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The Effect of Seed Storage and Water Balance Characteristics on Seed Germination Success in *Ficus* Species from Tropical and Subtropical South China

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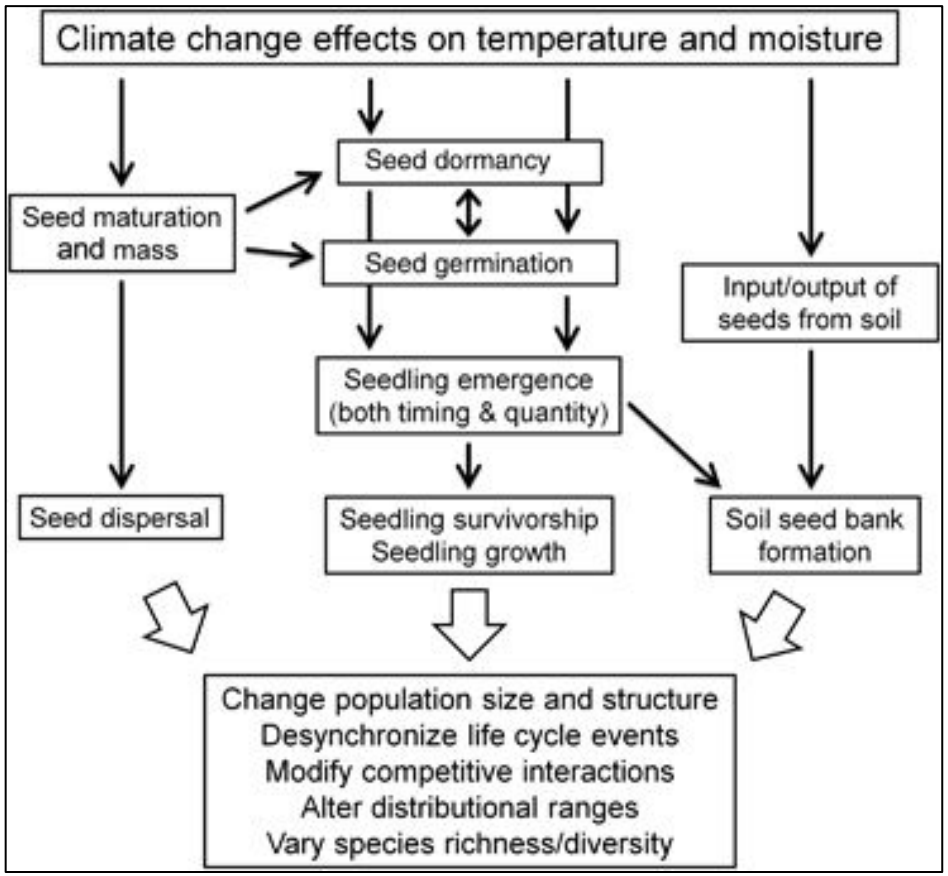
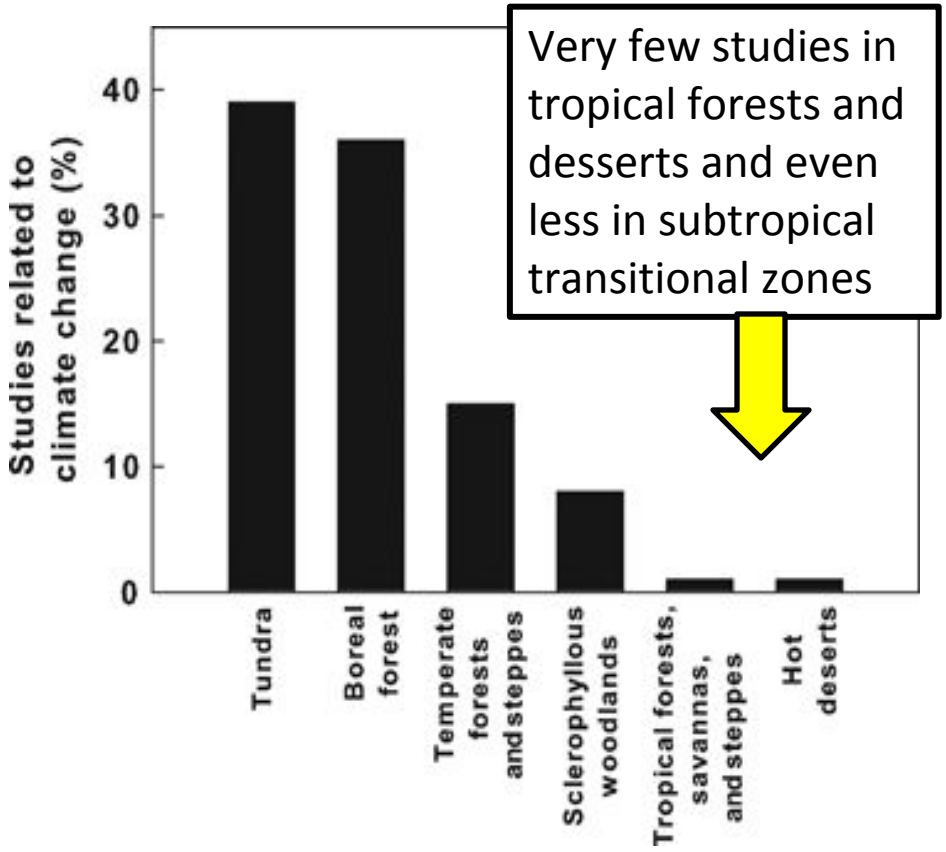
Climate Change and Plant Regeneration





- Changes in the regeneration ecology of a species can have cascading effects by affecting population dynamics leading to changes in species composition and diversity of communities.

