Acta Sci. Pol.
Formatio Circumiectus 21 (1) 2022, 17–32
ENVIRONMENTAL PROCESSES

www.acta.urk.edu.pl ISSN 1644-0765 DOI: http://dx.doi.org/10.15576/ASP.FC/2022.21.1.17

ORIGINAL PAPER Accepted: 9.02.2022

COMPARISON OF METEOROLOGICAL AND AGRICULTURAL DROUGHT IN THE NITRA RIVER BASIN IN 2014–2020

Vladimír Kišš[1]✉ 0000-0002-8527-2958, Andrej Tárník[2]✉ 0000-0001-7554-4713, Ján Čimo[2]

[1] Research Centre Agrobiotech, Slovak University of Agriculture in Nitra
[2] Faculty of Horticulture and Landscape Engineering, Slovak University of Agriculture in Nitra

ABSTRACT

Aim of the study
Droughts are one of the most costly natural hazards on a year-to-year basis. Their impacts are significant and widespread, affecting many economic sectors and people at any one time (WMO & GWP, 2016). In our paper we will focus on the comparison between meteorological drought (based on precipitation criterion) and agricultural drought (based on available soil water criterion) in the Nitra River basin, Slovakia.

Material and methods
Data from the Nitra River basin were provided from the meteorological stations (Svinná, Bystričany, Solčany, Veľké Ripňany, Jelenec and Pribeta) of the Slovak University of Agriculture in Nitra. The meteorological drought is defined as a period with no precipitation (Petrovič, 1960). Agricultural drought was determined as the value below the amount of water storage in the soil profile (0.20 m) accessible to plants.

Results and conclusion
We focused on the comparison between meteorological and agricultural drought, bearing in mind the fact that number of days with both types of drought has been increasing from the year 2014 onward. The worst year in every meteorological station was 2018, when the agricultural drought lasted, with short interruptions, from spring to winter. This trend can also be seen in the countries neighbouring Slovakia – Poland, Hungary, and Czech Republic.

Keywords: meteorological drought, agricultural drought, precipitation, soil moisture, Nitra River basin

INTRODUCTION

Drought as a randomly recurring extreme phenomenon is one of the main natural threats to the environment and can occur in any climate regime around the world, even in deserts and rainforests (WMO & GWP, 2016; Cebulska, 2021). Drought is defined as a marked deficiency of precipitation relative to normal conditions, it occurs as periods of below-average precipitation or complete lack of precipitation inputs, and can be limited to a single season or prolonged over multiple years (Palmer, 1965; Carroll et al., 2021). The discussion of the disciplinary perspectives of drought is the result of a review of more than 150 published definitions (Coles, Eslamian, 2018). These definitions are clustered into four types: meteorological, hydrological, agricultural, and socio-economic drought (Dracup et al., 1980; Wilhite, Glantz, 1985). Meteorological drought refers to the abrupt absence of or deficiency in precipitation compared to the "normal" conditions, which are represented by long-term mean value of precipitation at the given station (Bhuiyan, 2017; Quiring, 2009). Hydrological droughts are related to a period with inadequate surface and subsurface water resources for established

✉e-mail: vlado.kiss@gmail.com

water uses in the given water resource management system (Zhong et al., 2020; Stahl et al., 2020). Agricultural drought reflects the extent to which soil moisture is lower than the minimum requirement of plants by analysing the characteristics of soil moisture and morphology of plants during growth (Liu et al., 2016). Socioeconomic drought broadly refers to conditions whereby the water supply cannot satisfy the demand (Mehran et al., 2015), leading to societal and economic disruptions, and environmental impacts (Eklund and Seaquist, 2015). In our paper we will focus on the comparison between meteorological and agricultural drought in the Nitra River basin, Slovakia.

MATERIALS AND METHODS

Study region

The Nitra River basin (see: Fig. 1) with an area of 4501 km^2 is located in the western part of Slovakia to the west of Hron River basin, and to the south and west of the Váh River basin (Mazúr, Lukniš, 1980; Igaz et al., 2021). According to the orographic division, the territory is in the orographic subsystem of the Carpathian Mountains and the Pannonian basin (Borgula, 2004; Igaz et al., 2021). The basin consists of agricultural land (61% of the area) and forest (30% of the area) (Tárník, Igaz, 2015). In terms of climatic conditions, 65% of the basin belongs to the warm climate zone. The moderate climate zone is represented towards north of the basin, and the small area at the highest altitudes belongs to the cold climate zone. The mean annual temperature in the studied basin, according to long-term normal parameters, falls within the range of 7.5 to 10°C. Long-term average annual precipitation in the basin ranges from 540 mm (in the south part) to 733 mm (in the north part) (Atlas krajiny SR, 2002; Igaz et al. 2021).

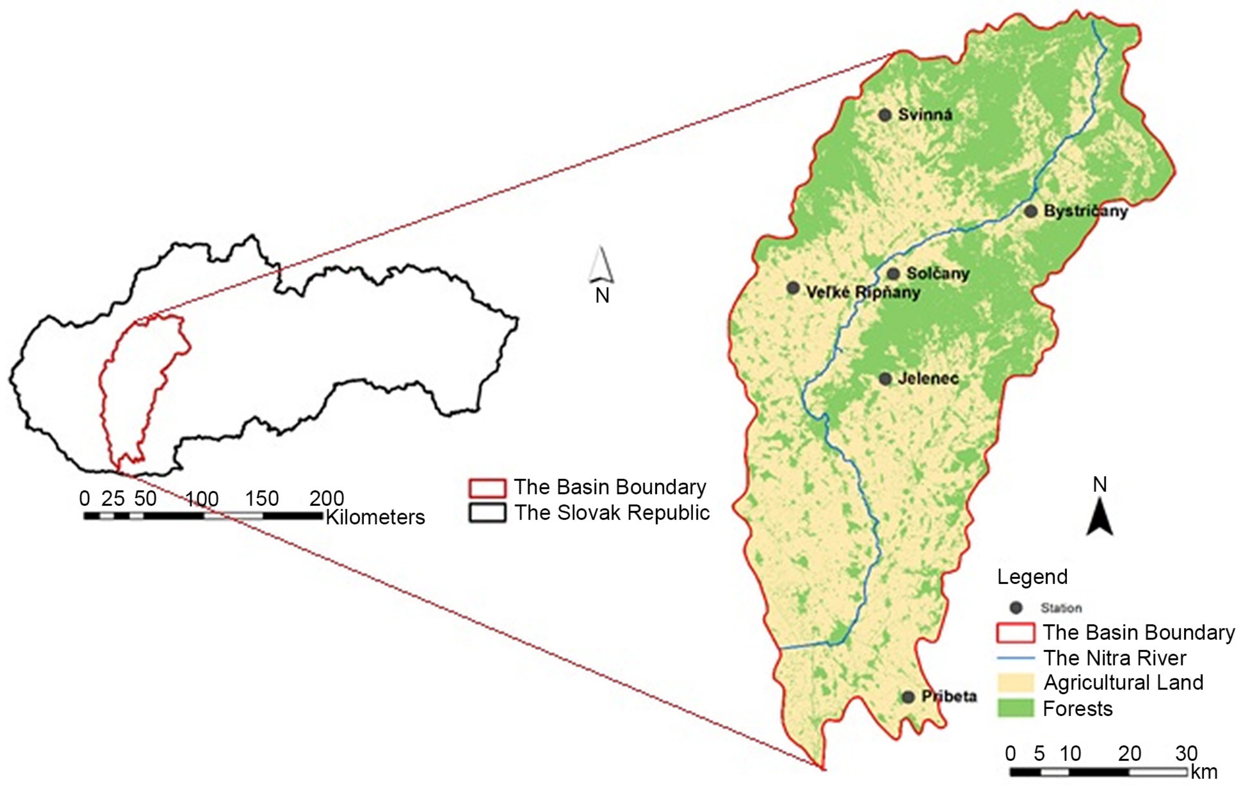

Fig. 1. The Nitra River basin

Table 1. Location of meteorological stations and selected soil parameters

Station	Location		Altitude [m a.s.l.]	Soil type[1]	K [cm/day][2]	Particle size distribution			
	long.	lat.				I. category < 0.01 mm [%]	II. category 0.05–0.01 mm [%]	III. category 0.1–0.05 mm [%]	IV. category 0.1–2.0 mm [%]
Svinná	48.7839	18.1630	249	Loam	23.32	38.27	43.37	2.75	15.61
Bystričany	48.6571	18.5157	264	Loam	2.68	30.85	45.25	8.34	15.56
Solčany	48.5439	18.2133	175	Loam	133.01	41.06	42.09	5.56	11.29
V. Ripňany	48.5094	17.9872	184	Loam	0.58	39.43	35.64	7.99	16.94
Jelenec	48.3840	18.2159	208	Loam	3.87	36.07	44.17	6.86	12.90
Pribeta	47.9033	18.3299	139	Sandy Loam	3.38	25.61	29.51	8.86	36.02

