Glandular Trichome Rupture in Tomato Plants is an Ultra-Fast & Sensitive Defense Mechanism Against Insects

UvA

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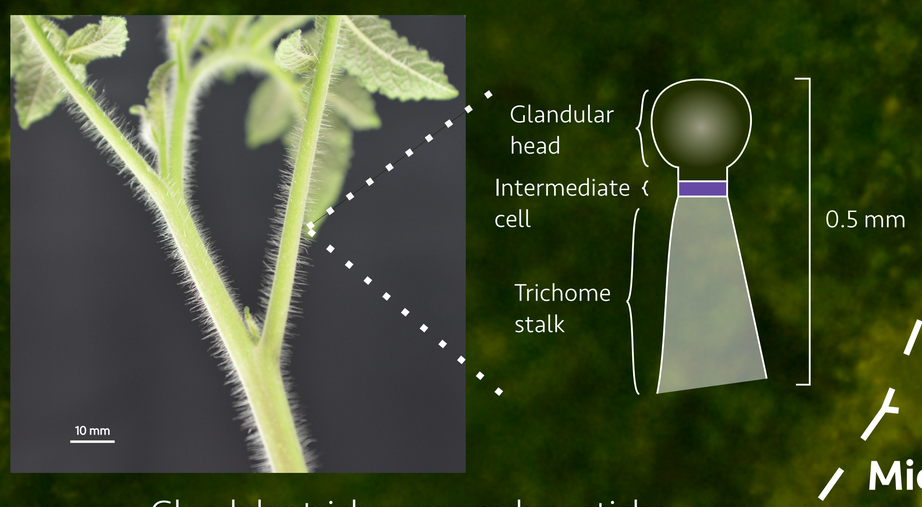
What are trichomes?

Trichomes are hair-like outgrowths on the aerial surfaces of many plants. They are a key defense mechanism against insect herbivory [1,2].



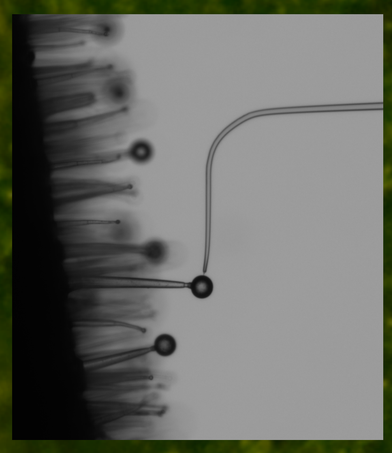
Glandular trichomes produce sticky chemicals that are released upon a very light touch. The mechanics of this release is unknown.

Natural pest defense

Understanding trichome-based defense could aid in developing pest-resistant crops and reducing pesticide use [3].

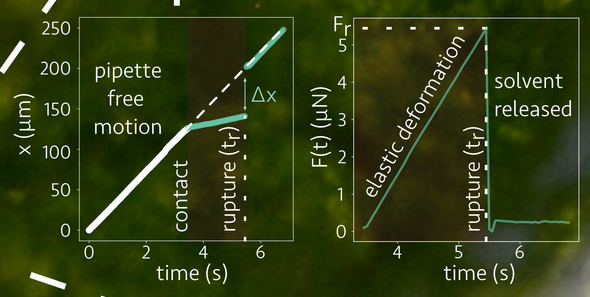
What mechanisms enable glandular trichomes in tomato plants to rupture and defend against insect pests?

Poking trichomes with artificial insect legs



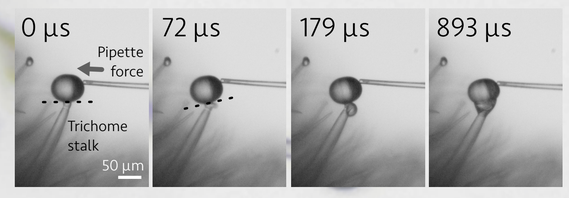
We use custom-made micropipette force sensors. Measurements of their deflection are sensitive to applied forces as small as 10 nN.

Micropipette deflection representative curves



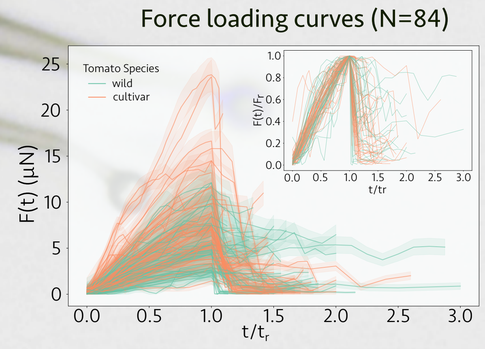
Rapid rupture

Glandular rupture occurs in under 1 millisecond, placing it among the fastest known plant movements [4]. Rupture consistently originates at the junction between glandular and intermediate cells.



