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EFFECT OF AMBIENT AND SIMULATED CO₂ ON THE GROWTH INVASIVE WEED *Potentilla recta* L.

SUMMARY

The invasive weed species have been found among the most important threats to the native vegetation during recent times. The recent climate changes, particularly the increasing atmospheric CO₂ levels are supposed to enhance the growth of invasive weed species. We evaluated the effect of ambient (current normal level of CO₂ in the atmosphere) and simulated (elevated to double of normal CO₂ in the atmosphere) CO₂ levels on the invasive weed species *Potentilla recta* L. The invasive weed species was grown under normal (~400 ppm) and elevated (~800-850 ppm) CO₂ in a controlled glasshouse. The data on fresh weight, dry weight, number of leaves, plant height and chlorophyll index were recorded. The results of the studies indicated that the elevated CO₂ levels increased the growth of *P. recta*. The high levels of CO₂ increased the fresh weight, dry weight, plant height and number of leaves of *P. recta* compared with ambient CO₂ while chlorophyll index was not affected. In conclusion, the increasing CO₂ levels in the atmosphere can increase the growth, and hence the invasiveness of the invasive weeds species. Further, the generation of such information is very important for devising management strategies of invasive weed species.

Keywords: Invasive weed species, *Potentilla recta* L., climate change, growth, CO₂.

INTRODUCTION

The invasive plants negatively impact the native plant communities through their fast spread capability (Vilà *et al.*, 2011). Invasive species can grow on diverse habitats such as agricultural fields, roadsides, water channels, field bunds and railway tracks (Pyšek *et al.*, 2012). Invasive plant species are supposed to possess advantages over their competitor native plants (Powell *et al.*, 2013). This advantage can be a result of several factors. Recent climatic changes are important among such factors. The carbon dioxide and temperature of this globe are on a steady rise.

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The concentration of these elements can reach the double of current levels by the end of current century. The increase in CO₂ concentration in our atmosphere is supposed to improve the growth and spread of plants including weed species (Vicente *et al.*, 2013). For example, the growth of *Schefflera actinophylla* (Endl.) Harms was improved at higher CO₂ levels. The leaf area and weight of *S. actinophylla* were increased by 35% and 45%, respectively, when the weed was grown at higher CO₂ levels (900 ppm) compared with the normal CO₂ concentration i.e. 450 ppm (Sheppard and Stanley, 2014).

Weeds interact with the crop plants to impact them negatively. The positive influence of higher CO₂ levels on plant growth also benefits the weeds. This will help the weeds to offer the crop plants a stronger competition challenge (Vicente *et al.*, 2013). Moreover, if the weed is an invasive species, that will harm the native species through increased invasiveness. In this study, we worked out the response of invasive weed species *P. recta* to increasing CO₂ levels.

The objectives of our study were to investigate the effect of normal and elevated CO₂ levels on the growth of invasive weed species *P. recta*. The influence of elevated CO₂ were evaluated on the fresh weight, dry weight, plant height, number of leaves and chlorophyll index of invasive weed *P. recta*.

MATERIAL AND METHODS

Location

The experiment was done in the glasshouse of the Department of Plant Protection, Adnan Menderes University Aydin (37.75°N, 27.75°E), Turkey during 2013.

Materials

The seeds of invasive weed species *P. recta* were provided by the Biology Department of the same University. The seeds of *P. recta* were sown in a plastic tray. The seeds were allowed to germinate in the tray to obtain seedlings for the experiment. Ten days old seedlings were transplanted in 2 kg pots which had been filled with a sandy loam soil. Four *P. recta* plant were planted in each pot. The experiment comprised of 4 replications with completely randomized design.

Treatments

The pots containing *P. recta* plants were settled in two different closed glasshouse compartments. Each of these glasshouse compartments was monitored with a CO₂ detection system to note the CO₂ concentration throughout the experimental period. One of the compartments was maintained with a continuous CO₂ supply equal to 800-850 ppm. The other compartment had the normal atmospheric CO₂ level (~400 ppm).

