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Sandy Peas: Can *Pisum sativum* Survive in Sandy Soil

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Introduction

As the world population continues to grow, we continue to expand the agricultural lands. Not every soil available is the most nutrient dense or ideally irrigated. It’s estimated that environmental stressors are increasingly contributing to the loss of crops (Macedo, A. F., 2011). Crops are needing to be grown in harsher environments than the ideal farmlands. Knowing what stressors a species can deal with and what will definitely destroy it can help farmers get more successful harvests in imperfect conditions. This experiment aims to test the resilience of pea plants (*Pisum sativum*) in sandy soil. If plants need nutrients to grow and maintain organs, then the lack of nutrients will inhibit growth by shorter height, lower leaf count, and more necrosis of leaves. Due to the nature of sand not holding water as well as typical soil may also lead to drought stress. In the experiments to follow, I looked at the possibility of both nutrient stress and drought stress affecting the growth, leaf count, water potential of the plants.

Methods & Materials

*Pisum sativum* plants were germinated in soil before being separated up. Plants were randomized for treatment and placement in the greenhouse. Individual plants were placed into individual plastic pots: 5 control plants and 5 treatment plants. All plants were secured to stakes with twist ties. Treatment plants were transplanted into a mixture of 25-33% sand and 75-67% original soil. No fertilizer was added to the treatment plants. Control plants were moved to individual pots but kept in original soil and given 14.8 cm^3^ of Osmocote pellet fertilizer per pot. Leaf height and count measurements were taken on all plants once a week along with being watered to capacity for 6 weeks. All tests done in lab were at 20°C while greenhouse controls were 22°C.

On the third week of treatment, the midday water potential of leaflets were taken using a pressure bomb (PMS Instrument Co., Corvallis, OR). Afterward, the plants were kept in the lab room under black plastic bags overnight. Dark acclimated water potential was taken the next day with the same instrument. All leaflets were folded 1/3 parallel to the main vein in order to fit in the seal. During week 4, leaflets were cut, scanned, and processed in Image J to determine area. Clear nail polish was applied to both the abaxial and adaxial side of each leaflet. I viewed the dried peel, removed from the leaf and taped to a slide, under a light microscope at 40x. I divided the stomata by the area to obtain stomatal density (SD). The same leaflets were then dried in an oven at 51°C for 18 hours. I used these data to determine specific leaf area (SLA). During week 5, I used the LI-6400 (LI-6400, Licor Inc., Lincoln, NE) to find max A, g, E, and dark R. Controls were set as follows: CO2 mixer at 390 µmol CO2/s, temperature 22°C. PAR was set to 1500 µmol m^-2^ s^-1^, and recorded each time before being decreased as follows: 1200, 900, 600, 400, 300, 50, 0. I used Microsoft Excel to process these data to find the light compensation point and quantum use efficiency. I also used Microsoft Excel to process, and graph, all previous data to run f-tests to determine specific leaf area (SLA). During week 6, I used the LI-6400 to determine photosynthetic electron transport (Marschner, 1995). For these reasons, shoot height and leaf count were also significantly lower for treatment plants (Okunlola, G., 2014). Adaxial stomatal density not significant (p > 0.05) while abaxial SD was significantly lower (p < 0.05) (Table 1). The abaxial SD was opposite to my prediction. This could be because the treatment plants are trying to reduce water loss due to lower water content in the sandy soil mix. This could be the reason the treatment dark acclimated PSI (Fig 2) was less negative than the control, which was opposite my prediction. With less stomata, the treatment plants can conserve water via less transpiration (Bucciarelli, B., 2006), and not have as great a need to pull water up from the soil. Max A, g, and E were not significantly different (Table 1). I predicted that they would be different. Interestingly enough, the average light curve was significantly different. This could mean that there was an error with the equipment or procedure, or that the max A, g, and E did not differ enough on their own but their combined effect was enough to change the light curve (Fig 3). The significantly lower SLA (Fig 5) could mean that the treatment plants are conserving resources or are limited to producing smaller leaves. It also means that they are limited by Calvin-Benson cycle reactions (Rubio, V., et al., 2008). I predicted that SLA would be high to lower resource investment but did not factor in leaf size as an investment. All the rest of the data supported my predictions.

