DOI: 10.17707/AgricultForest.65.3.01

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CLIMATE CHANGES AND SOIL WATER REGIME

SUMMARY

The research objective was to determine the duration of dry season based on the frequency of precipitation occurrence both upon 25% (Fa=25%) and 50% (Fa=50%) probability, respectively, for three major climate regions in Croatia (Mediterranean, moutainous and continental). In the Mediterranean region, soil water deficit was 246 mm upon 25% probability of precipitation occurrence. Upon 50% probability of precipitation occurrence, soil water deficit was lower, standing at 191 mm. In both cases, soil water deficit was determined during the summer months and it lasted for three months. In the mountainous region, there was a slight soil moisture deficit, which was 32 mm upon 25% probability of precipitation occurrence and 22 mm upon 50% probability of precipitation occurrence. Soil moisture deficit was determined in July or August. In the continental region, upon 25% probability of precipitation occurrence, soil moisture deficit was 230 mm and the dryness lasted for four months during the summer period, while upon 50% probability of precipitation occurrence, soil moisture deficit was 82 mm. Soil moisture deficit lasted for two months in the summer period (July and August). Higher soil water deficit with longer duration could be predicted in the future against the backdrop of the trend of increasing average annual air temperature in all the regions.

Keywords: Climate changes, soil water deficit, dry season duration

INTRODUCTION

Climate changes are altering the statistics of temperature and precipitation. Global climate changes and associated impacts on water resources are the most urgent challenges faced by mankind today and will have enduring social implications for generations to come. Potential impacts may include the change in hydrologic processes and watershed response, including timing and magnitude of surface discharge, stream discharge, evapotranspiration, and flood events, all of which would influence other environmental variables, such as nutrient and sediment flux on water sources (Simonovic and Li, 2004). Changes in

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Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.

precipitation are the prime drivers of change in the availability of both surface water and groundwater resources (Beare and Heaney, 2002). The trends of precipitation extremes in Europe vary greatly and depend not only on the region but also on the indicator used to describe an extreme (Groisman et al., 2005). The effects of climate change have become increasingly apparent over the past decades (Patt and Schröter, 2008). The average temperature increased by 1.1-1.3^{o}C in 100 years in Central Europe (Kutilek and Nielsen, 2010). More frequent and severe extreme weather events are anticipated to cause greater damage to ecosystems and agicultural systems (Wigley, 2009; Choi et al., 2015). Climate change (temperature increase, precipitation decrease) may be related to environmental pollution. In case of low temperature and low moisture, assimilation of nutrients is considerably worse. Consequently, they are leached from the soil with a more intensive drainage runoff (Root et al., 2003; Soussana and Luscher, 2007). Precipitation distribution in the territory and their changes within a year have a huge impact on hydrological phenomena, soil formation and plant growing seasons (Bukantis, 1994). Climate change impact on flora has been receiving increasing attention throughout the world (Fuhrer, 2003). Climate characteristics and soil water regime, as well as their variable and complex interrelations, define the efficiency of plant production. Each climate element participates, to a greater or lesser extent, in plant development. Nevertheless, water and temperature play dominant roles, the water status in soil being greatly influenced by precipitation and evaporation, and both by surface and groundwater. According to Beltrão et al. (1996), the highest yields are obtained at the time of the most favourable air-water ratio in the soil, mainly in the critical periods for each crop. All the participants in agricultural activities need to bear more responsibility for alleviating the consequences of climate changes although they cannot be fully eliminated (Šimunić et al., 2013). Climate change projections suggest a more variable climate with higher vulnerabilities in the lower income countries (Easterling et al., 2000).

The research objective was:

– to determine the duration of dry season based on the frequency of precipitation occurrence both upon 25% (Fa=25%) and 50% (Fa=50%) probability, respectively, for three major climate regions in Croatia (Medirerranean, moutainous and continental).

MATERIAL AND METHODS

The meteorological stations (MS) Poreč, Gospić and Virovitica belong to the meteorological station network of the Croatian Meteorological and Hydrological Service. The data from the previously mentioned MS for the period 1986–2015 has been used for analysis of agro–hydrological balance components for three major climate regions in Croatia (Mediterranean–Poreč, mountainous–Gospić and continental–Virovitica, Table 1). Thornthwaite-Mather method (TM, Thornthwaite and Mather, 1957) has been used for analysis of agro–hydrological balance components. Potential evapotranspiration (ETo) has been calculated using Thornthwaite method (Thornthwaite, 1948) and was used as input for water balance calculation. Other input data used included monthly precipitation amount (P) in a year with the amount of precipitation in the frequency of occurrence both in 25% of cases (Fa=25%) and 50% of the cases (Fa=50%) and upon the presumption that water storage in soil is 100 mm up to root zone depth at the beginning of the year.

