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Climate Change in Hessen – Chances, Risks and Costs for Fruit Growing and Viniculture

At the end of this century, climatic conditions in the fruit growing regions of Hessen (average of 5 climate model runs, scenario A1B and 19 relevant fruit growing grid points) will change, significantly (2071-2100 vs. 1971-2000). First of all, we can expect a significant increase in air temperature in all months and seasons. According to this scenario, mean annual air temperature will increase by 3.4 °C (daily maximum 3.7 °C and daily minimum 3.1 °C). Seasonally, the strongest temperature rise will occur in winter: 4.0 °C, followed by summer: 3.8 °C, autumn: 3.5 °C and spring 2.3 °C. Precipitation will significantly decrease in summer (-47 mm) and significantly increase in winter (+31 mm), especially in January (+12 mm). However, the annual mean precipitation does not change.

One of the consequences of temperature rise is the already observed shift in the timing of phenological stages. The rising temperatures, especially in late autumn and winter, could also influence the end of dormancy. For this reason it was important to know whether the significant increase in air temperature will lead to yield losses due to insufficient chilling, which requirement strongly varies among fruit varieties and species.

Our studies have shown that the temperature rise in the five regional climate model runs was not large enough to cause any significant dormancy damages in the investigated 30-year periods. However, the chilling hours significantly decreased up to a certain qualifying date in spring.

Calculations with improved phenological models (Blümel and Chmielewski 2012, Matzneller et al. 2013) for the beginning of fruit blossom (apple, pear, sweet-, sour cherry, plum, peach, strawberry, wine) showed a significant earliness of this date (2071-2100 vs. 1971-2000) between 15.0 (cherry, wine) and 22.0 days (peach). No significant changes in the flowering period were found (<1 d). The beginning of the picking ripeness was significantly advanced for all fruit species, between 11.5 days for the late-maturing apple and 19.0 days for the late-maturing plum. The grape harvest even advanced by 21.1 days. The length of the ripening period increased significantly by 3.4 days, 6.5 days for the early and late maturing apple, respectively, and by 6.8 days for the early-ripening pear (5.3 days for the late-maturing cultivars). For grapevine however, the maturity period reduced by 3.0 days until picking ripeness and by 6.0 days until vine harvest. All other fruit species showed no significant shift in the maturity date.

Based on changes in the flowering time of fruit trees, it was possible to calculate possible changes in the probability of spring frost damages - which are one of the most feared weather hazards in orchards. However, the results showed no significant or relevant change in fruit damages, so that the currently existing late frost risk probably remains in the future.

Another topic in this study was focused on changes in fruit yield and soil water budget. The yield calculations showed that the average yield losses for the late-maturing apple, the pear, the peach and the late-maturing plum slightly increased by 4 - 8 %, without consideration of summer irrigation and CO_2-fertilization (2071-2100 vs. 1971-2000, 19 relevant fruit growing grid points, mean yield changes which were calculated with the model SIMWASER on the basis of the results of 5 climate model runs). By the introduction of irrigation between the beginning of blossom and fruit ripeness, no significant yield changes were observed anymore, so that this application was already effective to stabilize the yields in the future. The additional irrigation amounts were for the late-maturing apple 166 mm per season, for the late ripening plum 105 mm, for grapevine 63 mm, and for the early and late ripening pear 90 mm, 135 mm, respectively. Alone the consideration of CO_2 fertilization led to a significant reduction of yield damages and finally to rising yields by about 14 % to 41 %, without irrigation and up to 18 % - 54 % with summer irrigation.

Due to the improved water use efficiency under elevated atmospheric CO_2 concentrations (decreased transpiration), the required summer irrigation was reduced by 20 to 40 mm, compared to the case without CO_2 fertilization.

Finally, as part of the economic evaluation, the total damage was calculated on basis of the analysed individual damages. This total yield damage, together with the costs for adaptation strategies, was part of the total costs of climate change. We found that only the late-ripening apple showed a significant negative change of cost (profits) in the case of two plausible adaptation strategies (2071-2100 vs. 1971-2000). If we consider again the CO_2 fertilization in our calculations, we calculated highly significant cost reductions due to the CO_2 effect. However, these calculations are still very uncertain.

References:

Blümel K, Chmielewski FM (2012) Shortcomings of classical phenological forcing models and a way to overcome them. Agricultural Forest Meteorology 164:10-19

Matzneller P, Blümel K, Chmielewski FM (2013): Models for the beginning of sour cherry blossom. Int J Biometeorol, http://dx.doi.org/10.1007/s00484-013-0651-1