Proceedings of the 3rd International Conference on Biological Engineering and Medical Science
DOI: 10.54254/2753-8818/22/20230994

The effects of camponotus japonicus ant on container-grown leguminous plants

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Abstract. Ants play a major role in changing the microscopic ecosystem. They constitute a significant part of the animal biomass and also act as soil engineers in soil ecosystems. The existence of ant colonies does affect the growth of surrounding plants and the living environment of other animals. This paper explores the impact of ants on the growth of leguminous plants. By placing C. japonicus individuals in an artificial environment, the nesting behavior and hunting behavior of ants could affect the environment in which legumes grow are maximized. The nesting behavior of ants causes seeds to sink into the soil, thereby slowing down the germination time of plants. Besides, the results suggested that the greater the number of ants, the greater their ability to influence the soil. At the same time, ants also produce more organic waste, accelerating the growth of legumes.

Keywords: camponotus japonicus, phaseolus vulgaris linn, canavalia gladiata (Jacq.) DC, plant growth, soil.

1. Introduction

Ants are the most widely distributed and abundant social insects, and they are found in almost all habitats on Earth, except the Poles. As Ants can significantly influence the environment by incorporating nutrients, aerating soils, and regulating populations of other organisms, they have high economic and ecological benefits [1]. The ant nests undergo daily and nightly erosion from wind and rain, resulting in changes to the chemical composition of their soil that are influenced by the surrounding environment in varying regions [2]. Thus, ants often clear the soil surface of vegetation and mobilize large amounts of underground soil to the superficial layers to construct and maintain their nests. They also concentrate organic matter and produce large quantities of organic waste that are deposited inside the nest in specific chambers or on the soil surface [3]. Because of these activities, the particular physical and biochemical properties of ant nest soils could affect surrounding vegetation. Therefore, ant nests are considered one of the key small-scale disturbances [4].

Furthermore, the number of ants present within an environment can influence their ability to modify the soil. Larger ant populations may engage in more extensive excavation, altering soil composition and structure [5]. These modifications can impact nutrient availability, water retention, and overall soil fertility, ultimately affecting the growth and productivity of plants. In addition to soil modification, ants produce organic waste during their foraging activities. This waste acts as a source of nutrients, accelerating the growth of plants. By examining the collective behavior of social insects, this study contributes to a deeper understanding of how ants shape plant growth and ecosystem dynamics.

This study explored the dispersion and composition of ant colonies and their adjacent soil in the natural environment. By cultivating the same plants in containers with and without ant nests, this research could effectively observe and chronicle whether the presence of ants has any impact on plant growth in a more intuitive manner. The research results also contribute to a better understanding of the influence of the collective behavior of social insects on plant growth.

2. Methodology

2.1. Insects and material

The four C. *japonicus* communities were purchased online and collected from Guangdong, China. Owing to the disparate sampling locations of these studies, and some of which even span different climate zones, the distribution of plants has emerged as a pertinent factor to consider, given that plant behavior varies across regions.

In order to ensure experimental conditions that are controllable, this research devised a number of artificial ant nests that were contained in vessels of identical size. Six identical cylindrical containers with a uniform lower diameter of 191 millimeters, upper diameter of 214 millimeters, and height of 210 millimeters were utilized. Two of the six containers served as the control group, with no ants present. Among the four containers containing ants, two buckets contain one queen and 100 worker ants, while the other two buckets contain two queens and 200 worker ants. In order to ensure the normal growth of ant colonies and to simulate the differences in the amount of food hunted by ant colonies at different population levels, two one-month-old cherry red cockroaches (*Blatta lateralis*) were placed daily in containers 1 and 2 (which contain one queen and 100 worker ants), while four one-month-old cherry red cockroaches were placed daily in containers 3 and 4 (which contain two queen ants and 200 worker ants).

Before all the experiments, the colonies were starved for 24 hours. A layer of cotton was placed at the bottom of each container, followed by a 20-centimeter-thick layer of plaster. The plaster was then covered by a 100-millimeter-thick soil layer. To ensure proper irrigation, a hole was drilled in the bottom of one side of each container, enabling smooth water injection and allowing the cotton and plaster to remain moist. The water was transferred from the bottom of the container to the soil layer via the plaster without causing any damage to it. This irrigation method was preferred over top-down watering to prevent the collapse of the ant nest and avoid drowning the ants. Every day, 200 milliliters of pure water will be injected into the bottom of the containers. Each container contained two sprouting bean seeds, including *Phaseolus vulgaris* Linn. and *Canavalia gladiate* (*Jacq.*) DC. Each bean in the containers was exposed under 10 hours of sunlight.