Table 1. Meteorological stations and their corresponding regions and the details concerning the position of meteorological stations

Meteorological stations	Climate regions	Latitude	Longitude	Elevation (m)
Poreč	Mediterranean	45°14' N	13°36' E	15
Gospić	Mountainous	44°32' N	15°23' E	546
Virovitica	Continental	45°49' N	17°23' E	118

The following equations were used for the calculation of ETo:

$$ETo=16\left(\frac{10t}{I}\right)^{a}\cdot k \tag{1}$$

$$i=\left(\frac{t}{5}\right)^{1,5} \tag{2}$$

$$a=\left(\frac{1.6}{100}\right)\cdot I+0,5 \tag{3}$$

t = monthly air temperature (°C); i = monthly thermal index; I = annual thermal index (sum of 12 monthly indices); and the exponent "a" = a function of I

Aridity Index (AI, Table 2) was calculated by dividing the total monthly precipitation (P) by the total monthly potential evapotranspiration (ETo), as adopted by United Nations Environment Programme (UNEP) (Salvati et al., 2013), as follows:

$$AI=\frac{P}{ETo} \tag{4}$$

Table 2. Classification of aridity index (AI)

Aridity Index (AI) values	Climate classification
<0.05	Hyper–arid
0.05–0.2	Arid
0.2–0.5	Semi–Arid
0.5–0.65	Dry sub–humid
0.65–0.75	Humid
>0.75	Hyper–humid

Agro–hydropotential (AHP) is the ratio of actual evapotranspiration (AE) and potential evapotranspiration (ETo) and derived from the water balance model (Petrasovits, 1984), as follows:

$$AHP=\frac{AE}{ETo} \tag{5}$$

AHP from 1.0–0.8 means that the water supply to the crops is continuous and not limited. The values from 0.8–0.5 indicate that the water supply to crops is still continuous, but it is getting increasingly restricted. The values from 0.5–0.3 show that the water scarcity is becoming high, the water supply to plants is periodical and restricting and water–stress develops. The value <0.3 shows that strong water stress occurs, causing considerably lower level of biomass and yield deficiency, and when this stage lasts long it also implies the death of the plant.

RESULTS AND DISCUSSION

The precipitation amount with the frequency of occurrence both in 25% of the cases and 50% of the cases and the associated air temperature upon the previously mentioned precipitation values have been presented in Table 3.

Table 3. The precipitation amount upon the frequency of occurrence in both 25% of the cases and 50% of the cases and the associated air temperature at the mentioned precipitation valuesfor the period 1986 - 2015

Month	Poreč				Gospić				Virovitica			
	Fa=25%		Fa=50%		Fa=25%		Fa=50%		Fa=25%		Fa=50%	
	T (°C)	P (mm)	T (°C)	P (mm)	T (°C)	P (mm)	T (°C)	P (mm)	T (°C)	P (mm)	T (°C)	P (mm)
I	5.5	25.0	5.3	54.4	3.8	128.2	-0.2	107.0	-1.6	87.4	0.8	51.5
II	5.4	28.3	5.4	54.1	2.0	138.4	0.6	101.1	2.6	39.4	2.2	47.7
III	8,4	11.9	8.2	49.6	3.1	167.2	4.5	88.9	7.1	33.1	6.7	53.5
IV	12.1	34.9	12.3	60.2	8.0	113.4	9.0	106.5	14.3	36.2	11.8	60.8
V	17.4	148.4	17.2	65.6	13.4	82.4	13.8	94.8	17.7	38.8	16.6	80.5
VI	19.2	70.8	21.0	70.2	15.6	109.2	17.4	88.1	18.9	85.1	20.0	94.4
VII	23.5	21.6	23.6	48.9	20.4	4.6	19.6	60.4	21.8	66.1	22.0	71.9
VIII	22.7	77.7	23.1	74.4	18.8	120.4	19.2	73.7	21.7	28.5	21.3	76.2
IX	20.3	21.6	18.6	98.2	13.6	81.1	14.0	150.8	17.5	28.4	16.3	98.3
X	12.8	80.2	14.4	98.7	9.4	73.6	9.8	161.0	11.1	92.5	11.2	77.8
XI	9.2	201.5	10.1	110.9	-0.1	105.8	5.0	185.6	8.3	85.2	5.8	75.6
XII	6.6	32.0	6.4	72.9	-0.2	118.4	0.4	142.0	3.1	115.6	1.7	66.4
Ave.	13.6		13.8		9.0		9.4		11.9		11.4	
Sum		753.9		858.1		1,245.4		1,360.8		736.3		854.6

The highest precipitation rate with the probability of occurrence in 25% of cases and 50% of cases was recorded at the MS Gospić (mountainous region), while the lowest rate was recorded at the MS Virovitica (continental region).

