MODULE NUMBER 2

LEGUMES AND THEIR USE

SUMMARY

Legumes and cereals are the two most important flowering plants used in agriculture. Legumes are useful as human and animal food, as wood, and as soil-improving components of agricultural and agroforestry systems. This module summarizes the history of legumes and the discovery of their role in the legume/rhizobia symbiosis. The four subfamilies of the legume family, Leguminosae, are discussed. Drawings of legume flowers, leaves, and pods should help identification in the field. A comprehensive table gives the subfamilies, species, common names, habits, uses, and geographic areas of some important legumes.

KEY CONCEPTS

- Legumes are among the three largest families of flowering plants and have a long history of use in agriculture.
- Some, but not all, legumes produce nodules in symbiosis with bacteria.
- Legumes belong to the family Leguminosae, (also known as Fabaceae) which consists of four subfamilies, the Papilionoideae, Caesalpinoideae, Mimosoideae, and Swartzioideae.
- The most dependable way to identify the legume subfamilies is by examining the plants' reproductive structure.
- Legumes have multiple uses.

THE LEGUMINOSAE

Legumes are among the three largest families of flowering plants. The flowering plants of greatest importance to world agriculture belong to the orders Gramineae (cereals and grasses) and Leguminosae (legumes or the bean family). The Leguminosae consist of about 750 genera and 19,000 species of herbs, shrubs, trees, and climbers. This large family is divided into four subfamilies—the Mimosoideae, Caesalpinoideae, Swartzioideae, and Papilionoideae. The Swartzioideae is a small subfamily of about 80 species and relatively unimportant economically.

People have been growing legumes as crops for 6000 years. In Switzerland, the lake dwellers who lived between 5000 and 4000 B.C. cultivated peas (*Pisum* sp.) and a dwarf field bean, both legumes. In China, farmers began cultivating soybeans between 3000 and 2000 B.C. Legumes like lentils were also components of the cropping systems of ancient Egypt, and faba beans are mentioned in the Bible.

NODULATION AND BNF

Discovery of Nodulation and BNF

Farmers have long appreciated the value of legumes for improving and sustaining soil fertility. In the nineteenth century, Lawes and Gilbert (England) showed that legumes improve soil fertility by adding nitrogen to the soil. Hellriegel and Wilfarth (Germany) showed that pea plants gain nitrogen only in the presence of soil microorganisms and that the legumes' root nodules are intimately involved in the process. In 1887, Marshall Ward (USA) showed that root nodules are formed only in the presence of soil bacteria. Finally, in 1888, Beijerinick (Holland) isolated the nitrogen-fixing bacteria from nodules and from soil. The generic name given to these bacteria was *Rhizobium.*

Does Nodulation Occur in All Legumes?

The discovery of BNF in some legumes, with its dramatic potential benefit to agriculture, created a strong incentive among scientists worldwide to investigate the extent of nodulation in the Leguminosae. **Table 2-1** gives an estimate of the incidence of nodulation, and hence likelihood of BNF, in the three important legume subfamilies.

Although nodulation has not been investigated in many species, **Table 2-1** suggests that most of the species in the Caesalpinoideae subfamily do not produce nodules. Common genera in this subfamily that do not produce nodules are *Caesalpinia, Cassia*, and *Bauhinia*. The highest incidence of nodulation appears to be in the Papilionoideae subfamily, followed by the Mimosoideae.

Table 2-1. Nodulation in the subfamilies of the *Leguminosae*.

		Number of species reported		
Subfamily	Estimated number of species	Nodulated	Not nodulated	Total
Mimosoideae	2,900	351	37	388
Caesalpinoideae	2,800	72	180	252
Papilionoideae	14,000	2,416	46	2,462
Total	19,700	2,839	263	3,102

From O.N. Allen and E.K. Allen, 1981. In Leguminosae: A Source Book of Characteristics, Uses, and Nodulation.

LEGUME IDENTIFICATION

Plants in the Leguminosae family have characteristic leaves and pods that help identify them as legumes. The leaves are usually alternate (**Figure 2-1**: 14) and compound (**Figure 2-1**: 8, 9, 13, 14, and 15). They may be pinnate (**Figure 2-1**: 9) or trifoliate (**Figure 2-1**: 12). All legumes have similar fruits, called `pods', as shown in **Figure 2–2**. Within the Leguminosae, particular subfamilies and species can only be distinguished reliably by an examination of their flowers. For accurate identification of legume species in the field, consult a botanist or send a specimen to the national arboretum in the country where you work.