Walck et al. 2011

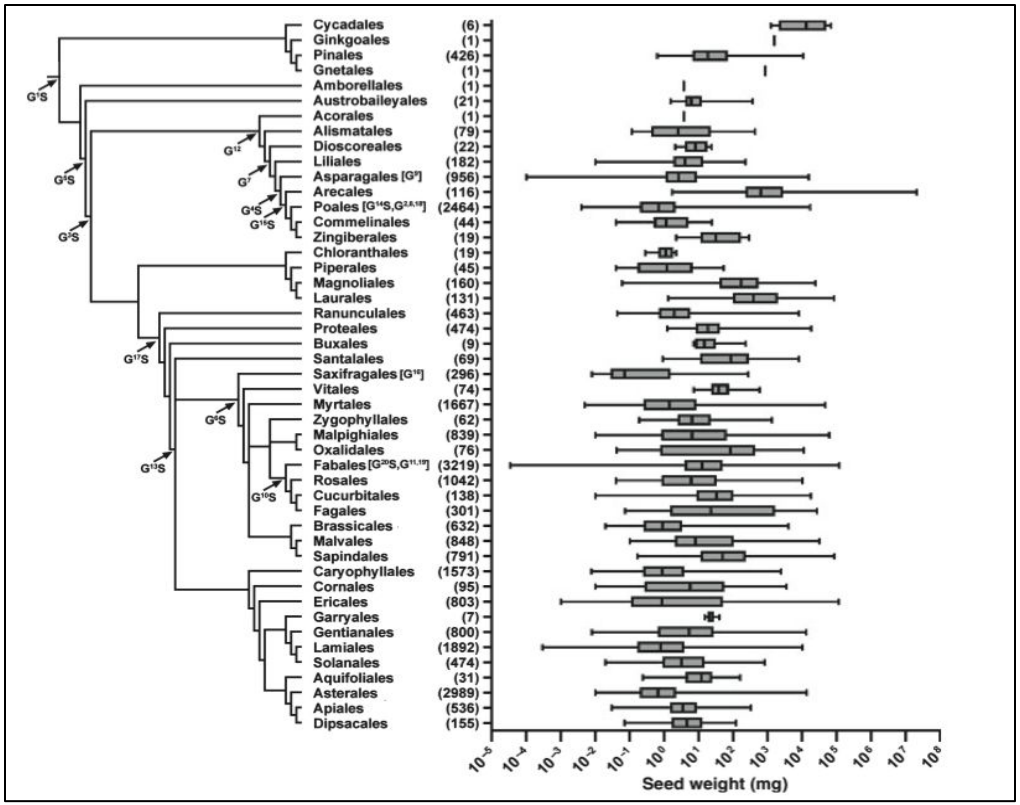
Importance of Water for the Germination Process

- On the most fundamental level, seed germination success depends on a trade-off between carbon gain and water loss.
- For most species, water uptake is the fundamental requirement for the initiation and completion of seed germination .
- This process is also governed by seed conditions such as seed coat permeability, location and conditions of the water gap, activation of hormones as well as external water availability and temperature.
- Despite the importance of water balance to complete the first step in germination, only a few studies have investigated seed water balance during this first stage in germination.

Yoder et al. 2000, Finch-Savage and Leubne-Metzger 2006, Manz 2006, Yoder et al. 2000, 2010, Gama-Arachchige et al. 2011, 2013,

Germination Strategies Vary Significantly Across Taxa

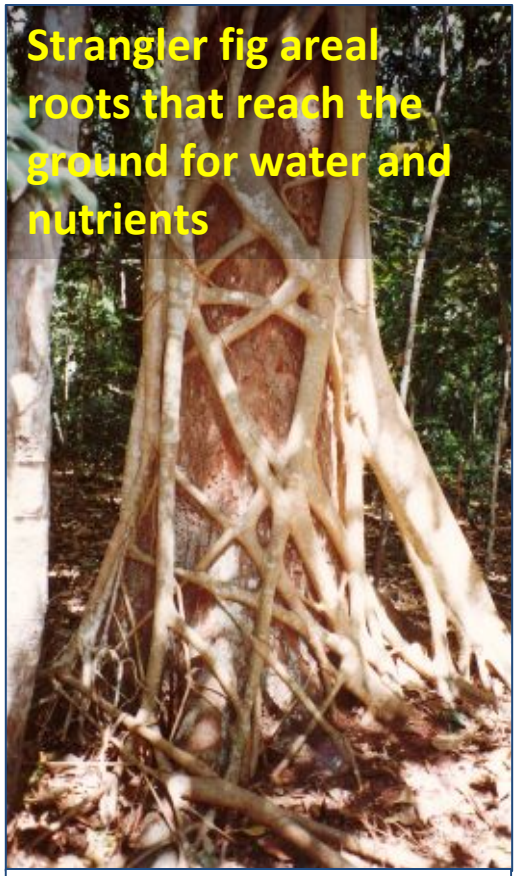
- Seeds are very diverse in size and in comparison to other seeds *Ficus* seeds are very small but not as small as dust seeds of orchids: 0.1 to .69 mg.
- Among species and within populations, seeds vary in their degree of dormancy and their in their rate of dormancy break.
- In some cases even species specific.



Linkies et al. 2010

Study Species: 18 *Ficus* Species

- Genus: *Ficus*
- Family: Moraceae
- > 850 species of woody trees, shrubs, vines, epiphytes and hemiepiphytes.
- Mostly tropical with only a few species occurring in semi-warm temperate zone.
- Keystone species that provide valuable food and habitats for wildlife, good candidates for restoration programs and biodiversity conservation.
- Provides a robust model for assessing the effect of temperature and water on seed germination, water balance characteristics and the effect of these functional traits on seed storage.



Harrison 2005, Rønsted et al. 2005, Cottee-Jones et al. 2015, 2016

Questions

1. How does variation in germination temperature and water availability in the germination medium and in air humidity affect the germination success of *Ficus* species?

2. How do seed water balance characterizes vary in *Ficus* species found in different habitat conditions and therefore affect germination success?

3. How do *Ficus* seed traits affect seed water balance and germination success?

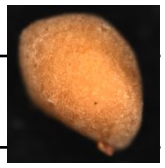
4. Can we use this information to predict storage success?

