THE EFFECT OF RISING CONCENTRATION OF ATMOSPHERIC CARBONE DIOXIDE ON CROP PRODUCTION

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Abstract: In the atmosphere, the amount of carbon dioxide and other greenhouse gases are rising in gradually increasing pace since the Industrial Revolution. The rising concentration of atmospheric carbon dioxide (CO2) contributes to global warming, and the changes affect to both the precipitation and the evaporation quantity. Moreover, the concentration of carbon dioxide directly affects the productivity and physiology of plants. The effect of temperature changes on plants is still controversial, although studies have been widely conducted. The C4-type plants react better in this respect than the C3-type plants. However, the C3-type plants respond more richer for the increase of atmospheric carbon dioxide and climate change.

Keywords: atmosphere, carbon dioxide, climate change, temperature change

Introduction

The rising concentration of atmospheric carbon dioxide (CO_2) contributes to global warming and thus the changes affect both the precipitation and the evaporation quantity. Moreover, the concentration of carbon dioxide directly affects the productivity and physiology of plants.

The atmospheric concentration of carbon dioxide content increases from decade to decade in increasing pace. In 1957, atmospheric carbon dioxide levels were around 315 ppm, while in 2012 it reached the 394.49 ppm concentration. The atmosphere's increased CO_2 level, which among other factors seemed to be responsible for climate change, has a direct impact on plant's development and growth (eg. changes in plant growth because of the changes in temperature, precipitation and evaporation conditions and due to changes in the growing season features). Among the indirect effects are results of changes of other factors which also affect the growth of plants, and the effect of the global result of increased CO_2 concentration are created. The atmospheric concentration of carbon dioxide is expected to reach 550 umol mol-1 in the middle of the century (Carter, Jones, Lu, 2007).

In parallel, the global temperature rises, and it is projected to average 1.5 to 4.5 °C. There are increasingly frequent occurrences of extreme weather events such as heat waves and / or drought (sub Carter et. 2007). These global environmental changes directly or indirectly influence the plants growth and development, yield and quality of the seed (Ainsworth and Rogers, 2007, Seneweera et al., 2005).

Materials and methods

In global level, increasing carbon dioxide (CO_2) concentration accompanied by a temperature increase, which is 0.6 - 1.5 °C to around 2030 and reach 2.2 - 2.5 °C by 2070. In the average annual amount of precipitation is from 2.5 to 10% reduction is expected between 2030 and 2070 (Cai, Cowan, 2008, CSIRO and BoM, 2007, Sinclair, 2011).

The effect of temperature changes on plants is still controversial, although it has been widely conducted (Wahid et al., 2007). The temperature directly affects the geographical distribution of the plants. A northbound shift is expected some of the crop areas, in response to the predicted temperature changes, especially in the Mediterranean regions (Bindi et al., 1992, Bindi et al., 1996, Bindi et al., 2000). The length of the production cycle is expected to change as temperatures rise, changing the production thresholds during the harvest and the beginning of the growing season as well (Porter, 2005). The global warming effect on the phenological stages of plants as well, which are especially necessary for a certain amount of solar radiation for the flowering or fertilization. If we take into account the impact of the carbon dioxide and the temperature on the growth of plants, as it did by Polley in 2002, we can obtain that the temperature increase is offset the concentration of carbon dioxide in the atmosphere. In connection with the carbon dioxide and the temperature increases, the effects are not additive on the species of crops, and what is most important, that the interaction between these two factors are less researched area (Polley, 2002).

Results and discussion

It is important to note that the ecological consequences of climate change to the future development of the vegetation changes in carbon dioxide concentrations also play a role. It increases the photosynthesis of plants, increase the biomass and the proportion of the crop, however only in a lesser extent. It could change the extent and rate the weight of certain plant parts (leaves, stems, roots). It may reduce evaporation capacity of the specific plants, and improve utilization of the available water. The C4-type plants react better in this respect than the C3-type. However, C3 plants respond more richer for the increase in atmospheric carbon dioxide and climate change together (Ördög, Molnár 2011).