[1] According to Novak's classification; [2] Hydraulic conductivity

Table 1 lists selected stations with their altitude, soil type at the location, hydraulic conductivity, and particle size distribution of the soil.

Data collection and analysis

Data from the Nitra River basin (Slovakia) were provided from the meteorological stations of the Institute of Landscape Engineering, Slovak University of Agriculture in Nitra. The Institute built up a network of twenty-five observation stations, which have the capacity to transfer data on-line. The stations measure soil moisture at 10 depths (0.10, 0.20, 0.30, 0.40, 0.50, 0.75, 1.00, 1.50, 2.00 and 2.5 m) with 10HS sensors by Decagon Devices (Tárník, Igaz, 2015). These sensors are based on Frequency Domain Reflectometry method. The accuracy of 10HS sensors in mineral soils is ± 0.03 m^3/m^3 if standard calibration equation is used (Meter group, 2017; Tárník, Igaz, 2020).

For our study we used data of soil moisture at a depth of 0.20 m at the locations of Svinná, Bystričany, Solčany, Veľké Ripňany, Jelenec, and Pribeta (see: Fig. 1). Measurements were taken in hourly intervals. During data processing, checks and corrections were made and incorrect data (due to sensor failure) were removed. From the hourly intervals, the daily average was calculated, and the agricultural drought was determined as the value below the amount of water storage (W_R) in the soil profile (0.20 m) accessible to plants, calculated from the following formula (Antal et al., 2014):

$$W_R = \sum_{i=1}^{n} \left(\theta - \theta_V\right)_i \cdot h_i \ \text{[mm]} \qquad (1)$$

where:

θ_i – current soil moisture of the i-th layer [$m^3 \cdot m^{-3}$]
$\theta_{V,i}$ – point of reduced availability of the i-th layer [$m^3 \cdot m^{-3}$]
h_i – the thickness of the *i*-th layer of the soil profile [mm]

In order to assess the available water storage in the soil for vegetation cover, the characteristic point of the moisture retention curve is selected based on a convention (Kutílek, Nielsen, 2015). The point of reduced availability (corresponding to a value of pF = 3.3) is characterized by soil moisture at which the physiological processes of the plant cover are limited by water deficiency (Gomboš et al., 2021). Data on soil retention properties were taken from Skalová et al. (2015) and Igaz et al. (2011) who analysed several soil properties in the Nitra River basin, when the undisturbed soil samples were fully saturated and then placed in a pressure-plate apparatus (Soil Moisture Equipment Corp., Santa Barbara, CA, USA) to determine the volumetric water content corresponding to each pressure potential (from pressure potential −20 kPa to −1500 kPa). Prior to every increase of pressure potential, the undisturbed soil samples were weighed and the water content corresponding to each pressure potential was calculated. Finally, the soil samples were dried for 24 h at 105 °C in the oven and weighed (Igaz et al., 2014; Igaz et al., 2021).

The total precipitation in the studied period was provided by the Slovak Hydrometeorological Institute (daily precipitation totals), as the object of the present study is meteorological drought defined as a period with no precipitation. The evaluation criterion is used as in Petrovič (1960). Dry periods are divided into three groups according to the number of consecutive days without precipitation: a) 5 days or more (5–9 days); b) 10 days or more (10–19 days); (c) 20 days or more, where the day of 0.1 mm rainfall does not interrupt the dry period.

RESULTS AND DISCUSSION

In the northern part of the basin the conditions of meteorological and agricultural drought in the Svinná location (see: Fig. 2) and in the Bystričany location (see: Fig. 3) are different. In the Svinná location, agricultural drought began to occur more significantly only in 2017 and 2018 (see: Fig. 2d–2e). Until then, in 2014 (see: Fig. 2a) and 2016 (see: Fig. 2c) it did not occur, and in 2015 (see: Fig. 2b) it occurred only for a brief period. In 2019 (see: Fig. 2f) we are missing data from the period between April, 17 and October, 15 because the station experienced technical problems. In 2020 (see: Fig. 2g), agricultural drought occurred after longer periods without precipitation in March, April, and the beginning of May. Precipitation in June and July alleviated both meteorological and agricultural drought. In the Svinná location, in the years 2017–2020, we see more frequent periods of meteorological drought at the beginning of the growing season.

In the Bystričany location, agricultural drought began in the spring of 2014 (see: Fig. 3a). It also occurred during the entire vegetation period in 2015–2020 (see: Fig. 3b–3g). In 2017 (see: Fig. 3d), the lack of soil moisture occurred in January, and in 2018 (see: Fig. 3e) agricultural drought persisted from July to December. The drought was not interrupted even with several days with precipitation above 10 mm (see: Fig. 3c).

In the middle part of the river basin – Solčany (see: Fig. 4), Veľké Ripňany (see: Fig. 5), and Jelenec (see: Fig. 6), the conditions are comparable. In 2014, agricultural drought occurred only for a short period of time, and since 2015, an increase in the number of days with a lack of soil water can be observed in each of the three locations. The worst year was 2018, when agricultural drought persisted with short breaks from May to December. Meteorological drought occurs at every location during all years. The vegetation period was mostly affected by a period of more than 20 days without precipitation in April 2020 in all locations.

In the southern part of the basin, the Pribeta station (see: Fig. 7) is located, where agricultural drought is manifested to a large extent throughout the observed period. The longest uninterrupted period of agricultural drought occurred in 2020 (see: Fig. 7g), lasting from the second half of April to the first half of October. In that year, there were also two periods without precipitation lasting more than 20 days. In 2019 (see: Fig. 2f) the station experienced a technical problem from March, 6 to August, 7, when we are missing data.

In the present work, we are comparing two types of droughts in the period from 2014 to 2020. It is not necessary to consider the previous winter period, because if there were rainfall or periods of drought in the winter of 2013, it would affect the values of meteorological and agricultural drought in the spring – as it happened in 2017, when agricultural drought occurred in all locations in the river basin in winter months (January and February).

