SLIDE NOTES AND EXPLANATIONS

1. M1/1 The Nitrogen Cycle. Gaseous nitrogen in the air is converted into a biologically useful form through biological nitrogen fixation in legumes and through chemical fixation in the fertilizer manufacture process.

2. M1/2 The Detailed Nitrogen Cycle. Crops require more nitrogen than any other plant nutrient. Nitrogen transformations in the biosphere are controlled by bacteria; nitrifying bacteria convert nitrogen in organic matter to ammonia and then nitrate; denitrifers convert nitrate in the soil back to atmospheric nitrogen; rhizobia convert this nitrogen back into ammonia within the root-nodule.

3. M1/3 The Leguminosae. The Leguminosae is the third largest plant family, with over 20,000 species represented in the temperate and tropical habitats, from herbs to large trees. Some of the worlds most important high protein foods are legumes, such as beans, soybeans, peas, peanuts and alfalfa.

4. M1/4 Rhizobia are Soil Bacteria. Rhizobia are rod-shaped soil bacteria which can be either free living or symbionts. When the proper legume root arrives in their soil habitat they can invade the root and eventually come to reside inside the host structure called a root-nodule. From inside the nodule, they carry out the process of biological nitrogen fixation.

5. M1/5 High Protein Products from the Symbiosis. The high nitrogen levels in a well nodulated legume give rise to high protein levels in the harvested plant. Soy sauce, tofu, and peanut butter are examples. Legumes such as peanut and soybean also produce high quality oils used in cooking.

6. M1/6 Matching the Plant and the Microbe. This field demonstrates two important points: 1) inoculation is necessary for proper growth of the plant (peanut, in this case) when the rhizobia are not present in the soil, and 2) different genetic varieties of the host require different rhizobia for an effective symbiosis.

7. M2/1 Subfamily Caesalpinoideae. A flower of *Bauhinia* sp. shows floral morphology typical of the species in the subfamily Caesalpinoideae.

8. M2/2 Subfamily Mimosoideae. Inflorescence of *Acacia farnesiana* which consists of small florets arranged to give a "head" common to species in the subfamily Mimosoideae.

9. M2/3 Subfamily Papilionoideae. "Butterfly" flowers of the subfamily Papilionoideae are typified by *Lathyrus* sp.

10. M3/1 What Rhizobia Look Like. These are rod-shaped bacteroides of *Bradyrhizobium japonicum* stained with fluorescent antibodies.

11. M3/2 Effective Symbiosis Nodule Color. Sections through effective nodules show the presence of leghemoglobin. Note the red color similar to human blood.

12. M4/1 The Infection Thread. Rhizobia enter the legume host usually through penetrating a root hair. The invagination of the host cell results in an "infection thread," by which the rhizobia travel to the site of the nodule primordia.

13. M4/2 Nodulated Soybean Root System. This soybean root system is covered with root-nodules. Within these structures are millions of rhizobia. It is within these nodules that nitrogen fixation occurs. The host expends a lot of energy maintaining these active nodules in return receiving ammonia which is converted to amino acids and proteins.

14. M4/3 Nodulated Peanut Root System. Nodule shape is determined by the host legume. Note the many smooth spherical nodules.

15. M4/4 Nodulated Birdsfoot Trefoil Root System.

16. M4/5 The Inoculated Seed. Farmers use the rhizobia by coating seed prior to planting with peat which carries the bacteria. Peat-based inoculants are available commercially to farmers in developed countries and increasingly in developing countries.

17. M4/6 Ineffective Native Rhizobia. The small plant on the left is a poorly nodulated alfalfa grown in a Washington state field. The native soil rhizobia were parasitic on alfalfa, and inoculation (in spite of severe competition) benefited the plants, as shown on the right.

18. M4/7 Inoculation Response in Soybean. This sandy soil in Florida showed a dramatic response to inoculation with soybean inoculant, as shown by

the rows on the left. The two rows on the right are uninoculated plants. The economic return in such a situation is quite high.

19. M4/8 Inoculation Response in Alfalfa. Perennial legumes such as alfalfa can be inoculated after planting. The middle and right plots were inoculated several months after planting, showing that perennial legumes can be rescued from nitrogen starvation. Annual legumes have too short of a growing season for this to work with them.

20. M4/9 Intercropping. The legume *Dolichos lablab* is used as an intercrop in this banana orchard in Honduras. It contributes nitrogen to the soil upon later incorporation and provides erosion control.

21. M5/1 The Slurry Inoculation Method. The following slides give an example of seed coating by the slurry method. First, measure corn syrup.

22. M5/2 Add peat based inoculant.

23. M5/3 Stir the mixture until a uniform slurry results.

24. M5/4 Measure seed into a roomy bucket.

25. M5/5 The slurry is added to the seeds which are stirred until seeds are well coated.

26. M5/6 Optionally, lime may be used for a protective coating after seed inoculation.

27. M5/7 A measured amount of lime is added to the seeds until they are uniformly coated.

28. M5/8 Seed Coating By the 2-Step Method. First, a measured amount of sticker material is added to seeds contained in a plastic bag. Then, the plastic bag is closed in such a way that as much air as possible is trapped in the bag. Vigorously shake the bag for one minute to uniformly wet the seeds with sticker. Next, the peat inoculant is added to the sticky seeds. Again close the bag and shake gently for another minute to coat the seeds with inoculant. Finally, the coated seeds are poured onto a clean surface, spread out and allowed to dry.

29. M6/7 Comparison Table. Soybean cultivation affects the number of soybean rhizobia in soil.

30. M6/7-2 Graphic: A Response Model. Factors controlling the response farmers can obtain by inoculating their legumes.

31. M6/7-3 Comparison of Nodule Amounts From Inoculated and Uninoculated Plants. Inoculation can increase the number of nodules on legumes. On the right, nodules from a system having poor nodulation on uninoculated legumes. Note the few, but relatively large nodules.

32. M6/7-2 Field Study View. Response to inoculation is evident by the size and color of plants.

33. M6/7-5 Starter N Benefit Chart. The benefits to starter nitrogen are a function of both the legume and the soil.

34. M8/1 You Are The Key. Introduce the concept of responsibility with this slide pointing out that each participant is responsible for their role in the BNF technology transfer process.

A series of self-explanatory text slides follows:

Communication & Teaching Skills:

35. M8/2 What Motivates People to Learn?

36. M8/3 What Adult Learners Expect

37. M8/4 How People Learn

38. M8/5 People Remember

39. M8/6 Teaching Method

Planning Technology Transfer:

40. M817 When Planning, Systematically consider