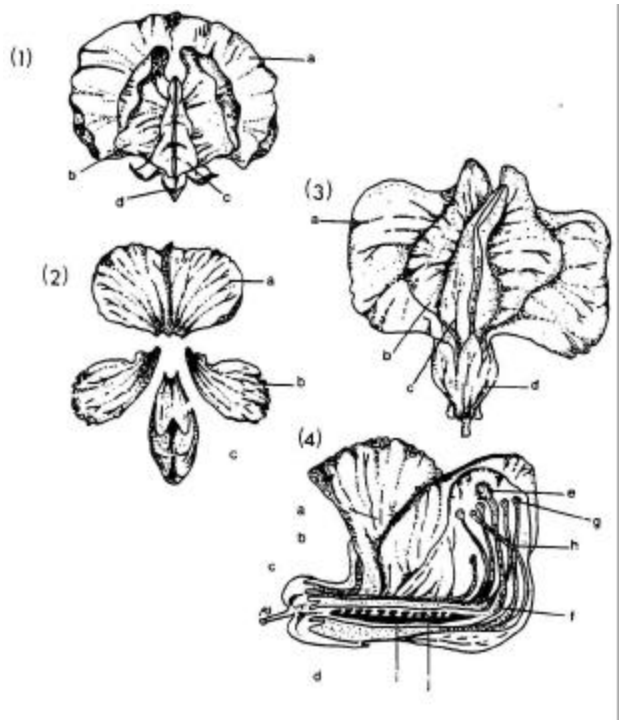


Figure 2-1. Subfamily Papilionoideae.
1. front view of flower of *Pisum sativum* (pea); 2. petals of *P. sativum*; 3. flower of *Psophocarpus tetragonolobus* (winged bean);
4. flower of *P. tetragonolobus* in longitudinal section. a-posterior or standard petal; b-lateral petal; c-keel petals (carina); d-sepals; e-stigma; f-style; g-anther; h-filament; i-ovary wall; j-ovule.

Figure 2-2. Subfamily Caesalpinoideae.
1. bud of *Cassia* sp.; 2. flower of *Cassia* sp.; and 3. longitudinal section through flower of *Delonix regia* (Flame of the Forest or Poinciana). a-petal; b-sepal;c-stigma; d-style; e-filament; f-anther; g-anther of staminoid; h-posterior or standard petal; i-ovary wall; j-ovule.

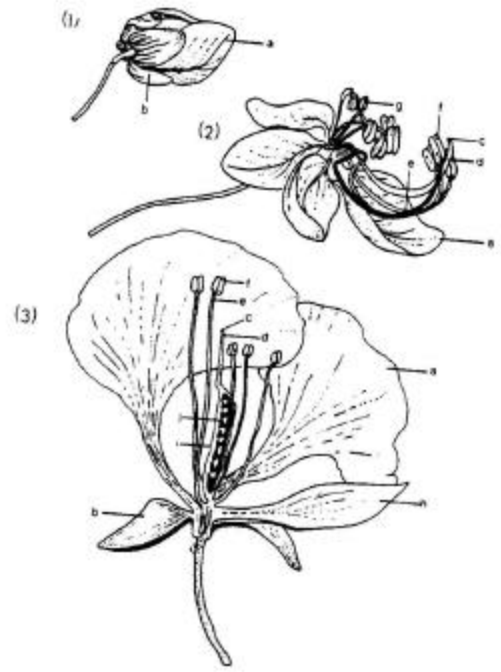


Figure 2-3. Subfamily Mimosoideae.
1. Floret of *Adenanthera pavonina*; 2. in-florescence (globose head) of *Leucaena leucocephala* in longitudinal section showing arrangement of florets on torus; 3. floret of *L. leucocephala* (side view); 4. floret of *L. leucocephala* (top view). a-petal; b-sepal; c-stigma; d-anther; e-filament; f-style; g-ovary