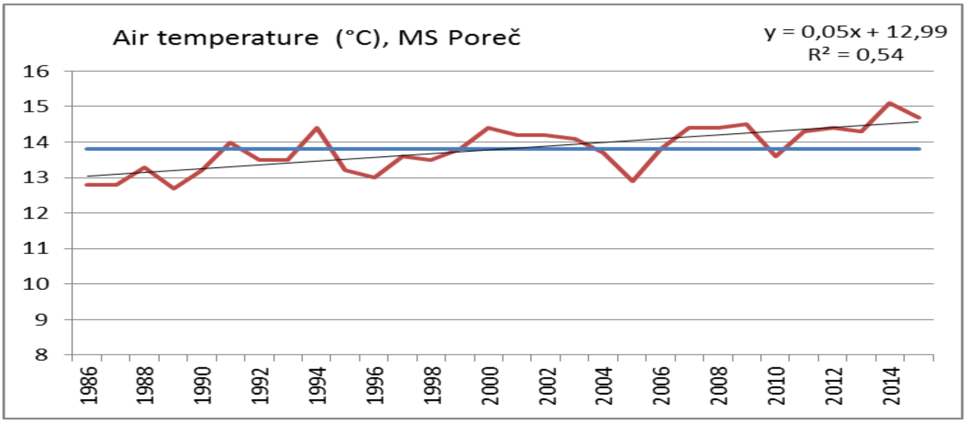
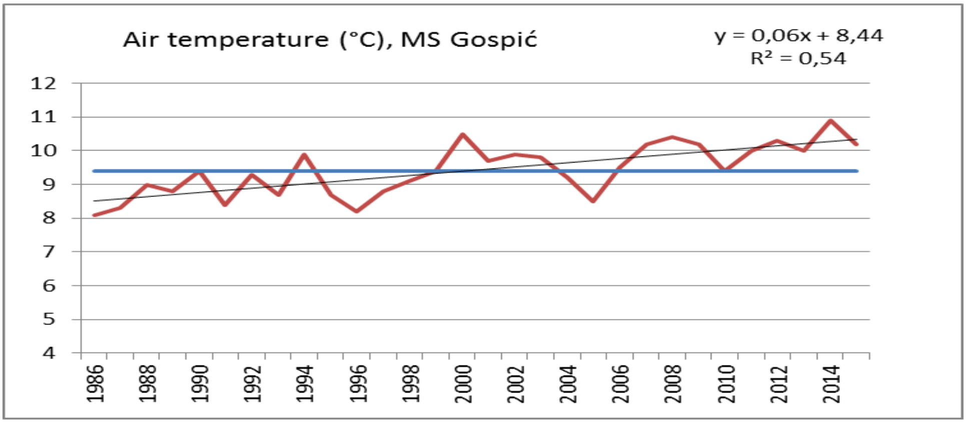


Figure 1a. Average annual air temperature (°C), multi–annual average (°C) and linear trend for the MS Poreč.



Fgure 1b. Average annual air temperature (°C), multi–annual average (°C) and linear trend for the MS Gospić.