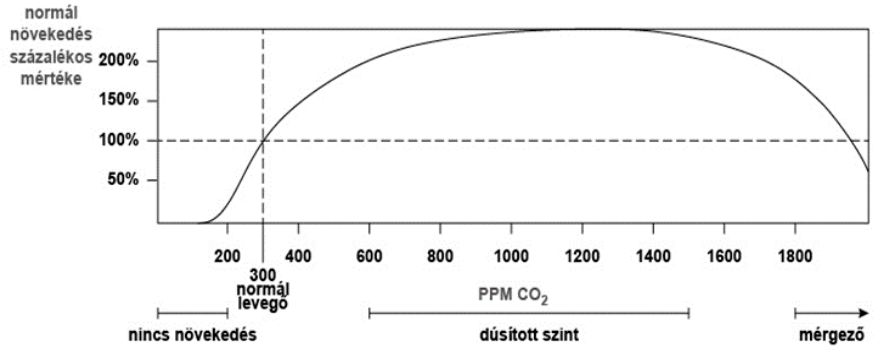

Figure 1. Effects of CO2 concentration on plant's development
%: of growth rate, PPM: no growth, enriched level, toxic level
Source: Babylon Grow: http://babylon-grow.eu/szen-dioxid-co2-i-44.html

Below 200 ppm the plants do not have enough CO_2 to the photosynthesis process takes place and essentially the growth stops. The atmospheric CO_2 content is around 300 ppm, so this concentration can take a 100% growth point. The figure shows that the

increased CO_2 can double the speed of growth of plants. Above 2000 ppm, CO_2 is toxic for plants and over 4000 ppm cause death for mammals and humans (Figure 1).

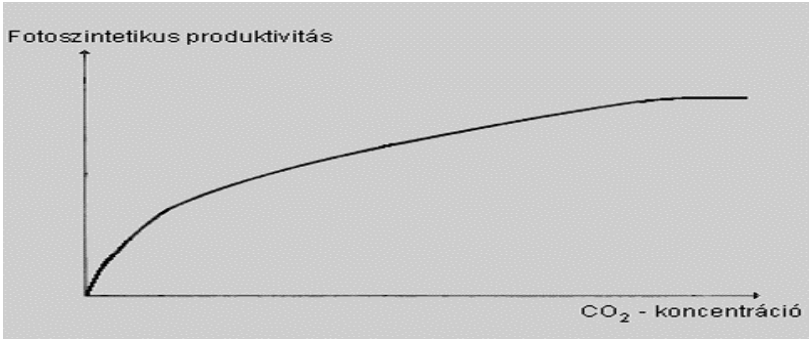

Figure 2. Low carbon dioxide content of the air impact on inhibiting photosynthesis
y-axis: photosynthetic productivity, x-axis: CO_2 concentration
Source: Növénytan, tankönyvtár: http://www.tankonyvtar.hu/hu/tartalom/tkt/novenytan-novenytan/ch16s05.html

The photosynthesis of the C3-type plants is increasing until a given brightness, in contrast to the C4-type plants, inwhich the speed of the photosynthesis continues to increasing at higher level of light intensity. The C4-type plants, calculated to a given size of leaf surface, are tying more CO2, their photosynthesis is much more effective, and their gaining of the dry matter is more than C3-type plants. These plants are vaporizing less, thus their water management is more stable. In point of temperature, the C3-type plants' optimum is around 25°C, whilst it can be found at higher temperature with C4-type plants' – usually around 35°C, but sometimes above 40°C. At lower temperature the activity of the C3-type plants' photosysthesis surpasses the C4-type plants, and about 27-30°C is the temperature, where they show the same activity. Over 30°C, the C4-type plants' activity far exceeds that C3-type plants' activity (Ördög, Molnár 2011).

Conclusions

In the future, while the photosynthetic activity of plants increases, and the stomatal conductance decreases, the plant production allows an effective water usage. The water requirement of plants and the quantity of irrigation will change depeding to the climate change, as certain plants' needs are have to be satisfied in given periods, however the climatic standards are changing. Especially in the mediterranean area, where higher warming expected than the usual, mainly in summer, plus hot heat waves and significant rainfall decreasing are also probable. The increase in temperature and decrease in the expected precipitation potential lead to concomitant water shortages. For winter-spring plants, such as wheat, additional water shortage is expected. In contrast, the spring-summer crops, such as tomatoes, water scarcity continues to increase, and therefore the importance of irrigation increases. But the fact is that during these periods the plants need not be compensated by evapotranspirative life and the partial stomatal closure (Lovell et al., 2010). It is possible that rice and wheat, zinc, iron and protein

content reduced by up to 10% by 2050. Certain crops, such as rice and it's various types react very differently to the carbon dioxide, thus, it will be formed some variants that are less sensitive to the carbon dioxide, so not lose from nutrient contents. The lowering nutrient effect of carbon dioxide is another blow to the world's food production as well. In Hungary 1,1^{o}C is an annual average rate of warming in the future. In summer and autumn, at a lower rate (0,7 - 0,8^{o}C), in spring and winter is much higher (1.1 - 1,6^{o}C). The number of summer days will be expected to 16% (average 9 days) increase and the number of frost days will be about 21% (average 15 days) declined. In annual rainfall 7% decline is expected, which has the most important period in spring. The number of rainy days is expected to decrease by 15-20%, a large number of precipitation days is expected to increase (Mezőhír, 2005).

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