Rupture force

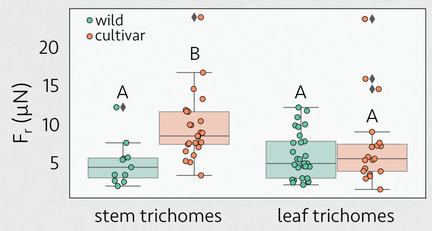
Force loading curves (N=84)

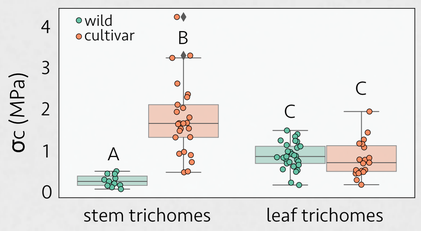


Mean rupture force: 7±4 µN

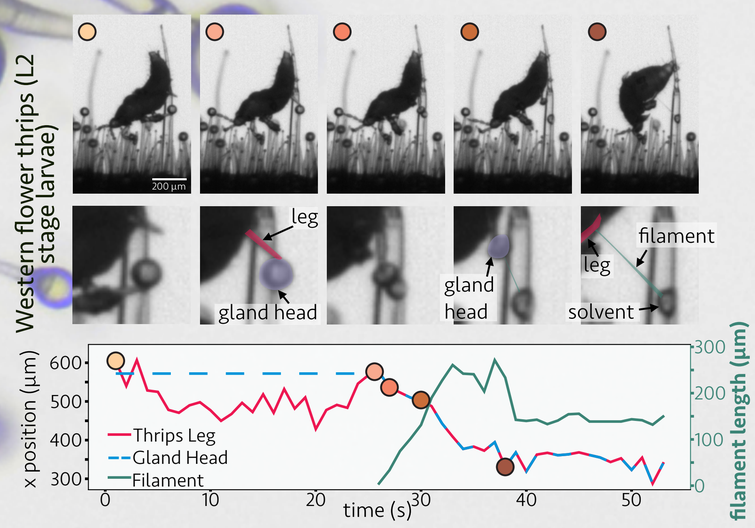
Consistent rupture process - brittle fracture

Cultivar stem trichomes required significantly stronger forces to rupture than wild type



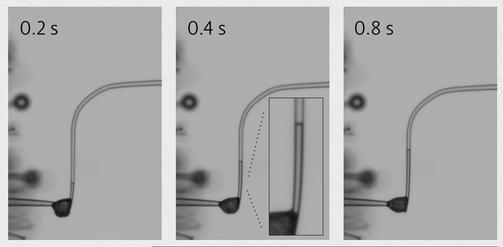


Insect interactions



The larvae triggered trichome rupture and accumulated solvent on its limbs, impeding mobility.

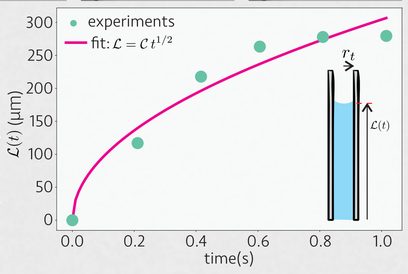
Fluid properties



Fit capillary flow to Washburn's equation:

$$\mathcal{L}(t) = \sqrt{\frac{\sigma\, r_t\, t\cos(\theta)}{2\,\mu}}$$

Released solvent is **highly viscous** (μ=2 Pa·s), with surface tension-dominated flow (low Re, We, Bo).



Preliminary rheological characterization suggests viscoelastic properties that enhance defensive function.

Conclusion

We quantified the ultra-fast and sensitive rupture mechanics of tomato glandular trichomes, revealing a sophisticated defense system operating at microsecond timescales.

Our findings suggest that modern cultivation may have inadvertently compromised some defensive capabilities, highlighting opportunities for enhancing crop resistance through targeted breeding.

References

1. Wang, Xiaojing, et al. "Analysis and review of trichomes in plants." *BMC plant biology* 21 (2021): 1-11.

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3. Glas, Joris J., et al. "Plant glandular trichomes as targets for breeding or engineering of resistance to herbivores." *International journal of molecular sciences* 13.12 (2012): 17077-17103.

4. Forterre, Yoël. "Slow, fast and furious: understanding the physics of plant movements." *Journal of experimental botany* 64.15 (2013): 4745-4760.

YouTube coverage (New Scientist):

arXiv: