Vascular Plant Adaptations

Emergents

Anoxia – in upland plants aerobic metabolism is shut down, anaerobic metabolism end products are toxic, mitochondria and other organelles are destroyed in 24 hours, and the availability of reduced metals (e.g. Fe, Mn, S) increases accumulating to potentially toxic levels

Adaptations

1. Structural (morphological) adaptations – changes stimulated by hormones, often ethylene
    a. Aerenchyma – air spaces in roots and stems allowing oxygen to diffuse to the roots from upper portions of the plant; up to 60% of root volume is empty space, compared to 2-7% for terrestrial plants; effectiveness based on root porosity
    b. Special organs or responses
        i. Adventitious roots – (prop roots, buttress roots) develop above the anaerobic zone; in both flood-tolerant and flood-intolerant species; examples: *Salix, Alnus*, tomato
        ii. Stem elongation – rapid stem growth; examples: floating heart, rice, bald cypress
        iii. Lenticels – tiny pores on tree prop roots above anoxic zone, pump oxygen to submerged roots, keeping concentrations as high as 15-18%; examples: red mangrove
        iv. Pneumatophores – "straws" 20-30 cm high and 1 cm wide coming out of main roots, on black mangroves; "knees" of bald cypress
    c. Pressurized gas flow – "thermo-osmotic" gas flow, air enters leaves and is forced through the arenchyma into the roots under slight pressure; due to a temp gradient between exterior air and interior gas spaces in plant tissue, stem is heated, internal gas molecule expand, can't move out lenticels, but cooler external air can diffuse into stem (See Figure 7-4)
2. Physiological adaptations
    a. Anaerobic respiration – hydrophytes have adaptions to minimize by-product toxicity
    b. Malate production – instead of alcohol production in anaerobic fermentation, allows fermentation to continue at a steady rate

Side Effects of Root Aeration

Oxygen leaks into the rhizosphere, oxidizes soluble reduced metals causing precipitation and detoxification, precipitation colors soils aids in wetlands delineation

Water uptake – flooded roots cause an increase in abscisic acid in leaves, which closes stomata, reducing evapotranspiration and photosynthesis

Nutrient absorption – flood intolerant plants can't control nutrient uptake, with increased oxygen nutrient uptake is maintained (See Figure 7-5)

N – converts to ammonium in anoxic conditions, oxygen root exudation in the rhizosphere changes it back to preferred nitrate, flood tolerant plants maintain N uptake

P – availability increases, flood tolerant species show increased uptake

Fe & Mn – toxic and more available in anoxic soils, wetland plants oxidize/immobilize ions, concentrated elements in intracellular vacuoles, and have a higher tolerance

S – toxic as sulfide in anoxic soils; wetland plants oxidize sulfide to sulfate, accumulate it in vacuoles, and convert it to gasses

Salt Stress - buildup of salts due to ocean intrusion, historic salt deposits or high rates of evaporations (playas). Salts cause an osmotic gradient that can passively draw water out of plant cells. Very similar to water stress.

Salt Adaptations – to maintain cell turgor, organic compounds in the cells substitute for inorganic salts
Exclusion – wetland plants show a selective exclusion, providing a barrier to sodium more than that for potassium
Secretory organs – wetland plants that don't exclude often excrete salts through glands in the leaves (salt marsh grasses), excreting more sodium than potassium

Reproduction: Sexual reproduction is rare, more commonly used methods are:

- Fragmentation, pieces break off and float away to another location where they get embedded in the substrate.
- Rhizomes: underground stems send up shoots to start a new plant.
- Stolon: same as rhizomes except these are above ground stems which form into shoots and start a new plant.

Seed germination: Plants have different strategies for seeds:

- Timing of seed production to occur during the non-flood season either by delayed or accelerated flowering.
- Production of buoyant sees that float on high unflooded ground.
- Seeds germinate while still attached to the plant.

Photosynthesis: Gas exchange: As the water gets deeper, the wavelength of light shortens until it's unavailable. The red and blue wavelengths are lost, and the green (not so good for photosynthesis) remains. Adaptations include:

- Wetland plants often use C4 biochemical pathway of photosynthesis instead of C3.
- C4 provides a possible pathway for recycling CO2 from cell respiration
- Plants using C4 have low photorespiration rates and the ability to use even the most
  intense sunlight efficiently.
- C4 plants more efficient than C3 plants in rate of carbon fixation and amount of water used per unit carbon fixed.

Submerged plants:

Reproduction:

- *Vallisneria* (submerged grasses) produce a coiled peduncle (female), which straightens out so the stigma can reach above the water surface. The spathe (male) also straightens out so its petals float on the surface. Its three leaves and anthers form a sailboat. The spathe floats along until hopefully it bumps into a stigma.

- *Ceratophyllum* (Coontail and Hornworts)*:* uses a strategy of hydrophily: the male releases pollen into the water where it floats until it sinks again, hopefully landing on a female plant.
- A chinese lotus can lay dormant for over 1,000 years.

Photosynthesis:

Algal blooms can block the sunlight and nutrients to submerged plants.

Other challenges that aquatic plants must adapt to include: flooding, desiccation (drying out) nutrient uptake, and vegetative reproduction.