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The Occurrence of Drought and its Effects on Plant Production in Eastern Serbia

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Abstract: According to the first estimations of regional climate changes, apart from the trend of the increase in air temperature within the region of southern Europe, the reduction of precipitation in the warm half of the year have been expected. The similar changes within the basic climate parameters were also registered at the local level of Serbia and Montenegro. In terms of degree of drought endanger the region of eastern Serbia particularly singles out.

Over 50 years (1951-2000), Palmer Drought Severity Index (PDSI) was used for the analysis of drought occurrence in Eastern Serbia. According to the analysis, a higher frequency of droughty years, with more severe drought intensity, was registered in last two decades of the twentieth century. Drought periods are frequently followed by high temperatures. Over last 39 years the number of tropical days (max. temperatures over 30^0C) averaged 35.7, with an increase trend, primarily over last 20 years. The aforementioned climate conditions drastically reduce the yields of agricultural crops, particularly of spring crops (maize, sunflower, beans) and in some years, the yield almost completely lacks (maize). The estimation of drought damage in plant production within entire region approximated over 50 million EUR.

These figures sufficiently indicate that our awareness on drought appearance and problems which negatively influence national economy should get important accent in future and as well some steps towards climate changes adaptability should be implemented.

Key words: Palmer Drought Severity Index, tropical days, plant production.

Introduction

Drought, as a complex natural phenomenon, represents the first step to a soil desertification. This means lower fertility of soil and aggravation in soil structure, or in other words, decline in its productive power. At the United Nations Ecological Meeting held in 2000 in Bonn it was estimated that 1/3 (one third) of European soil could be affected by a process of desertification due to climatic changes.

The latest results of scientific research prove that general contamination of the environment already induced its significant warming up within global proportions. In terms of the prospects concerning global climate changes, it is assumed that warming up will continue in the twenty-first century, and the expected mean global air temperatures towards the end of this century would be by $1.4^{o}C - 5.8^{o}C$ higher, as compared to the present values (IPCC, 2001). The most destructive consequences of climatic changes will be shown in spreading of semi-arid and arid regions, that is, in more often and more intensive occurrence of drought especially in the northern hemisphere regions.

A drought occurs regularly in different parts of Serbia, but it is manifested the most frequently and it is the most intensive in the region of eastern Serbia (Rakićević, 1991; Dragović et al., 1997). Hence, significant efforts concerning the modes for overcoming and alleviating negative drought consequences have been made in scientific and expert institutions within this part of Serbia (Milijić et al., 2000; Miletic et al., 2001). The Agricultural Research Institute "Serbia" and its Center for Agricultural and Technological Research in Zajecar was, from 1993 to 2004, in three research cycles, a coordinator of strategic projects on drought. The projects were realized by the help of the Ministry of Science and Technology of the Republic of Serbia.

Materials and Methods

Drought may be quantified by differing indices, out of which Palmer Drought Severity Index (Palmer, 1965), apart from some defects (Alley, 1984; Guttman, 1998), has been widely applied in the USA and Europe. Over 50 years (1951-2000), Palmer Drought Severity Index (PDSI) was used for the analysis of drought occurrence in Eastern Serbia. PDSI was calculated for Zaječar locality according to the monthly values of air temperature and precipitation, with the application of Thornthwaite method for the assessment of potential evapotranspiration (PET). Water constants of the prevailing soil within the Zaječar region were also considered, i.e. parameter of available water in the soil at field water capacity, coupled with humidity of withering. Thus, obtained values of PDSI enable quantification of the entire scope of humidity conditions, ranging from extremely humid (PDSI>4) up to extreme drought (PDSI<-4).

A number of data for 1967-2005 from meteorological station Zajecar was used for the determination of fluctuation and trend in number of tropical days (max. temperatures over $30^{0}C$).

An analysis was made about influence of drought and stressing temperatures on yield reduction of the most important cultivated plants and consequences on local economy.

