Plant Cuttings

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News in Botany: Nigel Chaffey presents a round-up of plant-based items from the world's media

Plant life at the temperature limit?

When it comes to life living on the edges of what's biologically plausible or possible one understandably thinks of those microbes known as extremophiles[1,2]. Living under conditions of, for example, extreme heat, cold or pressure[3,4], it's easy to see why they get the popular vote as Earth's extremists *par excellence*. However, although prevalent, that microbomyopic view of extremophilia is erroneous and needs to be corrected; extremophiles are found amongst eukaryotic fungi, animals and plants[1,5] as well as the prokaryotic microbes. And to add to that catalogue of 'extremobiota' we now have multicellular, eukaryotic plants inhabiting areas heated by subterranean geothermal energy[6,7]. Mark Smale *et al.* studied the vegetation clothing the geothermal fields in the Taupō Volcanic Zone[8], central North Island, New Zealand[9]. They identified 16 vegetation associations, almost all of which were dominated by species indigenous to the area, and unique to geothermal fields. Although flowering plants were few, the vegetation types reflect the broad mix of land plant groups and included moss fields (dominated by non-vascular mosses), fernlands, and one treefernland (typified by vascular, non-seed-bearing ferns and fern-allies), one grassland, shrublands, several scrub areas, a forest, and a treeland (exemplified by vascular, seed-bearing plants). In an attempt to determine the environmental variables influencing the vegetation, Smale *et al.* examined soil factors such as temperature, pH, and metal content. Of the abiotic factors measured, subsurface soil temperature – which ranged from ambient (7 °C) to near-boiling (98.5 °C) – was the main factor controlling vegetation composition. The dwarf swan-neck moss (*Campylopus pyriformis*[10]) was the most heat-tolerant plant being found in soil where temperatures reached 72 °C. But, where the soil was only marginally cooler – a mere 68 °C – kanuka (*Kunzea robusta*), a New Zealand endemic shrub[11] – i.e. a flowering plant – was found As impressive as these heat-defying phytological feats may seem, a note of caution must be introduced at this point. Soil temperatures recorded are *subsoil*, which means 10 cm below ground level, so plant tissues probably don't actually experience that temperature. Indeed, an adaptation to life in that thermally-challenging environment is the eminently sensible horizontal spreading of roots, or possession of shallow-penetrating root-like structures in the case of mosses, ferns, and fern-allies. Thus, their owners are shallow-rooted, and thereby avoid the extremes of temperature at greater depth. Nevertheless, such thermophilic behaviour is a pretty impressive feat for the multicellular, complex life forms of Kingdom Plantae. And, considering the temperatures in excess of 60 °C that *might* be encountered, maybe some of these plants contain water that behaves in the odd way we reported previously[12]? And talking of plants living in 'challenging' environments, Kenneth Wood and Warren Wagner have news of a fern that literally clings to survival[13]. Newly described *Athyrium haleakalae* appears to be an obligate rheophyte[14], preferring sites of fast moving water along concave walls of streams and waterfalls. And if that's not a precarious enough habitat, its specific epithet refers to its home in Haleakalā[15], East Maui (Hawaii), a large, dormant shield volcano[16](!). Needless to say, this plant is critically endangered, which designation means that the species faces the highest risk of extinction in the wild[17], an unenviable status it shares with animal taxa such as the black rhino, eastern lowland gorilla, and hawksbill turtle[18].

[Ed. – if you aren't able to get hold of the *Journal of the Royal Society of New Zealand* article, a similar study, entitled A Classification of the Geothermal Vegetation of the Taupo Volcanic Zone, New Zealand and authored by Mark Smale and Susan Wiser (the first two authors of the *JRSocNZ* article), is freely-available[19]. And for those who'd like even more details of the vegetation types identified in the NZ geothermal area, a technical report, entitled Geothermal vegetation types of the Taupō Volcanic Zone by Mark Smale and Neil Fitzgerald (first and last authors of the *JRSocNZ* article), is downloadable[20].]

