CLIMATE CHANGE IN THE FUNCTION OF SUGARBEET YIELD

MODIFICAREA PRODUCȚIEI SFECLEI DE ZAHAR IN FUNCTIE DE CONDITIILE CLIMATICE

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Abstract: *Two data sets have been used in this analysis of climatic conditions and their effects on sugarbeet yield. The first is a period from 1963 to 2007; the second is a period 1988 - 2007. Both periods were as analyzed for the same parameters.*
A comparison of the two data sets indicated that the average temperature for the growing season was increased by 0.4^{0}C (2.2%), the precipitation by 13 lm^{-2} (3.5%), ETR (actual evapotranspiration) by 4 lm^{-2} (1%), and the precipitation deficit by 10 lm^{-2} (5.6%). However, the overall picture changed when the climatic data were partitioned into three sub-periods, the dry sub-period (25% of the analyzed years), the average sub-period (50% of the years) and the humid sub-period (25% of the years). When the data were analyzed in that fashion, the drought became pronounced in the dry years, slightly increased in the average years and practically insignificant in the humid years. Unfortunately, yield performance did not follow this trend in climatic conditions, particularly not in the humid years.

Izvod: *U ovoj analizi klimatskih uslova uzete su dve serije podataka. Prvi analizirani period je od 1963. do 2007. godine, a u svrhu istog analiziran je period od 1988. do 2007. godine. Rezultati ovih istraživanja upućuju na zapažanje da su prosečne temperature, u vegetacionom periodu, povećane za 0.4^{0}C (2.2%), padavine za 13 lm^{-2} (3.5%), ETR (realna evapotranspiracija) za svega 4 lm^{-2} (1%), a manjak padavina za samo 10 lm^{-2} (5.6%). Međutim kada se klimatski uslovi razdvoje na tri podperioda zapažanja su drugačija. Prvi podperiod je sušni podperiod (25% analiziranih godina), drugi podperiod su prosečni klimatski uslovi (50% godina) i treći podperiod je podperiod vlažnih godina (25%). Analiza na ovaj način pokazuje da je suša jače izražena u sušnim godinama , blago izražena u prosečnim godinama i skoro beznačajna u vlažnim godinama. Ovaj trend vremenskih uslova nažalost nisu pratili prinosi, a ne naročito u vlažnim godinama.*

Key words: *sugarbeet, yield, climatic conditions*
Ključne reči: *šećerna repa, prinos, klimatski uslovi*

INTRODUCTION

Crop production as an integral part of agricultural production represents human involvement in the global organic matter production. Unfortunately, this involvement often goes at the expense of the nature. Frequently it is irresponsible, negligent and peremptory.

By enforcing the idea of controlling the production of organic matter via green plants, the man has seriously threatened the natural balance. To paraphrase Goethe, the nature is always right, it does not understand jests, it is always serious and rigorous; it is the humans who make mistakes and blunders. To apply agrotechnical measures properly, it is necessary to have good knowledge of soil and climatic conditions. This is why attention was focused in this paper on climatic conditions.

In the process of cultivation of field crops, agrotechnical measures should not be

divided into more important and less important ones. A deficiency in any measure contributes directly to yield reduction; when optimally provided, measures differ in their contribution to yield expression. Therefore, all measures are equally important while yield level is determined by the most inadequate of the agrotechnical measures applied. In the contemporary technology of crop production, knowledge, ability and skill are the most frequent inadequacies. In order to achieve "daily increases" in sugarbeet yields, all aspects of yield must be improved, perfected or enhanced. This is the reason for the existence of science, whose results should be turned to profit.

MATERIAL AND METHOD

The paper reviews an analysis of climatic conditions in the period of the last 45 years, but placing special emphasis on the period of last 20 years.

Two periods were analyzed, from1963 to 2007 and from 1988 to 2007. We analyzed the effects of winter, growing season and total precipitations, mean daily temperature, potential and actual evapotranspiration (ETP and ETR), and precipitation deficit and excess on yields of sugarbeet in both periods.

Each of the two periods was further partitioned into three sub-periods:

a) "dry sub-period", 25% of the years with lowest precipitation
b) "average sub-period" , 50% of the years with average precipitation
c) "humid sub-period", 25% of the years with high precipitation

The above climatic factors were analyzed for the sub-periods, taking into account the average values for the Vojvodina Province.

The sub-periods were formed (25-50-25%) by applying the stepwise multiple linear regression models. Mutual relations between yield and the climatic factors were analyzed by simple correlation coefficients and the linear regression analysis.

RESULTS AND DISCUSSION

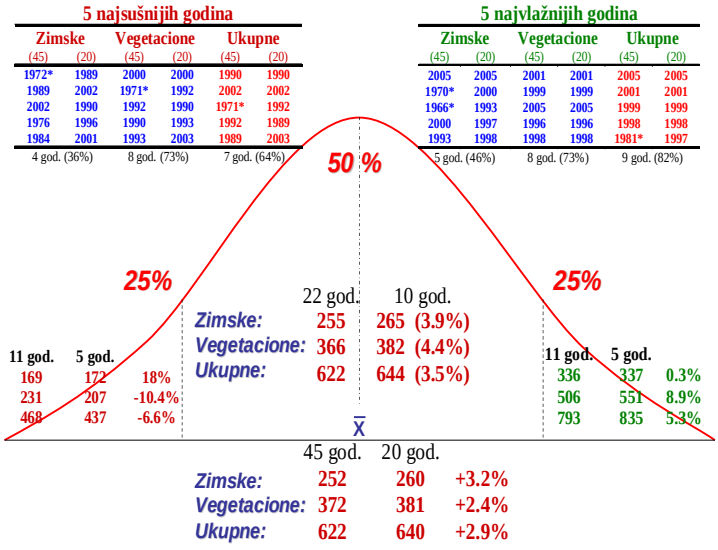

Figure 1. Analysis of precipitation at Rimski Šančevi, for the periods 1963-2007 and 1988-2007

Graph 1 shows the distribution of winter, growing-season and total precipitation per sub-period (dry, average, humid) for the two analyzed periods (45 and 20 years). The dry and humid sub-periods each lasted 11 and 5 years within the two periods. The average conditions were found to have occurred in 22 and 10 years, respectively. When the average values are considered alone, it may be seen that the amount of precipitation increased during the last 20 years. The precipitation increases in the winter was 8 lm^{-2} (3.2%), in the growing-season was 9 lm^{-2} (2.4%) and in the total precipitation increased 18 lm^{-2} (2.9%). These data do not provide indication of the climatic conditions undergoing serious changes. However, a different picture is seen when precipitation is considered per sub-period. In the dry sub-period, the winter precipitation was again increased by 3 lm^{-2} (2.8%). The growing-season precipitation in the last 20 years was reduced by 24 lm^{-2} (10.4%), and the total precipitation was less by 31 lm^{-2} (6.6%). These data indicate that the dry period became more pronounced, particularly in the course of the growing season. ANĐELKOVIĆ (2007) reported that the temperatures in July 2007 were an extreme climatic phenomenon. Our study supports his observation.

The humid sub-period was characterized by increased amounts of winter, growing-season and total precipitations in the 20-year period as compared with the 45-year period. While the winter precipitation increased by mere 1 lm^{-2} (90.3%), the growing-season precipitation increased by 45 lm^{-2} (8.9%) and the total precipitation by more than 42 lm^{-2} (5.3%). The sub-period of average precipitation also had an increased precipitation in the last 20 years. The winter precipitation was increased by 10 lm^{-2} (3.9%), the growing-season precipitation by 16 lm^{-2} (4.4%), and the total precipitation by more than 22 lm^{-2} (3.5%).

The above data give a clear indication that drought became more intensive in the dry sub-period, especially in the course of the growing season (a difference of 10.4%). On the other hand, the average and humid sub-periods had higher precipitation in the last 20 years as compared with the 45-year period. This is an indication that the dry years became drier and the average and humid years became more humid.

However, the increased precipitation was accompanied by increased temperatures. The water requirement of plants has increased accordingly (Graph 2), bringing in question the effectiveness of the increased precipitation. The effectiveness of precipitation may be influenced by agrotechnical measures. The actual effectiveness of the measures was presented in Graph 3. MOLNAR et al. (2001) proposed preventive measures in combating drought. These authors maintained that drought should be controlled before it actually occurred.