Results and Discussion

Monthly values of PDSI were calculated for Zajecar locality over 1951-2000. The aforementioned index includes all the major drought traits: intensity and the time of onset and completion in accordance with monthly estimates of changes in water reserves in the soil (soil moisture), evapotranspiration and draining out. Dynamics of PDSI may be observed, determining, therefore, the periods of drought occurrence with different intensity, coupled with humid intervals. Major character of 50-year PDSI analyzed is a higher concentration of droughty years during the last two decades of the twentieth century, with significantly pronounced drought intensity (Table 1).

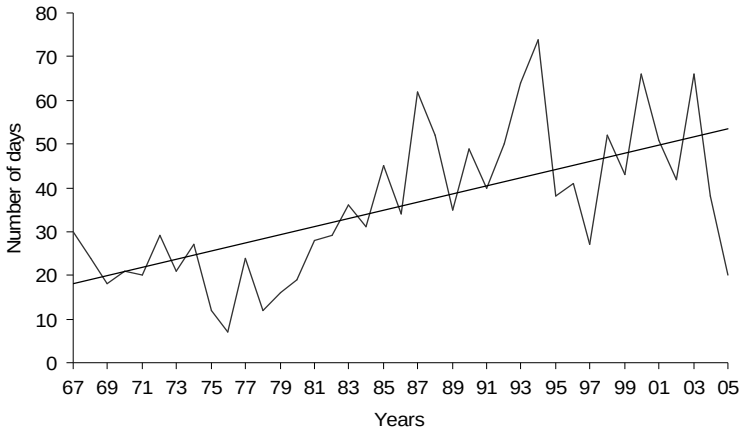
Table 1. The number of occurrences and percentage of mild, moderate, severe and extreme drought in Zajecar (Serbia) over 1951-2000.

Drought	PDSI	1951-60	1961-70	1971-80	1981-90	1991-00	1951-2000	
Mild	-1.00 to -1.99	13	32	15	29	16	105	17.5%
Moderate	-2.00 to -2.99	15	12	8	27	32	94	15.6%
Severe	-3.00 to -3.99	2	0	0	14	17	33	5.5%
Extreme	=< - 4.00	0	0	0	1	12	13	2.1%
Total		30	44	23	71	77	245	40.7%

Data presented in Table 1 show the increase in the number of months with negative values of PDSI from the onset towards the end of the period studied. Hence, out of total number of the months (600), 40.7% were droughty, with the following distribution of droughty categories: 17.5% - mild drought (PDSI ranging from –1.00 to –1.99); 15.6% - moderate (PDSI, from 2.00 to –2.99); 5.5% - severe (PDSI, from –3.00 to –3.99) and 2.1% - extreme (PDSI=<-4.00). It should be noted that the highest concentration of PDSI (<-3.00), with the traits of severe and extreme drought, was registered over the last 20 years, particularly over 1991-2000, whereas in the previous period, their absence is evident.

Intensity of drought consequences is particularly influenced by number of tropical days. Over 1967-2005 the number of tropical days averaged 35.7, with an increase trend, primarily over last 20 years. The smallest number of tropical days was recorded in 1976-7 days, while the largest number of tropical days was recorded in 1994-74 days (Figure 1). During tropical days, soil temperature at the depth of 5 cm is higher by 4-5^{o}C, as compared to air temperature, whereas relative air humidity decreases below 20% during the afternoon. High temperatures are particularly harmful if they last consecutively over several days.

Figure 1. Number of tropical days (max. temperatures over 30°C)



Decrease in precipitation amount, occurrence of drought periods and heat stress had extremely heavy consequences on plant production. All cultivated plants suffered smaller or larger damages. In a ten-year period, from 1989 to 1998, the average production of field crops grown in dry conditions, in relation to average production obtained in more favourable years (average humidity) was lower for wheat by 38.7%, maize (61.1%), sunflower (39.0%), potato (34.0%), beans (66.7%), apples (40.2%), plums (36.%), grapes (11.0%), etc. A total production of 806.398 tons was realized in the years more favourable for growth and development of plants, while in unfavourable drought conditions a total production was 476.240 tons, what is less by 330.158 tons or 40.9%. A value of overall reduced production due to drought is over 50 million EUR (Table 2).

