**Leaf Proteomics / Leaf N notes**

**Partitioning of N pools & implications for photosynthesis**

Hikosaka & Shigeno 2009

“RBUE (rubisco use efficiency) accounted for 70% of the interspecific variation in PNUE… *These results suggest that nitrogen allocation to cell walls does not explain the variation in PNUE.* The divergence in PNUE was not caused by a sole factor that was markedly divergent among species but by several factors each of which was slightly disadvantageous in low PNUE species.”

But see Onoda et al. 2003 “Allocation of nitrogen to cell walls decreases photosynthetic nitrogen-use efficiency” (opposite result, Hikosaka was also an author)

Hikosaka et al. 1996 - Nitrogen partitioning among photosynthetic components and its consequence in sun and shade plants

Hikosaka et al are testing the idea of optimal partitioning of N to components of photosynthetic machinery with different functions (light capture vs CO2 assimilation & processing) under different light conditions. Hikosaka & Terashima (1995) further developed a model to summarize the roles of all the photosynthetic components. They predicted that, at high light, increase in the allocation of nitrogen to Calvin cycle enzymes, coupling factor and electron carriers, all of which are important in determining the light-saturated rate of photosynthesis, will result in an improvement of daily photosynthesis. Under low light conditions, on the other hand, increase in allocation to chl protein com- plexes, which are involved in the use of low PFDs, will have an advantage. The predicted changes in the organ- ization of the photosynthetic apparatus were consistent with those observed in actual leaves (Hikosaka & Terashima 1995; Hikosaka 1996). Evans (1989b, 1993) suggested that actual nitrogen partitioning in some cul- tivar species was similar to the optimal partitioning…. *it remains unclear whether the acclimation of the photosynthetic appara- tus in sun and shade species to contrasting PFDs is always optimal*. It is still possible that limitations in the ability to acclimate restricts the range of habitats that these species can occupy. In the present study, the acclimation of the photosynthetic apparatus of two species, Chenopodium album (a sun species) and Alocasia macrorrhiza (a shade species) was investi- gated

Outcome: “4. For both species grown under any light conditions, estimated daily photosynthesis of actual leaves was very close to that of leaves with optimal partitioning. It is concluded that both species achieve nitrogen partitioning leading to nearly maximum carbon gain under any light condition”

“Photosynthetic components are categorized into six groups: (A) LHCII; (B) PSII core; (C) PSI; (D) electron carriers and coupling factor; (E) Calvin- cycle enzymes other than RuBPCase; (F) RuBPCase.”

This paper has some useful / interesting photosynthesis stoichiometry calculations, e.g.

“LHCII = (1000 chl - 184 PSI - 60 PSII)/13, eqn 1”

Yasumura & Ishida 2010 - Temporal variation in leaf nitrogen partitioning of a broad-leaved evergreen tree, *Quercus myrsinaefolia*

Throughout the leaf life span, metabolic protein and Rubisco content closely correlated with

total nitrogen content, while structural protein content was relatively stable after full leaf expansion.

Nitrogen resorption occurred in overwintering leaves in spring. Metabolic protein explained the majority of nitrogen being resorbed, whereas structural protein, which was low in degradability, contributed little to nitrogen resorption.

The extent of nitrogen resorption was calculated as:

Nitrogen resorption efficiency = (pre-resorption Narea - post-resorption Narea) / pre-resorption Narea \* 100

Structural proteins were those defined as ‘associated with cell walls’ – ask Steve whether his extraction method pulled this stuff out?

Guan and Wen 2011 - More nitrogen partition in structural proteins and decreased photosynthetic nitrogen-use efficiency of Pinus massoniana under in situ polluted stress

“needles of declining trees had about 1.8 times structural protein as those of healthy trees, suggesting that more

nitrogen allocation to structural protein are needed for stronger structural defenses under polluted stress. Decreases in PNUE of declining pine trees could be partially explained by increases in structural protein nitrogen.”

**Nutrient resorption**

**Killingbeck et al. 1996 – Nutrients in senesced leaves: keys to the search for potential resorption and resorption proficiency**

“Analyses of nitrogen and phosphorus in the senesced leaves of 89 species of deciduous and evergreen woody perennials were used (1) to discover the limits of ultimate potential resorption (maximal withdrawal of nutrients from senescing leaves), (2) to determine a means by which resorption can be categorized as complete or incomplete, (3) to develop the concept of resorption proficiency (measured as the levels to which nutrients have been reduced in senesced leaves), (4) to compare resorption in evergreen vs. deciduous species, (5) to assess the impact of phylogeny on resorption, (6) to compare resorption in actinorhizal vs. nonnitrogen-fixing species, and (7) to consider the efficacy of using multiple measures of resorption to answer questions regarding the function and evolution of this process, rather than relying solely on analyses of resorption efficiency (percentage reduction of nutrients between green and senesced leaves).”

