regions of Poland, time span with mean monthly air temperature higher or equal to 5ºC occurs, on average, from April to October (Koźmiński et al. 2012). Therefore, the monthly analyses included in the present paper adopt the aforementioned time span.

On the basis of monthly measurements of air temperature in 2015 taken in Reńsko, and data concerning the multi-year reference period of 1961–2014 as recorded in Lipnik, also the dates of the beginning as well as the end of the thermal vegetation period were calculated together with its duration. The calculations were made using methodology by Gumiński 1955 (after Kępińska-Kasprzak and Mager 2015). According to this methodology, the mean monthly air temperature is close to mean daily temperature recorded in the middle day of the month, and the increase, as well as decrease, varies linearly between the middle days of the subsequent months.

In order to determine hear resources in 2015 and for the purpose of comparison with the multiannual period, sums of effective temperatures were calculated as 24 hour values of air temperature exceeding the threshold of 5ºC.

The present study also makes use of the classification of thermal conditions of months and seasons by Lorenc (2000) based on the “three-sigma rule” adopted for the monthly air temperature values, referring to the multi-year period 1961–2014. The threshold values of 11 thermal classes and their names are presented in Table 1.

Table 1. Criteria for thermal classification of months and seasons
Tabela 1. Kryteria klasyfikacji termicznej miesięcy i sezonów

The threshold values of air temperature Wartości progowe temperatury powietrza	Thermal classification Klasyfikacja termiczna
Tz>Tśr + 2.5σ	extremely warm – ekstremalnie ciepły
Tśr + 2.0σ <Tz≤Tśr + 2.5σ	abnormally warm – anomalnie ciepły
Tśr + 1.5σ <Tz≤Tśr + 2.0σ	very warm – bardzo ciepły
Tśr + 1.0σ <Tz≤Tśr + 1.5σ	warm – ciepły
Tśr + 0.5σ <Tz≤Tśr + 1.0σ	slightly warm – lekko ciepły
Tśr – 0.5σ ≤Tz≤Tśr + 0.5σ	normal – normalny
Tśr – 1.0σ ≤Tz<Tśr – 0.5σ	slightly cool – lekko chłodny
Tśr – 1.5σ ≤Tz<Tśr – 1.0σ	cool – chłodny
Tśr – 2.0σ ≤Tz<Tśr – 1.5σ	very cool – bardzo chłodny
Tśr – 2.5σ ≤Tz<Tśr – 2.0σ	abnormally cool – anomalnie chłodny
Tz<Tśr – 2.5σ	extremely cool – ekstremalnie chłodny

Tz – air temperature in a given period – średnia roczna temperatura powietrza, Tśr – long-term mean temperature in a given period – temperatura średnia powietrza z wielolecia, σ – standard deviation of air temperature in a given period – odchylenie standardowe.
Source – Źródło: own study based on Lorenc (2000) – opracowano na podstawie Lorenc (2000).

The pluviometric conditions were assessed using the standardised precipitation index (SPI). Normalisation of precipitation sequences was done using: $f(P) = u = \sqrt[3]{P}$, where P stands for the value of the measured sum of precipitation. The value of the SPI index was calculated with the use of the following equation:

$$SPI = \frac{u - u_{śr}}{d_u}$$

where:

u – normalised sum of precipitation,

$u_{śr}$ – mean value of the normalised precipitation sequence,

d_u – standard deviation of the normalised precipitation sequence.

The classification of precipitation conditions was done using 9-grade SPI scale presented in Table 2.

Table 2. Classification of precipitation conditions according to SPI index
Tabela 2. Klasyfikacja warunków opadowych na podstawie wskaźnika SPI

Value of SPI Wartość SPI	Classification of precipitation conditions Kategoria warunków opadowych
≤ –2.00	extreme drought – susza ekstremalna
(–2.00, –1.50]	severe drought – susza silna
(–1.50, –1.00]	moderate drought – susza umiarkowana
(–1.00, –0.50]	mild drought – susza słaba
(–0.50, 0.50)	normal – warunki przeciętne
[0.50, 1.00)	wet – wilgotno
[1.00, 1.50)	moderately wet – umiarkowanie mokro
[1.50, 2.00)	very wet – bardzo mokro
≥ 2.00	extremely wet – ekstremalnie mokro

Source – Źródło: own study based on – opracowano na podstawie Łabędzki and Bąk (2013), Łabędzki et al. (2013).