Table 2. Average crop production in favourable and droughty years from 1989 to 1998 in Timok region (Adapted from Milutinović et al., 2000)

Crop	Production in favourable years in t	Production in droughty years in t	Yield reduction in t	Income reduction in 000 EUR
Wheat	181.776	111.450	70.326	6.698
Maize	210.974	82.026	128.948	12.280
Alfalfa	66.894	45.907	20.987	4.997
Clover	45.200	35.368	9.832	2.107
Meadow	132.770	92.116	40.654	5.809
Paisture	44.568	20.573	23.995	2.286
Sunflower	6.522	3.977	2.545	727
Potato	34.730	22.933	11.797	2.809
Bean	10.878	3.623	7.255	2.591
Apple	8.790	5.253	3.537	8.420
Plum	13.148	8.410	4.738	902
Grape	50.148	44.604	5.544	1.584
Total	806.398	476.240	330.158	51.210

In droughty years, soil moisture content is disturbed, ground water level decreased, which result in well and spring drying up, stream and small river exhaustion, drastically reduction in the level of large rivers. All these cause problem in drinking water and water for livestock supply. As an illustration of the hydrological situation we indicate the largest river in this part of Serbia – the Timok. Over 1985-2005 the Timok water level exceeded normal during 6-82 days annually and was below it during 283-365 days annually.

Conclusion

The research on drought problem in our country lasts for many years and is carried out in the institutions which cover different research fields such as: meteorology, agro-technique, soil irrigation, stress physiology, breeding and selection, etc. From time to time these institutions joined their research efforts through the projects on technological development financed by the Ministry of Science and Technology of the Republic of Serbia. The experience gained therein shows the necessity of systematic work and multidisciplinal approach in solving this problem.

Drought as a complex natural phenomenon penetrates into all society segments, and could be seen also as a political problem in the sense of migration of population and survival of people in certain regions. Therefore, it is of vital importance that a state should be more engaged in solving the drought problem. In this sense, in many surrounding countries the national committees for a fight against drought have been founded. There is an impression that in Serbia a problem of drought is much too easily forgotten, after one or two rainy seasons. A forthcoming admission of Serbia and Montenegro to the UN Convention on the struggle against desertification could be the first step in direction of making national strategy of struggle against drought and taking participation in regional cooperation programmes.

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POJAVA I EFEKTI SUŠE NA BILJNU PROIZVODNJU U ISTOČNOJ SRBIJI

- originalni naučni rad -

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Rezime

Prema prvim procenama regionalnih klimatskih promena u jugoistočnoj Evropi se pored trenda rasta temperatura vazduha očekuje i smanjenje padavina u toploj polovini godine. Slične promene osnovnih klimatskih elemenata registrovane su i na lokalnom nivou (Srbija i Crna Gora). U našoj zemlji po stepenu ugroženosti sušom naročito se izdvaja područje istočne Srbije.

Primenom kompleksnog Palmerovog indeksa jačine suše (Palmer Drought Severity Index) izvršena je analiza pojave suše u istočnoj Srbiji u toku 50 godina (1951-2000). Ova analiza pokazuje da se na posmatranom području veća učestalost sušnih godina javlja tokom poslednje dve decenije 20. veka, uz znatno izraženiji intenzitet suše. Sušni periodi su često praćeni visokim temperaturama. Za poslednjih 39 godina prosečan broj tropskih dana (kada je maksimalna temperatura vazduha bila veća od 30^0C) iznosio je 35.7, sa trendom porasta naročito u poslednjih 20 godina. Napred navedeni klimatski uslovi drastično smanjuju prinose poljoprivrednih kultura, a naročito onih koje se seju u proleće (kukuruz, suncokret, pasulj), a u pojedinim godinama prinos skoro potpuno izostaje (kukuruz). Vrednost ukupnog smanjena proizvodnje u celom regionu u sušnim uslovima u odnosu na povoljne uslove gajenja biljaka procenjena je na preko 50 miliona evra.

Ovi podaci jasno ukazuju da bi pojava suše i njene negativne posledice na nacionalnu ekonomiju, kao i preduzimanje mera u cilju prilagođavanja nastalim klimatskim promenama, trebali da budu predmet naše pune pažnje u budućnosti.