AGRY 515: Plant Mineral Nutrition

Study Guide for Final Exam, 2010

Classification and Function

1) Elements can be classified according to their function in plants. What are these functional groups? List elements commonly included in each group. Several elements can also be categorized in more than one group. Be able to list several examples of elements that could be classified in more than one group. Explain the different roles of each of these elements. In general, know a major function, the mobility within the plant, and a deficiency symptom of each of the essential elements.

2) There are many examples where the metabolic role of an element can be used to explain the symptoms of deficiency. Be able to give several examples (visual symptoms or their precursors such as composition / physiological changes). Certain elements have both metabolic and osmotic roles, which role is most likely non-substitutable by another element? Which elements are important osmoticants? Which pool (metabolic/osmotic) is more highly buffered as the element becomes limiting? How do the concentrations in these pools relate to the “critical concentration” for that nutrient element?

Nitrogen

3) What are the forms in which N is taken up by the plant? In what form is N stored in the plant? Do plants “like” NH_4^+ or NO_3^- better? What N source(s) result in the highest growth rates? Why?

4) Where within cells do the two components (be able to NAME THEM) of nitrate reduction occur? In which plant tissues is nitrate reduction most active? Why? What factors affect the amount of NO_3^- in the xylem of an actively transpiring plant? What factors control the location of NO_3^- reduction (root Vs shoot)?

5) How is NH_4^+/NH_3 detoxified in the plant? What are the two key enzymes in this process and what do they do?

6) List and briefly describe the major types of microbial strategies for fixing N_2. What are the energy sources and relative fixation capacities of the different approaches? Which systems involve host specificity? Describe the steps of the infection process? Where does specificity occur and can plants control the infection process?

7) Nitrogen fixation in a nodulated legume requires a good supply of carbohydrates from the plant. What are two critical processes dependent on carbohydrates for N_2-fixation? Explain why oxygen is both necessary and detrimental to N_2-fixation? What characteristics of the plant-rhizobium symbiosis exist to regulate the supply of oxygen within the nodule? Which

mineral elements are essential components of the nitrogenase enzyme? What factors control fixation potential?

8) What environmental factors regulate N2 fixation. Why is N2 fixation rate maximized at moderate levels of exogenous soil N supply? How does the exogenous concentration of other mineral elements effect N2 fixation?

K, P, Mg, S, Ca

9) How does K effect stomatal movement and why? What could replace K in this function? What is a photonastic response and what role does K play in it? Why is wilting an early symptom of K deficiency (2 reasons)?

10) What is the storage form(s) and where is the storage pool for P in the plant cell? What are proteoid roots? What mineral nutrient deficiencies promote their formation?

11) How is the assimilation process of sulfate similar to that of nitrate? How is it different? What is a phytochelatin? Sulfate content is a better indicator of plant S status that total S. Why?

12) Why can Ca be considered both a macro and micronutrient? Where is the majority of Ca located in plant tissue? What other nutrient element has a similar distribution? What other nutrient elements can substitute for Ca in its cell wall function? Why must Ca always be present in the external solution? Why must cytoplasm concentration be kept so low? What is Ca modulin and how does Ca function as a second messenger?

13) Why are root uptake rates of other nutrient ions negatively impacted by Mg deficiency? What is the relationship between plant K and plant Mg nutrition?

Micronutrients

14) What form of Fe do most plants transport across a root cell membrane? Why is Fe deficiency rarely seen in rice production? What are the morphological and physiological responses of roots to Fe deficiency? What is Strategy I and the related mechanism used to enhance Fe availability to the root? Strategy II? What types of plants use these alternative strategies? What are phytosiderophores? What are transfer cells?

15) What toxicity problems are enhanced by an acid soil? What deficiency problems are enhanced by low pH?

16) Which micronutrients influence the production or breakdown of superoxide radicals? How?

17) A mixed pasture (legumes / non-legumes) appears uniformly N deficient. How will Mo application effect the N status of the two types of plants 1) if total

exogenous N supply is low; 2) if the N supply is good and the predominant N source is nitrate, and 3) if the N supply is good and the predominant source of N is NH_4^+.

18) What are the probable roles of B in the plant (and why do we know so little about it)? Is B uptake active or passive? Why? Why is foliar application better than soil application?

19) What is the only known Ni containing enzyme and what are the related symptoms of Ni deficiency? Why has the essentiality of Ni been hard to demonstrate?

20) Why has the essentiality of Cl been hard to demonstrate? What is the role of Cl in stomatal opening and is it substitutable? H_2O splitting? PSII?

Nutrient element interactions

21) In field experiments the following results or experimental conditions were observed:

a) P application reduced symptoms of N deficiency in a legume.
b) S application reduced symptoms of Cu toxicity.
c) Switching from NH_4^+ to NO_3^- as the N source increases the proportion of N in protein form (i.e. increases protein synthesis) in a non-legume and enhances the starch content of a tuber.
d) A sewage sludge application induces Ca, Fe and / or Mg symptoms on a variety of different sites.
e) Plants grown on a field receiving optimal macronutrient supplies have smallish leaves with very high P, Cl, and B concentrations.

Be able to explain why.

22) Plant deficiency symptoms ~ be able to describe/identify at least one major symptom per nutrient and link the symptom to the physiological disruption caused by the deficiency. (Yes, a repeat of Q2 above so I guess you have to know this.)

Plant stress & adaptation

23) How do Type 1 and Type 2 plants respond to low nutrient availability? high nutrient availability? Which type of plant makes a better candidate for agronomic cultivation and why?

24) Review (yes, this was on the first exam and may be on the final as well) concepts of agronomic, physiological and uptake efficiencies; be able to define in words and characterize with an equation each of these terms. Which mechanisms would you explore first if you wanted to improve plant productivity in a low nutrient environment and why?

25) What are 6 different mechanisms a plant can use at the cellular level to mitigate heavy metal toxicity? Identify common mechanisms for tolerating high exogenous Zn, Cu, Ni?

26) What are the specific features/condition of acid mineral soils that cause plant nutritional disorders? What is the metal tolerance index and how is it used to select for Al and/or Mn tolerant cultivars? For Al tolerance what are mechanisms used by “includers” vs “excluders”?

Plant interactions with other organisms

27) Define mutualism (synergism), commensalism, neutralism, competition, parasitism, resistance, apparent resistance and tolerance (in the context of biotic stress).

28) State 3 general “rules of thumb” that broadly characterize plant nutrition & disease interactions.

29) What physiological conditions favor fungal spore germination on leaves and what nutritional disorders lead to these physiological conditions? Describe 3 inducible resistance mechanisms including role(s) of any essential mineral elements in the mechanism/response.

30) What is an obligate vs a facultative parasite and how do plant N and/or K status impact plant susceptibility to attack? How do bacterial spot and vascular infections occur/spread in plant tissues and what mineral nutrients are involved in disease severity? What about viruses?

31) What are the 3 main host resistance strategies to pest attacks? What nutrients are likely involved in host susceptibility?

32) What are the key differences between Ecto- (EC) and Vesicular-Arbuscular (VA) mycorrhizas? What is the nature of the relationship between mycorrhizae and host (using terms in Q27, above)? How do host roots become infected?

33) What is the impact of EC or VAM infection on host plant photosynthate allocation, root and shoot growth, and mineral nutrient status? What is the impact of a mycorrhizal infection on N2 fixation in a legume? Can mycorrhizas transfer nutrients between competing plants?