RESULTS AND DISCUSSION

Climatic conditions are one of the main factors determining the farming systems and technology of plant production (Szwejkowski et al. 2008). In the last two decades of the 20th and at the beginning of the 21st century, a gradual increase in air temperature was recorded in many regions of Poland (Michalska 2011; Majewski et al. 2012; Kirschenstein 2013). For example, the study by Michalska (2011) shows an increasing tendency of mean annual air temperature in the period 1951–2005 – particularly statistically significant in the north and west of Poland. The aforementioned increase in air temperature in Poland was from 0.07ºC per 10 years in Kraków, to 0.27ºC per 10 years in Toruń. The shift of the beginning and ending dates of thermal vegetation period is a consequence of such changes and, as a result, the length of vegetation period has extended (Żmudzka 2012). According to Nieróbca et al. (2013), in recent years (2001–2009) in Poland there has been an increase in the length of vegetation period by 8 days, or even by more than 9 days when considering only the north-west regions of Poland. On the basis of the analysis, it was found that in the multi-year reference period of 1961–2014 the length of vegetation period in the Szczecin Lowland increased on average by 5 days in the 10-year long period. The average length of thermal vegetation period in this area amounted to 231 days (Fig. 1). Since the beginning of the 1990s, the occurrence of extended thermal vegetation seasons has been reported much more frequently, and the following were particularly marked: 1990, 2006 and 2014. Thermal vegetation period in the reference period began, on average, on the 25th of March and ended on the 10th of November, yet the earliest beginning date was the 10th of February in 1990 and the latest the 12th of April 1964 and 1969. In comparison with the average values, the vegetation period of 2015 started relatively early – on the 19th of March, and ended late – on the 30th of November. Therefore, the difference is 26 days as compared with the average values. It was the fourth longest vegetation period as compared with the reference multi-year period.

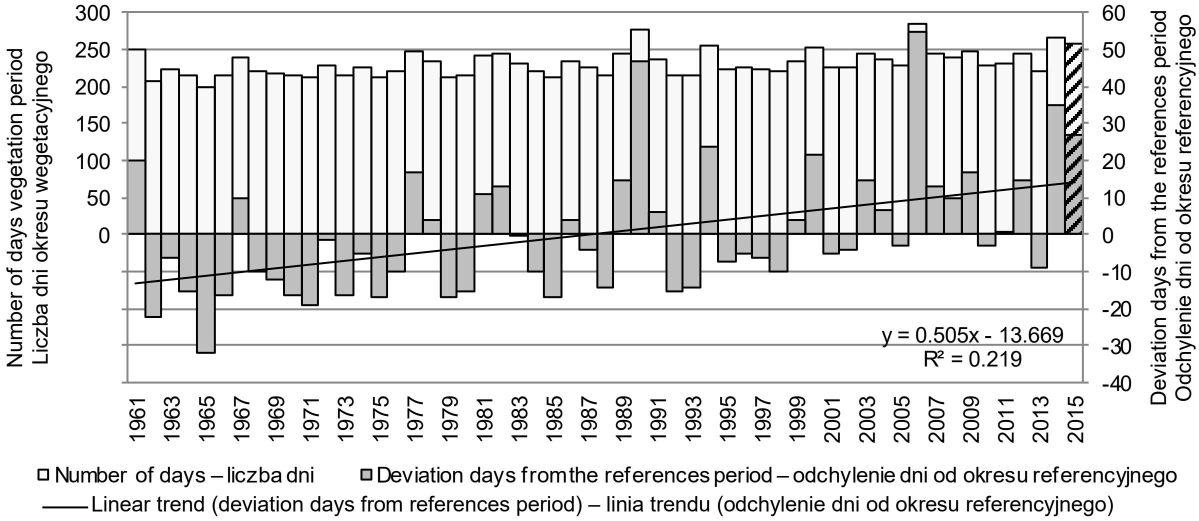

Fig.1. Number of days and deviation from the multi-year norm of the thermal vegetation period in the Szczecin Lowland, period 1961–2015
Ryc. 1. Liczba dni i odchylenie od normy wieloletniej termicznego okresu wegetacyjnego na Nizinie Szczecińskiej. Lata 1961–2015

One of the agro-meteorological features of heat resources relevant for determining the amount of heat received by plants is the sum of temperatures defined as above the specified threshold (Bartoszek and Banasiewicz 2007). In the multi-year reference period of 1961–2014, there was a positive trend of temperature sum above 5ºC threshold in the Szczecin Lowland (Fig. 2). The lowest thermal resources were reported in 1962 (1483,3ºC), and the highest in 2006 (2452,5ºC). In the vegetation period of 2015, the sum of temperature over 5ºC threshold amounted to 1984,9ºC. Therefore, the analysed vegetation period was marked by higher heat resources in comparison to thermal conditions till the mid-1990s, and by average resources as compared to the last several years. According to Żmudzka (2012), the lengthening of vegetation period and an increase in heat resources in Poland, apart from its negative effects such as emerging new plant diseases, may result in some substantial benefits to agriculture, i.e. starting agricultural works earlier, introducing plant with higher heat requirements (soybean) and minimizing the risk of thermophilic plant cultivation.

