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CLIMATE CHANGE IMPACT ON VITICULTURE IN POVARDARIE REGION OF MACEDONIA – ASSESMENT AND ADAPTATION

SUMMARY

The purpose of the simulations was to determine the effects on grape production of applying different amounts of irrigation water and different reductions in temperatures over a period of 50 years (2000 – 2050), as compared to not implementing any adaptation measures over the same period. From the simulations involving irrigation, it can be concluded that irrigation is necessary in intensive viticulture for maintaining plants for a long period as better as possible and for improving quality with a satisfactory yield. Without irrigation, vines face the threat of extinction. Comparing the simulations involving UV nets to those without UV nets, the conclusion is that the use of UV nets (which will cause a decrease in temperature of 2 0C), has a positive effect on the yields of both table grapes and wine grapes. Decreasing the temperature by 5 0C carries the risk of delaying the start of the ripening of the grapes, delaying harvesting and reducing yields.

Keywords: vineyard, simulation, irrigation, UV nets.

INTRODUCTION

Climate change can potentially influence vine yield and quality (Kenny and Harrison 1992). Recent temperature trends in viticulture regions show that mean temperatures in the growing-season increased globally by about 1.3 °C in the period 1950 – 1999 and by 1.7 °C in the period 1950 – 2004 in Europe (Jones et al. 2005 a, b). Climate change studies by Fraga et al. (2012) for Portugal, Neumann and Matzarakis (2011) for Germany, and Duchene and Schneider (2005) for Alsace in France, hint at an increase in the growing-season temperature. Santos et al. (2012a), using a multimodel ensemble for the Douro Valley (Portugal), demonstrated that springtime warming may lead to earlier budburst under a future warmer climate, which may affect wine quality.

Additionally, future projections for this same region suggest higher grapevine yields (Santos et al. 2011) and wine productions (Gouveia et al. 2011), but also suggest increased risks of pests and diseases. Santos et al. (2012 b) also showed increased summer dryness in southern Europe.

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The negative effects of climate change in the agriculture sector in Macedonia also increasing. One way of mitigating and coping with the negative effects of climate change in agricultural i.e. vineyard production is through the implementation of adaptation measures. Such measures should be carefully selected to ensure they are suitable for the crop concerned and applicable by the primary producers.

The main goal of this paper is to assess the vulnerability of the Povardarie Region to climate change, to identify appropriate adaptation measures and to model the impact of these measures on yield and gross biomass on table and wine grapes.

MATERIAL AND METHODS

CropSyst (Cropping Systems Simulation Model) is a multi-year, multi-crop, daily time-step crop growth simulation model which serves as an analytical tool to study the effect of cropping systems management on crop productivity and the environment.

With the model the crop yield projections are simulated per large land block fragments (25x25 km2). In one run, a uniform management regimen that is prepared in separate agro-management files representing BAU agro-management scenarios and scenarios with adaptation measures applied to every fragment that represents a biophysically homogeneous unit area. For the purpose of our analyses, the whole territory of the country is divided in a mash of 53 grids. The grids codes of Povardarie region are: 62149, 62150, 63148, 63149, 63150, 64148, 64149, and 65149, including manucipalities: Kavadarci, Demir Kapija, Caska, Gradsko, Rosoman, Negotino, Veles, Lozovo and Sv. Nikole (Fig. 1).

Grids (Number)	Municipality
62149	Kavadarci
62150	Kavadarci Demir Kapija
63148	Caska
63149	Gradsko; Rosoman
63150	Demir Kapija Negotino
64158	Veles
64159	Lozovo Sveti Nikole
65149	Sveti Niole

Figure 1. Selected grids of Povardarski region

The time horizons that are studied are 2025 and 2050, and the comparison is done against a baseline year – 2000, considered as a representative of current conditions.

The base agro-management scenario (depends from the applying measure, SC 0 or SC 1) which was used as a referent one to which comparisons were made is without irrigation and with applying agrotechnical and ampelotechnical measures that corresponds with traditional crop management in the study zones. In reality, of course, these measures vary within each region, but we did not have enough information to specify intra-regional variations. The additional agro-managements scenarios with the aim of comparing changes in crop yield with changing climate in order to find the most suitable strategy consist of different type, time and quantity of irrigation and applying of UV net in terms of temperature reducing which, according many investigations may also prove beneficial for future vineyards.