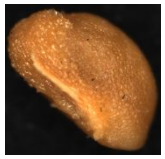
Study Species

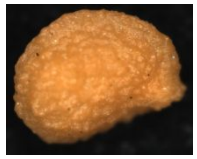
Species	Habit
1. Ficus auriculata Lour.	Terrestrial
2. Ficus beipeiensis S. S. Chang	Terrestrial
3. Ficus benjamina L.	Epiphytic
4. Ficus concinna (Miq.) Miq.	Epiphytic
5. Ficus curtipes Corner	Epiphytic
6. Ficus elastica Roxb. ex Hornem	Epiphytic
7. Ficus glaberrima Bl.	Epiphytic
8. Ficus hispida L. F.	Terrestrial
9. Ficus macleuandi king Varmaclellandi	Terrestrial
10. Ficus oligodon Miquel	Terrestrial
11. Ficus prostrata Wall. Ex Miq.	Hemi-epiphytic
12. Ficus racemosa L.	Terrestrial
13. Ficus religiosa L.	Epiphytic
14. Ficus semicordata Buch.-Ham. ex J. E.Sm.	Hemi-epiphytic
15. Ficus subulata Bl.	Hemi-epiphytic
16. Ficus tinctoria Forst subsp. gibbosa (Bl.)	Hemi-epiphytic
17. Ficus variegata Bl. var. chlorocarpa	Terrestrial


1.北碚榕


2.垂叶榕

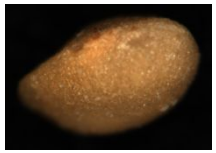

3.大果榕

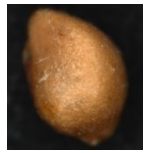

4.大叶水榕

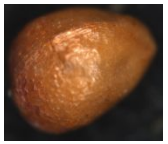

5.对叶榕


6.钝叶榕


7.鸡嗉子榕


8.聚果榕


9.假斜叶榕

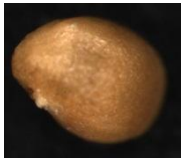

10.瘤枝榕


11.平枝榕

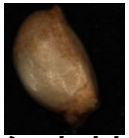

12.苹果榕


13.菩提树


14.青果榕


15.小叶榕


16.斜叶榕


17.海南榕

Research Methods

1. **Seed Collection, Transport and Storage**

- For each species, seeds were collected from a minimum of 5 mother trees and washed to remove fruit pulp and cleaned and air dried
- Seeds were stored at approximately 10°C

2. Assessment of Seed Traits

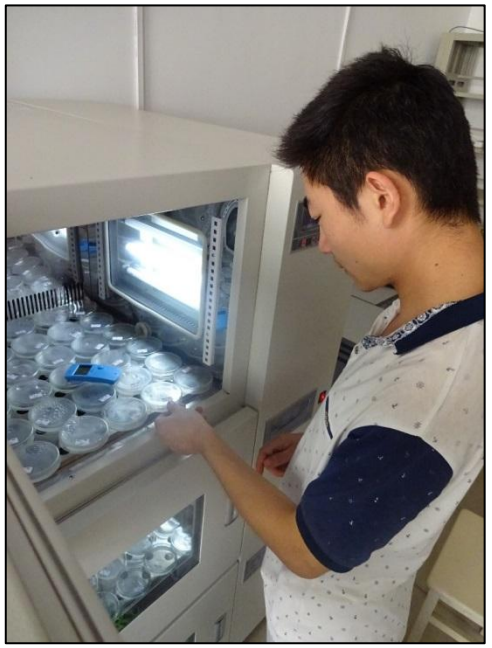
- 50 seeds were used for all trait measurements
- Seed fresh weight, dry weight & moisture content
- Seed width, length, perimeter, area and descriptive characteristics
- Seed water gap & micropylar region

Manz et al. 2006, Yoder et al. 2000, 2011

Research Methods

3. Seed Germination Experiments

- Experimental Design: A minimum of 20 *Ficus* species were used in the experiments, 50 seeds each for each *Ficus* species will be considered as the experimental unit, each germination treatment will be replicated four times.
- Germination and seedling development response to temperature: 15°C, 25°C, and 35°C
- Germination and seedling development response to water availability: Supplement the agar medium with polyethylene glycol (PEG) at -0.10 Mpa; -0.20 Mpa; -0.40 Mpa.



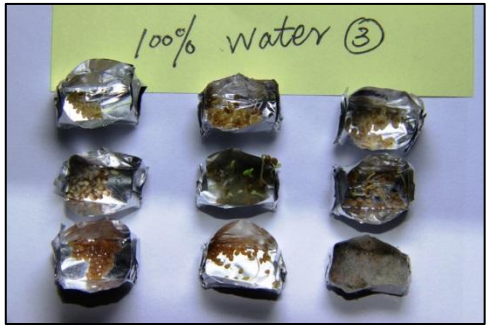


Photo Credit: Uromi M. Goodale

Research Methods

4. Seed Water Balance Experiments

- Experimental Design: A final tally of 17 *Ficus* species were used in the experiments, fifty seeds each for each *Ficus* species was considered as the experimental unit, tin boats containing seeds were randomly assigned to the designated relative humidity treatments. Each humidity treatment was replicated four times.
- Assessing seed water balance characteristics.
- Calculating water balance characteristics.

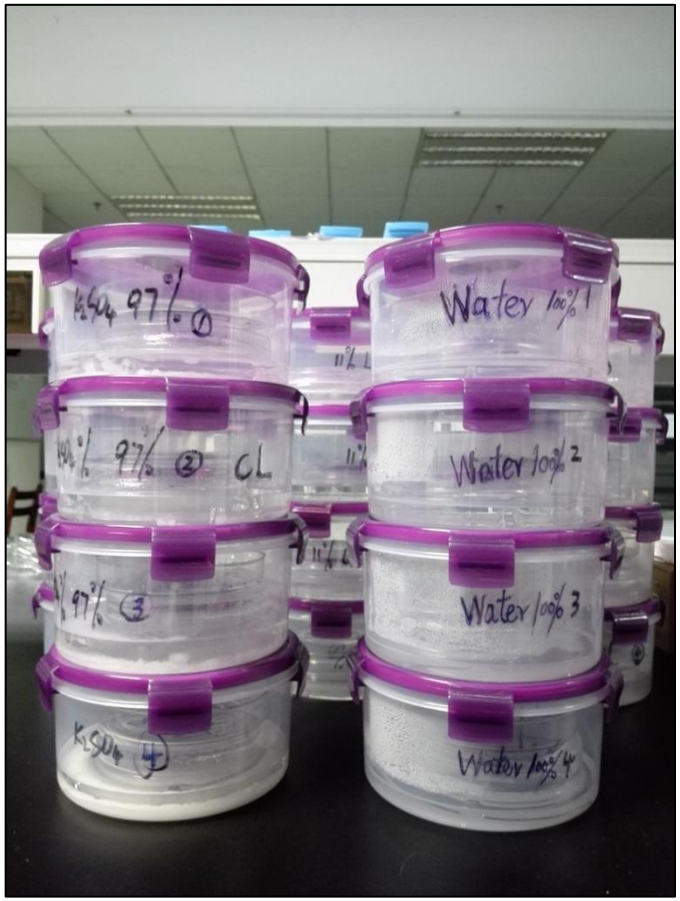


Photo Credit: Uromi M. Goodale

Statistical Analysis

- Assessing Temperature and Water Availability Effect on Germination Success
  - Logistic regression with mixed models
- Assessing Whether Seed Traits Can Influence Germination Success
  - Using seed traits as an explanatory variable in the mixed models
- Visualizing Whether Traits Cluster Based on Habitat Associations
  - Using correlograms
  - Using PCA analysis