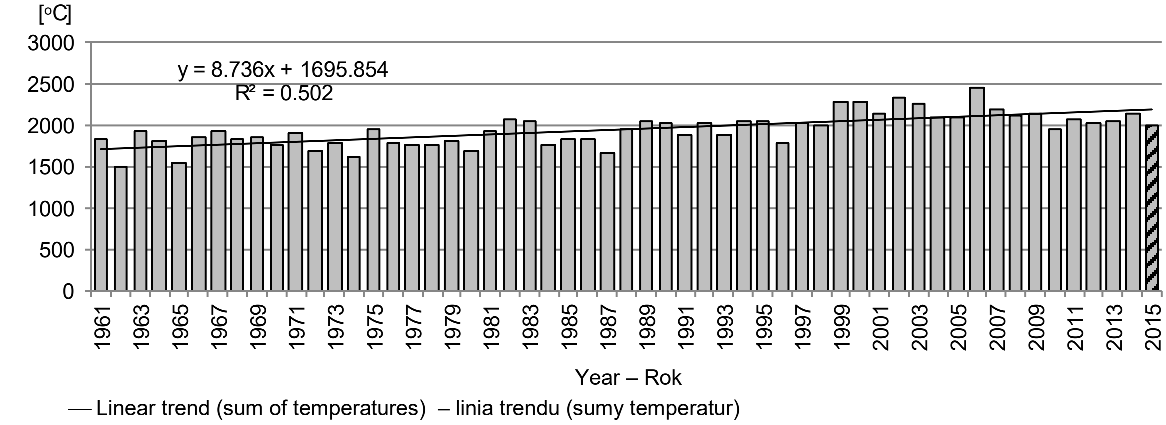

Fig. 2. Sums of air temperature above 5ºC threshold during vegetation period (April – October) in the Szczecin Lowland, period 1961–2015
Ryc. 2. Sumy wartości temperatury powietrza powyżej progu 5°C w okresie wegetacyjnym (IV–X) na Nizinie Szczecińskiej. Lata 1961–2015

The analysis of thermal conditions according to Lorenc (2000) shows that in the period of 1961–2014 the frequency of warmer as well as cooler than the reference vegetation periods in the Szczecin Lowland was similar (approximately 31% each). Among the warmer periods, the vast majority were slightly warm, and for the cooler periods – slightly cool. The very warm periods and abnormally warm constituted only 9% of all vegetation periods under analysis. The frequency of very cool and abnormally cool periods was comparable. Neither extremely warm, not extremely cold vegetation periods were found. The month in which the positive deviation from the mean monthly air temperature was observed most frequently was May, followed by June, July and August. Extremely warm months were recorded occasionally from June to September. Negative deviation from the reference period was found most often in August, followed by July and October. Extremely cold months were not recorded in the analysed multi-year reference period (Fig. 3).

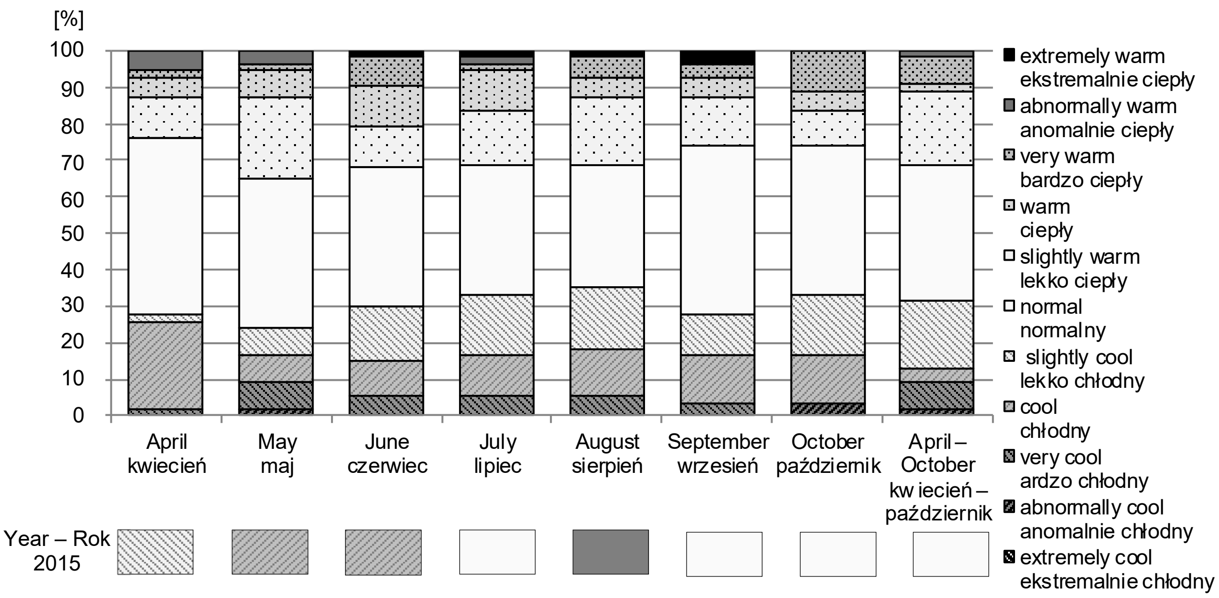

Fig. 3. The frequency of individual thermal conditions classes of the vegetation period (April – October) in the reference period 1961–2014 and 2015
Ryc. 3. Częstość występowania poszczególnych klas warunków termicznych w okresach wegetacyjnych (IV–X) w wieloleciu 1961–2014 i w 2015 roku

The analysed period of April – October 2015 was thermally classified as normal. However, there were deviations from the average of the multi-year period as for individual months of this period. April was classified as slightly cool, as in the first decade the mean air temperature was lower than the mean of the reference period, and in the subsequent two decades it was higher by 1.9 and 0.9ºC respectively. May and June were also classified as cool, as air temperature was lower than the reference period by 1.7ºC maximum in the third decade of May. The most distinguished month was August – abnormally warm, mean decade air temperature was higher by as much as 5.6ºC as compared with the average values. Thermal conditions recorded in the remaining months did not deviate from the multi-year reference period (Fig. 4).