RESULTS AND DISCUSSION

Agro-management adaptations where irrigation is included predicted 3 scenarios (SC1 – SC3), where 2 types of irrigation are implemented: furrow and drip irrigation, with irrigation volume of 120 and 160 mm and number of irrigation ranked from min. 2 to max. 5, depends from type of irrigation and development phase of grapevine (Table 1).

Table 1. Time, type and amount of irrigation

IRRIGATION	Scenario 0	Scenario 1	Scenario 2	Scenario 3
Time of irrigation	No Irrigation	Furrow Irrigation [mm]	Drip Irrigation [mm]	Drip Irrigation [mm]
1.Before vegetation period	0	0	20	0
2.Before flowering	0	0	20	0
3.After flowering (mid June)	0	80	40	40
4.Mid July	0	80	40	40
5.Beginning of August	0	0	40	40
TOTAL [mm]	0	160	160	120

Figures from 1 to 4 summarized the relationship between yields of vine in different applying irrigation scenarios. Without irrigation there will be a reduction of yields, from almost 26 tons as it was in 2000, to 25 tons in 2025 and to 24 tons in 2050 respectively (SC 0) (Figure 2).

In furrow irrigation the total amount of water of 160 mm was divided on two occasions: 80 mm after vine flowering (middle of June) and additional 80 mm in middle of July (Figure 3).

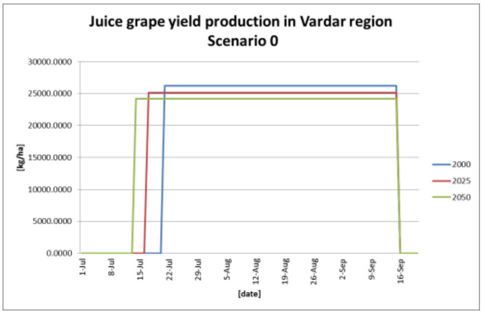

Figure 2. Juice (table) grape forecasted yield production in Povardarie region for the years 2000, 2025 and 2050 without irrigation

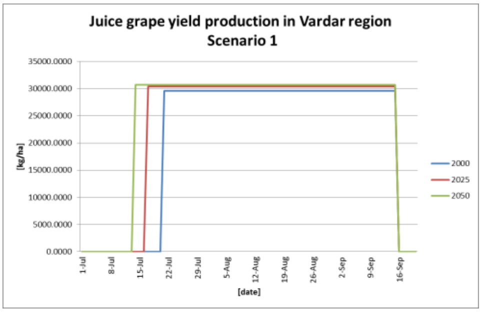

Figure 3. Juice (table) grape forecasted yield production in Povardarie region for the years 2000, 2025 and 2050 with furrow irrigation

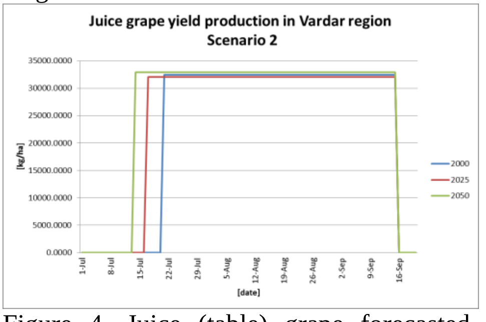

Figure 4. Juice (table) grape forecasted yield production in Povardarie region for the years 2000, 2025 and 2050 with drip irrigation (160 mm)

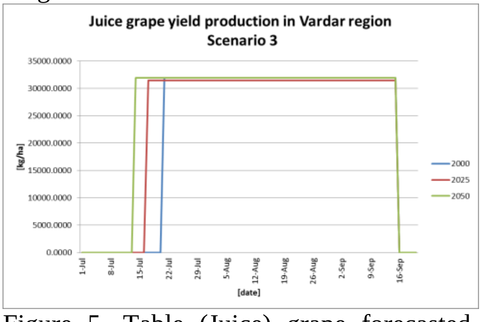

Figure 5. Table (Juice) grape forecasted yield production in Povardarie region for the years 2000, 2025 and 2050 with drip irrigation (120 mm)

According this scenario the average grape yield would be approximately 30 t/ha, or there are not differences in yield between years (periods) of investigation. Obviously, a progressive increasing of the average air temperature in all sub localities, in combination with furrow irrigation will lead to the higher yield at all. The most characteristic in this case is year 2050 where the yield is increased by almost 22% (30.5 t/ha), compared to the scenario SC 0 where irrigation is not included.