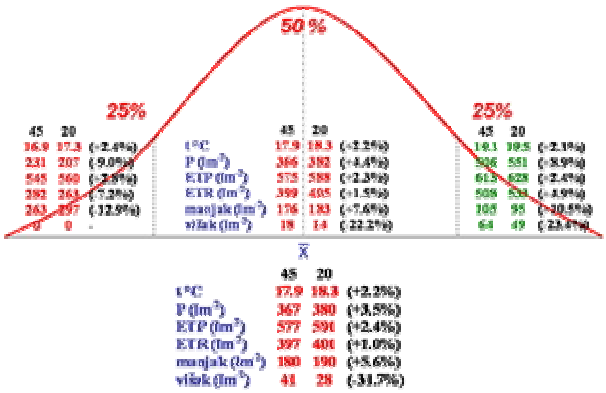

Figure 2. Elements of corn water balance in the analyzed periods

In the dry sub-period, 4 years had an outstandingly low winter precipitation. These 4 years make 9.1% of the total 45-year period and 36% of the 11-year sub-period. Of the 5 years with lowest winter precipitation, 4 occurred in the last 20 years and only 1972 were from the 45-year period. The situation was repeated regarding the growing-season precipitation, where only 1971 were not from the period of the last 20 years.

Out of the 45 years analyzed, 8 had an outstandingly low growing-season precipitation. These years make 18.2% of the 45-year period or 73% of the 11-year period. When the 5 humid years were analyzed, it could be seen that 2 years (1970 and 1966) were from the 45-year period and 3 were from the 20-year period. Regarding the growing-season precipitation, all 5 most humid years occurred in the period of the last 20 years. Regarding the total precipitation, only 1981 were from the 45-year period. The number of years with a humid winter in the 45-year period was 5 or 11.4%. This is one year more than the number of dry winters (9.1% as compared with 11.4%). The number of years with a humid growing season (8 years) was the same as the number of years with a dry growing season. The number of humid years regarding the total precipitation (9 years or 20.4%) was larger than the number of dry years (7 years or 15.9%)

Graph 2 shows water balances in sugarbeet production for the two periods and their three sub-periods. On average for the last 20 years, the mean temperature during growing season increased by 0.4^0C (2.2%) and the precipitation increased by 13 lm^{-2} (3.5%). These results are in agreement with the results of STARČEVIĆA et al. (1991-2003) and MARINKOVIĆ (2008) who reported temperature increases by 0.4 and 0.5^0C, respectively. Potential evapotranspiration (ETP) was increased by 2.4%, the actual one (ETR) by 1%. The increase of ETR was brought about by increased temperatures. However, these temperatures were not accompanied by corresponding precipitation, which resulted in the ETR being increased by less than 1.4% in comparison with ETP, which in its turn increased the total deficit by 10 lm^{-2}. These data clearly show that climatic changes did occur. POPOVIĆ et al. (2005) also reported of registering climatic changes. To approach the problem from a more realistic angle, we conducted the same analysis on altered data sets, i.e., on sub-groups. The mean temperature for the growing season, in all three sub-periods, increased during the last 20 years by 0.4^0C. The precipitation in the dry sub-period was decreased by 24 lm^{-2} (9.0%), and increased in the average and humid sub-periods by 16 lm^{-2} (4.4%) and 45 lm^{-2} (8.9%), respectively. It may be seen clearly that, at the same temperature increase, the amount of precipitation decreased in the dry sub-period and it increased in the humid sub-period by approximately the same percentages (9% and 8.9%, respectively). Concerning the yield, these variations in precipitation had opposite effects. MARINKOVIĆ et al. (2006, 2008) estimated the effects of precipitation, ETP, ETR, winter precipitation and nitrogen distribution along soil profile on yield formation. All these parameters are again considered in this study. Potential evapotranspiration was proportionally larger in the sub-periods, the increases being 2.8, 2.3 and 2.4%. However, the ETR in the humid sub-period was increased from 263 to 297 lm^{-2} (7.2%), and the precipitation deficit increased by 7 lm^{-2} (4%). Precipitation deficit was increased by temperature increases which were not accompanied by corresponding increases in precipitation rate. In the case of the humid sub-period within the period of the last 20 years, the ETR increased by 4.9 % (from 508 to 533 lm^{-2}), and the precipitation deficit decreased by 10.5% (10 lm^{-2}). The presented facts clearly show that sugarbeet yield was not high in the years in the dry sub-period. The years from the average sub-period were more favorable for sugar beet production in the period of the last 20 years, which should have affected the yield level. The years from the humid sub-period were particularly more favorable, and the yield level should have been considerably higher than that obtained in the 45-year period, as can be seen in Graph 3. As the target of production technology is to reconcile crop requirements and production conditions, it may be concluded