Image from: Wikimedia Commons

References

[1] **Pabulo Rampelotto**, *Life* **3**: 482–485, **2013**; doi: 10.3390/life3030482
[2] https://serc.carleton.edu/microbelife/extreme/extremophiles.html
[3] https://lco.global/spacebook/what-are-extremophiles/
[4] http://science.howstuffworks.com/life/cellular-microscopic/extremophile.htm
[5] https://lco.global/spacebook/what-are-extremophiles/
[6] http://www.nationalgeographic.com/environment/global-warming/geothermal-energy/
[7] https://geothermal.org/what.html
[8] http://www.explorevolcanoes.com/Taupo-volcanic-zone-new-zealand.html
[9] *Journal of the Royal Society of New Zealand*, doi: 10.1080/03036758.2017.1322619
[10] http://eol.org/pages/924845/details
[11] http://www.nzpcn.org.nz/flora_details.aspx?ID=7644
[12] https://www.botany.one/2017/05/new-forms-carbon-water-photosynthesis/
[13] *PhytoKeys* **76**: 115–124, **2017**; doi: 10.3897/phytokeys.76.11637
[14] https://en.oxforddictionaries.com/definition/rheophyte
[15] https://www.youtube.com/watch?v=V-7jM5qajXM
[16] http://www.nationalgeographic.com/travel/national-parks/haleakala-national-park/
[17] http://www.biodiversitya-z.org/content/critically-endangered-cr
[18] https://www.worldwildlife.org/species/directory
[19] https://pangea.stanford.edu/ERE/db/WGC/papers/WGC/2015/02042.pdf
[20] https://www.waikatoregion.govt.nz/assets/PageFiles/37173/tr201511.pdf

Food that really might taste like sawdust

A common complaint of food, for many reasons, is that it 'tastes like sawdust'[1,2,3]. Although that description is subjective – the food doesn't contain sawdust even if its taste may suggest otherwise*, there may be more than a grain of truth in it in the near future, if Luke's dream comes to pass. Who is Luke? And what is his vision? First, Luke isn't a 'who', but a 'what'; Luke is the acronym[4] for the Natural Resources Institute Finland**[5], which aims to 'provide new solutions towards the sustainable development of the Finnish bioeconomy and the promotion of new biobased businesses'. The 'vision' fits neatly with that goal in that it hopes to both find a use for a waste product of the timber industry and help to provide additional food source for the planet's ever-growing population. Finnish industry produces 3.3 million cubic metres of sawdust[6] annually. Although a large part of this material is used for pulp and energy production, a substantial fraction remains unused. Whilst the unused sawdust will eventually decompose and help to fuel natural nutrient cycles[7], Risto Korpinen (a researcher at Luke) believes that a better use of this material is as 'fish food'[8]. However, it's not a case of sprinkling sawdust on the rivers and lakes for it to be eaten by fish. Rather, the plan is to use the hemicelluloses [9] in the cell walls of the sawdust as a source of sugars that can then be used to produce 'single cell protein'. Unfortunately, all the news reports I've tracked down, which all seem to recycle the same source press release, are vague about how this single cell protein is to be made. However, Mr Cuttings infers that an alga is to be fed the sawdust-derived sugars, and other necessary nutrients, which will then grow and reproduce in sufficient numbers to be fed to the fish, which can then be eaten by humans. This lignovorous suggestion has the advantage of exploiting a sustainable resource – there are a lot of trees in Finland[10] – adding an income stream to the Finnish timber industry, and helping to move away from use of soy protein or wild fish to feed the fish (which reduces global fish stocks)[11]. The project, codenamed MonoCell, is still in its early stages, but sounds promising. So, Luke, helping to put the fin back into Finland...? [Ed. – who 'saw' that coming?]

*However, there are stories around that suggest some foods do include sawdust or wood (e.g. [12]).

**For those who are wondering how abbreviating Natural Resources Institute Finland can give Luke, I believe that Luke is derived from Luonnonvarakeskus, the name of the organisation in Finnish[13].