Data recording

The *P. recta* plants in the either of the compartments (~400 ppm or ~800-850 ppm) were harvested to record data. The first harvesting was done 20 days after seedling transplanting i.e. 20 days after exposure to normal and elevated CO₂ levels. Rests of the three samples were harvested with 15 days interval. Each time, the harvested plants of *P. recta* were weighed on an electric

balance (Sartorius GD 603-OCE) to record fresh weight in grams. After recording the fresh weights, the same plants were shifted to paper bags and placed in an oven (Mettler Schutzart DINEN 60529-IP20) at 70 °C until they attained a constant weight. The dried plants of *P. recta* were weighed to record dry weight. The first data on *P. recta* plant height was recorded 20 days after the plants were exposed to normal and elevated CO₂ levels. Later, the weed plant height (cm) was recorded with a 15 days interval. Hence, the *P. recta* height was recorded for a total of four times. Similarly, NDVI chlorophyll meter was used to record the chlorophyll index at the time of second, third and fourth harvest. The numbers of leaves for *P. recta* were counted towards the end of experiment.

Data analysis

Microsoft Excel Program was used to calculate the standard errors. The data on *P. recta* fresh weight (g), dry weight (g), plant height (cm), and chlorophyll index were presented by line graphs, while the difference among the treatments was exhibited by inserting the error bars on lines. The data on number of leaves was presented by bar charts while the standard error bars were inserted to show the difference among treatments.

RESULTS AND DISCUSSION

The elevated CO₂ level (~800-850 ppm) was found to positively influence the growth parameters of *P. recta* compared with the normal CO₂ (~400 ppm). The fresh weight of *P. recta* was similar for the first and second harvest (Fig. 1 a). However, at the second harvest, a higher fresh weight was recorded for *P. recta* plants grown at elevated CO₂ compared with the ones grown at normal CO₂. At the fourth harvest, although, the *P. recta* fresh weight was higher for the weed plants at higher CO₂, however, that was statistically similar with the fresh weight of *P. recta* plants grown under either of the environments. The dry weight of *P. recta* plants grown under elevated CO₂ was higher than the ones grown under normal CO₂ at the second and third harvest (Fig. 1 b). At the fourth harvest, the dry weight of plants under elevated CO₂ was far higher than the plants under normal CO₂; however, this difference was statistically non-significant (Fig. 1 b).

The *P. recta* plant height was higher for plants grown at elevated CO₂ than the ones grown at normal CO₂ during the first and second data recording (i.e. 20 and 35 days after seedling transplanting) (Fig. 2 a). The *P. recta* plant height was statistically similar for rest of the experimental duration. Nevertheless, the chlorophyll index was statistically similar for the *P. recta* plants grown either under the normal or elevated CO₂ (Fig. 2 b).

A significant difference was found for the number of leaves for *P. recta* plants grown either under the normal or elevated CO₂ (Fig. 3). The *P. recta* plants grown under the elevated CO₂ had a higher number of leaves than the one grown under the normal CO₂ (Fig. 3)

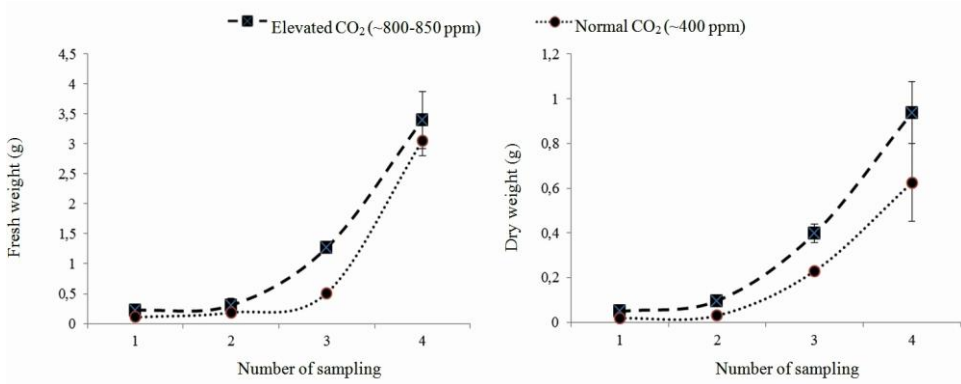


Figure 1: The effect of normal and elevated carbon dioxide on the (a) fresh weight, and (b) dry weight of *Potentilla recta* L.

