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STANDARDIZED EVAPOTRANSPIRATION AS AN AGRICULTURAL DROUGHT INDEX†

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ABSTRACT

Drought risk for sugar beet was estimated based on standardized evapotranspiration index ET_s and the frequency of drought occurrence. Standardized evapotranspiration index ET_s was calculated for four soil types of different useful soil water reserves using the series of actual evapotranspiration ET for sugar beet growing seasons in 1970–2004, taken from 40 meteorological stations located in various agroclimatic regions of Poland. A great spatial differentiation of the frequency of droughts depending on drought category and soils were determined. Differences between the stations were observed, whereas differences between soils were less. The minimum frequency was observed on soil with the greatest total available soil water. Frequency of all drought categories ranged from 20% to 40% on soil with low water retention and to 35% on soil with high water retention. Generally most drought periods according to the ET_s were recorded in central Poland from west to east. Taking into account the frequency of droughts in all categories, the central-west and central-east parts of Poland are most threatened by agricultural droughts. Copyright © 2008 John Wiley & Sons, Ltd.

KEY WORDS: agricultural drought; evapotranspiration; sugar beet

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RÉSUMÉ

L'évaluation du risque de sécheresse pour les betteraves sucrières a été effectuée sur la base de l'indicateur d'évapotranspiration standardisée ET_s et de fréquence d'apparition des sécheresses. L'indicateur d'évapotranspiration standardisée ET_s a été calculé pour 4 types de sols, avec différentes réserves d'eau utile, en appliquant l'évapotranspiration réelle ET en période de végétation des betteraves sucrières dans les années 1970–2004, mesurée dans 40 stations météorologiques situées dans différentes régions agro-climatiques en Pologne. On a constaté une grande différenciation territoriale de la fréquence des sécheresses en fonction de la classe de la sécheresse et du type de sol. On perçoit des différences entre les stations tandis que les différences entre les sols sont moins importantes. La fréquence la plus faible a été observée dans le cas de sols avec la plus grande réserve d'eau utile. La fréquence de toutes les classes de sécheresse était de 20 à 40% sur les sols avec un faible réserve d'eau utile et jusqu'à 35% sur un sol avec une grande réserve d'eau utile. D'après l'ET_s, la majorité des périodes sèches à été identifié en Pologne centrale, d'ouest en est. La partie centre-ouest et centre-est de la Pologne est la plus menacée par les sécheresses agricoles. Copyright © 2008 John Wiley & Sons, Ltd.

MOTS CLÉS: sécheresse agricole; évapotranspiration; betterave sucrière

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† L'évapotranspiration standardisée comme indicateur de sécheresse agricole.

INTRODUCTION

Poland is situated in a transitory temperate climate zone, influenced by a mild oceanic climate from the west and a dry continental climate from the east. Droughts in Poland, posing a serious economic, social and environmental problem, are hardly predictable. It is difficult to forecast the term of their occurrence, duration, territorial range and intensity. In spite of this unpredictability and irregularity of drought occurrence in Poland, one may observe some statistical properties of their frequency, duration and the regions affected. Although no significant decrease in the annual precipitation is predicted in Central Europe due to global climate change, considering the forecast increase in temperature, possible increase in water shortage and extreme weather events in the future, it is very likely that the frequency of drought occurrence and its severity will increase in that region (Olesen and Bindi, 2002; European Climate Assessment, 2008).

Climatic conditions in Poland are characterized by a considerable variability in weather during long periods of time (years) as well as short periods (days, weeks). The annual precipitation, averaged for the whole country, amounts to 600 mm and during the vegetation period (April–September) reaches on average 350 mm (Figure 1). During the vegetation period reference evapotranspiration in most of the country exceeds precipitation (Figure 1), resulting in water deficit, especially in light soils with low water retention capacity. The driest regions of Poland are almost the entire central region, as well as northwestern and mid-eastern parts. These are the regions most threatened by frequent and most severe meteorological droughts, with annual rainfall amount often less than 300 mm (Bąk and Łabędzki, 2002; Łabędzki and Bąk, 2005; Łabędzki, 2007).