“plants capable of symbiotic nitrogen fixation were significantly less proficient at resorbing nitrogen than were nonfixers (1.6% vs. 0.9% N in senesced leaves, respectively).”

“The ability of plants to reduce nitrogen in senescing leaves was significantly correlated with their ability to reduce phosphorus”

Euc species were highly proficient at resorbing both P and N compared with other clades (Ulnus, Fagus, Quercus etc.)

“Efficiency values are best suited for resolving issues related to the relative degree to which individuals, populations, and communities can conserve nutrients invested in foliage so as to minimize subsequent uptake. The unique feature of efficiency as a measure of resorption is that it encom-passes both nutrient demand (green-leaf nutrient con-tent) and nutrient withdrawal.

Proficiency values, the absolute levels to which nu-trients are reduced in senescing leaves, appear to be a more definitive and objective measure of the degree to which selection has acted to minimize nutrient loss… The most definitive, interpretable measure of re-sorption success may well be the level to which nu-trients can be reduced in senescing leaves (resorption proficiency)”

**R Aerts Nutrient resorption from senescing leaves of perennials: are there general patterns?**

*No effect of nutrient availability on nutrient resorption in this metaanalysis. Leaf lifespan much more important for reducing nutrient use in low fertility soils.*

*N has to be solubilised before it can be resorbed and various factors influence solubility of nitrogenous compounds (e.g. presence of phenoloics).*

*Phloem transport probably a greater limitation on resorption than breakdown. Soil water availability may be important.*

“Relations between leaf nutrient status and leaf nutrient resorption were absent or very weak. Assuming that leaf nutrient status reflects nutrient availability, this implies that nutrient resorption is only weakly controlled by nutrient availability…. At the intraspecific level, nutrient resorption was not very responsive to increased nutrient availability. There was no response in 63% of the experiments analysed (covering 60 spp.), whereas in 32% there was a decrease in N resorption in response to increased nutrient availability. For P (37 species analysed) there was no response in 57% of the cases and in 35% of the cases P resorption decreased upon enhanced nutrient supply. Evergreen shrubs and trees showed especially low responsiveness. 6 This review shows that there are no clear nutritional controls on nutrient resorption efficiency. Future research should focus on the biochemical basis of variation in nutrient resorption efficiency and on the factors, other than nutrient availability, that control nutrient resorption efficiency.”

“In a study with evergreen and deciduous woody species in Central Spain, Escu- dero et al. (1992a) showed that leaf longevity was far more important as a nutrient conservation mech- anism than high resorption efficiency. Reich et al. (1995) arrived at a similar conclusion in a study with evergreen and deciduous woody species of an oli- gotrophic Amazonian forest… Nutrient losses can also be reduced by the synthesis of tissues with low nutrient concentrations (Aerts 1990), a feature which is clearly characteristic of ever- greens (Table 1).”

“Hydrolysis of nucleic acids and phospholipids contributed 40-47% and 26-38%, respectively, to the total P resorbed from senescing leaves. Hydrolysis of proteins and sub- sequent resorption as amino acids was equivalent to 82-91% of the N resorbed from senescing leaves.”

“Pugnaire & Chapin (1993) showed that N resorp- tion efficiency from senescing leaves was positively related to the ratio between soluble and insoluble N… to understand the biochemical basis of variation in nutrient resorption we need to know the controls on the ratio of soluble and insoluble compounds in senescing leaves and the factors that control hydrolysis of organic compounds…. High concentrations of phenolic compounds may lead to precipitation of proteins prior to protein hydrolysis, which reduces nutrient resorption (Chapin & Kedrowski 1983).” (phenolics are often higher in defended leaves or in low-fertility soils)”

“Chapin & Moilanen et al. (1991) suggest that controls over phloem transport are more impor- tant than controls over breakdown of nutrient-con- taining fractions in the leaf as determinants of nutrient resorption efficiency.”

**Defense Proteins**

Sushida et al. 2012 Pathogenesis related proteins

PR-1 is the most abundant of the PR’s and accumulates to about 1–2% of the total leaf protein content. The expression of PR-1 genes serves as molecular marker to indicate plant defense response.

PR-2 group demonstrates B-1,3 glucanase activity. They catalyze the endotype hydrolytic cleavage of 1,3 B-D-glucosidic linkages in B-1,3 glucans. These proteins are abundant in plant tissues and are associated with formation of callose, leaf and stem hairs. Majority of the B-1,3 glucanases respond to developmental and pathogen signals.

PR5 –thaumatin like proteins. Highly soluble and protease resistant. Can accumulate to high levels.

Proteinase inhibitors are grouped under the PR-6 group of PR’s. They are highly stable defensive proteins that are developmentally regulated and induced only in response to insect and pathogen attack.