2.2. Stem height

The stem length of two leguminous plants was measured from the surface of the soil layer to the top using a measuring tape. Measurements of plant stem length were taken from the first day after planting the beans, until the fifteenth day of the experiment. If the plant did not sprout, its stem length was recorded as 0 until the beans began to germinate. After the experiment was completed, the leguminous plants in each container were taken out to measure the height of their stems (sinking below the soil). The measured height was then added to the stem length measured daily to obtain the final stem length.

2.3. Average leaf area

The time for measuring the average leaf area began on the day the leaf started to unfold. Due to slight differences in germination times between the two types of legumes, *P. vulgaris* leaf unfolding was measured from the first day. It was measured for a total of 5 days, from the 11th day to the 15th day of the experiment.

2.4. Root length

On the sixteenth day of the experiment, all the plants in the containers were removed, and their root lengths were measured using a measuring tape.

2.5. Fresh weight

The legumes were removed from the container and rinsed with pure water in order to clear soil and other particles. After drying at room temperature for two hours, all legumes were placed on the weighing device and weighed at their fresh weight.

3. Results

3.1. Stem height

The stem height of *C. gladiata* and *P. vulgaris* under different experimental controls was measured. The results showed a significant difference in the stem growth of *C. gladiata* and *P. vulgaris* between containers without ants and containers with ants (Figure 1). In the two containers without ants, the stem height of *C. gladiata* and *P. vulgaris* reached more than 25 cm and 23 cm, respectively. However, in the four containers with ants, they did not reach this height threshold.

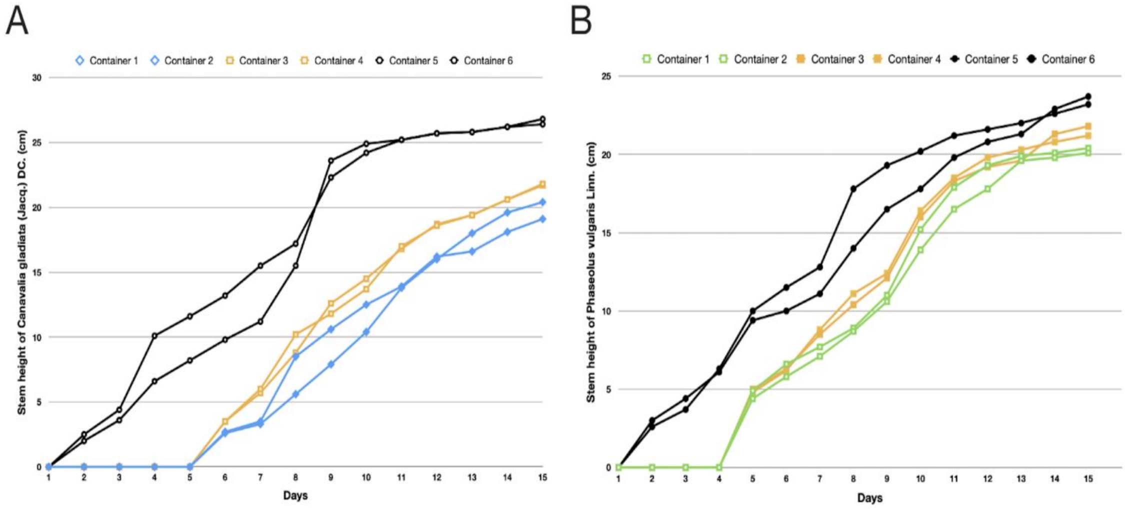

Figure 1. The effect of ant activity on the stem length of C. gladiata (A) and P. vulgaris (B).

3.2. Average leaf area

The average leaf area comparisons of *C. gladiata* and *P. vulgaris* under different experimental controls showed a significant difference between containers without ants and containers with ants (Figure 2). In the two containers without ants, the average leaf area of *C. gladiata* and *P. vulgaris* reached more than 13 cm^2 and 3 cm^2, respectively. However, in the four containers with ants, they did not reach the area threshold.

