Functional Ecology

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The traits of baby plants determine who wins and who withers under drought

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Ecologists often try to take the patterns they observe in the natural world and uncover the processes responsible for creating them. For example, if certain species survive much better than others during a sudden drought, what differences between them are responsible for the variation in performance? For decades, ecologists have explored the traits of plants (how thick their leaves are, how tall they grow, the efficiency of their roots) to try to find the silver bullets – those traits which can explain why some plants perform better than others when the going gets tough. We've made a great deal of progress linking traits to growth rates, reproductive output, and survival of established plants.

However, the largest bottleneck in the lifecycle of most seed-reproducing species is the vulnerable transition from seed to established seedling, when seedlings can reach for resources just a few centimeters in any direction. In theory, seedlings should exhibit differences in growth rates, tissue construction, and how much they invest in roots versus shoots, similar to the differences observed in mature plants. However, when seedlings are so small that you need a magnifying glass to distinguish between their roots and shoots, we have to wonder whether the variation between species in root, leaf, or seed traits will be big enough to lead to differences in survival.

In this study, we measured traits of four-day-old seedlings of sixteen annual plant species found in California. We wanted to explore whether combinations of traits suggested different seedling strategies for different species, how drought affected the expression of traits (i.e. whether traits exhibited 'plasticity'), and whether a species' traits or plasticity were linked to its survival under drought.

It turns out that these tiny seedlings vary substantially in several different ways.

When plants are just centimeters tall, investments in the seed, roots, or leaves could have implications for the success of a seedling under stress. Credit: Julie Larson.

Some species invest in thick roots and shoots while others invest in thinner, more efficient tissues. Separately, some invest in tougher roots and others in deeper roots. We also observed tradeoffs related to growth rates (fast or slow) and biomass allocation (above or belowground). Although many of these traits changed to some degree in a drier environment (e.g., most species created denser roots under water limitation), it was a species' average attributes that were linked to survival. Across all species, those with denser root tissues and greater investment in roots (relative to shoots) survived longer – and these tended to be grasses. This makes sense when resource limitation is occurring belowground, and for young seedlings which may not grow fast enough for a deep rooting strategy to payoff in a rapid-onset drought. However, the best predictor of drought survival was seed mass – the amount of stored resources for a young seedling to live on when water uptake and photosynthesis are not possible.

Knowledge is power when it comes to plant conservation efforts. If these few traits can explain patterns of seedling survival under drought, we may be able to predict which species will win or wither in climates expecting increasingly frequent or extreme dryspells.