[Ed. – if this sounds a little like *'déjà-vu'*[14], readers will be reassured to know that in hard times past Finns, and other Scandinavian peoples, have been known to use tree bark to make bread[15,16]. So, Luke is arguably rediscovering an old solution to a modern and future food shortage problem…]

Image from: Wikimedia Commons

References

[1] http://independence4seniors.com/index.php/blog/entry/3-tips-to-help-older-adults-regain-a-joy-of-eating-and-tasting-food
[2] **Tara Durra *et al*.**, *Top Stroke Rehabil*. **20**(1)**:** 78–86, **2013**; doi: 10.1310/tsr2001-78
[3] http://calmerme.com/changes-in-food-taste-eat-chemo/
[4] http://www.dictionary.com/browse/acronym
[5] https://www.luke.fi/en/
[6] https://www.merriam-webster.com/dictionary/sawdust
[7] https://blog.brightagrotech.com/nutrient-cycling-and-decomposition/
[8] https://www.luke.fi/en/transforming-wood-food/
[9] http://www.sciencedirect.com/topics/agricultural-and-biological-sciences/hemicellulose
[10] https://yle.fi/uutiset/osasto/news/study_finlands_forests_densest_in_the_world/8282753
[11] https://www.luke.fi/en/transforming-wood-food/
[12] https://www.thestreet.com/story/11012915/1/cellulose-wood-pulp-never-tasted-so-good.html?cm_ven=outbrain&psv=tscserps&obref=obnetwork
[13] https://uk.linkedin.com/company/lukefinland
[14] http://science.howstuffworks.com/science-vs-myth/extrasensory-perceptions/question657.htm
[15] http://sydaby.eget.net/swe/jp_bark.htm
[16] http://nordicfoodlab.org/blog/2015/11/24/tree-bark

Phyopathological future for plasma

Loss of crop plants to disease is a major constraint on our ability to provide sufficient food for human consumption and wellbeing. Attempts to control the disease-causing agents, such as bacteria or fungi[1,2], or their vectors, e.g. insects[3], have until now largely been chemical (e.g. fungicides[4]), biological (e.g. [5]) or biotechnological (e.g. [6]). Now a *physical* approach has recently been demonstrated by Ochi *et al.*[7] using plasma. Plasma is a state of matter additional to the usual trio of solid, liquid, and gas[8] and is described as 'a hot ionized gas consisting of approximately equal numbers of positively charged ions and negatively charged electrons'[9]. Although one of the best examples of a plasma is the Sun[10], plasmas can be made on Earth where they have many applications, such as – and back to plant pathology – irradiating rice seeds to protect them from microbial infections. Previously, plasmas have been shown to control fungal contamination of *harvested* plant material[11]. However, Ochi *et al.* looked at the other end of the plant life cycle – in treating seeds prior to germination and growth where it is important to ensure that the living cells aren't harmed by the treatment. Plasma was effective at preventing infection of rice by seed surface contamination from the fungus *Fusarium fujikuroi* *[12] and the bacterium *Burkholderia plantarii*, which causes bacterial seedling blight[13]. But, lest we get swept along on a tide of unwarranted excessive appreciation for this hi-tech approach, it's somewhat sobering to know that it wasn't plasma alone that was used. In fact, it was a combination of tried-and-tested exposure of the microbe-contaminated seeds to water at 60 °C for 10 minutes, followed by the plasma irradiation. This combination was more effective than hot water alone since it is often the case that the water is not hot enough or seeds are not treated for long enough[14]. But, it's good to see this marriage of the old and the new, and, as important as killing the microbial pathogens, the seeds germinated and grew and the seedlings appeared to have suffered no harm from the plasma treatment. Quite how the plasma works its 'magic' is not yet known, but it is thought that reactive oxygen compounds[15] generated by the irradiation may play a role in the phytopathological protection procedure. From an external use of plasma to an internal one, a key use of such plasmas is to deliver proteins into plant cells. This is a difficult feat to achieve, but Yuki Yanagawa *et al.* successfully introduced green fluorescent protein[16] – fused to adenylate cyclase – as a reporter protein[17] into cells of tobacco leaves by treatment with atmospheric nonthermal plasmas[18]. From 'ectoplasma' to cytoplasm, what will they think of next?

