AGRY 515 2010: Plant Mineral Nutrition

Study Guide: Exam 1

Review Session will be Monday, Oct. 4 in Lilly 2-425 (the AGRY main conference room)

What are the 3 criteria of element essentiality?

What are the 17 essential mineral and non-mineral elements?

What is a beneficial element? Be able to identify at least 2 beneficial elements and describe why they do not meet the three criteria.

What are the forms of the nutrient elements that plants can acquire?

What are macro and micronutrients? Be able to identify appropriate tissue concentrations for nutrients and several (5) factors that influence the expected concentration of a nutrient in a tissue.

What are the advantages and disadvantages of using (a) solution culture (b) sand culture and (c) soil for experiments in plant nutrition? Explain the physiological basis for the changes in solution pH that are commonly observed in solution culture studies. How can you alter an experiment to minimize pH changes during the course of the experiment?

Be able to graphically describe how plant growth (or yield) changes with the content of the mineral nutrient in the plant tissue. Be able to identify 4 ranges in nutrient content and define critical, deficiency and toxicity contents.

How can the concept and quantification approach of growth analysis and crop growth rate (CGR) be translated / applied to quantifying and understanding nutrient uptake rate (NUR)? What parameters determine CGR? What parameters determine NUR? What are the agronomic, uptake and physiological efficiencies of a nutrient and how are these efficiencies quantified?

What are the law of the minimum and the law of diminishing yield increment? Be able to draw response graphs to support your description.

What is nutrient bioavailability (plant availability)? What are the controlling factors? How can bioavailability be quantified? What are advantages/disadvantages of the approaches?

What are the processes responsible for the movement of ions in the soil solution? How does the movement of nutrients to the root surface differ from the

movement of nutrients to ground water? What are the driving forces of these processes? How are they defined quantitatively? What factors determine the effective diffusion coefficient? What are the parameters that determine the effective diffusion coefficient?

How important is root interception thought to be in the uptake process? Why? Have root hairs been considered in root interception? Should they be? How might consideration of root hairs in root interception change our understanding of the importance of root interception in nutrient uptake?

What is buffer power? How does buffer power relate to the depletion zones that develop around roots as nutrient uptake proceeds? What is a depletion zone? How do these differ in a sandy vs. a clayey soil?

Under what conditions would the ability of a root to absorb ions be limited by the supply of nutrients from the soil? Would this limitation be more pronounced in the daytime or the nighttime? Why?

What are the major soil processes and/or factors that effect the soil solution concentration of a cation (e.g. K+), an anion ($H_2PO_4^-$) and how is N different? Is S more like N or P? In general, be able to characterize the nutrient pools in the plant/soil system.

On a longitudinal cross section of a root tip, be able to identify: the root cap, mucigel, the meristematic zone, the zone of elongation, root hairs, the lateral root initiation zone, etc. Be able to characterize the significance of each of these to the plant. Be able to describe the origin and roles of the plant hormones that are thought to influence root growth.

Be able to describe a tap and a fibrous root system. What are these root systems best adapted for?

On the whole plant scale, what are the root system characteristics that can be modified?

Be able to describe changes that occur in root/shoot allocation patterns with varying shoot and root environments. How might the plant be able to communicate changes in the shoot environment to the root? How do root and shoot growth/development change with increased N supply to the whole root system? How do soil bulk density and aeration (anoxia) effect the growth and activity of the root system?

What happens when N, P, or K are enriched in only one portion of the root zone of a moderately N, P, or K deficient plant? What is compensatory root growth or function? What series of events might cause increased root branching in only a portion of the root system?

The concentrations in the xylem sap differ greatly from those in the medium bathing the roots. Where within the roots can this selectivity occur? On a cross section of a mature root (after maturation of the stele) be able to illustrate and describe the pathways of nutrient movement in the root. What is the apoplast? What apoplast characteristics influence the movement of ions? What is the symplast? Where within the symplast can selectivity take place?

Be able to define of explain the significance of: carboxylic groups in the cell wall, the casparian strip, water free space, apparent free space, Donnan free space, by-pass flow, plasmalemma, tonoplast, plasmadesmata, cytoplasmic sleeve.

Is exchange absorption essential for uptake into the cytoplasm? As cell wall CEC increases, how is the uptake of Ca, K, Zn, and B impacted? Explain.

What are the 3 membranes that an ion might cross in movement from the external nutrient solution to the xylem?

What is the Michaelis-Menten equation? Why and how is it applied to the study of plant mineral nutrition. What are the parameters? What parameter represents “capacity” and “efficiency” in the function? How would you expect the parameters to change under conditions of nutrient stress or excess? How does reality differ from the idealized M-M curves and what does this say about mechanisms of uptake at the plasma membrane of a root cell?

What is the chemical potential of a solute? Which components of a solutes chemical potential are important for determining movement across a membrane? How does charge develop across a membrane? What is "active" vs. "passive" transport? Describe and give the significance of the Nernst equation. How is the Nernst equation used to determine if a cation or anion is actively or passively transported across a membrane?

What is the primary driving force for ion movement into cells? How does the plant generate this force? What are coupling proteins, carriers, and channels? Define and give the significance of a uniport, symport, antiport. What pumps operate in the plasma membrane of a rhizodermal cell, the tonoplast, a xylem parenchyma cell for xylem loading?

What are the main differences between xylem and phloem transport (driving forces, composition, anatomy etc.)? How does transpiration effect xylem transport? Where along the xylem pathway can the nutrient composition be changed? What mineral elements are phloem-mobile? Immobile? How do elements of low mobility get to plant organs that have low transpiration rate? Why is Ca phloem immobile? What purpose(s) does nutrient cycling serve? What is the importance / significance of net remobilization of minerals for various growth stages?

Be able to describe 5 classes of nutrient function and know 2 (1 where appropriate) elements in each class. (We will go over this in class on Tuesday).