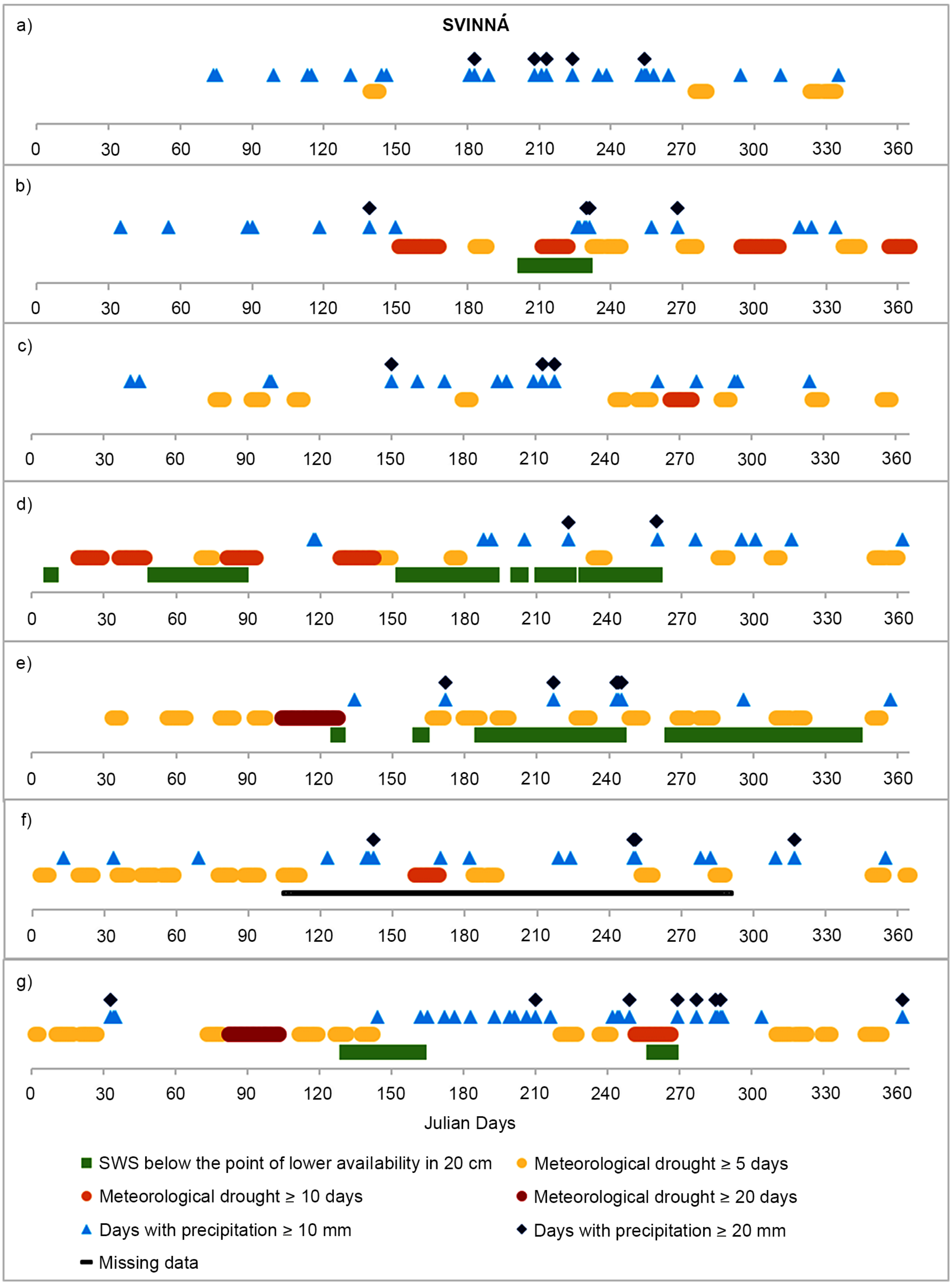

Fig. 2. Comparison between meteorological and agricultural drought in the Svinná location for the years: a) 2014; b) 2015; c) 2016; d) 2017; e) 2018; f) 2019 and g) 2020

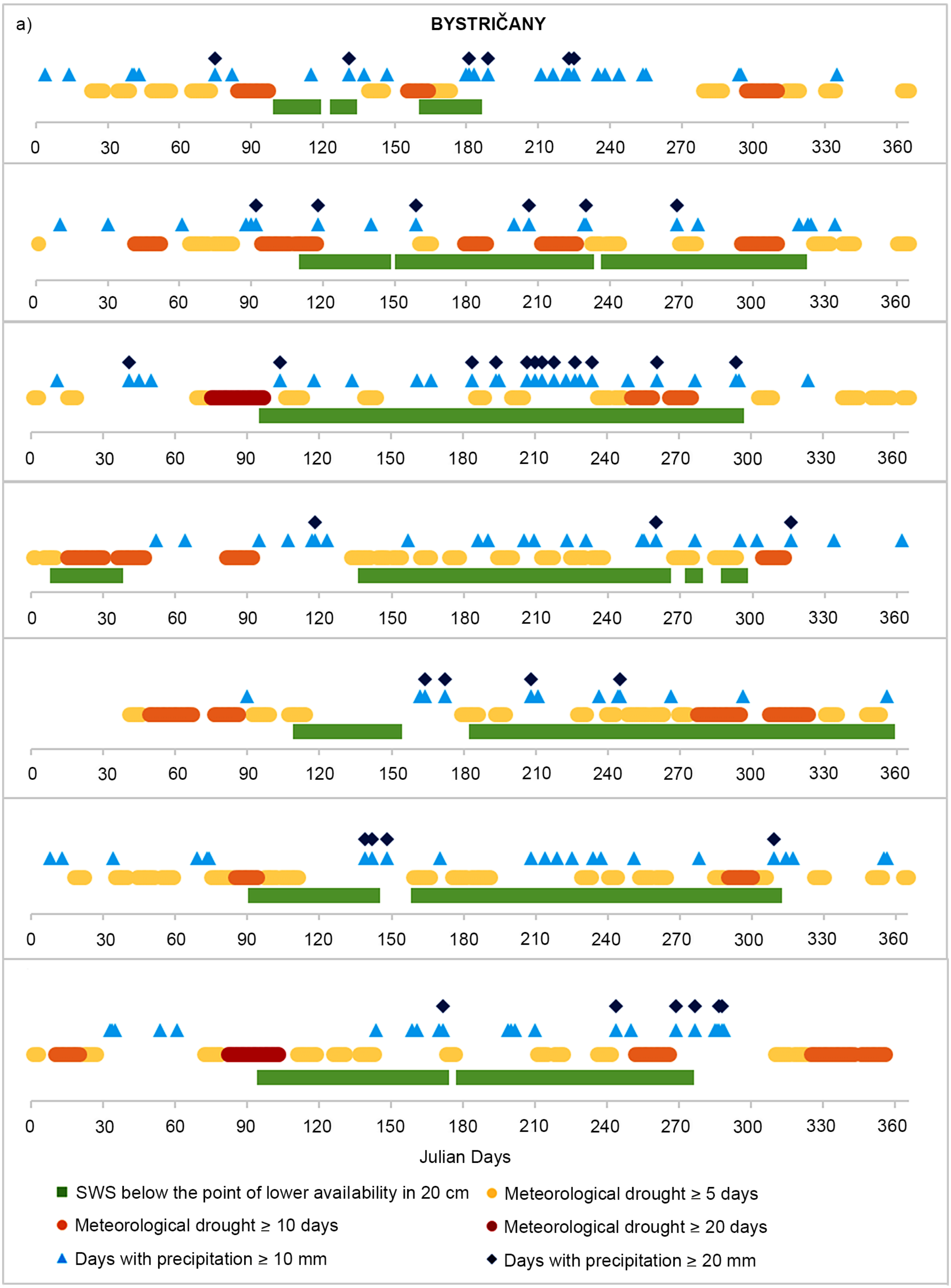

Fig. 3. Comparison between meteorological and agricultural drought in the Bystričany location for the years: a) 2014; b) 2015; c) 2016; d) 2017; e) 2018; f) 2019 and g) 2020