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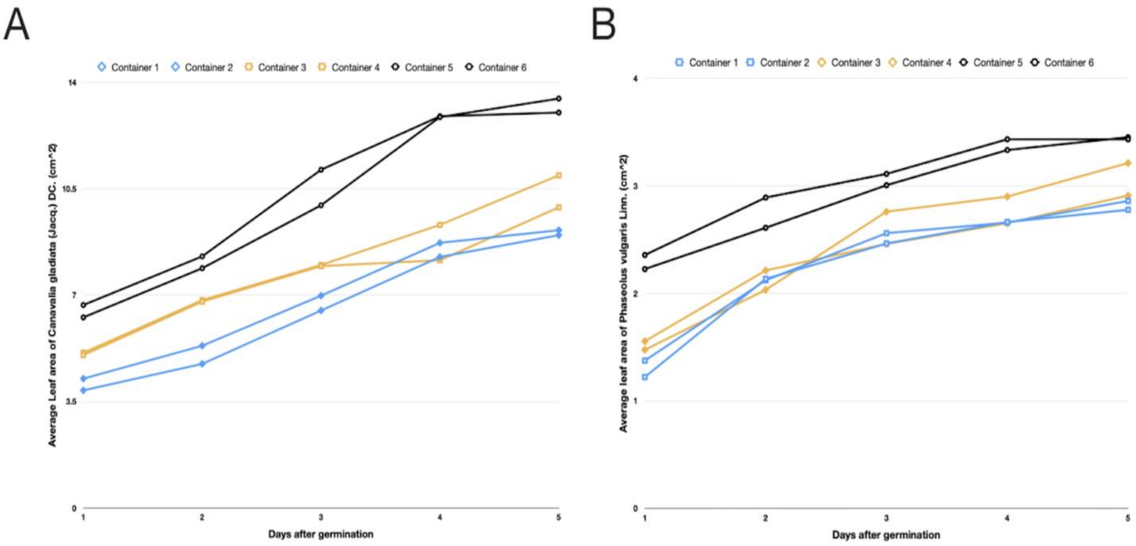

Figure 2. The effect of ant activity on the average leaf area of C. gladiata (A) and P. vulgaris (B).

3.3. Root length

The root lengths of *C. gladiata* and *P. vulgaris* under different experimental controls weres measured, and showed a significant difference in the root lengths of *C. gladiata* and *P. vulgaris* between containers without ants and containers with ants (Figure 3). In the two containers without ants, the root lengths of *C. gladiata* and *P. vulgaris* reached more than 15 cm and 7 cm, respectively, while the root lengths from the four containers with ants did not reach the length threshold.

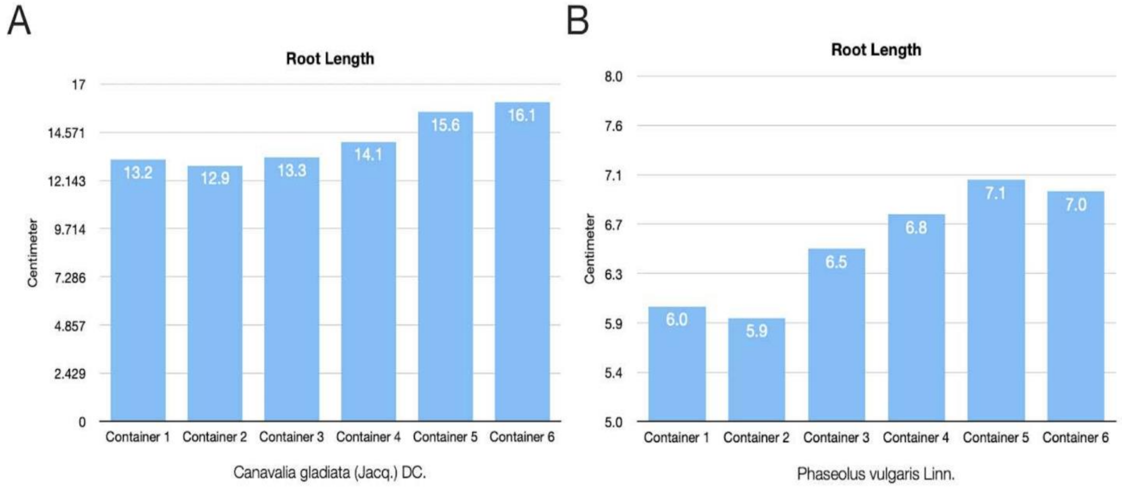

Figure 3. The effect of ant activity on the root length of C. gladiata (A) and P. vulgaris (B).

3.4. Fresh weight

Under different experimental controls, the afresh weight of *C. gladiata* and *P. vulgaris* performed significant differences between containers without ants and containers with ants, as shown in Figure 4. In the two containers without ants, the fresh weight of *C. gladiata* and *P. vulgaris* reached more than 480 grams and 280 grams, respectively, which were higher than those of the four containers with ants.