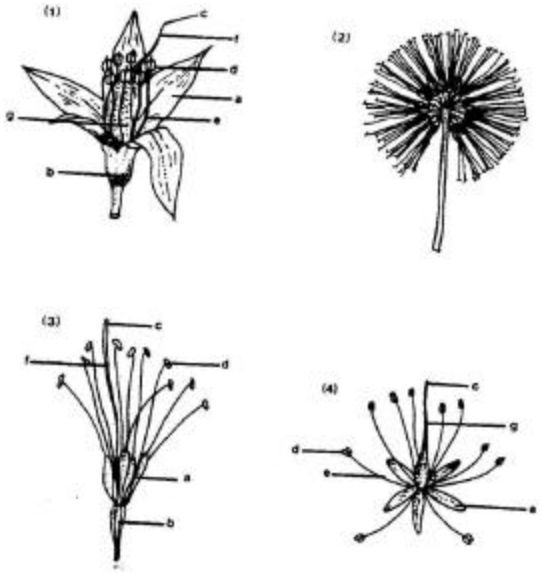


Figure 2-4. Leaves of legumes and associated structures. Leaf shapes: 1. oblong; 2. cuneate; 3. cordate; 4. linear; 5. lanceolate; 6. ovate; 7. oval. Leaf arrangements: 8. bi-pinnate; 9. pinnate; 10. palmate; 11. simple; 12. trifoliate; 13. branch of *Pisum* showing (a) five-branched tendril and (b) stipule; 14. (c) bi-pinnate leaf showing position of pulvinus; 15. *Acacia* seedling showing (d) simple phyllodes, and (e) true compound leaves.

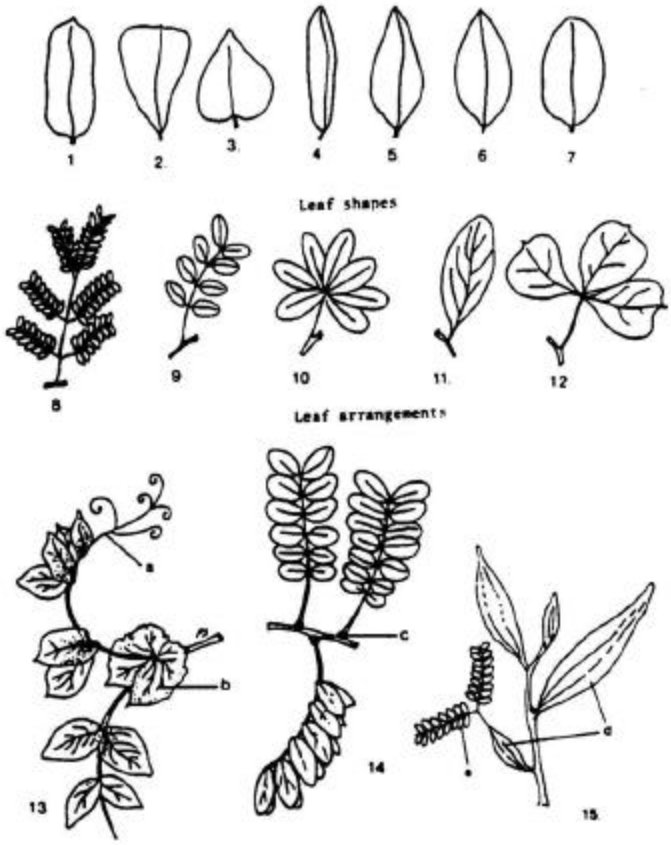
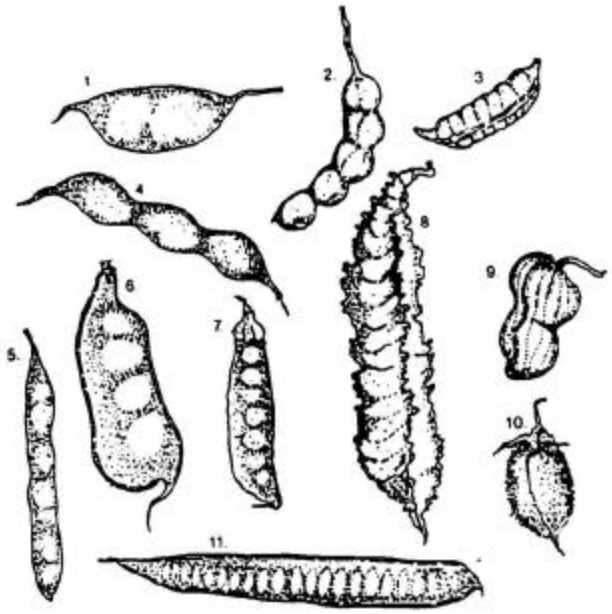


Figure 2-5. Legume pods. 1. *Strongylodon lucidus*; 2. *Tamarindus indica*; 3. *Acacia farnesiana*; 4. *Parkinsonia aculeata*; 5. *Prosopis pallida*; 6. *Lablab purpureus*; 7. *Pisum sativum*; 8. *Psophocarpus tetragonolobus*; 9. *Arachis hypogaea*; 10. *Cicer arietinum*; 11. *Leucaena leucocephala*.