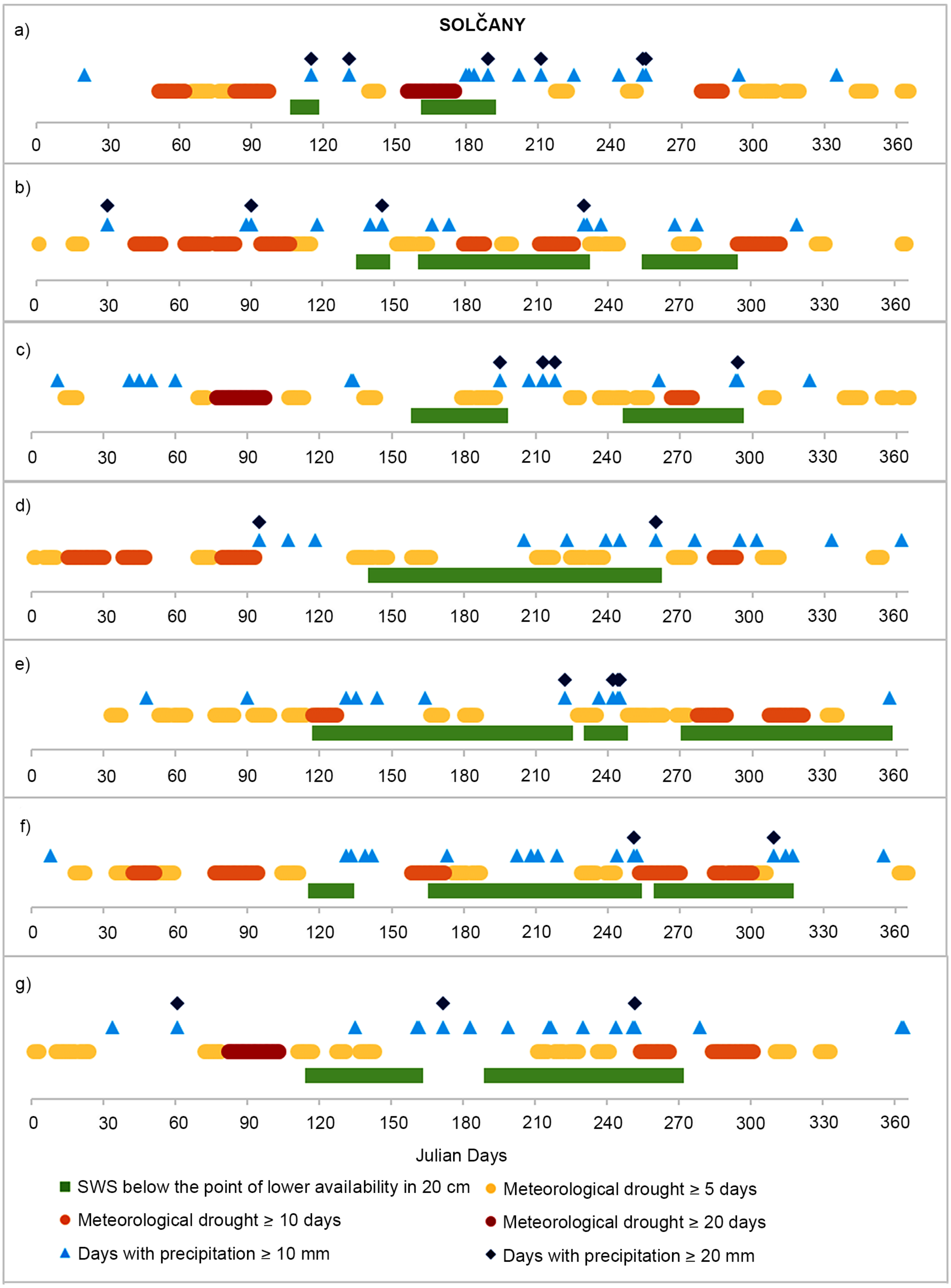

Fig. 4. Comparison between meteorological and agricultural drought in the Solčany location for the years: a) 2014; b) 2015; c) 2016; d) 2017; e) 2018; f) 2019 and g) 2020

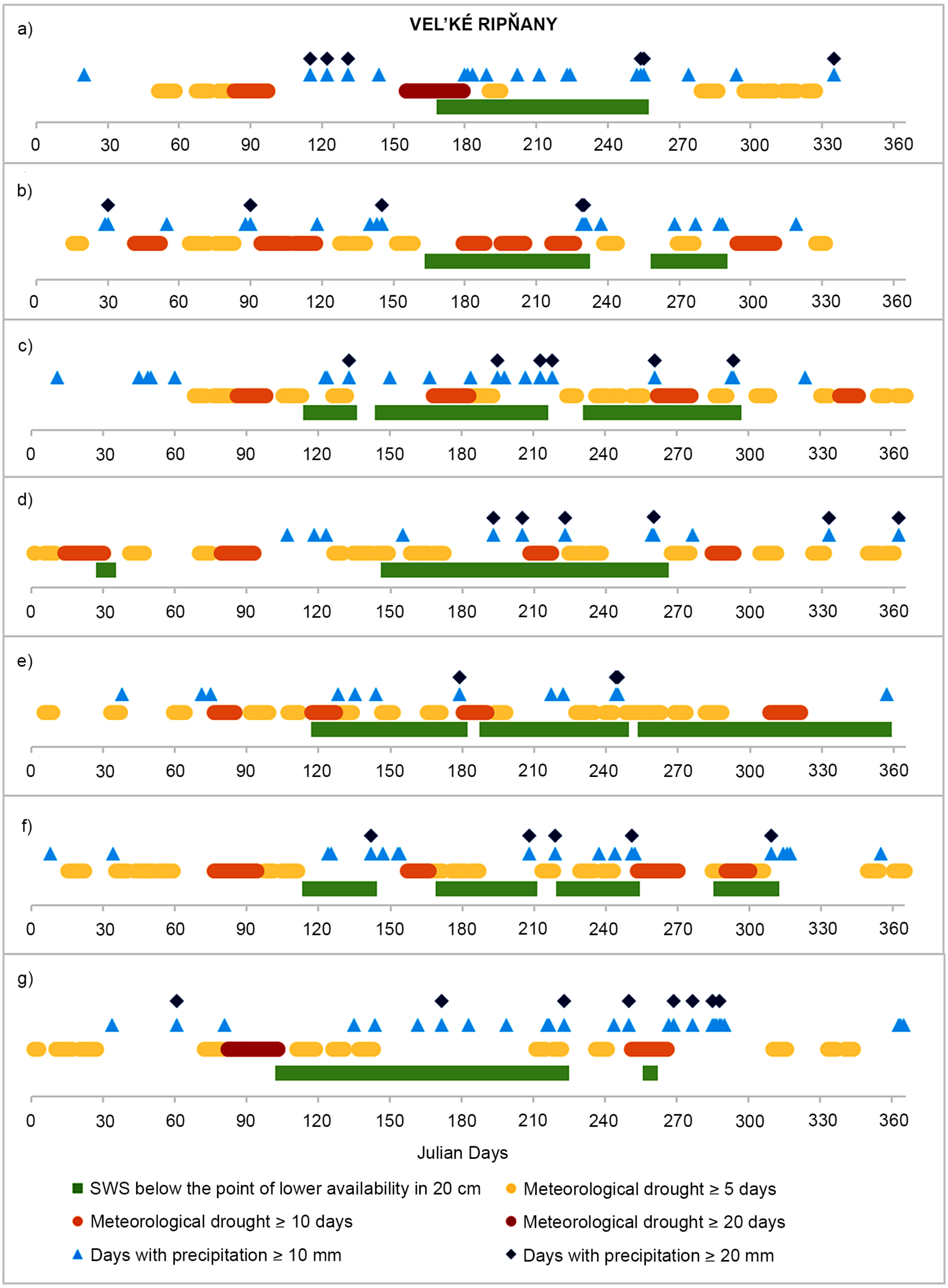

Fig. 5. Comparison between meteorological and agricultural drought in the Veľké Ripňany location for the years: a) 2014; b) 2015; c) 2016; d) 2017; e) 2018; f) 2019 and g) 2020