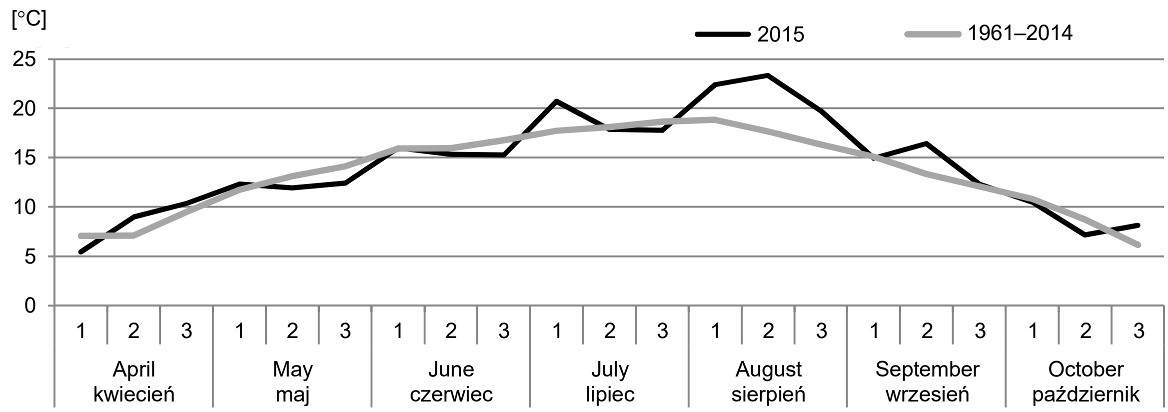

Fig. 4. The course of mean decade values of air temperature during vegetation period (Aril – October) in 2015 and in the reference period 1961–2014
Ryc. 4. Średnie wartości dekadowe temperatury powietrza w okresie wegetacyjnym (IV–X) w 2015 roku i w wieloleciu 1961–2014

The north-west of Poland is marked by great spatial and temporal variability of precipitation sum which amount to less than 500 mm in Dolina rzeki Płoni to more than 800 mm in Wysoczyzna Polanowska and Bytowskie Lakeland (Koźmiński et al. 2012). In the reference period of 1961–2014, in the Szczecin Lowland the mean sum of atmospheric precipitation in the vegetation period amounted to 344.6 mm, and the average number of days with precipitation ranged from 61 in 2008 to 122 in 1996. It was found that the month with the lowest average number of days with precipitation in the vegetation period was April (approx. 11), the highest average number of days with precipitation was recorded in July (approx. 14). However, it must be stressed that the prevalent precipitation was within the range from 0.1 to 5.0 mm, generally on approximately 9 days of each month. Daily sum of precipitation of more than 5.0mm was reported by far less frequently – on average from 2 to 4 days in a month. In the analysed period of April – October 2015 the sum of atmospheric precipitation in the Szczecin Lowland amounted to 247.9 mm and the recorded number of days with precipitation was 60, which is lower by 27 than that recorded for the multi-year reference period. In the year 2015, as well as in the multi-year reference period, precipitation ranging from 0.1 to 5.0 mm was observed most frequently – on average 6 days in a month. Precipitation over 5 mm was recorded each month of the analysed vegetation period apart from April and August. In turn, higher daily precipitation sums, i.e. over 10 mm, were recorded only in July and October. Daily precipitation sums of more than 20 mm were found only in July (Fig. 5).

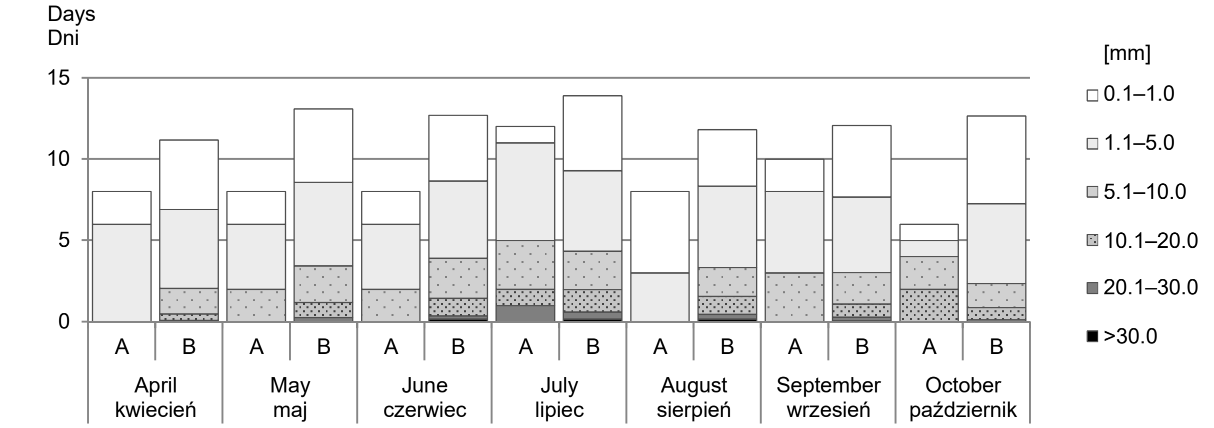

Fig. 5. Number of days with precipitation [mm] in the vegetation period (April – October) of 2015 (A) and in the reference period 1961–2014 (B) on criterion Olechnowicz-Bobrowska (1970)
Ryc. 5. Liczba dni z opadem [mm] w okresie wegetacyjnym (IV–X) w 2015 roku (A) i w wieloleciu 1961–2014 (B) na podstawie kryterium Olechnowicz-Bobrowskiej (1970)