Meteorological droughts, expressed as precipitation departure from normal over some period of time, are the primary cause of agriculture droughts, but do not necessarily coincide with periods of agricultural droughts (Wilhite and Glantz, 1985). Agricultural droughts are the complex phenomena linking various characteristics of meteorological droughts with their impacts in crop production. They can be expressed in terms of soil moisture deficit for a particular crop at a particular time, reduction of evapotranspiration and crop yield due to this deficit, actual crop water use in relation to potential evapotranspiration, difference between crop water demand and available soil water (Wilhite and Glantz, 1985; Vermes, 1998).

There is an agreement among the authors that there is no precise and universally accepted definition of agricultural drought (Tate and Gustard, 2000). This absence leads to confusion about whether or not a drought

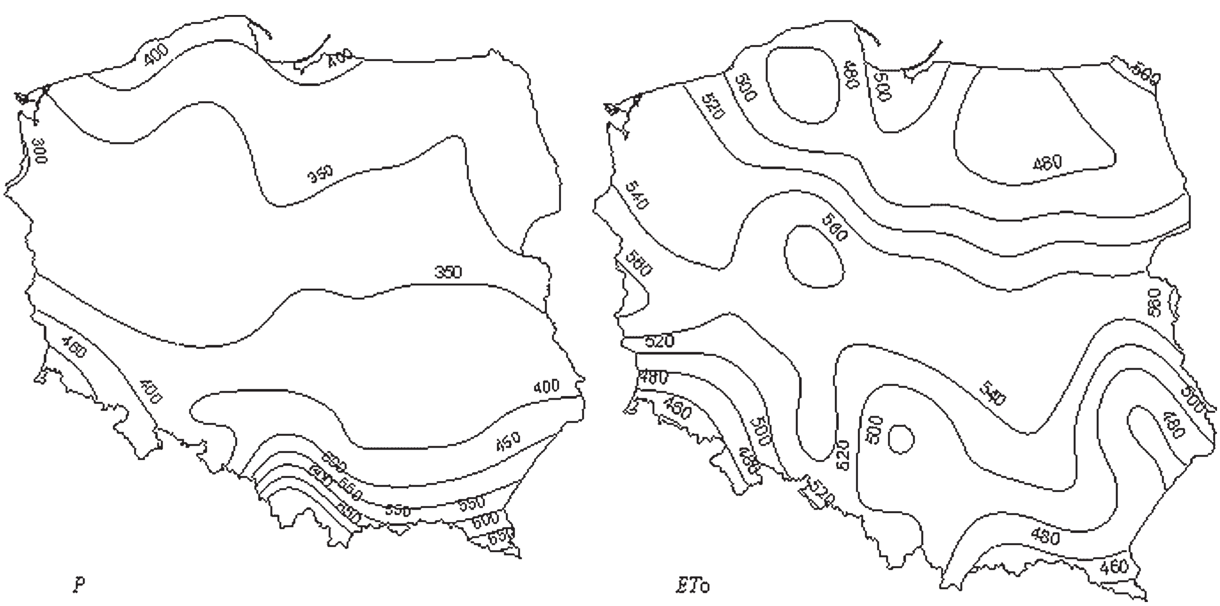

Figure 1. Mean precipitation P and reference evapotranspiration ET_o according to the Penman–Monteith equation in the vegetation period (April–September) in 1970–2004

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exists and – if it does – its degree of severity. Many indices and methods have been developed and are used to identify and determine the intensity of agricultural droughts (Vogt and Somma, 2000; Boken *et al*., 2005).

The paper gives an estimation of drought risk for sugar beet in Poland on soils with various available soil water reserves, in terms of spatial distribution of frequency of agricultural droughts. To identify and classify agricultural droughts the standardized evapotranspiration index ET_s is used.