Photo Credit: Uromi M. Goodale

Results
Seed Trait and Water Balance Experiments

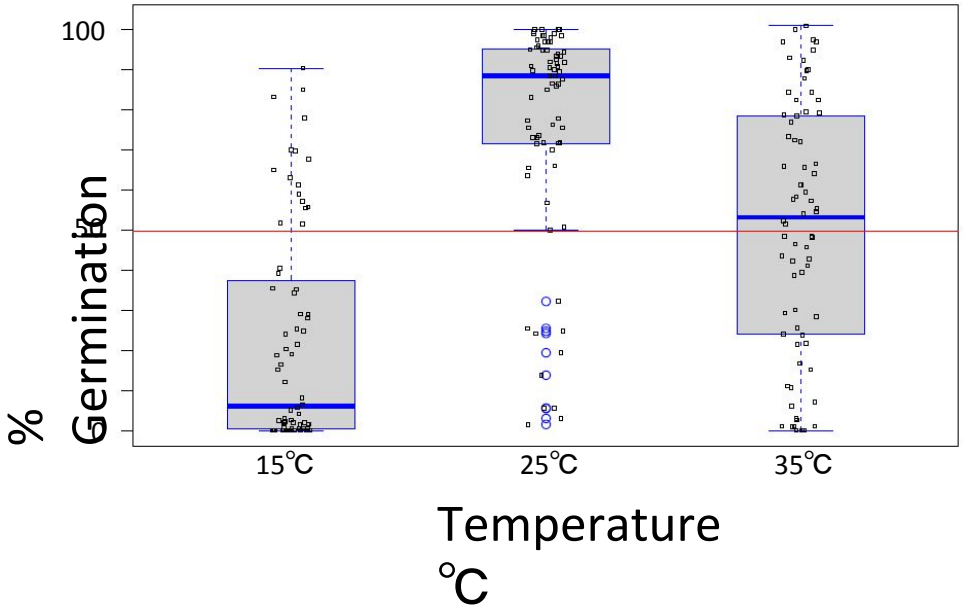
- Seeds of the hemi-epiphytic *Ficus* species were smaller, lighter, and were able to more quickly absorb as well as loose water compared to terrestrial species.

- There was significant differences between species for the equilibrium humidity because each species' seed characteristics including mass and coat surface are significantly different.

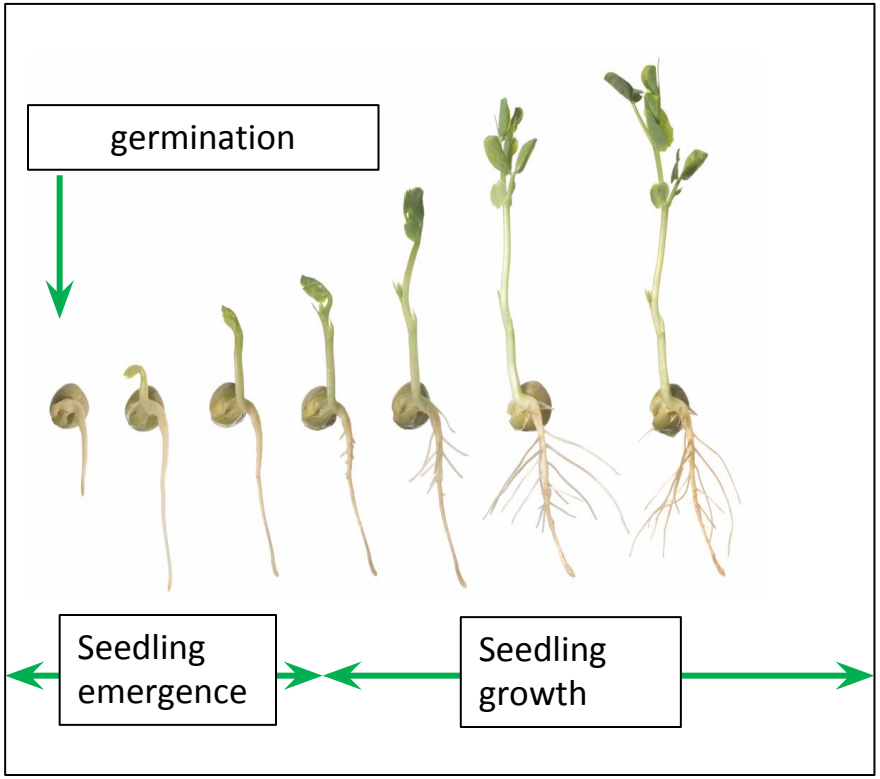
- The terrestrial and hemi-epiphytic *Ficus* seeds separately clustered in the principle components analysis visualization.