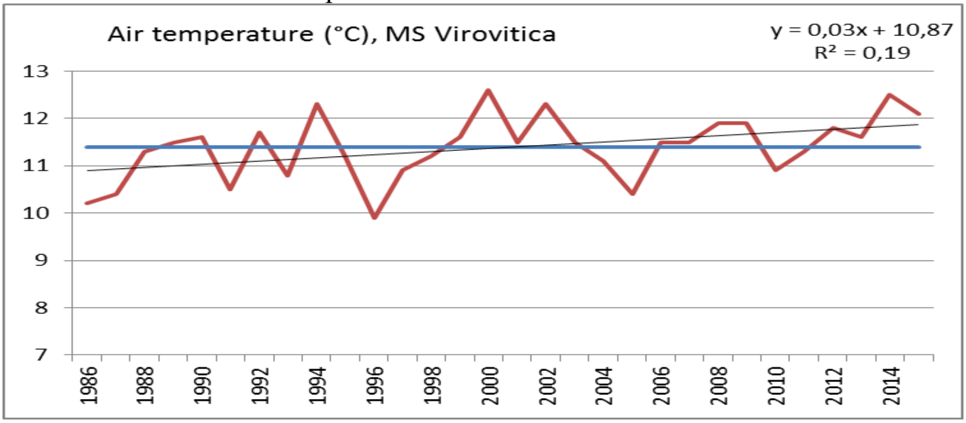


Figure 1c. Average annual air temperature (°C), multi–annual average (°C) and linear trend for the MS Virovitica.

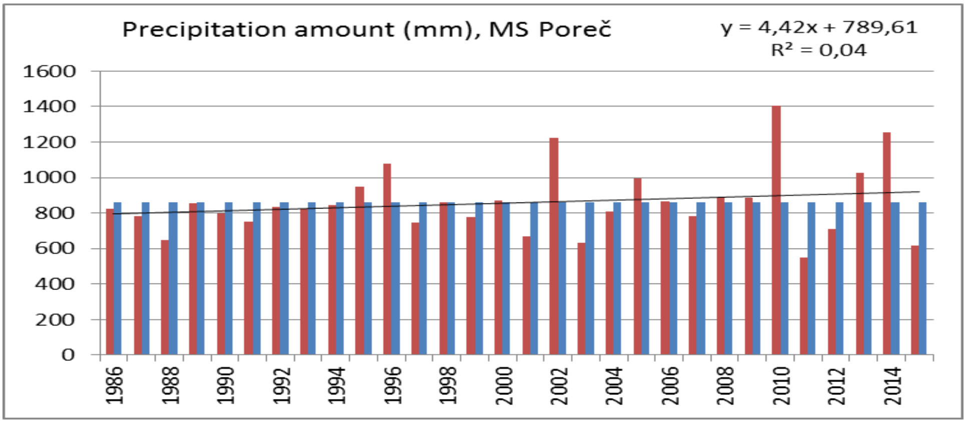


Figure 2a. Annual precipitation amount (mm), multi–annual average (mm) and linear trend for the MS Poreč.

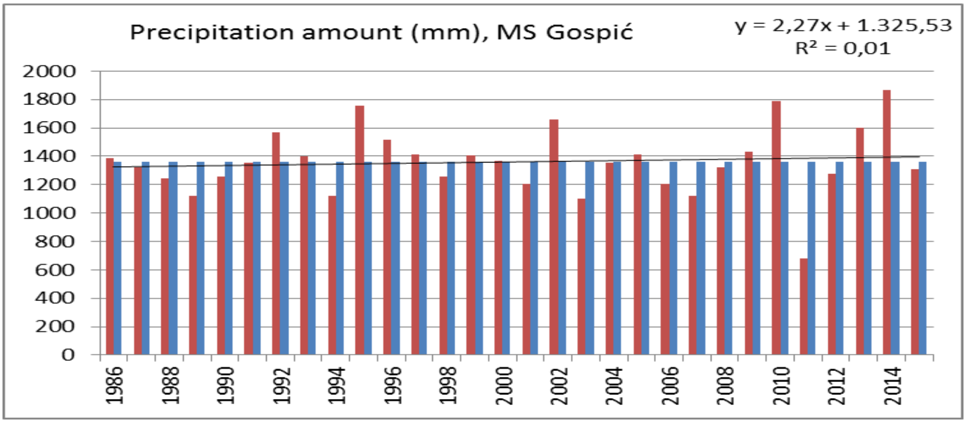


Figure 2b. Annual precipitation amount (mm), multi–annual average (mm) and linear trend for the MS Gospić.