Small atmospheric precipitation sum or even the shortage of precipitation leads to meteorological drought which is classified by its intensity and duration (Bąk et al. 2012). Drought is an atmospheric and hydrological phenomenon which occurs periodically in various seasons of a year (Kanecka-Geszke and Smarzyńska 2007). On the grounds of SPI index it was found that in the Szczecin Lowland in the period of 1961–2014 atmospheric drought occurred on 30% of vegetation periods, including severe drought (9%) and extreme drought (2%). Excessive amounts of water were recorded in 35% of cases – generally those were the periods classified as humid and moderately wet. Extremely wet vegetation periods were not recorded. Monthly severe and extreme drought were recorded most frequently in August, followed by May and July. In turn, the highest excess of monthly precipitation sum, classified as extreme and very wet, was recorded most frequently in October and in September (Fig. 6).

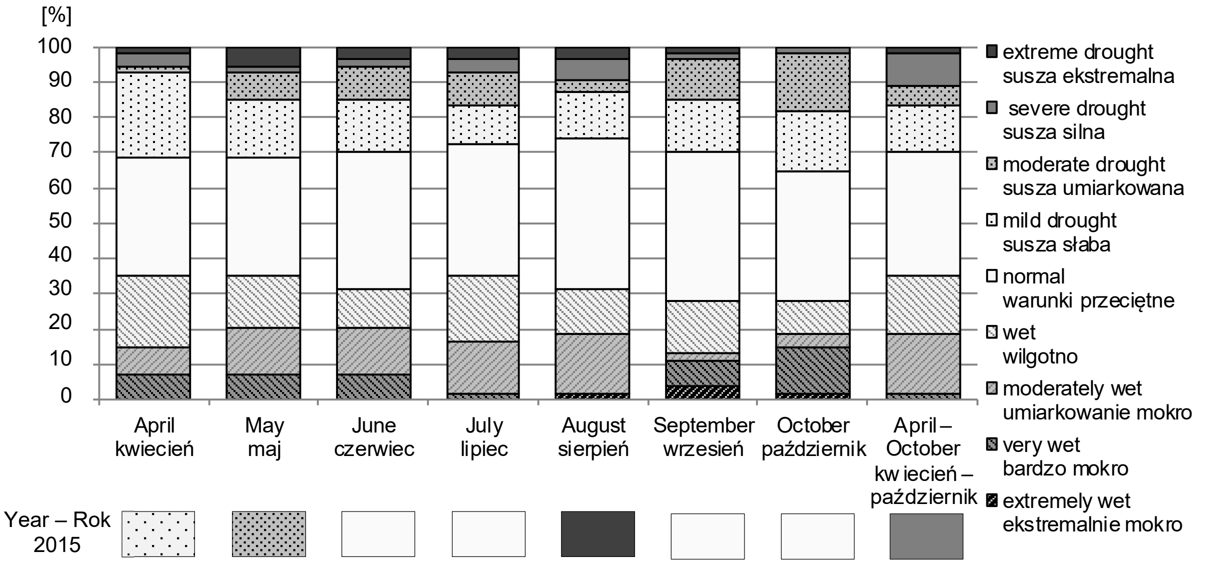

Fig. 6. The frequency of individual pluviometric conditions classes in the vegetation period (April – October) in the reference period 1961–2014 and 2015, on the basis of SPI index
Ryc. 6. Częstość występowania poszczególnych klas warunków pluviometrycznych w okresach wegetacyjnych (IV–X) w wieloleciu 1961–2014 i w 2015 roku na podstawie wskaźnika SPI

Taking into consideration the whole vegetation period of 2015 (April – October), on the basis of the SPI index, occurrence of severe atmospheric drought was found in the Szczecin Lowland. According to Koźmiński et al. (2001) and Kalbarczyk and Kalbarczyk (2005), the shortage of precipitation in the area of Szczecin may result in significant decrease in spring grain yield (by approx. 10%) and potato yield (by more than 20%). In the analysed vegetation period, the drought began as early as in the first two months (April, May) in which no or small decade precipitation sums from approx. 5 to 11mm were recorded (Fig. 7).