For drip irrigation two different scenarios were predicted depends of phenological stages of vine (Table 1) (Figure 4 and 5). From the bought scenarios it can be concluded that there are no differences in the height of the yield in table-grape variety, whether the amount of water of 160 mm is distributed in 5 irrigations, or 120 mm are spaced in 3 irrigations. Symbolic differences can be find if these yields are comparable with those obtained from furrow irrigation where the difference in yield regardless from the year, is 2 to 3 t/ha. Evident differences arise if the proceeds obtained from drip irrigation are compared to the baseline scenario, without irrigation, from where the yield in 2025 is increased by 22% and by 26% in 2050 respectively. In these and other simulations the grape quality was not registered, which despite the yield, is one of the key factors for cost effective production.

The agro-management adaptations with UV nets predicted 3 scenarios: SC 1 – without UV net, SC 2 – with UV net where the temperature will be decrease for 2 0C, and SC 3 – with UV net where the temperature will be decrease for 5 0C. In all three scenarios furrow irrigation is used, 2 x 80 mm. The results are presented in Figures 6, 7 and 8.

The results showed weak corrections of grapes yield between 2000, 2025 and 2050, which is around of 30 t/ha. Mild displacement is observed in the beginning of maturation of the grapes. If in 2000 it is between 15 and 22 July, in 2005 it is on July 15, while in 2050 is between 8 and 15 July. Higher temperatures impact on the duration of the individual stages of phenological development of the crop, contributing to the rapid onset of grapes ripening (Figure 6).

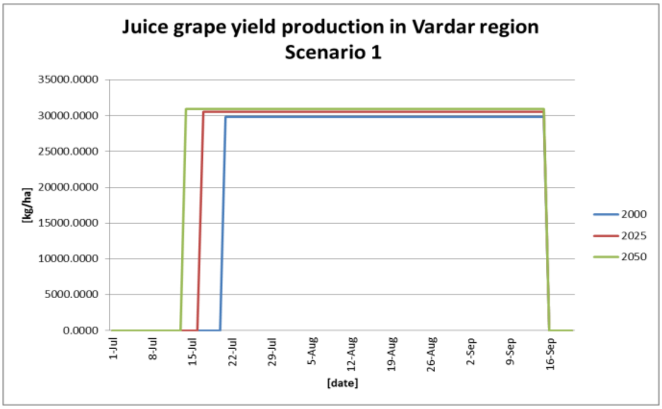

Figure 6. Table (Juice) grape forecasted yield production in Povardarie region for the years 2000, 2025 and 2050 without UV net

Some grape varieties require a certain amount of heat to successfully growing. Each phase in the life of the vine takes place at a specific temperature conditions, i.e., when the average daily temperatures reach a certain level. In our region the movement of juices begin at 8-10 0C, buds moving at 10 -12 0C, flowering at about 18 0C, and the maturation of grapes at about 20-30 0C. The predictions are that by increasing of the average temperature some of the phenological phases will not have the necessary temperature conditions, the duration of each phase separately will become shorten which will greatly influence to the reduction of vegetation and may reduce the yield.

In Scenario 2 where using of UV Net is simulated and decreasing of temperature is 2 0C (Figure 7), the obtaining yield in all three periods of investigation is between 32 and 33 t/ha, while the period of beginning of maturation is later and in this case is between 22 and 29 of July. Compared with SC 1, the differences in yield is around 2 to 3 t/ha, and the differences from the beginning of the period of maturation is from 7 – 10 days. In SC 3 the applying UV nets reduced the temperature for 5 0C. Figure 7 summarized the grape yield according this scenario. What is most evident in this scenario is much later start of the period of maturation of the grapes which in this case is between 12 and 19 August in 2000, on August 12 in 2025 and between 5 and 12 August in 2050 respectively. Maybe it would lead to later start of grapes harvesting, but in all scenarios, whether irrigated or not, whether it is used the UV Net or not, the beginning of harvest of grapes started at September 16. The achieved yield was as same as in Scenario 1 i.e. about 30 t/ha. However, the bigger shading and lower temperature do not leads to the higher yield and this is a fact which should be taken into consideration when is choosing the UV Net for the certain vineyard.

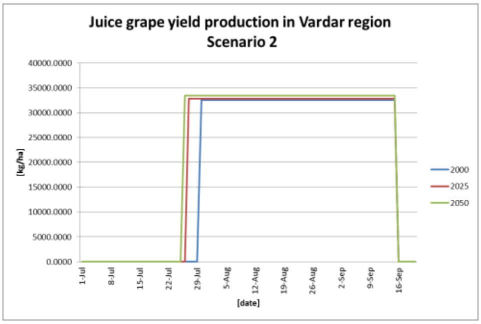

Figure 7. Juice (table) grape forecasted yield production in Povardarie region for the years 2000, 2025 and 2050 with UV Net (average decrease of temperature for 2 ^{0}C)

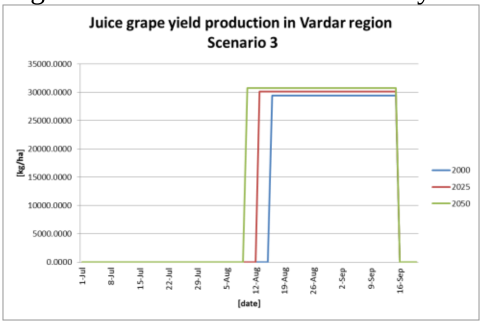

Figure 8. Juice (table) grape forecasted yield production in Povardarie region for the years 2000, 2025 and 2050 with UV net (average decrease of temperature for 5 ^{0}C)

CONCLUSIONS

From the simulations which we made in this study, the following can be concluded:

Without irrigation there will be a reduction of yields of table grapes from 26 tons (as it was in 2000), to 25 tons (in 2025) and to 24 tons (in 2050). The yields of wine grape will also be reduced, from almost 12 tons (in 2000), to 11 tons (in 2025) and to 10 tons in (2050) respectively.

With furrow irrigation (quantity of water for irrigation 160 mm), the average table grape yield would be approximately 30 t/ha, or there will be no differences in yield between years (periods) of investigation. For the yield of wine grape the average yield would be approximately 14 t/ha, with also not differences in yield between years (periods) of investigation. Using drip irrigation, there were no differences in the height of the yield in table-grape variety, whether the amount of water was 160 mm or 120 mm. Symbolic differences can be find if these yields are comparable with those obtained from furrow irrigation where the difference in yield regardless of the year, is 2 to 3 t/ha. Evident differences arise when the proceeds obtained from drip irrigation are compared to the SC 0, from where the yield in 2025 will be increased by 22% and by 26% in 2050 respectively. The same conclusion applies to the wine grape. No differences in the height of the yield in wine-grape variety, whether the amount of water of 160 mm is distributed in 5 irrigation, or 120 mm spaced in 3 irrigation. The obtaining yield is around 14 t/ha. Evident differences arise if the yields obtained from drip irrigation are compared to the baseline scenario, from where the yield in 2025 is increased by 22% and by 29% in 2050 respectively. This may lead to the conclusion that despite the increase in temperature which is real and should be expected in Povardarie region, proper and irrigation on time as an agricultural measure will mitigate the effects of high temperatures and will contribute to increased production.

In simulations of scenarios using UV nets to decrease the temperature by 2 0C, the yield of table grapes in all three periods of investigation would be between 32 and 33 t/ha, while the period of beginning of maturation would become later. Compared to scenarios without UV nets, the differences in yield was around 2 to 3 t/ha, and the differences from the beginning of the period of maturation were from 7 to 10 days. For wine grapes, the obtaining yield in all three periods of investigation will be above 14 t/ha, while the period of beginning of maturation will start later, between 22 and 29 July.

The scenario in which UV nets are used to decrease temperature by 5 0C is characterized by a later beginning of the period of maturation of the table grapes. The achieved yield is around 30 t/ha. In the case of wine grape, a more equal beginning of maturation is noticed, which was not the case with table grapes. The achieved yield was at the level of 14 t/ha. Clearly, greater shading and lower temperatures do not lead to higher yields.

Comparing the simulations involving UV nets to those without UV nets, it may be concluded that the use of UV nets (to the certain level of shading which will cause a decrease in temperature of 2 0C), has a positive effect on the yields of both table grapes and wine grapes.

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