USES

Of the thousands of known legume species, less than 20 are planted extensively today. Those in common use include peanuts (groundnuts), soybeans, peas, lentils, pigeon peas, chickpeas, mungbeans, kidney beans (also known as common or dry beans), cowpeas, alfalfa (lucerne), clovers (*Trifolium* spp.), and vetches. They represent all three subfamilies of the Leguminosae. The Papilionoideae, with a worldwide distribution, are the largest subfamily. They are mostly herbs and include the most important species for human food. The Mimosoideae and Caesalpinoideae are mostly woody trees and shrubs. Many are valuable for lumber, fuelwood, tannins, and animal fodder. **Table 2-2** summarizes the uses of some of the important legumes.

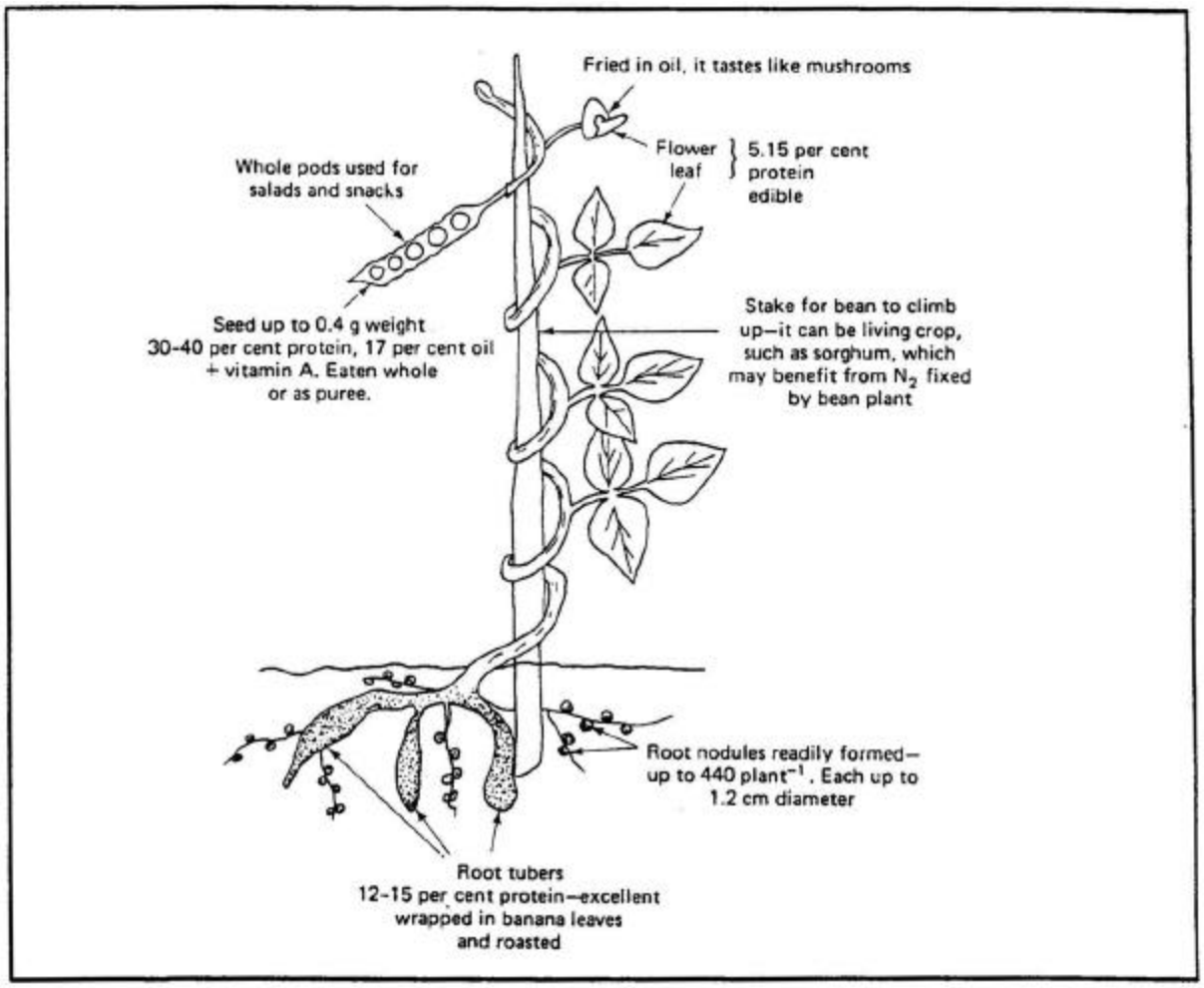


Figure 2-6. The winged bean, just one of many important legumes, is a multi-use plant.