MATERIALS AND METHODS

In the study long-term daily records of meteorological parameters in the vegetation period of sugar beet (April–September) of 1970–2004 are used. The data came from 40 meteorological stations, distributed uniformly in Poland (Figure 2, Table I). These parameters are used to calculate reference evapotranspiration according to the Penman–Monteith formula and then actual (adjusted) evapotranspiration using the crop and water stress coefficient approach. The meteorological parameters include air temperature, air humidity, sunshine hours and wind velocity.

The simulation of sugar beet evapotranspiration in 1970–2004 was performed in the 10-day periods of the growing period from April to September, for four soil types of different available soil water. The chosen soil types are appropriate for sugar beet cultivation in Poland and they encompass soils of different texture – from fine-textured soils ($G3$, $G4$) to more coarse textured soils ($G1$, $G2$).

Total available soil water (TASW) was calculated in the 10 cm layers of a 100 cm soil profile, on the basis of data given by Walczak *et al.* (2002), as the difference between the water content at field capacity ($pF = 2.0$) and wilting point ($pF = 4.2$), using the formula:

$$\text{TASW} = \text{SWC}_{pF2.0} - \text{SWC}_{pF4.2} \tag{1}$$

where $\text{SWC}_{pF2.0}$ and $\text{SWC}_{pF4.2}$ are the soil water content (in mm) at $pF = 2.0$ and $pF = 4.2$.

Total available soil water in the 100 cm soil profiles amounts to 120, 158, 202 and 270 mm (Table II).

Actual evapotranspiration in the growing seasons of sugar beet in 1970–2004 was calculated as a sum of daily values determined using the methodology described by Allen *et al*. (1998). Evapotranspiration ET^t in a day t is calculated as:

$$\text{ET}^t = k_s^t\, k_c^t\, \text{ET}_0^t \tag{2}$$

Figure 2. Geographical location of studied meteorological stations

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Table I. Geographical location of the studied meteorological stations

No.	Station	Altitude (m a.s.l.)[a]	Latitude	Longitude
1	Białystok	139	53° 13′	23° 10′
2	Biebrza	117	53° 39′	22° 36′
3	Bielsko-Biała	398	49° 48′	19° 00′
4	Bydgoszcz	46	53° 08′	18° 01′
5	Chojnice	173	53° 42′	17° 33′
6	Częstochowa	261	50° 49′	19° 06′
7	Elbląg	38	54° 10′	19° 26′
8	Gniezno	110	52° 33′	17° 34′
9	Gorzów	65	52° 44′	15° 15′
10	Jelenia Góra	342	50° 54′	15° 48′
11	Kalisz	140	51° 44′	18° 05′
12	Kłodzko	316	50° 26′	16° 39′
13	Koło	95	52° 12′	18° 40′
14	Koszalin	33	54° 12′	16° 09′
15	Kórnik	77	52° 15′	17° 06′
16	Kraków	209	50° 04′	19° 57′
17	Lesko	386	49° 28′	22° 20′
18	Leszno	93	51° 51′	16° 35′
19	Lublin	171	51° 14′	22° 34′
20	Łódź	184	51° 44′	19° 24′
21	Mława	141	53° 06′	20° 21′
22	Nowy Sącz	292	49° 37′	20° 41′
23	Olsztyn	133	53° 46′	20° 25′
24	Opole	176	50° 40′	17° 58′
25	Piła	72	53° 08′	16° 45′
26	Płock	62	52° 33′	19° 40′
27	Poznań	86	52° 25′	16° 50′
28	Puławy	142	51° 25′	21° 58′
29	Racibórz	190	50° 05′	18° 13′
30	Rzeszów	200	50° 06′	22° 03′
31	Siedlce	146	52° 11′	22° 16′
32	Skierniewice	129	51° 57′	20° 09′
33	Skroniów	256	50° 38′	20° 16′
34	Suwałki	165	54° 08′	22° 57′
35	Szczecin	1	53° 24′	14° 37′
36	Toruń	69	53° 03′	18° 35′
37	Warszawa	106	52° 09′	20° 59′
38	Włodawa	175	51° 38′	23° 33′
39	Wrocław	116	51° 06′	17° 05′
40	Zielona Góra	182	51° 56′	15° 30′