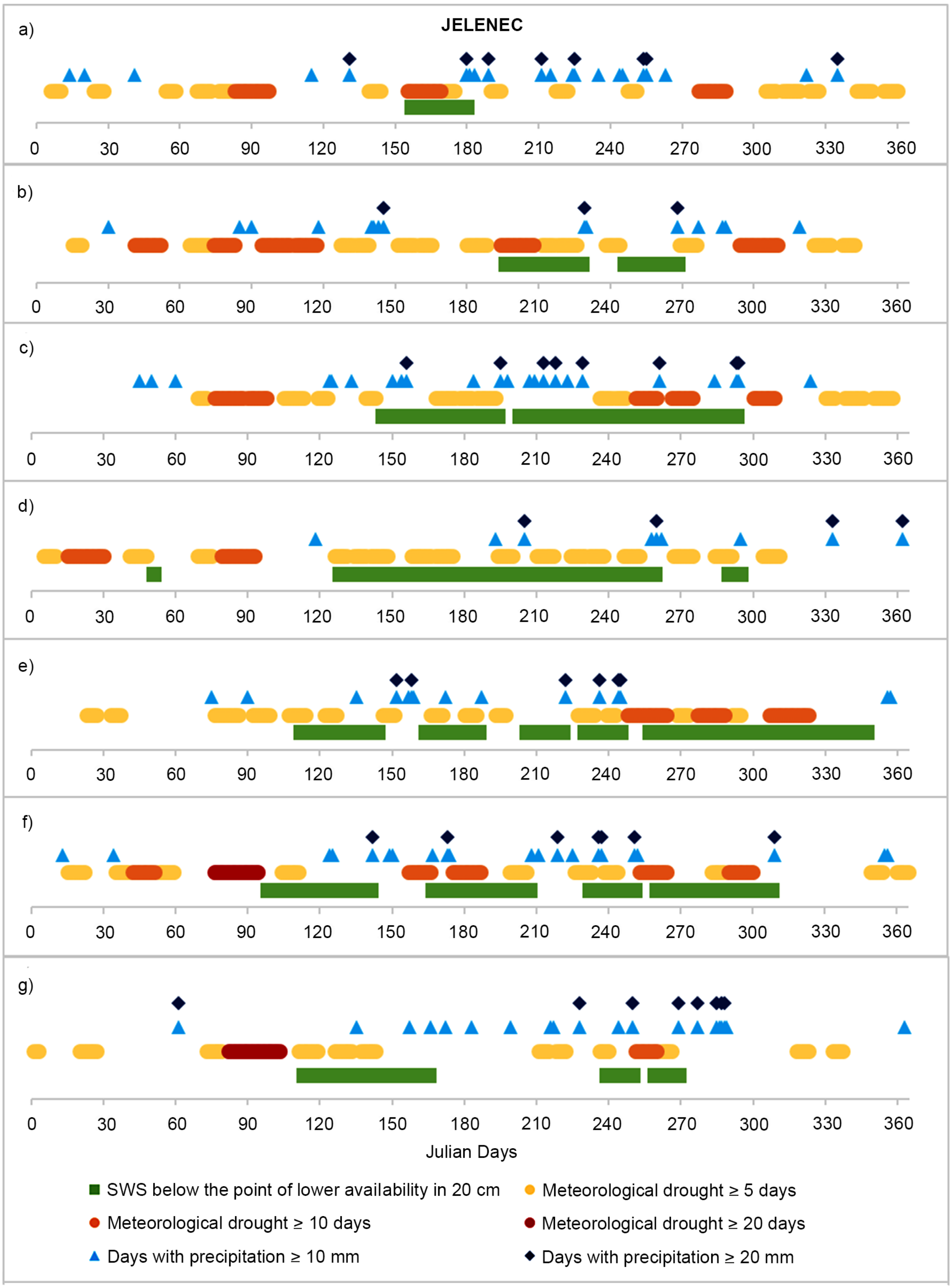

Fig. 6. Comparison between meteorological and agricultural drought in the Jelenec location for the years: a) 2014; b) 2015; c) 2016; d) 2017; e) 2018; f) 2019 and g) 2020

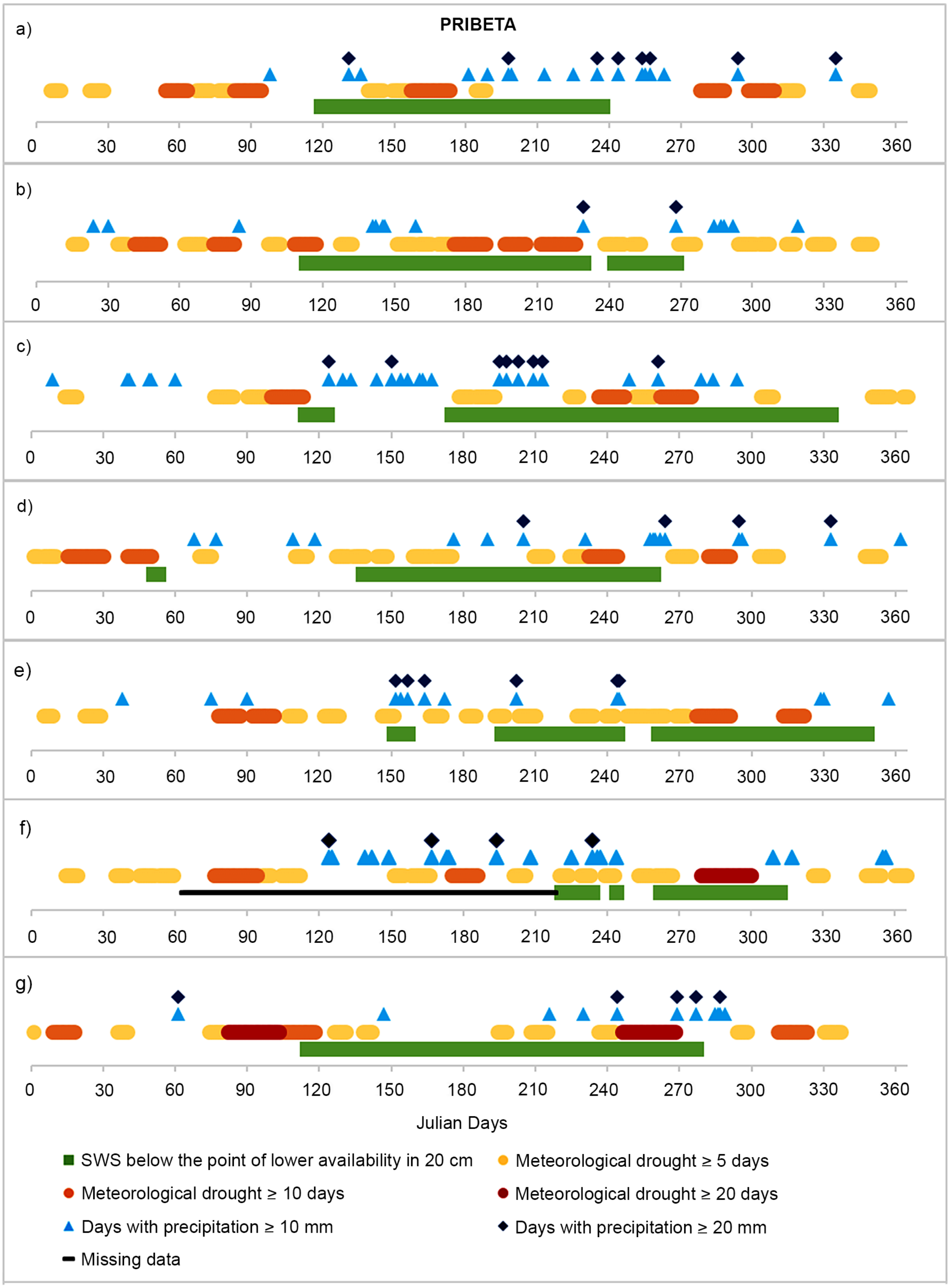

Fig. 7. Comparison between meteorological and agricultural drought in the Pribeta location for the years: a) 2014; b) 2015; c) 2016; d) 2017; e) 2018; f) 2019 and g) 2020

