The effect of trampled soil on the biomass allocation of *Ambrosia trifida*

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ABSTRACT: *Ambrosia trifida* is an invasive species that is believed to have first arrived in Korea with the American troop deployment during the Korean War and has since taken root in the ecosystem. *Ambrosia trifida* is most commonly found in military or developmental areas where there is a high level of human activity. Since trampled soil is a result of human activity, this study was conducted with the aim of analyzing the growth process of *Ambrosia trifida* in trampled soil by examining biomass allocation. Biomass allocation indicates how the plant optimizes resources by distributing nutrients to different parts of the plant. By measuring the number of leaves, stem length, stem thickness, and root growth of *Ambrosia trifida*, this study found that plants in the control group allocated more resources to their leaves. On the contrary, plants in trampled soil allocated more resources to their roots. There were no significant differences between the control group and the treatment group in stem length, stem thickness, and the number of leaves.

Keywords: ambrosia trifida, trampled soil, biomass allocation

Introduction

According to previous studies, trampled soil decreases the number of plants in the surrounding environment but has no effect on biodiversity (Jägerbrand & Alatalo, 2015). In another study examining the response of weeds and plants to trampled soil, it was observed that the more severe the trampling, the smaller the size, leaf length, leaf width, and leaf thickness of the plant (Sun & Liddle, 1993). Invasive species, however, show somewhat different responses. Earlier studies have suggested that certain invasive plants thrive even

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in a trampled environment, which is useful when reviving barren land into a fertile environment (Foster & Sandberg, 2004). Also, invasive species have higher species abundance and diversity near roads with trampled soil (Winkle, 2014).

Ambrosia trifida, fitting this very pattern as an invasive species, spread throughout Korea and especially in the demilitarized zone (Kim et al., 2017). This species originated from the United States (Park et al., 2017)—ranging between 1 to 4 meters in size and preferring sunny and humid soil. The plant's notable characteristics are that the roots grow wide and deep, and the stems are thick and thorny, hence, making it difficult to remove them after a bit of growth (Kang et al., 1998). The seeds germinate for four to five years and must be extracted every year to be completely removed, and its rapid growth rate and use of surrounding resources causes a major disturbance in the ecosystem (Yin et al., 2010). In addition, it grows in areas where human activity is more common than in forests or mountains (Park et al., 2017). Since human activity naturally leads to trampled soil (Rendeková et al., 2019), *Ambrosia trifida* was a suitable plant for studying the effect of trampled soil.

This study measured the biomass allocation of *Ambrosia trifida* under normal circumstances and in trampled soil. Biomass allocation refers to the relative ratio at which plants invest resources for the growth of each part, such as the leaves, stem, and roots. Most of the previous studies on this ratio examined the responses of resource-deprived plants (Hermans et al., 2006; Muller et al., 2000; Ingestad & Agren, 1991). These studies mostly show that the distribution of biomass does not change based on nutrients, but changes depending on the size of the plant and various factors in the surrounding environment of the plant. In our experiment, we hypothesize that the trampled soil will stress plants, causing them to allocate more resources to root growth.

Methods

Locale & Conditions

The *Ambrosia trifida* seeds were collected near Munbae-dong, South Korea on April 18, 2021. The experiment was conducted from May 14, 2021 to August 16, 2021 at Seoul International School located in Sujeong-gu, South Korea. The region's average minimum temperature between May and June was 15°C, and the average maximum temperature was 25°C. Between July and August the average minimum temperature was 23°C, and the maximum temperature was 30°C. In addition, the rainy season in 2021 was approximately from July 3 to July 19, during which the number of times plants were watered was decreased.

Method & Measurement

30 pots, each 30cm wide, 30cm long, and 40cm deep, were prepared and filled with soil until 10cm

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of space was left on top (Figure 1). The soil was prepared with fertilizer and soil from the school garden. The treatment group, which consisted of 15 pots, was trampled with our feet, and the remaining 15 were left untouched. Four *Ambrosia trifida* seeds were planted in each pot, and a week later, the smaller two plants were removed.

(a)

(b)

Figure 1. Field photos of *Ambrosia trifida* from 5/21. (a): Pots with untrampled soil. (b): Pots with trampled soil.

All plants were watered three to five days a week. Once a week, the length of all plant stems, the number of leaves, and the thickness of the stems were measured. The stem length and stem thickness were measured with a tape measure, and the number of leaves was counted. In addition, five plants were extracted from the treatment group and the control group on June 12, July 12, and August 16. A total of five plants were selected by selecting three plants closest to the average stem length of each group, the smallest plant, and the largest plant. After rinsing the roots clean with water, then separating the leaves, stems, and roots, the different parts of the plant were put in different folders. Afterwards, they were dried in a room with a dehumidifier for a week before the dry mass of each part was measured on a scale.