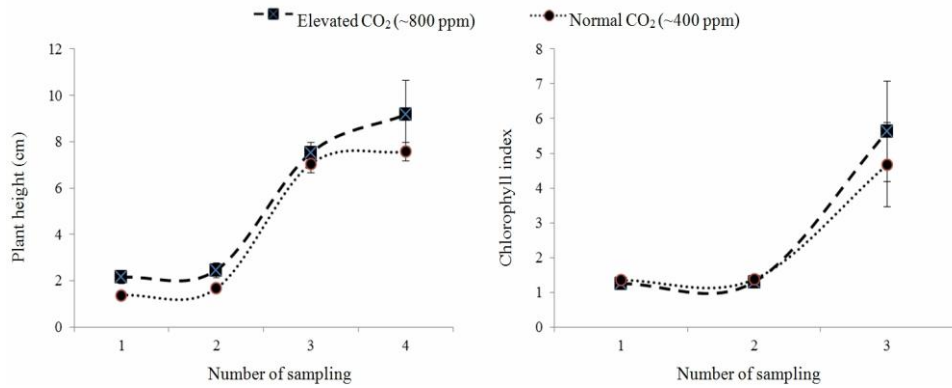


Figure 2: The effect of normal and elevated carbon dioxide on (a) plant height, and (b) chlorophyll index of *Potentilla recta* L.

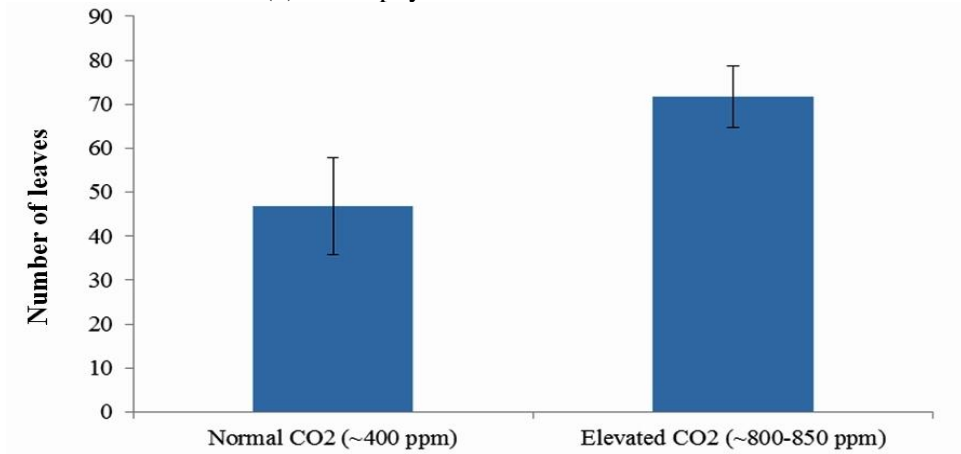


Figure 3: Effect of simulated and ambient carbon dioxide on the number of leaves of *Potentilla recta* L.

The results of studies clearly elaborated that the current climatic changes like the increased CO₂ levels in the atmosphere can aid the weeds to improve their growth. Further, if the weed species is an invasive one, the climatic changes can augment the invasiveness of that species (Dukes and Mooney, 1999). Several recent studies explain the increase in growth of invasive and other weeds at the future atmospheric CO₂ levels (Fuhrer, 2003; Tubiello *et al.*, 2007). For instance, a study conducted in United States showed that the dry matter gains of weeds such as *Centaurea solstitialis* L., *Cirsium arvense* (L.) Scop., *Sonchus arvensis* L., *Convolvulus arvensis* L., *Centaurea maculosa* Lam. and *Euphorbia esula* L. were significantly higher when the weeds were grown at elevated CO₂ levels (719 ppm) compared when these were grown at the current atmospheric CO₂ (382 ppm) (Ziska, 2003). The author concluded that increase in atmospheric CO₂ may be most important among the reasons which helped the species to be invasive (Ziska, 2003).

CONCLUSIONS

The growth of invasive weed *P. recta* was increased under the elevated CO₂. This implies that changing climate (the increasing CO₂ in particular) can aid to the invasiveness of weed species. Hence, in order to avoid the damaging effects of invasive species after their increased spread due to changing climate, special monitoring of such species will be required.

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