Table 2. Number of days with meteorological and agricultural drought

↑	increase in the number of days compared to 2014
↓	decrease in the number of days compared to 2014
→	no change in the number of days compared to 2014

SVINNÁ	2014	2015	2016	2017	2018	2019	2020
Days with agricultural drought	0	↑23	→0	↑78	↑133	–	↑33
Meteorological drought (5 days and more)	22	↑91	↑59	↑95	↑116	↑95	↑126
Days with precipitation (1.0 mm and more)	97	↓84	↓89	↓92	↓85	↓93	↑103
BRYSTRIČANY	2014	2015	2016	2017	2018	2019	2020
Days with agricultural drought	42	↑192	↑192	↑153	↑207	↑195	↑162
Meteorological drought (5 days and more)	109	↑143	↑121	↑147	↑145	↑138	↑154
Days with precipitation (1.0 mm and more)	99	↓96	↑103	↓96	↓82	↑107	↑105
SOLČANY	2014	2015	2016	2017	2018	2019	2020
Days with agricultural drought	33	↑111	↑79	↑117	↑199	↑147	↑119
Meteorological drought (5 days and more)	120	↑150	↓115	↑133	↑128	↑139	↑131
Days with precipitation (1.0 mm and more)	82	↓74	↑96	↓75	↓80	↑90	↑84
V. RIPŇANY	2014	2015	2016	2017	2018	2019	2020
Days with agricultural drought	84	↑91	↑145	↑114	↑218	↑115	↑118
Meteorological drought (5 days and more)	101	↑147	↑144	↑157	↑146	↑161	↑122
Days with precipitation (1.0 mm and more)	87	↓77	↑97	↓77	↓86	↑92	↑93
JELENEC	2014	2015	2016	2017	2018	2019	2020
Days with agricultural drought	24	↑55	↑130	↑128	↑179	↑149	↑70
Meteorological drought (5 days and more)	130	↑172	↑135	↑153	↑137	↑146	↓106
Days with precipitation (1.0 mm and more)	88	↓72	↑90	↓75	↓79	↓86	→88
PRIBETA	2014	2015	2016	2017	2018	2019	2020
Days with agricultural drought	119	↑144	↑161	↑122	↑144	–	↑163
Meteorological drought (5 days and more)	121	↑180	↑129	↑162	↑137	↑162	↑141
Days with precipitation (1.0 mm and more)	88	↓81	↑93	↓68	↑97	↓83	↓82

In Table 2, we compared the number of days with agricultural drought, meteorological drought that lasted at least 5 days or more, and the number of days with precipitation of 1.0 mm and more. The arrows show the increase or decrease in the number of days compared to 2014. We chose this particular year for comparison as the first year of measurements, and based on that we determined the development of the number of days with drought and with precipitation. Although the number of days fluctuates, an increasing trend is seen in the number of days with meteorological and agricultural drought, while the number of days with precipitation above 1.0 mm decreases slightly. A period of 7 years is sufficient for us to be able to identify a future short-term trend .

Agriculture is one of the most important industries. In Europe, we observe increasingly frequent droughts (Ionita and Nagavciuc, 2021; Hološ and Šurda, 2021) alternating with extreme rainfall (Zittis et al., 2021), which affects crop yields (Harsányi et al., 2021). Meteorological and agricultural droughts have been considered by many authors (Karamuz et al., 2021; Łabędzki, Bąk, 2014; Shengzhi et al., 2015; Rimkus et al., 2020), but they defined drought mostly by drought indices. Also, authors in Slovakia analyse precipitation, meteorological and hydrological drought mainly on the basis of indices (Zuzulová et al.; Jurík, Kaletová, 2018; Fendeková et al., 2018; Zuzulová, Šiška, 2017; Nagy et al., 2020).

The Supreme Audit Office of the Slovak Republic states on the basis of the identified shortcomings that the Slovak Republic is not prepared to deal with drought so as to eliminate future threats to the environment and society, because the issue of drought is not addressed comprehensively and systemically, and no strategy has been developed to deal with it (NKÚ SR, 2021). In this paper we focused on the comparison between meteorological drought according to the number of days without precipitation and agricultural drought according to the point of reduced availability, when the availability of water for plants in the soil decreases, but the plants do not yet wilt. Vitková et al. (2015) made a similar comparison, but they assessed the agricultural drought according to the wilting point. During the study, we did not find another author who would make a similar comparison of meteorological and agricultural drought based on the parameters that we have assumed. The number of days with both meteorological and agricultural droughts is increasing. This trend can also be seen in the countries neighbouring Slovakia: in Poland (Przybylak et al., 2020; Oleksiak et al., 2021), Hungary (Alsafadi et al., 2020; Buzási et al., 2021), and Czech Republic (Brázdil et al., 2013; Bartošová et al., 2015). Therefore, it is necessary to make the area optimally functional (Pagáč Mokrá, et al., 2020) to effectively manage rainwater (Pokrývková et al., 2021), build sufficient irrigation systems, and focus on growing drought-resistant crops.

CONCLUSION

Meteorological and agricultural drought is the first visible sign of water deficiency in the country. As can be seen in the evaluation of the years 2014–2020 in the Nitra River basin, periods of water deficiency occur more often and not only in the southern part of the Nitra River basin (Pribeta), but also in the northern part (Svinná and Bystričany). Therefore, it is necessary to pay more attention to this issue and to develop irrigation systems and use water efficiently, in order to prevent another category of drought – the socio-economic drought, which will have an even greater impact on the population.

The article provides comprehensive assessments of drought in the country. The simplest identification of droughts is by periods without precipitation. However, the occurrence of precipitation does not actually have a direct effect on vegetation. The vegetation depends on the water in the soil – in our case on the agricultural drought. The article provides information on the delay in the occurrence of agricultural drought after the meteorological drought. At the same time, this points to the fact that agricultural drought may not automatically occur even after a prolonged period of meteorological drought. It is also clear from the data that even the occurrence of one-off heavy rainfall does not necessarily mean the interruption of agricultural drought.

ACKNOWLEDGEMENTS

This publication was supported by the Operational Program Integrated Infrastructure within the project: Demand-driven Research for the Sustainable and Innovative Food, Drive4SIFood 313011V336, financed by the European Regional Development Fund; by the Scientific Grant Agency no. VEGA 1/0064/19; by the Cultural and Educational Grant Agency no. KEGA 026SPU-4/2020; by the Grant Agency of SUA in Nitra no. 19-GASPU-2021; and by the Cultural and Educational Grant Agency no. KEGA 031SPU-4/2021.

REFERENCES

Alsafadi, K., Mohammed, S.A., Ayugi, B., Sharaf, M., Hasrsányi, E. (2020). Spatial-Temporal Evolution of Drought Characteristics Over Hungary Between 1961 and 2010. Pure Appl. Geophys. 177, 3961–3978. https://doi.org/10.1007/s00024-020-02449-5.

Antal, J., Bárek, V., Čimo, J., Halaj, P., Halászová, K., Horák, J., Igaz, D., Jurík, Ľ., Muchová, Z., Novotná, B., Šinka, K. (2014). Hydrológia poľnohospodárskej krajiny [Hydrology of agricultural land]. Nitra: SPU.

Atlas krajiny Slovenskej Republiky [Atlas of the Landscape of the Slovak Republic] (2002). https://geo.enviroportal.sk/atlassr/ (accessed on 15 November 2021) (In Slovak).