Seed Morphology and Germination Test Results

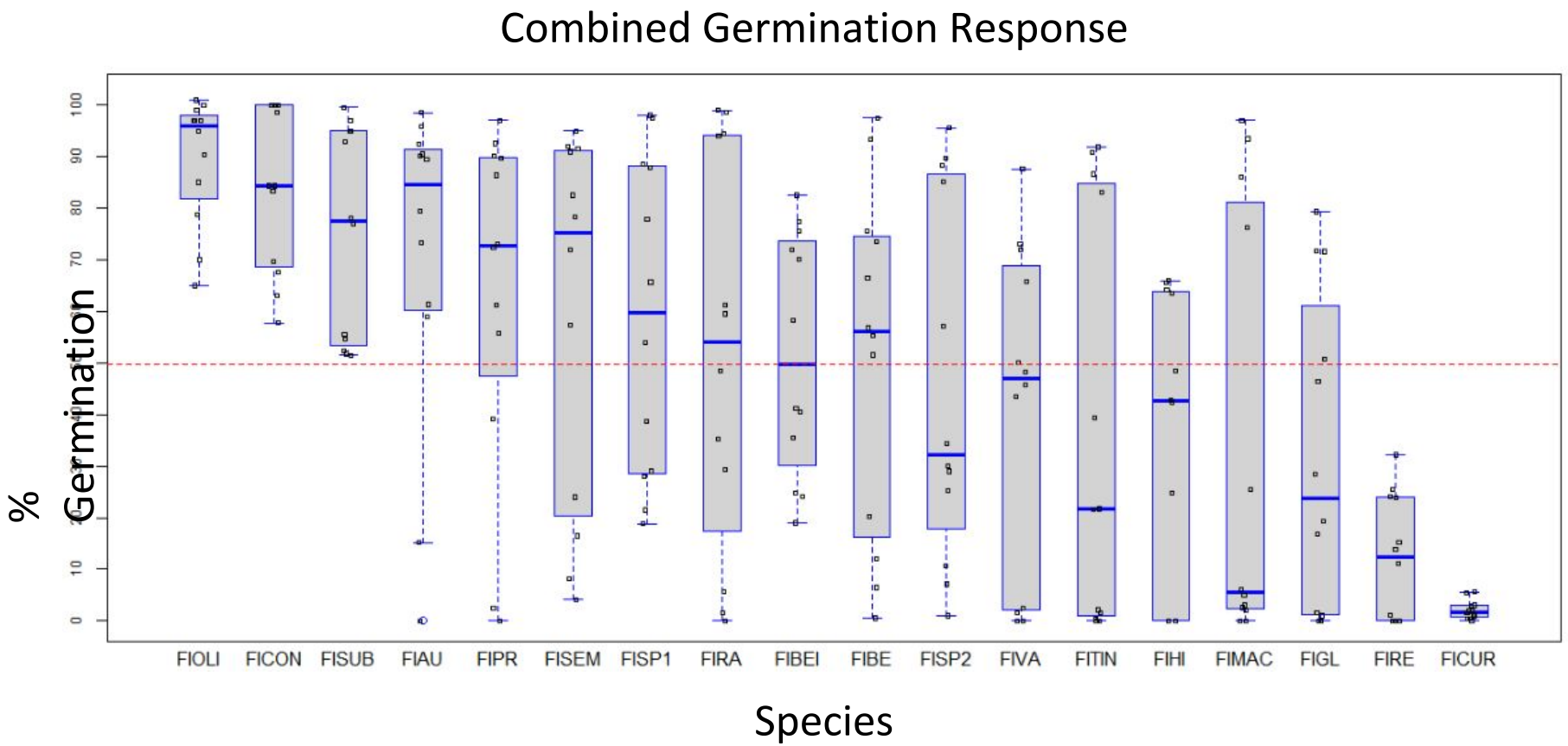
Germination Response to Temperature



25°C response was the highest for all species



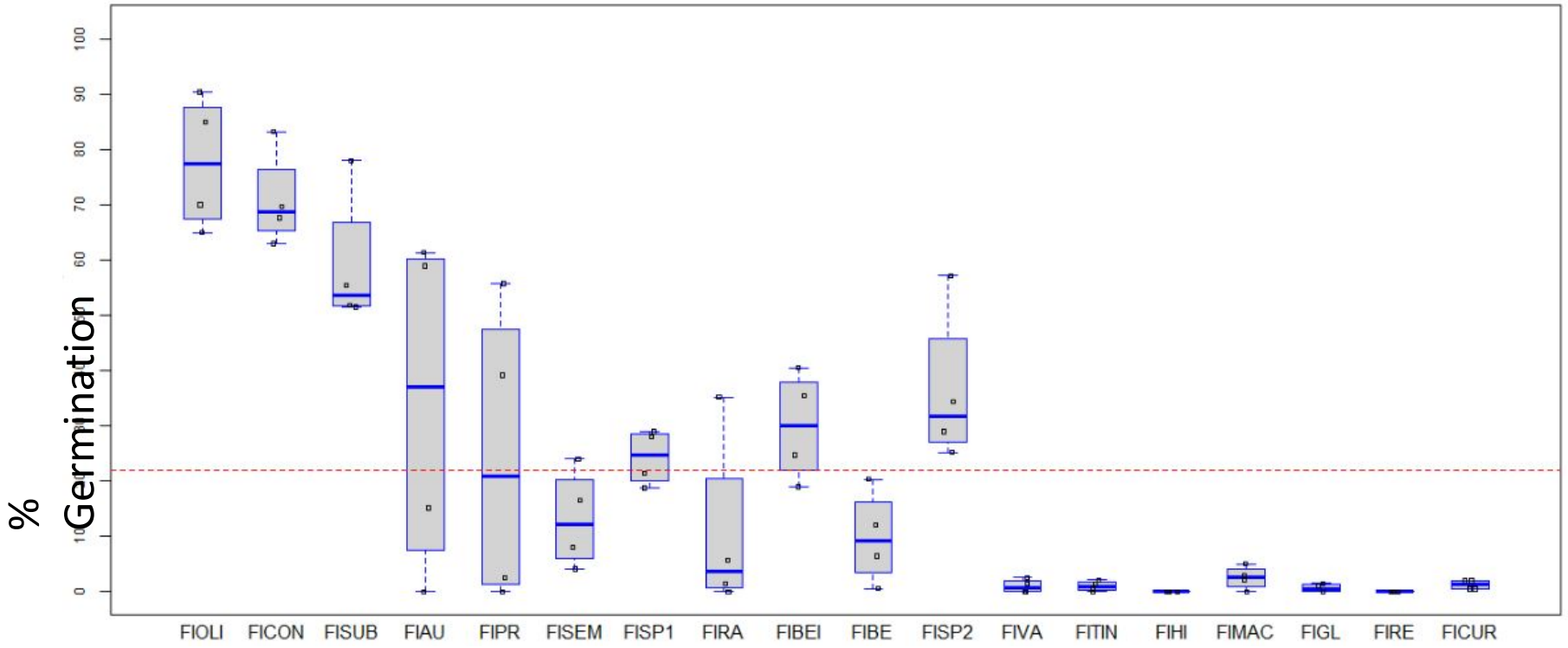
Seed Morphology and Germination Test Results