[a]m a.s.l., metres above mean sea level.

where

ET_0^t = reference evapotranspiration according to the Penman–Monteith equation (Allen *et al.*, 1998) in a day t (mm d^{-1})
k_c^t = crop coefficient (dimensionless)
k_s^t = water stress coefficient (dimensionless).

Reference evapotranspiration ET_0^t incorporates the effect of weather conditions on evapotranspiration. Crop coefficient k_c^t predicts evapotranspiration under standard conditions, i.e. under excellent agronomic and soil water conditions. For this study the 10-day crop coefficients (Table III) were determined in multi-year lysimeter measurements carried out in Poland (Łabędzki, 2006). Although the different terms of phenophases were observed

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Table II. Total available soil water (TASW) in analysed soils

Layer (cm)	TASW (mm) in the soil			
	G1	G2	G3	G4
0–10	13.5	19.5	19.5	25.5
10–20	13.5	19.5	19.5	25.5
20–30	13.6	18.0	21.0	25.5
30–40	13.5	16.5	22.4	25.5
40–50	13.5	16.5	22.4	25.5
50–60	10.5	13.6	19.5	28.5
60–70	10.5	13.5	19.5	28.5
70–80	10.5	13.5	19.5	28.5
80–90	10.5	13.5	19.5	28.5
90–100	10.5	13.5	19.5	28.5
0–100	120.1	157.6	202.3	270.0

in each year the terms and coefficients were averaged. That is why in the study the same 10-day coefficient values are used for the mean terms of phenophases in every year of 1970–2004.

The effect of soil water stress on crop evapotranspiration is described by reducing the value of the crop coefficient, multiplying it by the water stress coefficient k_s^t. It is calculated as (Allen *et al.*, 1998):

$$k_s^t = \frac{\mathrm{ZWU}_p^t}{(1-p)\mathrm{TASW}_r} \tag{3}$$

where

ZWU_p^t = available soil water in the root zone at the beginning of a day t (mm)

Table III. Plant and soil-water parameters in the 10-day periods in the sugar beet vegetation period

Month	10-day period	k_c	d (m)	p	$\mathrm{TASW_r}$ (mm) in the soil			
					*G*1	*G*2	*G*3	*G*4
April	1	0.2	0.1	0.50	13.5	19.5	19.5	25.5
	2	0.2	0.1	0.50	13.5	19.5	19.5	25.5
	3	0.53	0.1	0.50	13.5	19.5	19.5	25.5
May	1	0.61	0.2	0.50	27.0	39.0	39.0	51.0
	2	0.66	0.3	0.50	40.6	57.0	60.0	76.5
	3	0.78	0.4	0.50	54.1	73.5	82.4	102.0
June	1	0.88	0.5	0.50	67.6	90.0	104.8	127.5
	2	1.01	0.6	0.50	78.1	103.6	124.3	156.0
	3	1.21	0.7	0.50	88.6	117.1	143.8	184.5
July	1	1.21	0.8	0.50	99.1	130.6	163.3	213.0
	2	1.26	0.9	0.50	109.6	144.1	182.8	241.5
	3	1.24	1	0.50	120.1	157.6	202.3	270.0
August	1	1.21	1	0.50	120.1	157.6	202.3	270.0
	2	1.20	1	0.50	120.1	157.6	202.3	270.0
	3	1.20	1	0.60	120.1	157.6	202.3	270.0
September	1	1.17	1	0.65	120.1	157.6	202.3	270.0
	2	1.13	1	0.65	120.1	157.6	202.3	270.0
	3	1.07	1	0.65	120.1	157.6	202.3	270.0

k_c = crop coefficient for the Penman–Monteith equation (dimensionless); d = root depth; p = fraction of total available soil water (dimensionless); $\mathrm{TASW_r}$ = total available soil water in the root zone.