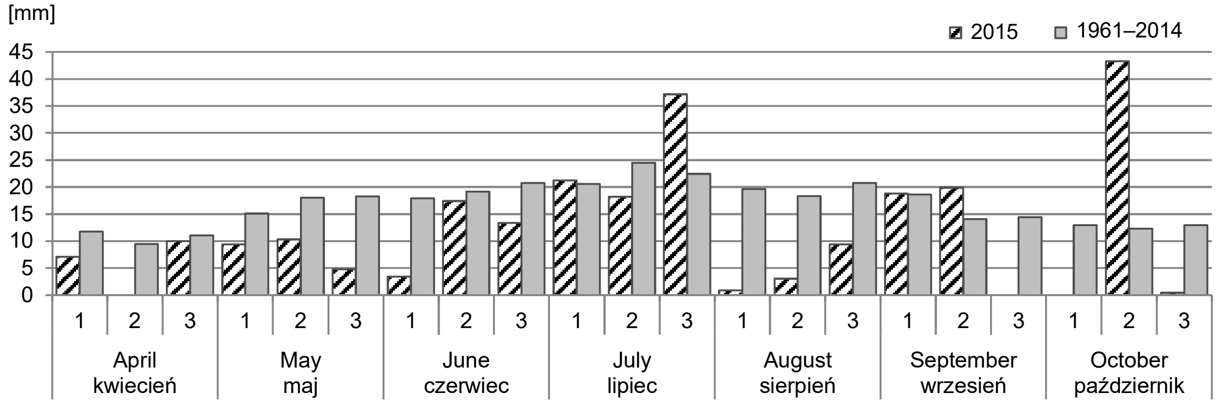

Fig. 7. Decade sums of atmospheric precipitation in the vegetation period of 2015 and in the reference period 1961–2014
Ryc. 7. Dekadowe sumy opadów atmosferycznych w okresie wegetacyjnym w 2015 roku i w wieloleciu 1961–2014

In April, shortage of precipitation resulted in slight drought, and in May it caused further aggravation of humidity conditions eventually leading to moderate drought. One of the reasons behind spring draught is the instability of humidity conditions, for example the uptake of horizontal water resources by plant after the initiation of the vegetation period (Czarnecka et al. 2004). According to IMGW (Biuletyn… 2014, 2015), in the winter season preceding the analysed vegetation period, i.e. the winter of 2014/2015, the retention period of snow cover in West Pomeranian voivodeship was markedly shorter in comparison with the multi-year period. Moreover, the depth of show cover was very low and ranged from 2 to 4 cm on the days of occurrence. Shortage of precipitation in the Szczecin Lowland was recorded from the end of the first decade of June, whereas from the second decade of this month till the end of July, the recorded precipitation sum was comparable with the multi-year reference period – in the third decade of July even higher by approx. 15 mm.

Shortage of atmospheric precipitation recorded in the first months of the vegetation period coincided with the period of increased water demand by spring as well as winter cereals. For example, the highest water demand for rye in this region is, on average, from the first decade of May to the second decade of June (Koźmiński and Michalska 2000). Another precipitation shortage period in 2015 occurred in August and led to extreme drought. The results are in line with multiannual analyses of pluviometric conditions in the Szczecin Lowland by Michalska and Kalbarczyk (2007), where the authors point to a negative tendency of the SPI index value which means an increased risk of drought occurring in August. The drought which occurred in

August combined with high air temperatures could have negatively affected the yield of medium late potato which, according to Koźmiński and Michalska (2000), has the highest water demand from the second decade of June to the third decade of August. Shortage of moisture in soil additionally resulted in unfavorable conditions for sowing and growth of winter rape. In the first and second decade of September atmospheric precipitation sum of the analysed vegetation period of 2015 was comparable with the multi-year reference period and, despite the lack of precipitation in the third decade of September, the month was classified as average in terms of SPI index values. Pluviometric conditions of October were classified similarly, even though precipitation occurred almost exclusively in the second decade of the month in the amount corresponding to the total monthly norm.

CONCLUSION

In the analysed year 2015, thermal vegetation period lasted 257 days and was by 26 days longer than the average vegetation period in the period 1961–2014 in the Szczecin Lowland. The vegetation period, as determined by the threshold value of 5ºC, started early – March 19, and ended late – November 30. The lengthening of vegetation period resulted from earlier than average beginning date and later than average date of end. Because of earlier beginning of the vegetation period in 2015, it was possible to commence agro-technical procedures and sowing earlier. In the analysed year during the vegetation period, sum of temperatures over 5ºC amounted to 1984.9ºC. Therefore, the thermal resources of that time were unremarkable in comparison with past several years.

The assessment of thermal and pluviometric conditions of the entire vegetation period of 2015 shows that the conditions recorded in the Szczecin Lowland were average, yet the deficit of atmospheric precipitation resulted in severe atmospheric drought. The agrometeorological conditions of individual months of the analysed period were found to vary. The first three months (April – June) were characterised by negative deviation of thermal conditions from the mean multi-year reference period as well as shortage of precipitation leading to slight or moderate drought. This shortage of precipitation occurred in the period of increased water demand by plants, particularly cereals, which may have resulted in decreased number of ears, poor development of grains and, consequently, in lower yield. It was found that out of all months of the vegetation period of 2015, only August was marked with abnormally warm thermal conditions. Moreover, marginal sum of precipitation in August caused extreme drought. Water shortage and high temperatures recorded in August had a negative effect on, among others, yield of medium late potato, sowing and growth conditions of winter rape. Agrometeorological and particularly pluviometric conditions lasting from April to the first decade of June, and also occurring in August, had the greatest impact on the general assessment of the analysed vegetation period. In the remaining months (July, September and October), thermal and pluviometric conditions in the Szczecin Lowland were in line with the reference period.