9 species germinated more than 50%, only a few had more than 80% germination

Seed Morphology and Germination Test Results

15℃ Germination Response

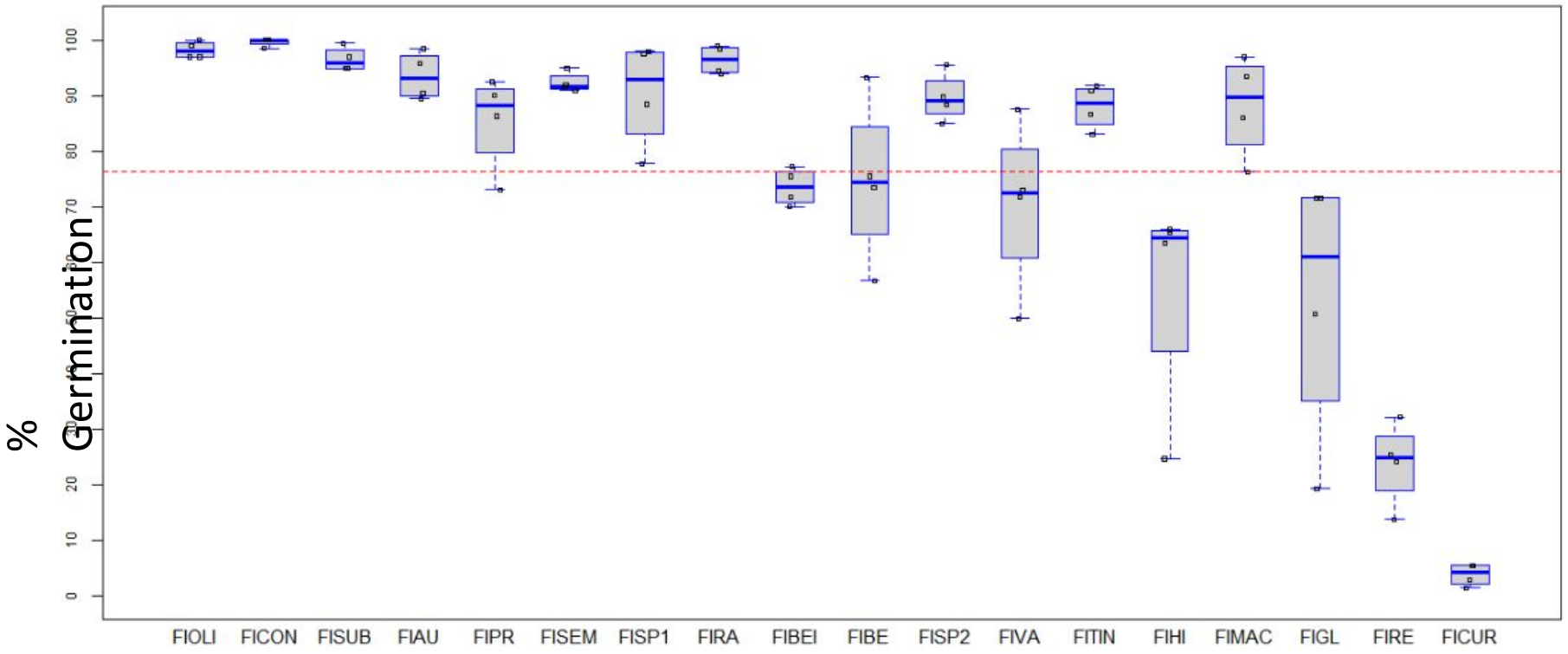


Species

Only three species had more than 50% germination rate of 50% or more

Seed Morphology and Germination Test Results

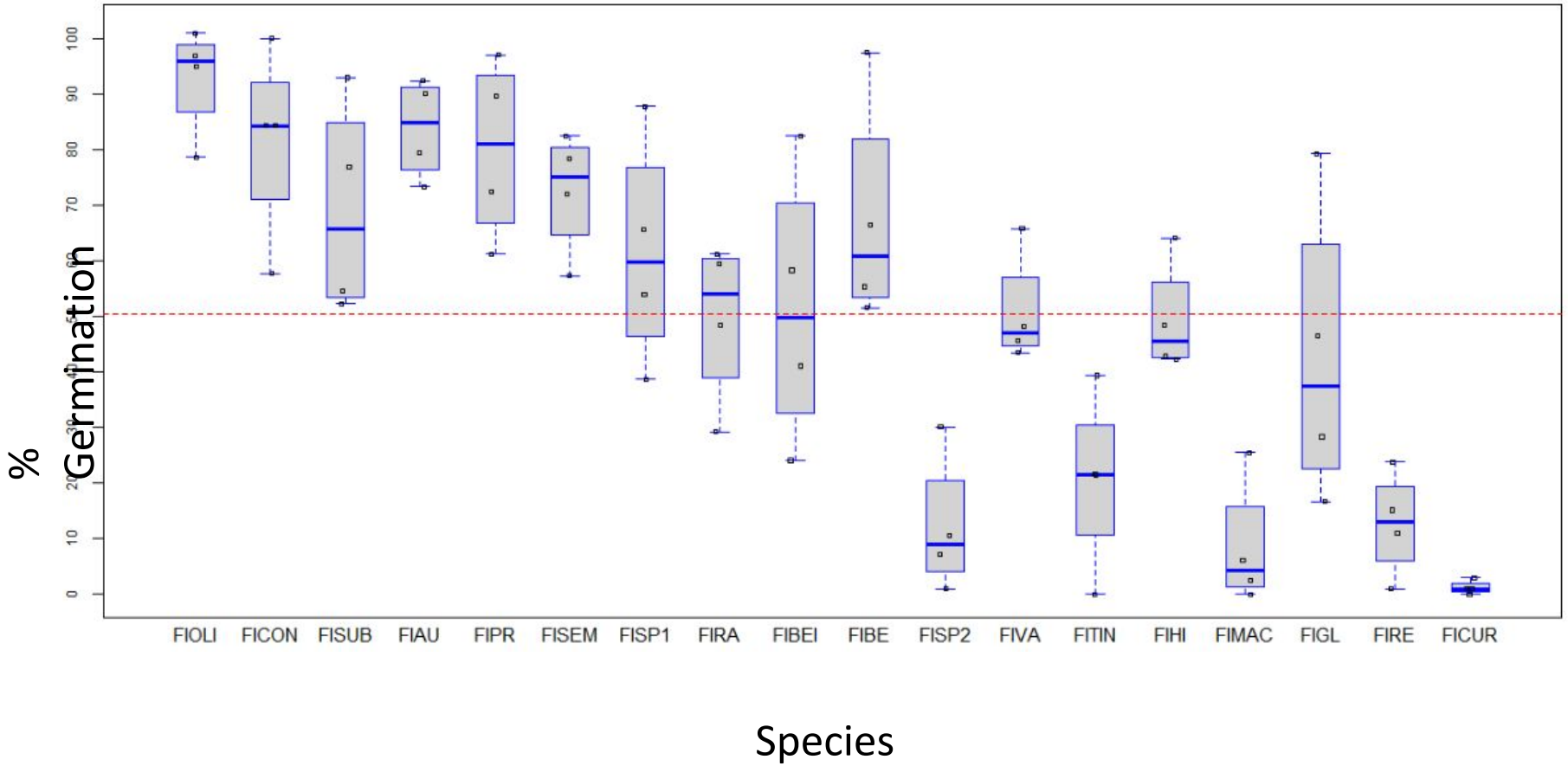
25℃ Germination Response



25 ℃ is the most suitable temperature for germination

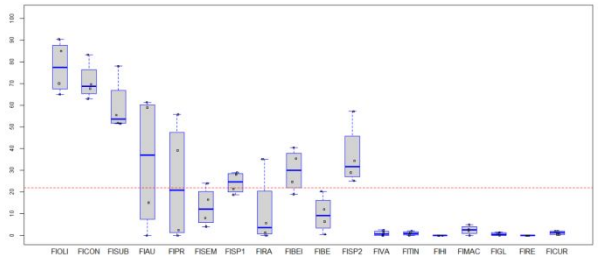