Bartosová, L., Trnka, M., Hlavinka, P., Semrádová, D., Balek, J. Monitoring Agricultural Drought in Czech Republic – Drought Episode of 2015. Listy Cukrovarnické a Reparské. 132, 9–10, 280–284.

Bhuiyan, Ch. (2017). Drought Vulnerability. In Eslamian, S., & Eslamian, F. A. (Ed.), Handbook of Drought and Water Scarcity: Environmental Impacts and Analysis of Drought and Water Scarcity, (689 p). Florida: CRC Press.

Borgula, A. (2004). Rieka Nitra v Okolí Mesta Nitra [The Nitra River Near the Nitra City]. http://riekanitra.szm.com/ (In Slovak).

Brázdil, R., Dobrovolný, P., Trnka, M., Kotyza, O., Řezníčková, L., Valášek, H., Zahradníček, P., Štěpánek, P. (2013). Droughts in the Czech Lands, 1090–2012 AD, Clim. Past, 9, 1985–2002, https://doi.org/10.5194/cp-9-1985-2013.

Brezianská, K., Vitková, J. (2015). Analýza bezzrážkových období a ich vplyv na zásobu vody v pôde na Záhorskej nížine [Analyse of Periods Without Precipitation and their Influence on Soil Water Storage at Záhorská Lowland], Acta Hydrologica Slovaca, 16 (TC1), 260–266.

Buzási, A., Pálvölgyi, T., Esses, D. (2021). Drought-related vulnerability and its policy implications in Hungary. Mitig Adapt Strateg Glob Change 26, 11. https://doi.org/10.1007/s11027-021-09943-8.

Carroll, Ch.J. W., Slette I.J., Griffin-Nolan, R.J., Baur, L.E., Hoffman, A.M., Denton, E.M., Gray, J.E., Post A.K., Johnston, M.K., Yu, Q., Collins, S.L., Luo, Y., Smith, M.D., Knapp, A.K. (2021). Is a drought a drought in grasslands? Productivity responses to different types of droughts. Oecologia, 197,1017–1026. https://doi.org/10.1007/s00442-020-04793-8.

Cebulska, M. (2021). Atmospheric drought in the Polish Tatras and their foreland in the years 1951–2017. Acta Scientiarum Polonorum. Formatio Circumiectus, 20(1), 55–67.

Coles, N.A., Eslamian, S. (2018). Definition of Drought. In: Eslamian, S., & Eslamian, F.A. (Ed.), Handbook of Drought and Water Scarcity: Principles of Drought and Water Scarcity, (690 p). Florida: CRC Press.

Dracup, J.A., Lee, K.S., Paulson Jr., E.G. (1980). On the definition of droughts, Water Resource Research, 16 (2), 297–302. https://doi.org/10.1029/WR016i002p00297.

Eklund, L., Seaquist, J. (2015). Meteorological, agricultural, and socioeconomic drought in the Duhok Governorate, Iraqi Kurdistan, Natural Hazards, 76, 421–441. https://doi.org/10.1007/s11069-014-1504-x.

Fendeková, M., Gauster, T., Labudová, L., Vrábliková, D., Danáčová, Z., Fendek, M., Pekárová, P. (2018). Analysing 21st century meteorological and hydrological drought events in Slovakia. Journal of Hydrology and Hydromechanics. 66, 4, 393–403. https://doi.org/10.2478/johh-2018-0026.

Gomboš, M., Tall, A., Kandra, B., Pavelková, D. (2021). Influence of Soil Type on Statistical Characteristics and Graphical Results Interpretation of the Water Storage Distribution Monitoring Along the Vertical of the Soil Profile. Acta Hydrologica Slovaca, 22, 1, 97–105. https://doi.org/10.31577/ahs-2021-0022.01.0011.

Harsányi, E., Bashir, B., Alsilibe, F., Alsafadi, K., Alsalman, A., Széles, A., Rahman, M.H.U., Bácskai, I., Juhász, C., Ratonyi, T., Mohammed, S. (2021). Impact of Agricultural Drought on Sunflower Production across Hungary. Atmosphere, 12, 1339. https://doi.org/10.3390/atmos12101339.

Hološ, S., Šurda, P. (2021). Evaluation of Drought – Review of Drought Indices and their Application in the Recent Studies from Slovakia. Acta Horticulturae et Regiotecturae, 24, 97–108. https://doi.org/10.2478/ahr-2021-0015.

Huang, S., Huang, Q., Chang, J., Leng, G., Xing, L. (2015). The response of agricultural drought to meteorological drought and the influencing factors: A case study in the Wei River Basin, China, Agricultural Water Management, 159, 45–54, https://doi.org/10.1016/j.agwat.2015.05.023.

Igaz, D., Horák, J., Šinka, K., Kondrlová E. (2014). Soil hydro physical characteristics in the Nitra River basin (Slovakia): Their monitoring, analysis, online publishing. Eurasian Journal of Soil Science, 3, 2, 108–115. https://doi.org/10.18393/ejss.98721.

Igaz, D., Šinka, K., Varga, P., Vrbičanová, G., Aydin, E., Tárník, A. (2021). The Evaluation of the Accuracy of Interpolation Methods in Crafting Maps of Physical and Hydro-Physical Soil Properties. Water, 13, 212. https://doi.org/10.3390/w13020212.

Igaz, D., Štekauerová, V., Horák, J., Kalúz, K., Čimo, J. (2011). Analýza hydrofyzikálnych charakteristík pôd v povodí rieky Nitra [The Analysis of Soils Hydrophysical Characteristics in the Nitra River Basin]. Influence of Anthropogenic Activities on Water Regime of Lowland Territory Physics of Soil Water, 17–19. (In Slovak).

Ionita, M., Nagavciuc, V. (2021). Changes in drought features at the European level over the last 120 years, Nat. Hazards Earth Syst. Sci., 21, 1685–1701, https://doi.org/10.5194/nhess-21-1685-2021.

Jurík Ľ., Kaletová T. (2018). Drought as Stress for Plants, Irrigation and Climatic Changes. In: Negm A., Zeleňáková M. (eds) Water Resources in Slovakia: Part II. The Handbook of Environmental Chemistry, 70. Springer, Cham. https://doi.org/10.1007/698_2018_271.

Karamuz, E., Bogdanowicz, E., Senbeta, T.B., Napiórkowski, J.J., Romanowicz, R.J. (2021). Is It a Drought or Only a Fluctuation in Precipitation Patterns? – Drought Reconnaissance in Poland. Water, 13, 807. https://doi.org/10.3390/w13060807.

Kutílek M., Nielsen D.R. (2015). How Water Flows in Soil. Soil. Springer, Dordrecht. https://doi.org/10.1007/978-94-017-9789-4_9.

Łabędzki, L., Bąk, B. (2014). Meteorological and agricultural drought indices used in drought monitoring in Poland: a review. Meteorology Hydrology and Water Management, 2(2), 3–14. https://doi.org/10.26491/mhwm/34265.

Liu, X., Zhu, X., Pan, Y., Li, S., Liu, Y., Ma, Y. (2016). Agricultural drought monitoring: Progress, challenges, and prospects. Journal of Geographical Science. 26(6), 750–767. https://doi.org/10.1007/s11442-016-1297-9.

Mazúr, E., Lukniš, M. (1980). Geomorfologické Jednotky. Atlas SSR [Geomorfological Units. Atlas of Slovakia]; SAV, SÚGK: Bratislava, Slovakia. (In Slovak).

Mehran, A., Mazdiyasni, O., AghaKouchak, A. (2015). A hybrid framework for assessing socioeconomic drought: Linking climate variability, local resilience, and demand. Journal of Geophysical Research: Atmospheres, 120. https://doi.org/10.1002/2015JD023147.

Meter Group. (2017). https://www.metergroup.com/environment/products/ech20-10hs-soil-moisture-sensor/ (accessed on 15 November 2021).

