CLIMATE CHANGE AND AGRICULTURE IN THE 2030S

The EU produced around 12.5% of the world's cereal in 2015[1], including 6% of the world's maize and 18% of the world's wheat. The EU is also the world's leading producer of sugar beet[2]. This PESETA III study assessed the impact of climate change on six crops, including cereals (wheat, barley, maize), oilseeds (rapeseed and sunflower) and sugar beet. Agriculture in irrigated areas may be sensitive to whether crops will respond positively or not to elevated CO_2 levels with climate change. For rain-fed areas, patterns of precipitation change will dominate the effects of climate change on crops, resulting in high spatial variability of crop yields across Europe.

IMPACTS ON IRRIGATED AGRICULTURE

Assuming there is no CO_2 fertilisation effect, increases in temperature by the 2030s, under a high warming scenario, could result in declines in irrigated crop yields across all of Europe, for all crops modelled except for maize in regions of central Europe and England (Figure 1 overleaf). Yields decline by up to 20% from what they are nowadays. The declines are in large part due to a shortening of the growing season.

The extent to which yields will increase under elevated CO_2 levels is a major scientific uncertainty, demonstrated by the contrast between the maps on the left and right sides of Figure 1.

IMPACTS ON RAIN-FED AGRICULTURE

The response of crops to climate change is more complex for rain-fed agriculture. In this case, yields are dominated by regional water availability. Some regions and crops see increases in yields with climate change, others see decreases (Figure 1).

On the one hand, a favourable pattern emerges in Eastern Europe for all crops modelled, both when the CO_2 fertilisation effect is excluded, and when it is included. There are some large yield increases relative to now, such as over 30% for wheat and maize.

On the other hand, an adverse pattern emerges in Southern Europe. Here there are declines in yields, both without and with the CO_2 fertilisation effect, for some crops. Maize, sugar beet and sunflower decline in Italy and Portugal. The lower crop yields are in part caused by large declines in soil moisture in this region (see the PESETA III Science for Policy Summary on Drought).

ADAPTATION

Whilst the CO_2 fertilisation effect appears to show some favourable effects on crop yields, large scientific uncertainties with this process, and how it interacts with other processes such as water stress, imply that the projections are very uncertain and therefore not reliable for policy purposes. To this end, a range of adaptation options should be explored and implemented to lessen the chances of negative effects of climate change on crop yields.

This PESETA III study did not explore potential adaptation options, such as the development and sowing of crops with enhanced drought resilience, nutrient management, and the exploitation of new crop varieties. Such schemes have been shown to work with some success in some parts of the world.

Adaptation to, and ways of dealing with, a number of factors not explicitly included in the modelling process will also be needed. These include the adverse effects of over-wet conditions, the occurrence of pests and diseases, the impact of ozone concentrations, and the long-term adaptation of crops to CO_2 fertilisation.