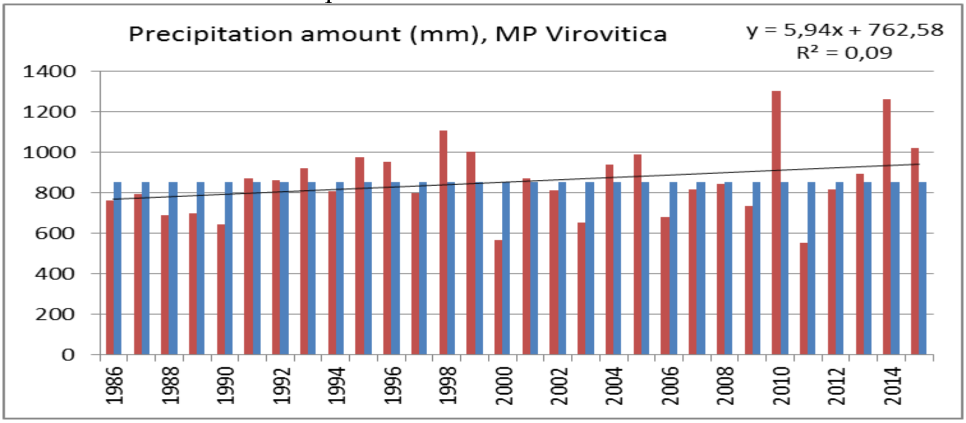


Figure 2c. Annual precipitation amount (mm), multi–annual average (mm) and linear trend for the MS Virovitica.

The highest average air temperature upon the probability of precipitation both in 25% of the cases and 50% of the cases was recorded at the MS Poreč (Mediterranean region), and the lowest at the MS Gospić (mountainous region, Table 3). The precipitation amount with the probability of occurrence in 25% of the cases was lower than upon the probability of occurrence in 50% of the cases, in Poreč about 104 mm, in Gospić 115 mm and Virovitica 118 mm. The average air temperature both in the Mediterranean region and the mountainous region was higher by 0.2^{o}C or 0.4^{o}C when the precipitation occurred in 50% of the cases, while in the continental region it was higher by 0.5^{o}C upon the probability of precipitation in 25% of the cases.

The average annual air temperature (^{o}C), multi-annual average (°C) and linear trends for the period 1986 –2015 have been shown in Figure 1a, 1b and 1c. There is a clear tendency of increase in the annual air temperature in all the regions (MS). The highest air temperature in Poreč was 15.1^{o}C (2014), in Gospić 10.7^{o}C (2014) and in Virovitica it was 12.6^{o}C (2000), while the lowest temperature observed was 12.5^{o}C in Poreč (1988), 8.1^{o}C in Gospić (1986) and 9.9^{o}C in Virovitica (1996). Multi-annual average was 13.8^{o}C in Poreč, 9,4^{o}C in Gospić and 11.4^{o}C in Virovitica.

The annual precipitation amount (mm), multi-annual average (mm) and linear trends for the period 1986–2015 have been shown in Figure 2a, 2b and 2c. The annual precipitation has the tendency to increase in all the regions (MS). The wettest year in Poreč was the year 2010 (1403 mm), in Gospić the year 2014 (1866 mm), while in Virovitica it was the year 2010 (1303 mm). The driest year in all the regions was 2011. Moreover, 550 mm precipitation fell in Poreč, as opposed to 683 mm in Gospić and 552 mmm in Virovitica. Multi-annual average was 858 mm in Poreč, 1361 mm in Gospić and 855 mm in Virovitica. The linear trends are positive in all the MS (regions).

Positive trends of air temperature and precipitation in their research have been quoted by Šimunić et al. (2013) and Miseckaite et al. (2018). Irrespective of a relatively small increase in air temperature and a relatively short time of monitoring, this could be considered as a mild climate warming (Šimunić et al., 2013)

Soil water balance for all the MS (regions) has been shown in Tables 4a, 4b, 5a, 5b, 6a and 6b. In the Mediterranean region (MS Poreč), upon 25% probability of precipitation occurrence, the annual soil moisture deficit was 246 mm and it was determined during the period in question (July, August and September). The largest monthly soil moisture deficit was in July (94 mm). When the precipitation occured upon 50% probability, the annual soil moisture deficit was expected to be lower and it was 191 mm, as was determined during the summer months (June, July and August). The largest monthly soil moisture deficit was also determined in July and it was 116 mm. In both cases, the surplus water in the soil was 170 mm upon Fa = 25% of precipitation probability and 211 mm upon Fa = 50% of precipitation probability and it was determined during the autumn and winter period.

Table 4a. Soil water balance for the frequency of precipitation occurrence upon 25% probability, MS Poreč.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
ETo	11	11	27	54	102	121	166	146	106	48	25	14	831
Precipitation	25	28	12	35	148	71	22	78	22	80	202	32	755
Water storage in soil	100	100	85	66	100	50	0	0	0	32	100	100	
AE	11	11	27	54	102	121	72	78	22	48	25	14	585
Surplus	14	17	0	0	12	0	0	0	0	0	109	18	170
Deficit	0	0	0	0	0	0	94	68	84	0	0	0	246
P/ETo	2.27	2.55	0.44	0.65	1.45	0.59	0.13	0.53	0.21	1.67	8.08	2.29	
AE/ETo	1.00	1.00	1.00	1.00	1.00	1.00	0.43	0.53	0.21	1.00	1.00	1.00	

Table 4b. Soil water balance for the frequency of precipitation occurrence upon 50% probability, MS Poreč.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
ETo	11	11	26	54	101	136	165	148	92	54	28	12	838
Precipitation	54	54	50	60	66	70	49	74	98	99	111	73	858
Water storage in soil	100	100	100	100	65	0	0	0	6	51	100	100	
AE	11	11	26	54	101	135	49	74	92	54	28	12	647
Surplus	43	43	24	6	0	0	0	0	0	0	34	61	211
Deficit	0	0	0	0	0	1	116	74	0	0	0	0	191
P/ETo	4.91	4.91	1.92	1.11	0.65	0.51	0.30	0.50	1.07	1.83	3.96	6.08	
AE/ETo	1.00	1.00	1.00	1.00	1.00	0.99	0.30	0.50	1.00	1.00	1.00	1.00	

Table 5a. Soil water balance for the frequency of precipitation occurrence upon 25% probability, MS Gospić.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
ETo	13	7	14	43	85	101	137	116	70	43	0	0	629
Precipitation	128	138	167	113	82	109	5	120	81	73	106	118	1.240
Water storage in soil	100	100	100	100	97	100	0	4	15	45	100	100	
AE	13	7	14	43	85	101	105	116	70	43	0	0	597
Surplus	115	131	153	70	0	5	0	0	0	0	51	118	643
Deficit	0	0	0	0	0	0	32	0	0	0	0	0	32
P/ETo	9.85	19.71	11.23	2.63	0.96	1.08	0.04	1.03	1.16	1.70	-	-	
AE/ETo	1.00	1.00	1.00	1.00	1.00	1.00	0.77	1.00	1.00	1.00	0.00	0.00	

Table 5b. Soil water balance for the frequency of precipitation occurrence upon 50% probability, MS Gospić.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
ETo	0	2	19	53	82	108	124	112	68	43	17	1	629
Precipitation	107	101	89	107	95	88	60	74	151	161	186	142	1.361
Water storage in soil	100	100	100	100	100	80	16	0	83	100	100	100	
AE	0	2	19	53	82	108	124	90	68	43	17	1	607
Surplus	107	99	70	54	13	0	0	0	0	101	169	141	754
Deficit	0	0	0	0	0	0	0	22	0	0	0	0	22
P/ETo	-	50.50	4.68	2.02	1.16	0.81	0.48	0.66	2.22	3.74	10.94	142.00	
AE/ETo	0.00	1.00	1.00	1.00	1.00	1.00	1.00	0.80	1.00	1.00	1.00	1.00	

In the mountainous region (MS Gospić) there was a slight soil moisture deficit, which was 32 mm concerning precipitation occurrence upon 25% probability and 22 mm in case of precipitation occurrence upon 50% probability. Soil moisture deficit was determined in July or August. Soil moisture surplus was 643 mm and 754 mm, and it was determined from November to April upon Fa = 25% probability and from October to May upon Fa = 50% probability.

Table 6a. Soil water balance for the frequency of precipitation occurrence upon 25% probability, MS Virovitica.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
ETo	0	5	24	67	100	109	134	123	80	40	23	6	711
Precipitation	87	39	33	36	39	85	66	29	28	93	85	116	736
Water storage in soil	100	100	100	69	8	0	0	0	0	53	100	100	
AE	0	5	24	67	100	93	66	29	28	40	23	6	481
Surplus	87	34	9	0	0	0	0	0	0	0	15	110	255
Deficit	0	0	0	0	0	16	68	94	52	0	0	0	230
P/ETo	-	7.80	1.36	0.54	0.39	0.78	0.49	0.24	0.35	2.33	3.70	19.33	
AE/ETo	0.00	1.00	1.00	1.00	1.00	0.85	0.49	0.24	0.35	1.00	1.00	1.00	

Table 6b. Soil water balance for the frequency of precipitation occurrence upon 50% probability, MS Virovitica.

Month	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Sum
ETo	1	5	24	57	100	128	147	130	79	44	16	3	734
Precipitation	52	48	54	61	81	94	72	76	98	78	76	66	856
Water storage in soil	100	100	100	100	81	47	0	0	19	53	100	100	
AE	1	5	24	57	100	128	119	76	79	44	16	3	652
Surplus	51	43	30	4	0	0	0	0	0	0	13	63	204
Deficit	0	0	0	0	0	0	28	54	0	0	0	0	82
P/ETo	52.00	9.60	2.25	1.07	0.81	0.73	0.49	0.58	1.24	1.77	4.75	22.00	
AE/ETo	1.00	1.00	1.00	1.00	1.00	1.00	0.81	0.58	1.00	1.00	1.00	1.00	

In the continental region (MS Virovitica) in case of precipitation occurrence upon 25% probability soil moisture deficit was 230 mm, while in case of precipitation occurrence upon 50% probability soil moisture deficit was 82 mm. Soil moisture deficit upon Fa = 25% was determined from June to September, and Fa = 50% was determined in July and August. In both cases, the largest monthly soil moisture deficit was determined in August and it was 94 mm and 54 mm. Soil moisture surplus was 255 mm and 204 mm, and it was determined from November to March upon Fa = 25% probability and from November to April upon Fa = 50% probability.

In all the regions soil moisture deficit was determined in the summer months, during the vegetation period. The largest soil moisture deficiency was determined in the Mediterranean region, followed by the continental region, and the lowest soil moisture deficiency (insignificant) was determined in the mountainous region, which has the greatest precipitation amount in comparison with the other two regions. By comparing the precipitation amount in the Mediterranean and continental region upon Fa = 25% and Fa = 50%, it is evident from the tables (4a, 4b, 6a and 6b) that the precipitation amount is equal, but because of the higher air temperature there is a greater evaporation of water from soil in Mediterranean region, whose consequence is soil moisture deficit.

Soil water deficit affects the growth and development of field crops, which in turn affects both their yield and quality. Hence, efficient agricultural production requires provision of water through an adequate irrigation system to compensate the estimated water deficit for plant production. Water deficit is especially harmful for plants if it occurs during the "period of critical development of the plant" (Šimunić et al., 2013).

According to aridity index (AI), in the Mediterranean region (Table 4a and Table 4b) in case of the frequency of precipitation upon Fa = 25% probability, one month was arid (July), two months were semi–arid (March and September), two were dry sub–humid (June and August) and the other seven months were in the humid or hyper–humid climate category. The strongest drought was determined in July when aridity index was 0.13. In case of the frequency of precipitation upon Fa = 50% probability, one month was semi–arid (July), two were dry sub–humid (June and August), one humid (May) and all the other months were hyper–humid. The strongest drought was determined also in July when aridity index was 0.30. According to aridity index (AI), in the mountainous region in case of the frequency of precipitation upon Fa = 25% probability, one month was hyper–arid (July) and the others were in the hyper–humid category. The strongest drought was determined in July when aridity index was 0.04. In case of the frequency of precipitation upon Fa = 50% probability, one month was semi–arid (July), one was in the humid category of climate (August) and the other months were hyper–humid. The strongest drought was determined also in July with aridity index reaching 0.48. In the continental region in case of the frequency of precipitation upon Fa = 25% probability, four months were semi–arid (May, July, August and September), one was dry sub–humid (April), while the other months were in the hyper–humid category. The strongest drought was determined in May when aridity index stood at 0.39, and in case of the frequency of precipitation upon Fa = 50% probability, one month was semi–arid (July), one was was dry sub–humid (August), one humid (June) and the other months were hyper–humid. The strongest drought was determined also in July, with aridity index reaching 0.49. As had been assumed, the dry period lasted longer, with less precipitation compared with the highest precipitation. The duration of the dry season was equal in the Mediterranean region and in the continental region (five months) and the shortest (one month) in the mountainous region upon Fa = 25% probability, i.e. three months in the Mediterranean region, one month in the mountainous region and two months in the continental region upon Fa = 50% probability.