REFERENCES

Bartoszek K., Banasiewicz I. 2007. Agrometeorologiczna charakterystyka okresu wegetacyjnego 2005 w rejonie Lublina na tle wielolecia 1951–2005 [Agrometeorological characteristics of the vegetation period in 2005 against the background of the period of 1951–2005 in the Lublin region]. Acta Agrophis. 9(2), 275–283. [in Polish]

Bąk B., Kejna M., Uscka-Kowalkowska J. 2012. Susze meteorologiczne w rejonie stacji ZMŚP w Koniczynce (Pojezierze Chełmińskie) w latach 1951–2010 [Meteorological droughts in the region of the station of integrated environmental monitoring in Koniczynka (Chełmno Lakeland) in the years 1951–2010]. Woda Środ. Obsz. Wiej. 12(2), 19–28. [in Polish]

Biniak-Pieróg M., Kostrzewa S., Żyromski A. 2008. Tendencje sum opadów dziennych i nocnych półrocza letniego jako wskaźnik zmian klimatycznych [Trends in daily and nightly rainfall totals of summer half-year as indicator of climate change]. Acta Sci. Pol., Formatio Circumiectus 4(7), 31–40. [in Polish]

Biuletyn Państwowej Służby Hydrologiczno-Meteorologicznej [Bulletin of the National Hydrological and Meteorological Service]. 2014, 13(150). [in Polish]

Biuletyn Państwowej Służby Hydrologiczno-Meteorologicznej [Bulletin of the National Hydrological and Meteorological Service]. 2015, 13(163). [in Polish]

Czarnecka M., Koźmiński C., Michalska B., Kalbarczyk E., Kalbarczyk R. 2004. Warunki wilgotnościowe powietrza i gleby na Pomorzu (w: Współczesne problemy inżynierii środowiska. III. Bilanse wodne ekosystemów rolniczych). Red. M. Rojek. Wrocław, Wydaw. AR, 27–45. [in Polish]

Górski T. 2006. Zmiany warunków agroklimatycznych i długość okresu wegetacyjnego w ostatnim stuleciu (w: Długotrwałe przemiany krajobrazu Polski w wyniku zmian klimatu i użytkowania ziemi). Red. M. Gutry-Korycka, A. Kędziora, L. Starkel, L. Ryszkowski. Poznań, Komitet Narodowy IGBP, 65–77. [in Polish]

Kalbarczyk E., Kalbarczyk R. 2005. Identyfikacja okresów suszy atmosferycznej w okolicy Szczecina w latach 1963–2002 [Identification of atmospheric drought periods in the vicinity of Szczecin]. Woda Środ. Obsz. Wiej. 5(14), 171–183. [in Polish]

Kalbarczyk E., Kalbarczyk R. 2006. Identification of atmospheric drought periods in North-West Poland over 1965–2004. Electron. J. Pol. Agric. Univ., Ser. Agronomy 9(4), http://www.ejpau.media.pl/ /volume9/issue4/art-15.html.

Kanecka-Geszke E., Smarzyńska K. 2007. Ocena suszy meteorologicznej w wybranych regionach agroklimatycznych Polski przy użyciu różnych wskaźników [Assessing meteorologia drought in some agro-climatic regions of Poland by Rusing different indices]. Acta Sci. Pol., Formatio Circumiectus 6(2), 41–50. [in Polish]

Kępińska-Kasprzak M., Mager P. 2015. Thermal growing season in Poland calculated by two different methods. Ann. Wars. Univ. Life Sci. – SGGW, Land Reclam. 47(3), 261–273.

Kirschenstein M. 2013. Zmienność temperatury powietrza i opadów atmosferycznych w północno- -zachodniej Polsce. Słupsk, Wydaw. Nauk. AP. [in Polish]

Koźmiński C., Michalska B. 2000. Klimatyczna charakterystyka rejonu stacji agrometeorologicznej w Lipkach k. Starogardu Szczecińskiego. Szczecin, Wydaw. AR. [in Polish]

Koźmiński C., Michalska B., Czarnecka M. 2012. Klimat województwa zachodniopomorskiego. Szczecin, AR. [in Polish]

Koźmiński C., Raszka E., Witos-Watras A. 2001. Niedobory opadów. Ryzyko uprawy pszenicy jarej, jęczmienia jarego i owsa (w: Atlas klimatycznego ryzyka uprawy roślin w Polsce). Szczecin, Wydaw. AR. [in Polish]

Lorenc H. 2000. Studia nad 220-letnią (1779–1998) serią temperatury powietrza w Warszawie oraz ocena jej wiekowych tendencji [Studies on 220-years (1779–1998) air temperature series in Warsaw and Assessment of Centuries Tendencies]. Mat. Bad. IMGW, Ser. Meteorologia 31. [in Polish]

Łabędzki L., Bąk B. 2004. Zróżnicowanie wskaźnika suszy atmosferycznej SPI w sezonie wegetacyjnym w Polsce [Diversity of the SPI index of atmospheric drought in the growing season in Poland]. Woda Środ. Obsz. Wiej. 4(2a), 111–122. [in Polish]

Łabędzki L., Bąk B. 2013. Monitoring i prognozowanie przebiegu i skutków deficytu wody na obszarach wiejskich [Monitoring and forecasting the course and impact of water deficit in rural areas]. Inf. Ekol. Teren. Wiej. 2, 65–76. [in Polish]

Łabędzki L., Bąk B. 2015. Susza w Polsce w 2015 r. i ocena skutków na trwałych użytkach zielonych [Drought in Poland in 2015 and an assessment of impacts in permanent grassland]. Wiad. Melior. Łąk. 58(3), 102–106. [in Polish]