Results

The treatment shoot biomass (Table 1) was significantly less than the control biomass (p < 0.05). Nutrient deficiency inhibits the growth of *Pisum sativum*. Without enough nutrients, the plants don’t have enough resources to grow to maximum height. The presence of minerals, or lack thereof, influences the photosynthetic electron transport (Marschner, 1995). For these reasons, shoot height and leaf count were also significantly lower for treatment plants (Okunlola, G., 2014). Adaxial stomatal density not significant (p > 0.05) while abaxial SD was significantly lower (p < 0.05) (Table 1). The abaxial SD was opposite to my prediction. This could be because the treatment plants are trying to reduce water loss due to lower water content in the sandy soil mix. This could be the reason the treatment dark acclimated PSI (Fig 2) was less negative than the control, which was opposite my prediction. With less stomata, the treatment plants can conserve water via less transpiration (Bucciarelli, B., 2006), and not have as great a need to pull water up from the soil. Max A, g, and E were not significantly different (Table 1). I predicted that they would be different. Interestingly enough, the average light curve was significantly different. This could mean that there was an error with the equipment or procedure, or that the max A, g, and E did not differ enough on their own but their combined effect was enough to change the light curve (Fig 3). The significantly lower SLA (Fig 5) could mean that the treatment plants are conserving resources or are limited to producing smaller leaves. It also means that they are limited by Calvin-Benson cycle reactions (Rubio, V., et al., 2008). I predicted that SLA would be high to lower resource investment but did not factor in leaf size as an investment. All the rest of the data supported my predictions.

Conclusion

*Pisum sativum* can tolerate some sandy soil although it does cause the plants to flower earlier than the controls. The treatment plants were smaller but may not hold up to prolonged drought. If a farmer has a sand-soil environment, is looking to have an earlier harvest, or wants smaller plants to conserve water, these pea plants will hold up to the job. They will have a few tradeoffs as mentioned, as well as smaller leaves.

Acknowledgements

I'd like to start by thanking my group members, Karissa Merrill and Jose Aido Cervantes, for assisting with my data collection and analysis. Thank you to Dr. Ava Howard for assistance with understanding processes going on inside of my plants. A huge thank you to Alissa Whiting for teaching my how to use Microsoft Excel.

References


Table 1. Compares control averages to treatment averages along with t, d.f. and p.

<table>
<thead>
<tr>
<th>Shoot Height (cm)</th>
<th>Time (weeks)</th>
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<tbody>
<tr>
<td>Control</td>
<td>Sandy Soil</td>
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<tr>
<td>6 weeks</td>
<td>7 weeks</td>
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<tr>
<td>60</td>
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<td>120</td>
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<table>
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<tr>
<th>Abaxial Stomatal Density</th>
<th>Adaxial Stomatal Density</th>
<th>Shoot Biomass</th>
<th>Max A</th>
<th>Max g</th>
<th>Max E</th>
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<td>&gt; 0.05</td>
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<tr>
<td>g</td>
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<tr>
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<tr>
<td>E</td>
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</table>

Figure 1. Average stem height (cm) of control plants and treatment plants over 6 weeks. Error bars are calculated standard deviation. Data is significantly different with p < 0.05, t= 2.437, d.f. = 4, and n= 5.

Figure 2. Water potential of dark acclimated plants and light acclimated plants. Midday psi was not significant with p > 0.05, t= 0.072, d.f. = 7. Dark acclimated psi was significantly different with p < 0.05, t= 3.4, d.f. = 8, n= 5.

Figure 3. Average light curve of control plants and treatment plants. Light level was PM1 µmol m^-2^ s^-1^.

Average control light compensation point (LCP) is 1330.625 while treatment LCP is 15.122. Average control quantum use efficiency (QUE) is 0.008 and average treatment QUE is 0.049, where n= 5.

Figure 4. Average control leaf count and average treatment leaf count for final measurements on the 6th week. These data are significantly different with p < 0.05, t= 4.128, d.f. = 4, and n= 5.

Figure 5. Average SLA of control plants and treatment plants collected on week 4. These data are significantly different with p < 0.05, t= 3.29, d.f. = 5, and n= 5.