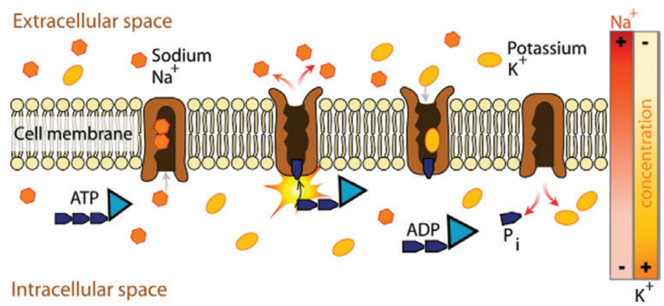
* For those of us who attempt to teach plant biology to undergraduates *F. fujikuroi* may be more familiar by its old name of *Gibberella fujikuroi*[19], which causes bakanae in rice[20], a seed-borne disease[21]. The plant hormones known as gibberellins[22,23] were first identified in this fungus[24] and were named after its generic name. Bakanae is known as 'foolish seedling' disease in English because infected plants undergo excessive lengthening compared to non-infected plants[25]. Growth-promotion – such as stem elongation of rice – is one of the effects of gibberellin[26]. Teaching plant biology via plant pathology, my little 'shout-out' for the importance of fungi in an attempt not to neglect them[27].

Image from: Wikimedia Commons

References

[1] http://www.bspp.org.uk/news/article.php?id=40;
[2] http://www.epi.ufl.edu/pathogens/plant-pathogens/
[3] https://projects.ncsu.edu/cals/course/ent425/text18/plantvectors.html
[4] **Margaret McGrath 2004**. *The Plant Health Instructor*. doi: 10.1094/PHI-I-2004-0825-01)
[5] **Shazia Parveen *et al*.**, *Czech Mycology* **68**(1)**:** 41–66, **2016**; doi =??
[6] **Khokhar *et al*. (2012)** Biological Control of Plant Pathogens using Biotechnological Aspects: A Review. 1:277; doi:10.4172/scientificreports.277
[7] *Plant Pathology* **66**: 67–76, **2017**; doi: 10.1111/ppa.12555
[8] https://education.jlab.org/qa/plasma_01.html
[9] http://pluto.space.swri.edu/image/glossary/plasma.html
[10] https://science.nasa.gov/science-news/science-at-nasa/1999/ast07sep99_1
[11] **Nobuya Hayashi *et al*. 2014** *Jpn. J. Appl. Phys.* **53** 05FR03; doi: https://doi.org/10.7567/JJAP.53.05FR03
[12] http://www.bioscience.org/2017/v9e/af/806/2.htm
[13] http://www.tgw1916.net/Pseudomonas/plantarii.html
[14] https://phys.org/news/2017-05-plasma-rice-crops.html
[15] http://www.biology-pages.info/R/ROS.html
[16] http://www.chm.bris.ac.uk/motm/GFP/GFPh.htm
[17] https://www.nature.com/subjects/reporter-genes
[18] ***PLoS ONE* 12**(2): e0171942; doi:10.1371/journal.pone.0171942
[19] http://www.mycobank.org/Biolomics.aspx?Table=Mycobank&MycoBankNr_=314213
[20] http://www.bioscience.org/2017/v9e/af/806/2.htm
[21] http://www.knowledgebank.irri.org/index.php?option=com_zoo&task=item&item_id=924&Itemid=739
[22] https://www.nature.com/subjects/gibberellins;
[23] http://www.biology-pages.info/G/Gibberellins.html
[24] http://pubs.acs.org/doi/abs/10.1021/bk-1979-0111.ch003
[25] http://www.plantwise.org/KnowledgeBank/Datasheet.aspx?dsid=25158
[26] http://www.yourarticlelibrary.com/science/9-major-physiological-effects-of-gibberellins/23198/
[27] https://www.nature.com/articles/nmicrobiol2017120.pdf

Not one, but two second messengers?