According to the agro–hydropotential (AHP), in the Mediterranean region, in case of the frequency of precipitation upon Fa = 25% probability, three months showed water scarcity in the soil (July, August and September), where strong water stress occured (0.21) in September. In all the other months the supply of water to crops was not limited. In case of the frequency of precipitation upon Fa = 50% probability, two months (July and August) showed a soil water deficit. In July AHP was 0.30 and it also showed the occurrence of strong water stress. In the mountainous region, in case of the frequency of precipitation upon Fa = 25% probability, one month (July) was dry, AHP was 0.77 and it indicated that the water supply to crops was still continuos, but increasingly restricted. The same applied in case of the frequency of precipitation upon Fa=50% probabiliy. One month was also dry, AHP was 0.80 and it was determined in August. In the continental region in case of the frequency of precipitation upon Fa = 25% probability, four months showed soil water deficit (June, July, August and September). In June AHP was 0.85 and it showed that the water supply to crops was not limited, while AHP during the three months in question (July, August and September) was below 0.5, of which September showed 0.24 and it implied a strong water stress. In case of the frequency of precipitation upon Fa = 50% probability, one month showed 0.81 (July) and in August AHP was 0.58. Based on the agro-hydro potential as a ratio of actual and potential evapotranspiration it is evident that a there was a higher soil water deficit in case of the frequency of precipitation upon Fa = 25% compared with the frequency of precipitation upon Fa = 50%. Comparing the regions, the longest dry season was defined in the continental region (four months) upon Fa = 25%, followed by the Mediterranean region (three months) and the shortest (one month) in the mountainous region. This may be due to the fact that the continental region had slightly less precipitation than the Mediterranean region (19 mm difference), while the highest rainfall was recorded in the mountainous region. Upon Fa=50% the same applied concerning the drought duration in the Mediterranean region and in the continental region. The drought lasted for two months. Almost the same amount of precipitation (858 mm or 856 mm) fell in both of these regions. A milder form of drought was recorded in the mountainous region over one month.

CONCLUSIONS

In the period 1986-2015 annual air temperature and annual precipitation showed a positive trend in all the three regions (MS).

In all the regions in question soil moisture deficit was determined over the summer months, during the vegetation period. The largest soil moisture deficiency was determined in the Mediterranean region (246 mm upon Fa=25% and 191 mm upon Fa=50%), followed by the continental region (230 mm upon Fa=25% and 82 mm upon Fa=50%) and the lowest soil moisture deficiency (insignificant) was determined in the mountainous region (32 mm upon Fa=25% and 22 mm upon Fa=50%).

The duration of dryness in the Mediterranean region was three months upon Fa=25% and also three months upon Fa=50%, in the continental region it was four months upon Fa=25% and two months upon Fa=50%, while in the mountainous region the duration of dryness was one month in both cases of probability of precipitation occurrence.

According to aridity index, in the Mediterranean region, in case of the frequency of precipitation upon Fa = 25% probability, one month was arid, two months were semi–arid, two were dry sub–humid and the other seven months were in the humid or hyper–humid climate category, upon Fa = 50% probability, one month was semi–arid, two were dry sub–humid, one humid and all the other months were hyper–humid. In the continental region, in case of precipitation upon Fa = 25% probability, four months were semi–arid, one was dry sub–humid, while the other months were in the hyper–humid category and in case of the frequency of precipitation upon Fa = 50% probability, one month was semi–arid, one was was dry sub–humid, one humid and the other months were hyper–humid. In the mountainous region, in case of precipitation upon Fa = 25% probability, one month was hyper–arid and all the other months were in the hyper–humid category. In case of the frequency of precipitation upon Fa = 50% probability, one month was semi–arid, one was in the humid category and the other months were hyper–humid.

According to the agro–hydropotential, in the Mediterranean region in case of precipitation upon Fa = 25% probability, three months showed water scarcity in the soil (July, August and September), where September saw the occurrence of strong water stress (0.21). In all the other months, water supply to crops was not limited. In case of the precipitation upon Fa = 50% probability, three months (June, July and August) showed soil water deficit. In July, AHP was 0.30 and it also showed a strong water stress. In the continental region, in case of the frequency of precipitation upon Fa = 25% probability, four months showed soil water deficit (June, July, August and September). In June, AHP was 0.85 and it indicated that the water supply to crops was not limited, while AHP during the three months in question (July, August and September) was below 0.5, where September saw 0.24, which indicated a strong water stress. In case of the frequency of precipitation upon Fa = 50% probability, one month showed 0.81 (July) and, in August, AHP was 0.58, indicating that water supply to crops was still continuos, yet it was getting increasingly restricted. In the mountainous region in case of the precipitation upon Fa = 25% probability, one month (July) was dry, AHP was 0.77. In case of the frequency of precipitation upon Fa=50% probability, one month (August) was dry, AHP was 0.80, yet it showed that water supply to crops was not limited.

An even higher soil water deficit with longer duration could be predicted in the future against the backdrop of upward trend in annual air temperature in all the regions.

ACKNOWLEDGEMENTS

This research was supported by The Croatian Science Foundation (IP- 01-2018-1717).

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