Results & Discussion

Comparison of Stems & Leaves

In the study, there was no statistically significant difference between the plants grown in trampled soil and plants grown in untrampled soil in terms of stem thickness, stem length, and number of leaves. From graphing the stem thickness, the standard error bars had an overlap of zero to two (Fig. 2a). The stem lengths also had an overlap of one to two (Fig. 2b). The standard error bars for the number of leaves did have a gap, but the gap was never larger or equal to one, so the difference was never statistically significant.

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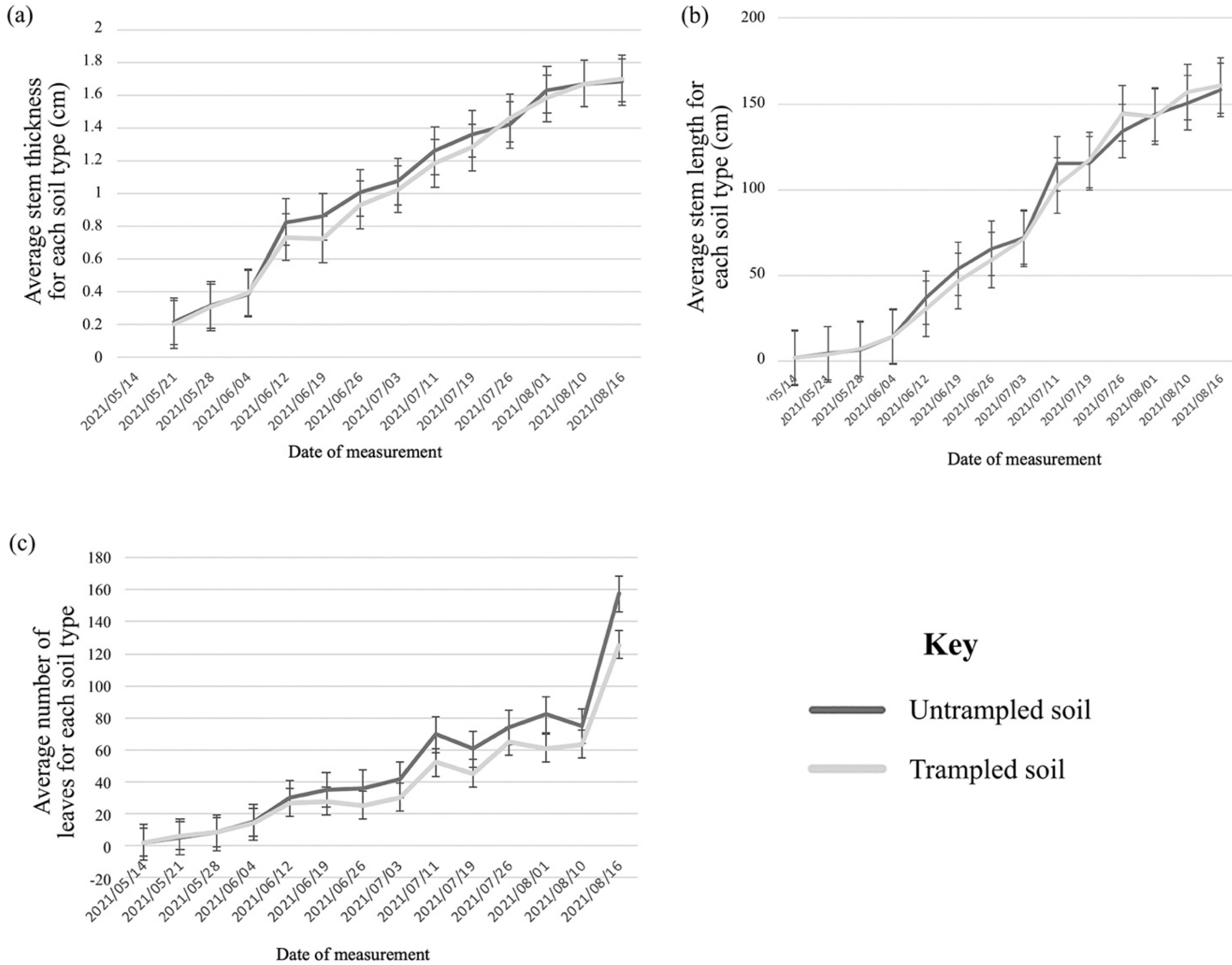

Figure 2. (a) Soil condition and the average stem thickness throughout each period. (b) Soil condition and the average stem length throughout each period. (c) Soil condition and the average number of leaves throughout each period. The standard error is shown.

Comparison of Roots

Since the entire plant had to be pulled out to measure the roots, the dry weight could only be obtained once a month. For the control group, the root to shoot ratio did not change significantly over time. On the other hand, the root to shoot ratio of the trampled soil decreased significantly between June and July, but did not change significantly between July and August. In June, the ratio of the control group was 0.229 and the ratio of the treatment group was 0.316 (Fig. 3).