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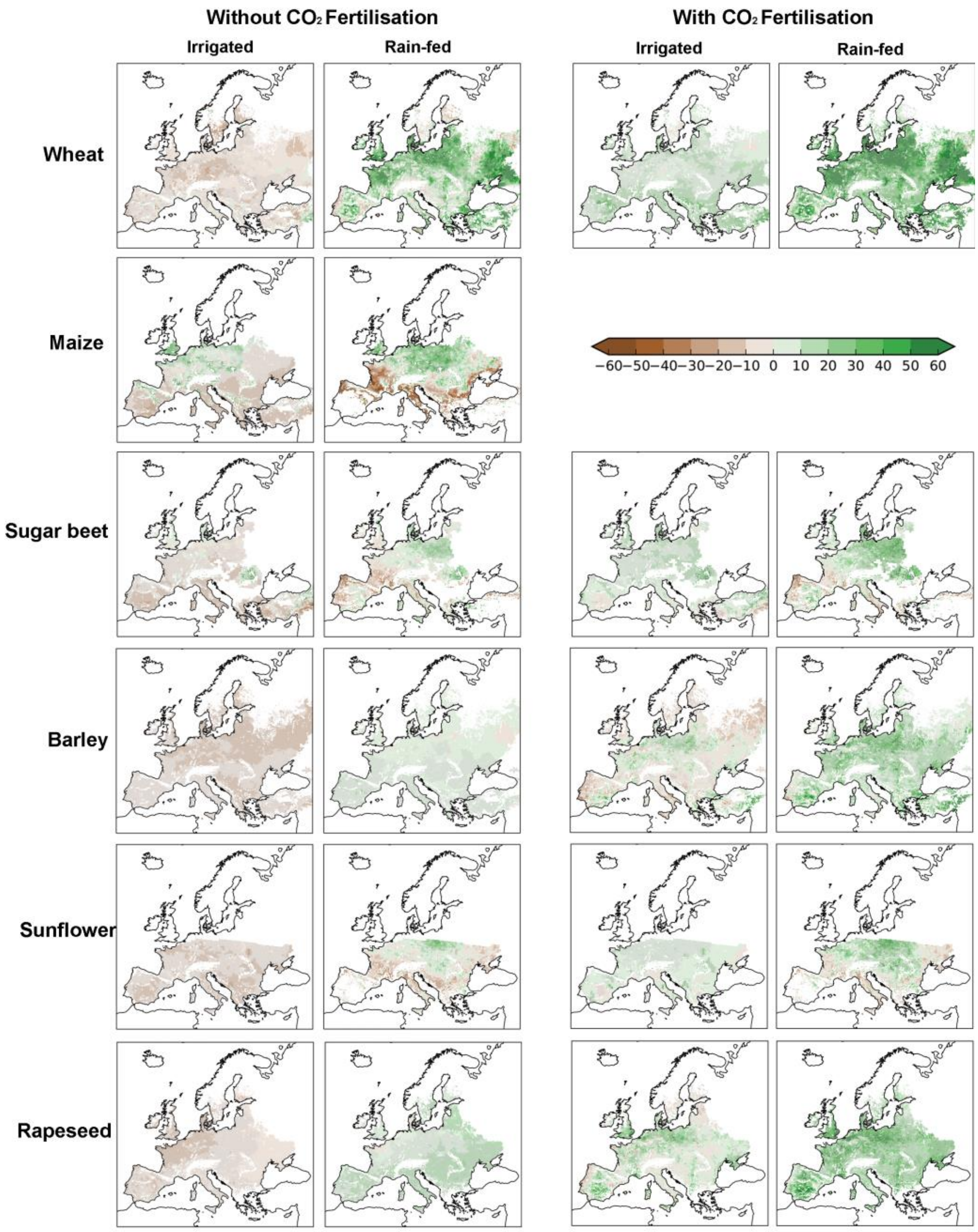
[1] Based on estimates by FAO: http://www.fao.org/3/a-I5703E.pdf

[2] European Commission's Directorate- General of Agriculture and Rural Development: http://ec.europa.eu/agriculture/sugar/index_en.htm

Figure 1. Changes relative to present (%) in irrigated and rain-fed yields, without and with the CO_2 fertilisation effect in the 2030s under a high warming scenario (this approximates a 2°C warming scenario). Yields are the average from using 5 different climate models. Note: grain maize yields with CO_2 are very similar to yields without CO_2 and so are not shown.



Approach

A gridded crops model was run with climate inputs from 5 different climate models, under a high warming scenario for the 2030s, to estimate the impact of climate change on irrigated crops and rain-fed crops respectively. This approximates a 2°C warming scenario. Climate change will affect crops in different ways, depending upon whether a crop is grown by irrigation or rainfall. Therefore crop yields in PESETA III were simulated in two separate ways. One way is by calculating "potential yields", which assumes water and nutrients are in ample supply and the environment is free from pests and diseases. Only temperature, radiation from the sun, and plant properties, such as the rates at which different crops grow, are considered. Potential yields give an indication of how crops grown by irrigation only might be affected. The second way of simulating crop yields calculates "water-limited" yields. Changes in water supply due to climate change are considered, which in turn can affect soil moisture and result in water stress. This provides an indication of how rain-fed crops might be affected. The model does not account for partial irrigation – crops are grown either by irrigation or rain-fed, not a mixture. The PESETA III model simulations were conducted without and with the CO_2 fertilisation effect respectively, to understand how sensitive changes in crop yields are to this effect. **This resulted in four sets of simulations in total**: two for irrigated yields (without and with CO_2 fertilisation) and two for rain-fed yields (without and with CO_2 fertilisation). The geographical scope of the study was all of Europe.

Read more

PESETA III Task 3: Agriculture biophysical modelling. Available on our website https://ec.europa.eu/jrc/en/peseta