

Photosynthesis - Beyond The Leaf

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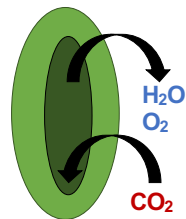


- The majority of studies on plant physiology and photosynthesis have mainly focused on leaves, however non-leaf tissues are gaining interest for their photosynthetic abilities and contribution to yield.
- Evidence of non-leaf organs/tissues ability to photosynthesise have already been portrayed in pods, ears/panicles, fruits, tubers and stems, however limited research has focused on stomatal behaviour and gas exchange in these tissues.



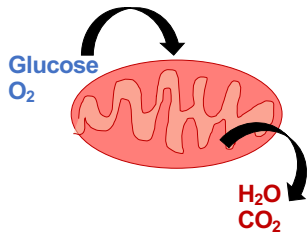
There Are Two Major Sources Of CO₂ For Photosynthesis In Non-leaf Material

Atmospheric CO₂ Uptake



CO₂ is taken in via the stomata from the atmosphere

Respiratory CO₂ Production



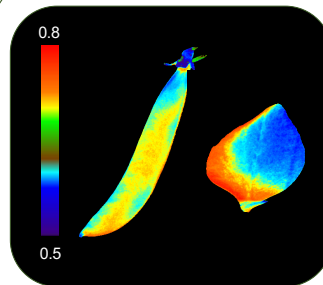
CO₂ is produced in the mitochondria during respiration

Both are then assimilated via the C₃ pathway.



Example Ways To Measure Non-leaf Photosynthesis

Chlorophyll Fluorescent Imaging



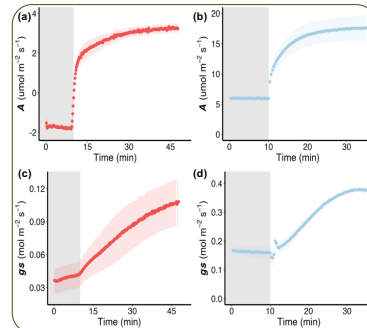
Non-invasive way to measure photosynthetic efficiency.

Can be used to determine:

- F_v/F_m
- F_q'/F_v'
- F_q'/F_m'
- F_v'/F_m'
- NPQ

Figure 3. Example of Chlorophyll fluorescence imaging of a Cymeor pea pod and leaf. Chlorophyll fluorescence image of photosystem II operating efficiency (F_v/F_m) was used to demonstrate differences in efficiency between the two tissue types. Colour scale bar represents an F_q'/F_m' of 0.5–0.8.

Gas Exchange Analysis



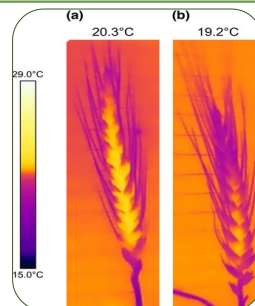
Gas exchange on non-leaf tissues can determine:

- Assimilation
- Stomatal Conductance
- Photosynthetic Capacities
- WUE

In response to light and CO₂ concentration changes.

Figure 4. Example of gas exchange analysis in Cymeor pea pods and leaves. Mean (a) pod and (b) leaf assimilation (A), (c) pod and (d) leaf stomatal conductance (g_s) was measured in response to a step in light intensity from 100 to 1000 $\mu\text{mol m}^{-2} \text{s}^{-1}$ photosynthetic photon flux density (PPFD), at 400 ppm CO₂ and 23°C within a bespoke pod chamber. Grey shaded areas represent when the light source is at 100 $\mu\text{mol m}^{-2} \text{s}^{-1}$ PPFD. Error bars represent mean \pm SE (n = 3). All measurements are normalised to an illuminated projected area (typically used for leaves).

Thermal Imaging



Thermal imaging is a quick and non-invasive method to visualise and measure non-leaf stomatal conductance.

Provides information on:

- Stomatal kinetics
- Transpiration
- Impacts on evaporative cooling

Figure 5. Example of thermal imaging of wheat ears. The thermal images demonstrate functional differences due to variation in stomatal density (SD): (a) SD of 12 mm^{-2} and (b) 35 mm^{-2} . Measurements were made following 1 h exposure to 27°C. Colour scale bar represents a difference in temperature from 15°C to 29°C.



Non-leaf Stomata Vary From Foliar Material

Non-leaf vs Leaf Material

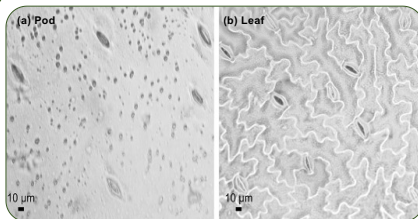


Figure 1. Example of the difference between non-foliar and foliar stomata. Cymeor pea (a) pod and (b) leaf epidermal impressions were pictured at a 200× magnification.

- Non-leaf stomata are fewer in number but sometimes larger than their leaf counterparts.
- Could lead to differences in kinetics and WUE.

... And Between Non-Foliar Tissue Types

Different Ear Components

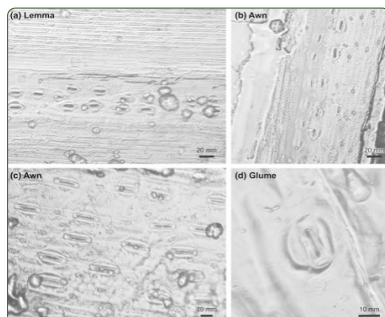


Figure 2. Example of how stomata vary between non-leaf tissues. Epidermal impressions show stomata from a barley (a) lemma and (b) awn and a wheat (c) awn and (d) glume.

- Stomata have been identified on most components of barley and wheat ears, including the lemma, awns and glumes.
 - Studies have predominantly identified the awns as having the highest SD, enabling greater transpiration.

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