Łabędzki L., Bąk B., Kanecka-Geszke E., Smarzyńska K., Bolewski T. 2013. System monitorowania i prognozowania warunków wilgotnościowych ekosystemów rolniczych [System of monitoring and forecasting moisture conditions of agricultural ecosystems]. Wiad. Melior. Łąk. 56(4), 152–158. [in Polish]

Majewski G., Odorowska M., Rozbicka K. 2012. Analiza warunków termicznych na stacji Ursynów-SGGW w Warszawie w latach 1970–2009 [Ananalysis of the thermal conditions at Ursynów-SGGW station in Warsaw for the years 1970–2009]. Woda Środ. Obsz. Wiej. 12(2), 171–184. [in Polish]

Michalska B., Kalbarczyk E. 2007. Ocena intensywności suszy atmosferycznej na Nizinie Szczecińskiej w roku 2006 na tle wielolecia [Evaluation of drought intensity in the Szczecin Lowlands in 2006 in comparison to a multi-year period]. Acta Agrophys. 10(1), 159–173. [in Polish]

Michalska B. 2011. Tendencje zmian temperatury powietrza w Polsce [Recent trends of air temperature in Poland]. Pr. Stud. Geogr. 47, 67–75. [in Polish]

Nidzgorska-Lencewicz J. 2006. Elementy meteorologiczne kształtujące wilgotność gleby w okresach rozwojowych żyta i ziemniaka [Meteorological factors affecting the soil moisture at rye and potato development stages]. Acta Sci. Pol., Agricultura 5(2), 57–64. [in Polish]

Nieróbca A., Kozyra J., Mizak K., Wróblewska E. 2013. Zmiana długości okresu wegetacyjnego w Polsce [Changing length of the growing season in Poland]. Woda Środ. Obsz. Wiej. 13(2), 81–94. [in Polish]

Olechnowicz-Bobrowska B. 1970. Częstość dni z opadem w Polsce [Frequency of days with precipitation in Poland]. Pr. Geogr. IG PAN, 86. [in Polish]

Radzka E. 2014. Tendencje zmian temperatury powietrza okresu wegetacyjnego w środkowo-wschodniej Polsce (1971–2005) [Tendencies of air temperature changes of vegetation period in central-eastern Poland (in years 1971–2005)]. Acta Agrophys. 21(1), 87–96. [in Polish]

Smolik S. 2013. Opis zróżnicowania uśrednionych miesięcznych opadów w Warszawie i Zakopanem [Average rainfall assesment description in Warsaw and Zakopane]. Acta Sci. Pol., Formatio Circumiectus 4(12), 95–106. [in Polish]

Szwejkowski Z., Dragańska E., Banaszkiewicz B. 2008. Scenariusze warunków agroklimatycznych okolic Olsztyna w perspektywie spodziewanego globalnego ocieplenia w roku 2050 [Forecast of agroclimatic characteristics of Olsztyn area in the perspective of global warming in the year 2050]. Acta Agrophys. 12(2), 543–552. [in Polish]

Woś A. 1999. Klimat Polski. Warszawa, Wydaw. Nauk. PWN. [in Polish]

Ziernicka-Wojtaszek A., Zawora T. 2008. Częstość występowania w południowo-wschodniej Polsce niekorzystnych dla roślin uprawnych warunków pluwiotermicznych w perspektywie globalnego ocieplenia [Frequency of deficient pluvio-thermal conditions for cultivated plants in southeastern Poland in the light of global warming]. Acta Sci. Pol., Formatio Circumiectus 7(4), 41–47. [in Polish]

Żmudzka E. 2012. Wieloletnie zmiany zasobów termicznych w okresie wegetacyjnym i aktywnego wzrostu roślin w Polsce [Long-term changes of thermal resources in the vegetative period and the active growth of plants in Poland]. Woda Środ. Obsz. Wiej. 12(2), 377–389. [in Polish]

Abstract. The present study presents the analysis of thermal and pluviometric conditions on the basis of selected agro-meteorological indices in the vegetation period (IV–X) in 2015 in the Szczecin Lowland against the reference period of 1961–2014. With the use of the results of automatic measurements of air temperature, the following were identified: the beginning, the end and duration of vegetation period, as well as the sum of effective temperatures above the 5ºC threshold. Additionally, the months were thermally classified according to Lorenc (2000) and the pluviometric conditions were assessed with the use of standardised precipitation index (SPI). It was found that in 2015 in the Szczecin Lowland, the thermal vegetation period lasted for 257 days

with the date of beginning 19th of March, and the ending date 30th November. Therefore, the period was by 26 days longer than the average and fourth in terms of length as compared with the reference multi-year period. As compared to thermal conditions till the second half of the 1990s, the vegetation period under analysis was marked by high heat resources – the resources were average in comparison to the last several years. However, according to thermal classification, the period was characterised by average thermal conditions, yet the shortage of precipitation resulted in severe atmospheric drought as defined by the values of SPI index. The most unfavorable weather conditions were recorded in August which was marked by abnormally warm thermal conditions and extreme atmospheric drought.

Agro-meteorological measurements in Reńsko under the Multiannual Programme – Action 1.2, realised by the Institute of Technology and Life Sciences in Falenty.

The authors would like to thank Paweł Androwiak, the head of the Agricultural Facility in Reńsko of Spółdzielcza Agrofirma Witkowo, for the assistance received while conducting the research.