Calcium[1] is a macronutrient[2] and has many important roles in the biology of plants – e.g. physiological, biochemical, and structural[3,4]. Additional to those, and for many years now, one has been used to the notion that calcium is a so-called second messenger[5,6,7] for plants. As a second messenger calcium is the tangible means by which external 'factors' are ultimately converted into intracellular actions with physiological and biochemical consequences for the well-being of the plant. Given the importance of that mediating role, one might have imagined that a back-up plan would have evolved in the fullness of evolutionary time. Well, guess what! Yep, it now seems that calcium is not the only second messenger in plants. In an open access viewpoint article Sergey Shabala expresses the view that potassium[8] should also be viewed as a second inorganic second messenger[9]. What prompts this suggestion is the recognition that the efflux of potassium in response to salt-stress[10,11] could act as a metabolic signal that slows growth and elicits defence responses in response to this abiotic stress[12]. Although a second messenger role for potassium may not be as widespread as that for calcium – yet! – it's certainly a point of view, and shows that there's still more to learn about the interaction between inorganic elements and organic life forms. By way of achieving some uniformity among all living things, a role of potassium as a second messenger in plants extends the notion beyond prokaryotes where this element is seen as a second messenger in bacteria controlling gene expression and enzyme activity[13]. Akin to the way that calcium is a second messenger in plants, animals and micro-organisms[7]. Aha, I get it now. Calcium and *kalium* (the Latin name for potassium[14] and the reason why its chemical symbol is K[15] and not P which is for phosphorus[16]...). I guess it was plain to 'c' all along…

[Ed. – for more on the regulation of potassium transport and signaling in plants, see Yi Wang and Wei-Hua Wu's article[17].]

Image from: Wikimedia Commons

References

[1] http://www.rsc.org/periodic-table/element/20/calcium
[2] http://rubisco.ugr.es/fisiofar/pagwebinmalcb/contenidos/Tema11/macro%20y%20micronutrient.pdf

[3] http://www.biologydis cussion.com/plant-physiology-2/mineral-nutrition/7-essential-elements-of-macronutrients-plants/25674
[4] **Philip White** and **Martin Broadley**, *Annals of Botany* **92**: 487–511, **2003**; https://doi.org/10.1093/aob/mcg164
[5] http://www.plantcell.org/content/17/8/2142
[6] **Benoît Ranty *et al*. (2016)**. *Front. Plant Sci*. **7**:327; doi: 10.3389/fpls.2016.00327;
[7] **Kai Edel *et al*.**, *Current Biology* **27**: R667–R679, **2017** http://dx.doi.org/10.1016/j.cub.2017.05.020] for plants
[8] http://www.rsc.org/periodic-table/element/19/potassium
[9] *Journal of Experimental Botany* **68**: 4003–4007, **2017**; https://doi.org/10.1093/jxb/erx238
[10] https://www.intechopen.com/books/abiotic-stress-in-plants-mechanisms-and-adaptations/salinity-stress-and-salt-tolerance
[11] https://www.liverpool.ac.uk/~sd21/stress/salt.htm
[12] **Andy Pereira**, *Front Plant Sci*. **2016**; **7**: 1123; doi: 10.3389/fpls.2016.01123
[13] **Alexander Ninfa**, *PNAS* **104**: 4243–4244, **2007**; doi: 10.1073/pnas.0700325104
[14] https://en.wiktionary.org/wiki/kalium
[15] https://www.thoughtco.com/potassium-facts-606579
[16] https://www.thoughtco.com/phosphorus-facts-606574
[17] *Current Opinion in Plant Biology* **39**: 123–128, **2017**; http://dx.doi.org/10.1016/j.pbi.2017.06.006.

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