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$TASW_r$ = total available soil water in the root zone (mm)
p = fraction of $TASW_r$ that a crop can extract from the root zone without suffering water stress (dimensionless) (Table III).

$TASW_r$ was calculated in the root zone, changing in time according to root depth, which was assumed to increase by $1\,\text{cm}\,\text{d}^{-1}$ (Table III).

The estimation of water stress coefficient k_s^t requires a daily water balance computation for the root zone. It is calculated as:

$$\mathrm{ZWU}_p^t = \mathrm{ZWU}_k^{t-1} = \mathrm{ZWU}_p^{t-1} + P^{t-1} - \mathrm{ET}^{t-1} \tag{4}$$

where

$\mathrm{ZWU}_k^{t-1}, \mathrm{ZWU}_p^{t-1}$ = available soil water in the root zone at the end and at the beginning of a day $t-1$ (mm)
P^{t-1} = precipitation in a day $t-1$ (mm)
ET^{t-1} = evapotranspiration in a day $t-1$ (mm).

This simple procedure assumes that the infiltration of daily precipitation to the root zone is within the same day and that the time of deep percolation from the root zone when soil water content exceeds field capacity is also 1 day.

The 1 m layer of the soil might not be saturated at the beginning of the vegetation period every year. To estimate the beginning value of ZWU each year, the water balance equation for the previous winter period is used:

$$\mathrm{ZWU}_{1IV} = \mathrm{ZWU}_{30IX} + Pz - \mathrm{ET}z \tag{5}$$

where

ZWU_{1IV} = available soil water at the beginning of the vegetation period (1 April) (mm)
ZWU_{30IX} = available soil water at the end of the vegetation period (30 September) in the previous year (mm)
P_z = precipitation from October to March (mm)
E_z = evaporation from October to March (mm), assumed to be equal to 120 mm (Kędziora, 1995; Rojek and Żyromski, 2004).

The standardized evapotranspiration index $\mathrm{ET_s}$ is an index based on the probability distribution of actual evapotranspiration. It depends on the fitted density probability function, the length of the series used to estimate the parameters of the probability function and the method of estimation. In the study a gamma probability density function was fitted to the series of evapotranspiration sums in the growing periods of 1970–2004, checking goodness-of-fit by using the χ^2-Pearson test. The parameters were estimated by the method of maximum likelihood. An equiprobability transformation was then applied from the fitted distribution to the standard normal one. The values of the standard normal variable are actually the $\mathrm{ET_s}$ values.

This method allows the evapotranspiration distribution at the station to be represented by a mathematical cumulative probability function. One can then tell the probability of the evapotranspiration being less than or equal to a certain amount. The probability of evapotranspiration being less than or equal to the median evapotranspiration is 0.5; the probability of evapotranspiration less than or equal to a smaller than the median is also lower. Low cumulative probability of a particular evapotranspiration indicates an agricultural drought quantified by reduction of evapotranspiration, caused by soil water deficit.

The standardized evapotranspiration index $\mathrm{ET_s}$ can effectively represent the amount of evapotranspiration, giving also information on its relation to the normal and its non-exceedence probability. The probability can show how often one can expect a particular reduction of evapotranspiration and a crop growing season classified as a drought event.

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Table IV. Classification of the ET_s values and drought categories used in the study

ET_s	Drought category	Cumulative probability for the lower threshold
−0.50 to −1.49	Moderate drought	0.3085
−1.50 to −1.99	Severe drought	0.0668
≤−2.00	Extreme drought	0.0228

The negative values of ET_s characterize the drought season for sugar beet growing. To categorize and evaluate the severity of drought, ET_s should be compared with the boundaries of different classes of drought. There are many classifications used by different authors. Four categories of drought can be distinguished, similar to the original classification of the standardized precipitation index (SPI) proposed by McKee *et al*. (1993): mild, moderate, severe and extreme, with the threshold value for the mild drought category equal to $ET_s = 0$. This means that for 50% of the time drought is occurring. It seems not to be rational as regards evapotranspiration. Some extent of reduction of evapotranspiration should be admitted but not yet classified as a drought event.

Following the example of the classification of SPI used by the National Drought Mitigation Center (2008) in the USA and according to Vermes (1998), in this study the three-category drought classification is used, with a modified threshold for the first class of moderate drought. The threshold of ET_s for moderate drought ($ET_s = -1.0$) would correspond to evapotranspiration with a non-exceedence probability of 16%. In our opinion this probability level is far too low. The first and the most important reason for the required modification is that the meteorological conditions in Poland are highly variable (high value of standard deviation). That is why evapotranspiration reduction (with regard to the median), less than that corresponding to $ET_s = -1.0$, is commonly evaluated as mild drought. Poland is situated in a climate zone without distinct rainy and dry seasons. Most of annual rainfall occurs in summer and droughts also occur in the same season. For the above reasons it is proposed to spread the range of ET_s in the first class from −1.0 to −0.5. $ET_s \leq -0.5$ corresponds to evapotranspiration with a non-exceedence probability of 31%. The ET_s values in the range (−0.5; −1.0) enable one to distinguish periods with mild drought, showing dryness or abnormal drought but not yet drought (Drought Monitor: State-of-the-Art Blend of Science and Subjectivity, 2008). This can be a source of additional information on periods with insufficient precipitation in a given region and significant for monitoring of soil and agricultural drought. The classification of dry periods, used in the paper, is shown in Table IV.

The number of drought growing periods of sugar beet was established at each station for different soils according to the assumed classification. Spatial analysis of the frequency of droughts in each category of drought severity was carried out using the Regularized Spline Radial Basic Function method with the Spatial Analyst Module of ArcView GIS 9.1. The spatial distribution of frequency of agricultural droughts can serve as the estimation of drought risk for sugar beet in Poland on soils with various available soil water reserves.

RESULTS

ET_s was calculated for the whole vegetative period of sugar beet. Based on these results the number of drought periods and the frequency were calculated at each station according to the assumed classification (Table IV).

Table V. Frequency of droughts in the vegetation season of sugar beet in Poland, averaged for 40 stations

Soil	Frequency of drought (%)			
	Extreme	Severe	Moderate	Total
*G*1	3.6	3.4	21.0	28.1
*G*2	3.1	3.7	21.7	28.5
*G*3	2.1	4.1	24.9	31.1
*G*4	2.1	3.9	23.6	29.6

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Between 1970 and 2004 in total at all stations there were 393–415 growing periods drier than normal (10 on average), which made up about 30% of all summer seasons (Table V). The lowest contribution was found in extremely dry seasons: 2–3.5% on average at all stations. There were 3.5–4% severely dry seasons on average. Most numerous were moderately dry seasons: 21–25% at all station on analysed soils. The frequency of severe and moderate droughts achieved the highest values on *G*3 soil (29.0%), whereas the lowest was on *G*1 soil (24.4%). The frequency of extreme droughts was highest (3.6%) on *G*1 soil, with the lowest total available soil water.

The differences in frequency of all droughts as well as of severe and moderate droughts are not significant on the soils of different total available soil water. Yet it can be seen that the least number of droughts was identified on the *G*1 soil with the least available soil water (3.4% severe droughts, 21.0% moderate droughts and 28.1% totally at all stations). Only extreme droughts were most frequent on this soil. This feature was determined at most stations. This odd relationship can be explained by two facts. Firstly, the reference for calculation of ET_s is the median of actual evapotranspiration, which was lowest on the *G*1 soil of the smallest soil water reserves. Secondly, the value of ET_s for a given evapotranspiration depends not only on this reference, i.e. the median evapotranspiration, but also on the variability of actual evapotranspiration in the years under consideration.

This parameter is highest on the same *G*1 soil. These two features, under similar meteorological conditions (precipitation, reference evapotranspiration) and similar reduction of evapotranspiration in relation to the median evapotranspiration, due to soil water deficit, caused ET_s to be higher and the drought less severe on the *G*1 soil with lower total available soil water.

In the whole analysed period (1970–2004) the lowest $ET_s = -3.41$ was noted in 1992 at the station located in the central-west part of Poland on *G*1 soil with TASW equal to 120 mm. On the other soils, with greater soil water retention, ET_s was higher that year: -3.38 on the *G*2 soil (TASW = 158 mm), -2.75 on the *G*3 soil (TASW = 202 mm) and -0.81 on the *G*4 soil (TASW = 270 mm). The drought in 1992 was a disaster, characterized

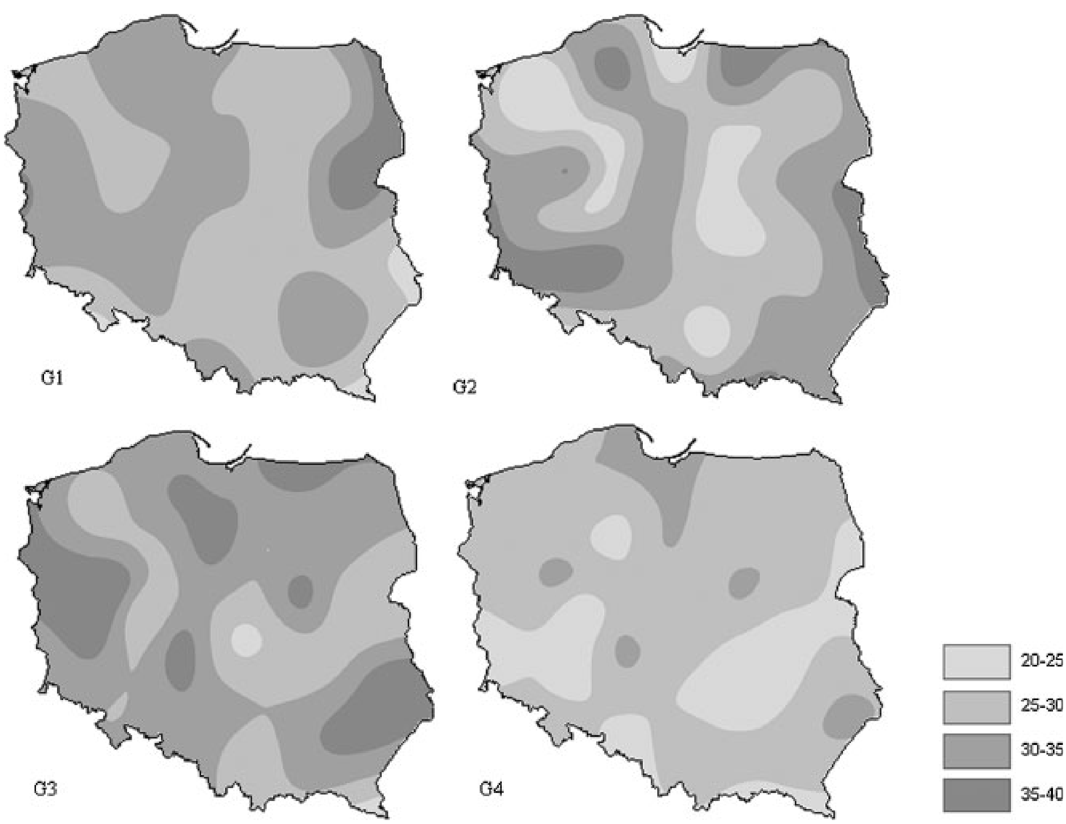

Figure 3. Frequency (%) of all drought categories in *G*1, *G*2, *G*3 and *G*4 soils