Looking at the standard error bars, it overlaps by more than one in July and August, and did not overlap in June. At first, there was a greater

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difference due to the treatment group plants having smaller shoots, but over time, the root to shoot ratio between the control and treatment groups became similar. Plants grown in trampled soil tend to have smaller shoots (Kobayashi et al., 1999), which explains why the root:shoot ratio was higher for the treatment group in the first stage of our experiment. In addition, Chen et al. (2002) also reported that plants grown in soil without aeration, which is similar to the conditions of trampled soil, have smaller shoots.

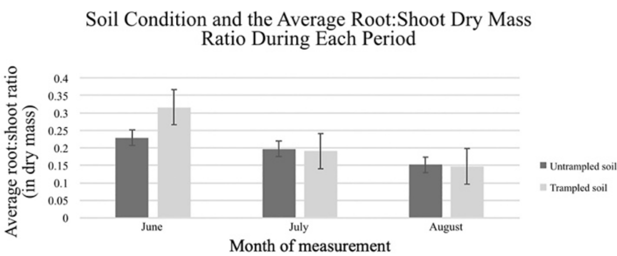

Figure 3. Bar graph displaying the root:shoot ratio (in dry mass) of the control and experimental groups at different times. The standard error is shown.

Next, we compared the ratio of root:stem. In June, the ratio of the treatment group was 0.950, slightly higher than that of the control group, which was 0.833. But in July and August, the control group was very slightly higher (Fig. 4). The root:stem ratio of the control group was 0.427 and 0.230 in July and August respectively, whereas the treatment group had ratios of 0.320, and 0.205 in those months. However, there was not a statistically significant difference between the two groups in any month.

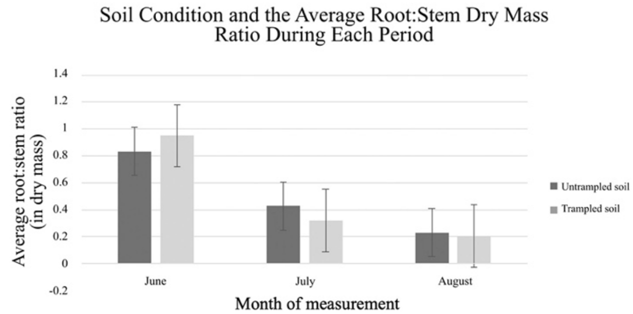

Figure 4. Bar graph displaying the root:stem ratio (in dry mass) of the control and experimental groups at different times. The standard error is shown.

Finally, we calculated the root:leaf ratio. In the first month, the treatment group had a ratio of 0.618 while the control group plants had a ratio of 0.351 (Fig. 5). As the gap between the standard error bars was larger than one, this was a statistically significant difference. However, there was no statistically significant difference in July and August. The ratios of the treatment group were 0.509 and 0.566 in July and August, respectively, and the ratios of the control group were 0.426 and 0.506. The difference in the root:leaf ratios between the control group and the treatment group in the first month was the most statistically significant difference found throughout the entire experiment.

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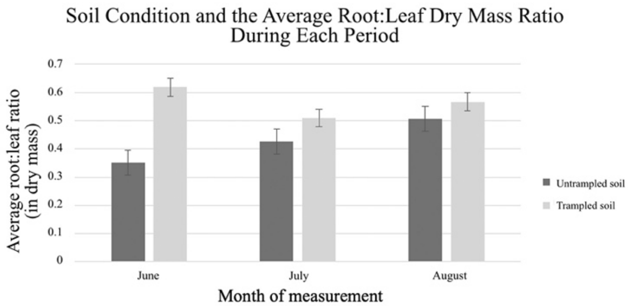

Figure 5. Bar graph displaying the root:leaf ratio (in dry mass) of the control and experimental groups at different times. The standard error is shown.

In our experiment, there was no significant difference in the number of leaves, stem length, and stem thickness between the two groups, but there was still a statistically significant difference when we calculated the root:leaf ratio using dry mass. This implies that the dry mass of the treatment group leaves was smaller (Figure 5), possibly because the leaves had less surface area or were less dense. The root: stem dry weight ratio was also higher for the treatment group in June (Figure 4), but it was not a statistically significant difference, so it seems that there was a difference in resource allocation for the leaves rather than the stem. In conclusion, the treatment group plants seem to have distributed more nutrients to their roots instead of their leaves.

Conclusion

It was hypothesized that *Ambrosia trifida* grown in trampled soil would allocate more nutrients to root growth, and the experiment showed that the shoots of the treatment group, particularly the leaves, were smaller than that of the control group. On the other hand, there were no statistically significant differences in stem length, stem thickness, and number of leaves, but the dry weight of leaves of the treatment group plants was significantly smaller (Fig. 4 & Fig. 5). It seems that the dry weight was lower because the surface area or density of the leaves was smaller. This result is consistent with previous studies (Kobayashi et al., 1999; Chen et al., 2002), and the plant seems to repress shoot growth early in its development, since the statistically significant difference came in the first month. By doing so, the plant is able to develop its roots and increase its nutrient absorption in the trampled soil (Kozlowski, 1999).

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