that in the last 20 years the sugarbeet production technology in our country failed to reach its objective. SPASOJEVIĆ et al. (1991) and KONSTANTINOVIĆ et al. (1995) also saw the production technology as a key element of yield formation.

Sugarbeet yields shown in Graph 3 exhibited high variations. It has been shown previously that the climatic conditions underwent considerable changes. However, the high yield variations were an indication of the agrotechnical measures not being adequately adapted to the prevailing climatic conditions (as also reported by SPASOJEVIĆ et al. (1991), MARINKOVIĆ et al. (2006, 2008) and MLADENOV et al. (1999). In 15 out of the last 20 years, the ETR was higher than the average ETR for the previous 45-year period. It is realistic to expect the yield to be increased in these years, especially in the 5 years of the humid sub-period. All facts listed above indicate that climatic extremes became more pronounced, which calls for the production technology to be adapted to each year, field, cultivar or hybrid. That is the only way to achieve good production results. Otherwise, effects of using the available edaphic and climatic conditions fall short of the expected target.

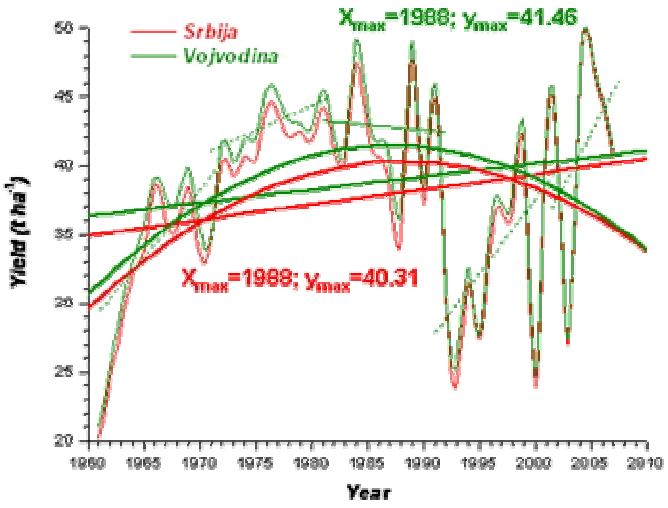

Figure 3. Trend of sugar beet yields

CONCLUSIONS

Following conclusions may be drawn on the basis of the reviewed results.

- Over the last 20 years, the temperature increased by 0.4^{0}C.
- The total precipitation increased by 18 lm^{-2} (2.9%), the growing-season precipitation by 9 lm^{-2}.
- Of the 5 driest years in the period of 45 years, 4 occurred in the last 20 years.
- The five most humid years occurred in the last 20 years.
- In the sub-period of dry years, the growing-season precipitation went down from 231 to 207 lm^{-2} (9%) and the precipitation deficit increased from 263 to 297 lm^{-2} (12.9%).
- In the sub-period of moderate climatic conditions, the precipitation increased by 4.4%, ETP increased from 575 to 588 lm^{-2} (2.3%) and the precipitation deficit increased from 176 to 183 lm^{-2} (4.0%).

- In the sub-period of humid years, the precipitation was increased by 45 lm^{-2} (2.1%).
- The potential and actual evapotranspiration increased by 15 and 25 lm^{-2} (2.4 and 4.9%), respectively.
- The precipitation deficit decreased from 105 to 95 lm^{-2}.
- The yield variations were more manifest than the climatic variations.
- The yield increase was not in proportion with the increase in ETR.
- The applied agrotechnical measures were not did not fit the weather conditions, crop potentials and soil conditions.

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