An Agent-Based Model of Pollen Competition in Arabidopsis thaliana
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I. Introduction

Background:
• Pollen competition occurs when pollen from different accessions compete to fertilize ovules while consuming limited resources.
• When Arabidopsis thaliana is pollinated by Columbia and Landsberg accessions, Columbia sires disproportionately more seeds.
• Previous research has studied which pollen performance traits differ between Columbia and Landsberg that may account for this:
  – Proportion of pollen germinated: the proportion of pollen grains from each accession that grow pollen tubes.

Agent-based Modeling
• Agent-based models (ABMs) show how unique individuals interact with other agents and their local environment.
• Interactions between individuals cause properties to emerge in ABMs - the emergent property of interest in our model is the proportion of seeds sired by each accession.

NetLogo
• We created our model in NetLogo 6.1.0.
• One tick represents one minute and one patch represents the dimensions 0.01 mm × 0.01 mm.

II. The Model

Figure 3: The decision tree describes the potential actions of a pollen tube tip during each tick of the model.

Table 1: The variables to be tuned.

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<thead>
<tr>
<th>Attractants</th>
<th>slope chemoattractant-radius</th>
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Figure 4: Distribution of proportion of pollen germinated for the two accessions.

Time to germination
We compared families of functions to represent the differential germination time of each accession. The most parsimonious of these was the Gompertz function.

The number of pollen grains which germinate $N(t)$ at a given tick $t$ is modeled as the derivative of these functions.

$NCol(t) = 14.22 \exp (3.560 (1 - \exp (-0.0823t)))$

$NLer(t) = 1.5565 \exp (5.3619 (1 - \exp (-0.0914t)))$

Figure 5: Number of pollen grains germinated over time for the two accessions.

Chemoattractants
We modeled the strength of chemoattractants by $A(x, y, t) = F(t) \left( \text{distance from ovule} - d(x,y) \right)$ where $d(x,y)$ is the distance from the ovule and $F(t)$ determines the saturation rate of chemoattractant strength.

$F(t) = \begin{cases} 
0 & \text{if } 0 \leq t < t_1 \\
K (t - t_1) & \text{if } t_1 \leq t < t_1 + \frac{1}{2} \\
1 & \text{if } t_1 + \frac{1}{2} \leq t 
\end{cases}$

III. Results

Figure 6: Q-Q plot for Col at 6 hours with the following parameter combinations: step-size=0.5, slope=0.01, chemoattractant radius=5, blue-energy-from-patch=0.5, red-energy-from-patch=0.5, blue-energy-from-patch=0.5, red-energy-from-patch=0.5, blue-movement-cost=2, red-movement-cost=2, and no starch regeneration.

Figure 8: Histogram of Col pollen tube length at 6 hours in the ABM.

Figure 10: Histogram of Col pollen tube length at 6 hours using exponential distribution ($\sigma = 0.144$) from literature.

IV. Future Work

• Run further experiments exploring a larger region of parameter space to better calibrate our model parameters.
• Since the ABM pollen tube growth rates do not follow an exponential distribution as closely as desired, try comparing them to a Gamma distribution.
• Once the model parameters determining pollen tube growth rates have been calibrated, compare the proportion of seeds sired by each accession to empirical data.

V. Acknowledgments

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