Seed Morphology and Germination Test Results

35℃ Germination Response

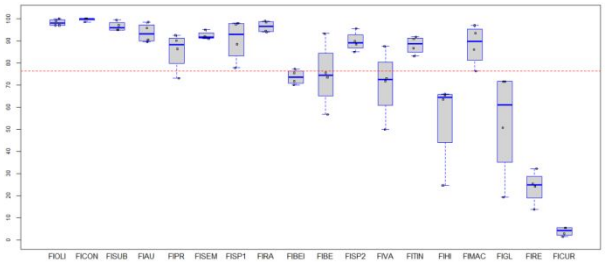


Higher germination but seedling emergence and growth much lower than in 25℃

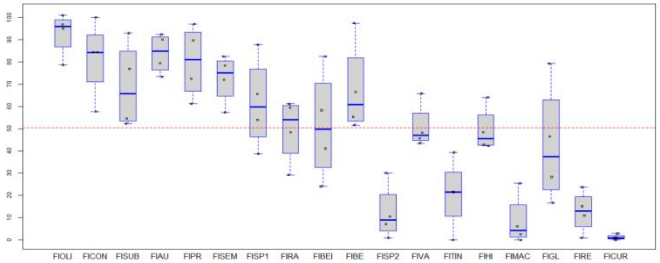
Seed Morphology and Germination Test Results



15℃



25℃

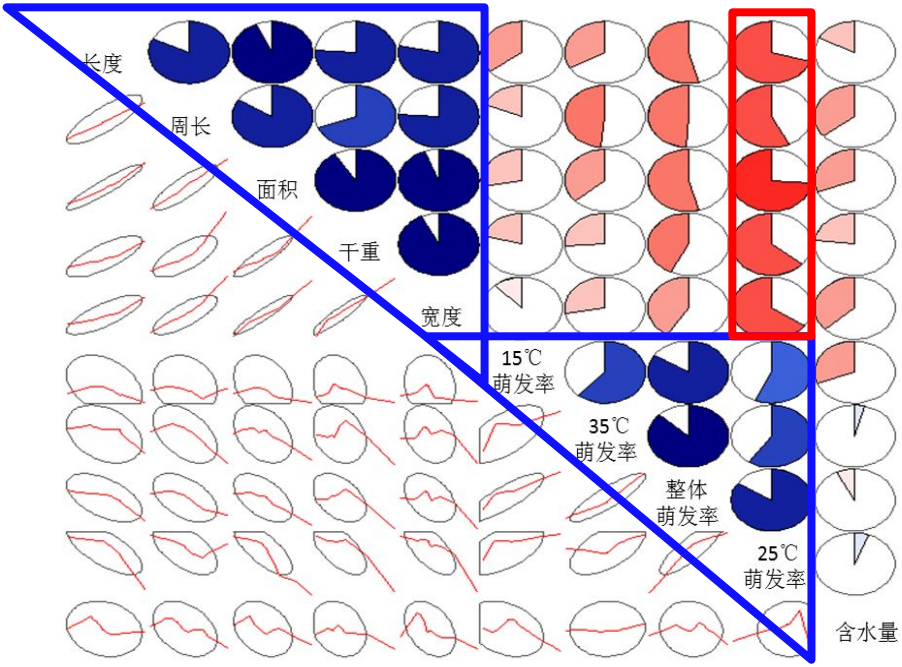


35℃

Factor	DF	Chi^2	*P* value
Temperature	2	3022.9	< 0.0001
Species	8	4861.1	< 0.0001
Temperature*Species	11	2546.8	< 0.0001

