Effect Of Carbon Dioxide Concentrations And Light Intensity On Photosynthesis In Eruca

Introduction

With the increasing pressure to feed a growing population, the ability to understand plant growth has never been more crucial, especially as the surrounding environment continues to change due to global warming (Semenov and Halford, 2009)(FAO, IFAD and WFP, 2014). As photosynthesis is directly related to a plant's potential growth, knowledge of factors that affect this process, such as light and carbon dioxide, is essential. The implications of climate change, with rising concentrations of carbon dioxide and predicted increase in the frequency of extreme weather (Song et al., 2010?)?, could have drastic effects on both native vegetation and agricultural crops as the organisms struggle to adapt at such a rapid pace.

However, plant growth is limited by the way in which each individual species photosynthesises and it's phloem loading strategies (White et al., 2015). These adaptations arise from exposure to various environments and will, hence, be effected differently by climate change in accordance with their current ability to withstand hot temperatures, varying levels of carbon dioxide and the way in which they convert light energy into chemical energy.

During this investigation, the effect of carbon dioxide and light intensity on photosynthesis and, therefore, plant growth in ?Eruca sativa ?is measured via the total leaf surface area and dry biomass. If light drives plant growth then plants exposed to the higher intensity light will have a greater leaf surface area and biomass as opposed to the plants exposed to the low light. Furthermore, if carbon dioxide promotes plant growth then exposure to elevated levels of CO2 will increase the plant's leaf surface area and biomass in comparison to those only exposed to the ambient levels. Hence, if the plant is exposed to both the high light and elevated carbon dioxide levels then it will have a greater growth rate than those exposed to the other conditions.

Discussion

Though the hypothesis was correct in predicting that the high light and elevated carbon dioxide would experience the most growth, it did not account for light playing a more significant role in determining plant growth than carbon dioxide (Figure 1, 2). In addition, the t-test found that these results were only significant in relation to the leaf's surface area and not the dry biomass. This indicates that the plant's response to increased light is to increase the leaf's surface area, which allows for the additional photons to be captured. Furthermore, this study demonstrates that the expected increasing carbon dioxide concentrations in the coming years due to human-induced climate change will not equate to an increase in plant growth as once believed (Kellogg and Schware, 2018).If light intensity and carbon dioxide concentrations were continued to be increased the photosynthetic rate would only increase to a certain point at which point it would plateu due to saturation.

Whilst the extending importance of light was not highlighted in the hypothesis, it is not shocking as it is the basis of photosynthesis and, thus, plant growth. The predicted increasing tempretures and driness as a result of climate change will undoubtedly effect photosynthetic rates as such conditions cause the stomates to close (Song et al., 2010). However, certain species have already evolved to withstand such climates and will, therefore, be at an advantage. Crassulacean acid metabolism (CAM) plants are adapt to dry environments and uptake carbon dioxide during the cooler tempretures of the night, store it as carbon-4 until daylight at which point the carbon goes to the calvin cycle. Carbon-4 plants also have an advantage as they are able to store excess carbon in bundle sheaf cells whilst the stomates are closed which shields it from oxygen build that occurs when the stomates are closed.

However, 85% of plants and, hence, the majority of the species that are used as crops as carbon-3 plants, meaning that any carbon dioxide that enters the plant is immediately transported to the calvin cycle (Kami et al., 2010). These plants are most at risk of decreased production as as global warming continues and the stomates are forced to close due to rising temperatures, carbon-3 production is inhibited (Woodward and Cramer, 1996).

During this investigation some limitations were discovered, one of which was the sample size and type, which was only 150 ?E. Sativa? being used. This effects both the reliability, due to the relatively small sample size, as well as the validity due to the various mechanisms employed by different species. Whether a plant is a symplastic (passive) or apoplastic (active) phloem loader will greatly effect the impact of increased carbon dioxide concentrations. Symplastic species depict significantly less growth at elevated carbon dioxide levels as sucrose is transported through fixed structures (Bishop et al., 2018). Whereas, apoplastic loaders have an increased growth potential both generally and at higher carbon dioxide concentrations and, though this mechanism does require energy input, it does not cause an accumaltion of non-structural cabronhydrates which can reduce photosynthesis (De Schepper et al., 2013).

Furthermore, though this study did investigate plant growth, it can be altered so as to be more easily applicable to existing issues such as agricultural crop growth. In ecosystems, there is competition for resources and, hence, plants grow in an upward trajectory so as to receive the most sunlight, forming a canopy, as opposed to growing as individuals which is the method used in this study. This limitation is primarily focused on the effect of light as it can only reach the top layers of the canopy, as opposed to carbon dioxide which is able to penetrate to lower strata leaves (Liu, Wang and Cai, 2016). The population density and arrangement of the plants can greatly impact the amount of resources available thus altering how a plant might grow in relation to the number of leaves as opposed to the sheer size (Wells, 1991). This can be overcome by growing ?E. Sativa? in more compacted groups so as to imitate how crops and natural vegetation commonly develop, with this further research being able to increase crop production and restorative programs.

Another limitation is the use of leaf surface are and biomass as a measurement of plant growth. A more accurate method would be to calculate specific leaf area (the multiplication of the area of an individual leaf and its dry weight) or absolute growth rate which measures the change of dry weight of carbon in the plant over time (White et al., 2015). Overall, this investigation depicts how factors such as carbon dioxide concentration and light intensity can impact the growth of a plant via their effect on photosynthesis. As the ramifications of climate change intensify, studies investigating the effects of altering abiotic factors on various plant species and ecologies becomes increasingly important to ensure the survival of crops and native vegetation. Without such research, it is impossible to influence change that can prevent irreversible consequences.

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