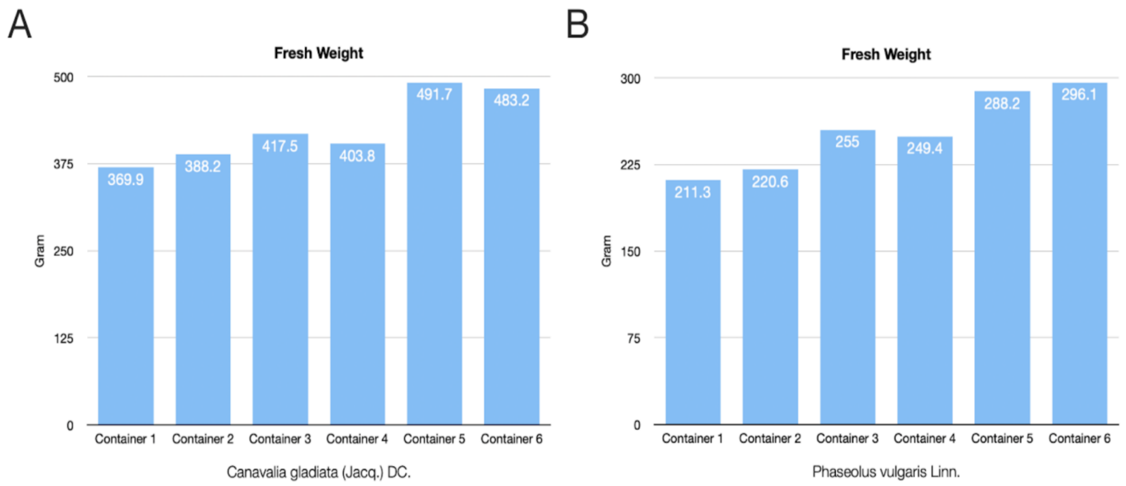

Figure 4. The effect of ant activity on the fresh weight of C. gladiata (A) and P. vulgaris (B).

4. Discussion

4.1. Plant growth

The experimental results indicated that soil disturbance (pedoturbation) caused by ants could delay the germination time through the sinking of seeds. However, with an increase in the duration of the experiment, the growth of leguminous plants with a larger ant population was slightly better than that with a smaller ant population. This also suggested that the activity and nesting behavior of ants contribute to an increase in the growth rate of plants after germination to a certain extent. Lafleur et al. stated that plants around ant nests grew significantly faster and performed at higher density than plants in other areas [6]. As this experiment involved placing ants and plants in the same container simultaneously, the ants' nesting behavior caused the seeds to sink. This also resulted in beans in containers with ants taking longer to germinate than plants in the control group. Therefore, a new ant colony looking for a new habitat and nesting site would have a certain impact on the surrounding plants. There was also sufficient reason to believe that planting seeds directly above fully developed ant nests would significantly improve plant growth. Ant activity has significant effects on seed positioning and subsequent plant growth. While ant activities can lead to the sinking of seeds and delayed germination, the increased permeability of the soil due to ant tunneling can facilitate better access to water, nutrients, and oxygen. Additionally, a larger number of ants results in increased nutrient cycling through the deposition and decomposition of organic waste, which can enhance plant growth [7]. The changes in micro-spaces of the soil caused by ants can promote plant growth, which is also related to the higher number of ants resulted in better growth of leguminous plants in this experiment [8].

For soil structure, ants augment the volume of rough sand and diminish the quantity of clay within their nesting area, thereby potentially making a substantial impact on the vegetation community, because alterations in the physical attributes of soil can expedite the process of plant establishment within the soil [9]. Ants possess the capability to alter the chemical properties of soil, and such alterations can be attributed to their foraging activities (because ants were allowed to carry prey items to their nest), excrement, and the decomposition of ants that may die in the experimental nest.

4.2. Root length

The sinking of beans in containers with ants could be attributed to the activities of the ants themselves. Ants are known to dig and tunnel in soil, potentially causing the displacement of plant roots. Their movement and nest-building behaviors may create voids or channels in the soil, leading to the sinking of the beans [10]. The observation of root growth towards the container walls, irrespective of ant presence, suggested that the leguminous plants exhibited a natural behavior of utilizing available space. The presence of a solid structure, such as the container wall, may serve as physical support for the roots as they explore the soil for resources.

5. Conclusion

Understanding the intricate relationship between ants, seeds, and plants is essential for comprehending ecosystem dynamics and advancing agricultural practices. Overall, ants are served as important ecological agents to affect seed dispersal, soil structure, and nutrient cycling, ultimately shaping plant communities and ecosystem functioning. This study expands our understanding of the complex web of life and offers potential solutions for addressing ecological challenges in various environments.

This study was conducted solely under artificial intervention and cannot completely simulate natural environments. Additionally, only a limited number and variety of bean species were studied. In the future, the types of ants used in experiments can be verified to determine their impact on plant growth by raising different species of ants. Besides, further research is needed to investigate the specific mechanisms involved in seed positioning and the nutrient dynamics associated with ant-mediated processes. These could be applied to ecosystem restoration efforts, conservation strategies, and sustainable agriculture practices that harness the positive aspects of ant-plant interactions.

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