Nagy, P., Purcz, P., Galas, S., Portela, M.M., Hlavatá, H., Simonová, D. (2020). rend analysis of drought indices in the eastern Slovakia. Young Scientist 2020. DOI:10.1088/1757-899X/867/1/012033.

Najvyšší kontrolný úrad SR (2021). Správa o výsledku kontroly: Pripravenosť Slovenskej republiky na riešenie sucha [Inspection result report: Readiness of the Slovak Republic to deal with drought]. https://www.nku.gov.sk/aktuality/-/asset_publisher/9A3u/content/slovensko-treba-pripravit-na-riesenie-sucha-chyba-system-a-strategia.

Oleksiak, T., Spyroglou, I., Pacoń, D., Matysik, P., Pernisová, M., Rybka, K. Effect of drought on wheat production in Poland between 1961 and 2019. Crop Science. https://doi.org/10.1002/csc2.20690.

Pagáč Mokrá, A., Pagáč, J., Muchová, Z., Petrovič, F. (2020). Analysis of Ownership Data from Consolidated Land Threatened by Water Erosion in the Vlára Basin, Slovakia. Sustainability 2021, 13, 51. https://dx.doi.org/doi:10.3390/su13010051.

Palmer, W. C. (1965). Meteorological Drought. Washington, D.C.: U.S. Weather Bureau.

Petrovič, Š. (1960). Klimatické pomery Hurbanova [Climatic Conditions of Hurbanovo]. HMÚ, Praha, 138–161. (In Slovak).

Pokrývková, J., Pagáč, J., Hanzlík, R., Pagáč Mokrá, A. (2021). Possibilities of Rainwater Management in the Current Climate Conditions. Veda mladých 2021 – Science of Youth 2021, 149–160, https://doi.org/10.15414/2021.9788055223384.

Przybylak, R., Oliński, P., Koprowski, M., Filipiak, J., Pospieszyńska, A., Chorążyczewski, W., Puchałka, R., Dąbrowski, H. P. (2020). Droughts in the area of Poland in recent centuries in the light of multi-proxy data, Clim. Past, 16, 627–661, https://doi.org/10.5194/cp-16-627-2020.

Quiring, S.M. (2009). Monitoring Drought: An Evaluation of Meteorological Drought Indices. Geography Compass, 3(1), 64–88. https://doi.org/10.1111/j.1749-8198.2008.00207.x.

Rimkus, E., Maciulyte, V., Stonevicius, E., Valiukas, D. (2020). A revised agricultural drought index in Lithuania. Agricultural and Food Science, 29(4), 359–371. https://doi.org/10.23986/afsci.92150.

Skalová, J., Kotorová, D., Igaz, D., Gomboš, M., Nováková, K. (2015). Regionalizácia pedotransferových funkcií vlhkostných retenčných kriviek pôd Slovenska [Regionalization of Pedotransfer Functions of Soil Moisture Retention Curves]. STU: Bratislava, Slovakia. (In Slovak)

Stahl, K., Vidal, J.P., Hannaford, J., Tijdeman, E., Laaha, G., Gauster, T., Tallaksen, L.M. (2020). The challenges of hydrological drought definition, quantification, and communication: an interdisciplinary perspective, Proceedings of the International Association of Hydrological Sciences, 383, 291–295. https://doi.org/10.5194/piahs-383-291-2020.

Tárník, A., Igaz, D. (2015). Quantification of soil water storage available to plants in the Nitra River basin. Acta Scientiarum Polonorum Formatio Circumiectus. 14(2), 209–216. http://dx.doi.org/10.15576/ASP.FC/2015.14.2.209.

Tárník, A., Igaz, D. (2015a). Determination of Plant Available Soil Water Storage in Agricultural Land of the Nitra River Catchment. Acta Horticulturae et Regiotecturae. 18(1), 16–19. https://doi.org/10.1515/ahr-2015-0004.

Tárník, A., Igaz, D. (2020). Spatial Scale Analysis of Soil Water Content in Agricultural Soils of the Nitra River Catchment (Slovakia). Journal of Ecological Engineering, 21, 1, 112–119. https://doi.org/10.12911/22998993/113076.

Vitková, J., Šútur, J., Šurda, P., Stradiot, P. (2015). Možnosti interpretácie monitorovaných hodnôt zásob vody v pôde (Possibilities of Interpretation of Monitored Values of Water Supplies in Soil), Acta Hydrologica Slovaca, 16(1), 3–12.

Wilhite, D.A., Glantz, M.H. (1985). Understanding the Drought Phenomenon: The Role of Definitions, Water International, 10(3), 111–120.

World Meteorological Organization (WMO), Global Water Partnership (GWP). (2016). Handbook of Drought Indicators and Indices (M. Svoboda and B. A. Fuchs). Integrated Drought Management Programme (IDMP), Integrated Drought Management Tools and Guidelines Series 2. Geneva.

Zhong, F., Cheng, Q., Wang, P. (2020). Meteorological Drought, Hydrological Drought, and NDVI in the Heihe River Basin, Northwest China: Evolution and Propagation. Advances in Meteorology, 2020, 26. https://doi.org/10.1155/2020/2409068.

Zittis, G, Bruggeman, A. Lelieveld, J. (2021) Revisiting future extreme precipitation trends in the Mediterranean. Weather and Climate Extremes, 34, https://doi.org/10.1016/j.wace.2021.100380.

Zuzulová, V., Šiška, B. (2017). Identification of Drought in Western Slovakia by Palmer Drought Severity Index (PDSI). Acta Regionalia et Environmentalica. 14, 1. 7–14. https://doi.org/10.1515/aree-2017-0002.

Zuzulová, V., Žilinský, M. Šiška, B. (2019). Seasons of Drought in Slovakia During the Period from 1957 to 2016. Acta Regionalia et Environmentalica. 16, 2, 38––44. https://doi.org/10.2478/aree-2019-0008.

PORÓWNANIE SUSZY METEOROLOGICZNEJ I SUSZY ROLNICZEJ W DORZECZU RZEKI NITRY W LATACH 2014–2020

ABSTRAKT

Cel pracy

Susze, które obserwujemy w kolejnych latach, stanowią jedno z najbardziej kosztownych zagrożeń naturalnych. Ich negatywny wpływ jest znaczący i rozległy, uderzając jednocześnie w wiele sektorów gospodarki i populacji ludzkich (WMO i GWP, 2016). W artykule skupiamy się na porównaniu suszy meteorologicznej (kryterium opadów atmosferycznych) i suszy rolniczej (kryterium wody w glebie dostępnej dla roślin) w dorzeczu rzeki Nitry na Słowacji.

Materiał i metody

Dane z dorzecza rzeki Nitry zostały dostarczone ze stacji meteorologicznych (Svinná, Bystričany, Solčany, Veľké Ripňany, Jelenec i Pribeta) prowadzonych przez Słowacki Uniwersytet Rolniczy w Nitrze. Suszę meteorologiczną zdefiniowano jako okres bez opadów (Petrovič, 1960). Suszę rolniczą określono jako wartość poniżej minimalnej ilości wody w profilu glebowym (0,20 m) dostępnej dla roślin.

Wyniki i wnioski
W naszych badaniach skupiliśmy się na porównaniu suszy meteorologicznej i rolniczej, przy czym zauważyliśmy, że liczba dni, w których równocześnie występują obydwa rodzaje suszy, wzrasta począwszy od 2014 roku. Najgorszy pod tym względem był rok 2018 – co dotyczy wszystkich badanych stacji meteorologicznych – kiedy rolnicza susza występowała z krótkimi przerwami od wiosny aż do zimy. Podobny trend można zaobserwować również w krajach sąsiadujących ze Słowacją – w Polsce, na Węgrzech czy w Republice Czeskiej.

Słowa kluczowe: susza meteorologiczna, susza rolnicza, opady, wilgotność gleby, dorzecze Nitry