***P<0.0001; **P<0.01; *P<0.05

Seed Morphology and Germination Test Results

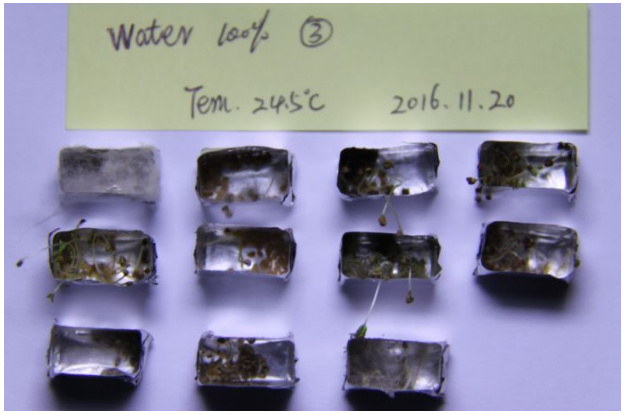


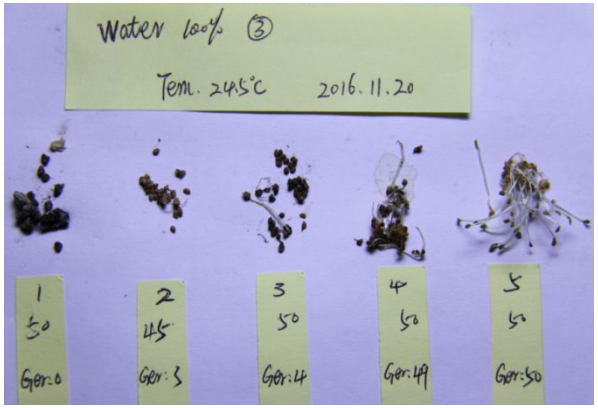
1. The blue triangular region shows a strong correlation between the morphological characteristics of the seed, and the germination at 15 ℃, 25 ℃ and 35 ℃ is also strongly correlated.
2. Red area shows that germination at 25 ℃ and seed length, width, perimeter, area has a strong relationship.
3. The strongest association with the area of the seed, indicating that the larger seeds provide a larger surface area for the sorption of the seeds and can absorb moisture very quickly, which is the first step in the initiation of germination.

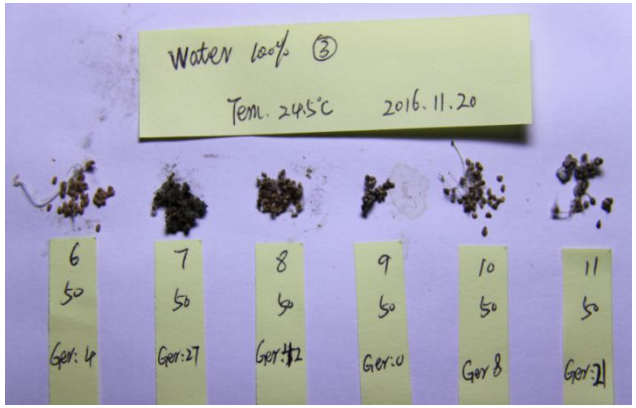
Temperature	Width	Length	Perimeter	Area	Dry Weight	Water
15℃	NS	NS	NS	NS	NS	NS
25℃	-0.65**	-0.70 **	-0.57*	-0.74***	-0.64**	NS
35℃	NS	NS		NS	NS	NS
All	NS	-0.54*	-0.49*	-0.54*	NS	NS

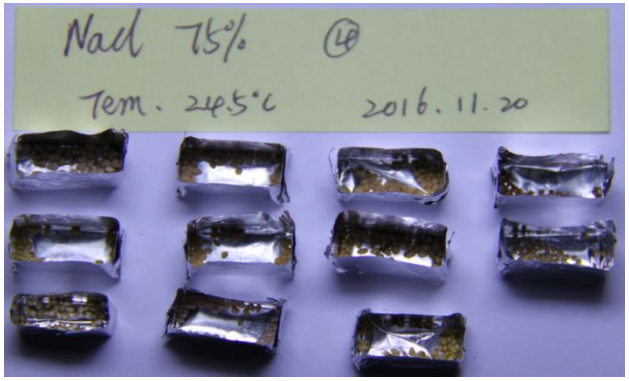
Water Balance Experiments

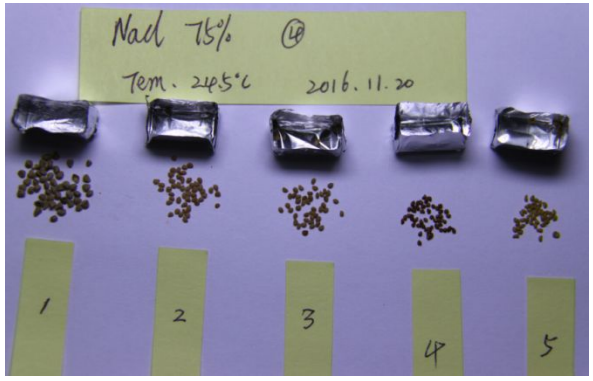
Completed work on 11 species in relative humidity gradients show that figs will germinate during storage only at near saturating air humidity. So they are robust for storage under regular RH conditions found in tropical environments but best to keep below 15 ℃.

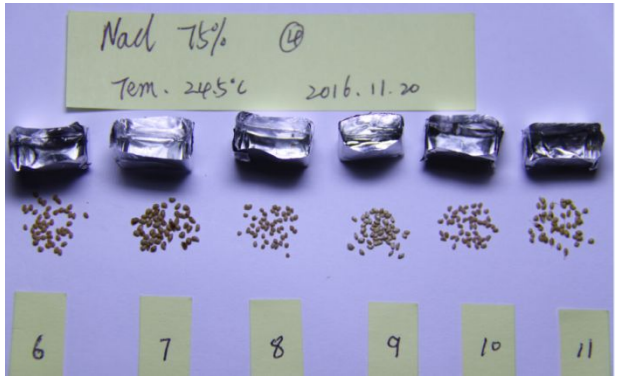












There is a significant species effect as to which species responds by germinating under high humidity conditions. This has significant restoration implications using the seeds of these species.

Conclusion

1. The water balance characteristics of germinating seeds have not been successfully assessed outside of a few species such as Orchids and Tobbacco seeds.

2. This is the first investigation of water balance characteristics of germinating seeds in *Ficus* that also accounts for variation in water availability and temperature conditions.

3. This study can improve our understanding of the ecophysiological processes that govern the first stage of germination, imbibition and also help in seed storage assessment and restoration potential using seeds.

Thank You for your Attention!

All of you present today!

Professor Cao Kunfang
Professor Eben Goodale
Chen Ying, Imena Valdez, Zhang Yumeng
Plant Ecophysiology and Evolution Group
Mr. Wei Miao Qin from Qing Xiu Shan
Ms. Yi Kong from Menger village

Funding: Invited Research project on "Regeneration ecology and seed conservation biophysiology of tropical and subtropical seed plants" from Guangxi University.

Institute of Applied Ecology!

Any Questions?

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(3) Support the development of a new
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The preceding presentation was delivered at the

2017 National Native Seed Conference

Washington, D.C. February 13-16, 2017

This and additional presentations available at http://nativeseed.info

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