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by high air and soil temperatures, very high insolation and a negative climatic water budget. From the middle of April precipitation did not exceed 50% of the average and in June there was no precipitation at all. Precipitation during the second half of the growing period (July–September) was 40–55% of the multi-annual average. Its negative consequence was long lasting, with burdensome heat and dried soil. It is estimated that this drought decreased the value of crops by 25%. At the end of September 1992 the SPI6 (standardized precipitation index at the 6-month timescale) showed an extreme drought event in that region (Łabędzki, 2007). It should be mentioned that 1992 was the next driest year after the severely dry 1991, the moderately dry 1990 and extremely dry 1989. The SPI48 (standardized precipitation index at the 48-month time scale) at the end of September 1992 was −3.71 and at the end of December was −3.55. The succession of the dry years (1989–1992) caused the accumulation of negative impacts of meteorological droughts on soil water retention and agricultural production.

A spatial differentiation of the frequency of droughts depending on drought category and soils is observed in Poland. The frequency of extremely dry seasons in the area of the country ranged from 0 to 9% on the *G*1 and *G*2 soils and 0 to 6% on the *G*3 and *G*4 soils, of severely dry (0–12% on all soils and of moderately dry soils), 10–40% on the *G*1, *G*2 and *G*3 soils and to 30% on the *G*4 soil. Frequency of all drought categories ranged from 20% to 40% on the *G*1, *G*2 and *G*3 soils and to 35% on the *G*4 soil (Figure 3). Thus the minimum frequency of all stations was observed on the soil with the greatest total available soil water.

The highest number of extremely dry growing periods of sugar beet was noted in the east part (*G*1 soil) and the central-west part (*G*4 soil) of the country. Severe droughts most often occurred in the southwest part. Moderate droughts occurred rather uniformly over all the country on *G*1 and *G*4 soils; on *G*2 and *G*3 soils there are some areas with higher frequency of that category of drought. Taking into account the frequency of droughts in all categories, no visible regularity is observed, but the central-west parts of Poland can be most threatened by agricultural droughts.

CONCLUSIONS

Drought risk estimation for sugar beet was made on the basis of standardized evapotranspiration index ET_s and frequency of occurrence of drought. In this paper the index of agricultural drought ET_s is the standardized index used; i.e., it relates actual evapotranspiration to the median and the variability of evapotranspiration, determined for the multi-year period. Therefore, one can compare evapotranspiration reduction in relation to the median in various regions differing in precipitation and reference evapotranspiration and on various soils differing in soil water reserves.

Agricultural drought detection with the standardized evapotranspiration index ET_s, based on actual evapotranspiration simulated with the model, has an advantage over the popular drought-monitoring approach limited only to meteorological parameters (e.g. standardized precipitation index, SPI). ET_s also accounts for the type and stage of crop for evapotranspiration losses, the type of soils and their total available soil water and the fraction that can be used by crops without limitations.

In the study, standardized evapotranspiration index ET_s was calculated on four types of soils with different useful soil water reserves for the growing seasons (IV–IX) in the years 1970–2004, from 40 meteorological stations located in various agroclimatic regions of Poland. Three categories of drought have been distinguished in the range of negative values of ET_s.

A spatial differentiation of the frequency of droughts depending on drought category and soils were determined. The minimum frequency was observed on the soil with the greatest total available soil water. Frequency of droughts in all categories ranged from 20% to 40% on soil with low water retention and to 35% on soil with high water retention.

A small spatial differentiation in the frequency of droughts could be expected because of standardization. If the fitting of the probability distribution were exact and the series long enough the frequencies would be similar in each location. However, the differences among soils were distinct.

ET_s needs careful interpretation. It is a relative measure indicating evapotranspiration lower than the median for the period and location under consideration. In the ET_s methodology the average evapotranspiration is treated as normal in locations with different evapotranspiration amounts. This index is not related to the common reference

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but to the locally dependent evapotranspiration. This can be its disadvantage but also – from the other side – its advantage.

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