Human Food

Legume seeds (also called pulses or grain legumes) are second only to cereals as a source of human and animal food. When legumes and cereals are eaten together, they provide complete protein nutrition. Nutritionally, legume seeds are two to three times richer in protein than cereal grains. Some legumes, such as soybeans and peanuts, are also rich in oil. Kidney beans and other legumes are a major source of food in Latin America, while lentils, pigeon peas, and chickpeas are important in South Asia. In the Middle East and North Africa, faba beans, lentils, and chickpeas are particularly important. Common food products made from legumes include tofu, peanut butter, and soymilk.

Animal Feed

As standards of human nutrition improve in all countries, there is a corresponding increase in demand for animal products such as milk, butter, eggs, and meat. This demand can only be met by using animal feeds with a high protein content. Among the grain legumes, soybeans are the most extensively used in animal feed.

Forage legumes are commonly provided to animals in grass-legume mixtures. In the temperate regions, clovers, medics, trefoils, and vetches are important. In tropical and subtropical pastures, *Stylosanthes, Pueraria, Lablab, Desmodium,* and other tropical pasture crops are important sources of livestock fodder.

Other Uses

Many species in the Mimosoideae and Caesalpinoideae subfamilies provide valuable timber, dyes, tannins, resins, gums, insecticides, medicines, and fibers. Many provide green manure for crops, such as *Sesbania rostrata* in rice cropping systems and *Gliricidia sepium* and *Leucaena leucocephala* in alley cropping. Many tree legumes have been identified as useful multipurpose species, and these are being introduced through agroforestry, soil restoration, and erosion control programs in many countries.

Table 2-2. Key aspects of selected legume species.

Species (common name)	Habit	Main Uses	Distribution
Subfamily *Mimosoideae*			
Acacia albida	Tree	Fodder, shade	West Africa, Sudan
Acacia auriculiformis	Tree	Shade, ornamental, fuel	Southeast Asia
Acacia farnesiana (cassie, huisache)	Tree	Perfume, tannin, wood, fodder	Australia, India, Java, West Indies
Acacia glauca (syn. *Acacia villosa*)	Tree	Green manure	Indonesia
Acacia koa (koa)	Tree	Fodder, lumber	Hawaii
Acacia lutea	Tree	Fodder	Argentina
Acacia mangium	Tree	Lumber, fuelwood	Southeast Asia
Acacia mearnsii (black wattle)	Tree	Fuelwood, lumber, tannin	South America, East Africa, India
Acacia nilotica (babul, Egyptian mimosa)	Tree	Fodder	Sudan
Acacia pennatula	Tree	Shade coffee, fuel	Central America, Mexico
Acacia senegal (gum arabic, senegal gum)	Tree	Gum arabic	Sudan, Somalia, Senegal, Zambia, Kenya, Ethiopia
Acacia seyal (shittim wood)	Tree	Lumber, fodder	Tropical Africa
Albizia amara	Tree	Browse	India
Albizia falcataria	Tree	shade	Indonesia, Malaysia, Uganda
Albizia lebbek	Tree	Fodder, shade	India, Tropical Africa, West Indies
Albizia sumatrana (syn. *Albizia carbonaria*)	Tree	Shade, green manure	Indonesia, Zaire
Archidendron jiringa (syn. *Pithecellobium lobatum, Pithecellobium jiringa*) (jiring)	Tree	Browse, fodder, food	Indonesia, Malaysia

Species (common name)	Habit	Main Uses	Distribution
Archidendropsis basaltica (syn. *Albizia basaltica*)	Tree	Fodder	Australia
Calliandra calothyrsus	Tree	Fuel, green manure, land reclamation	Indonesia, Philippines
Inga edulis	Tree	Shade for coffee	Colombia, Mexico
Leucaena leucocephala (lamtoro, ipil-ipil, koa haole)	Tree	Green manure, forage fuelwood, land reclamation, paper pulp	South America Asia, Africa
Parkia javanica (petai)	Tree	Food (pods)	Indonesia, Malaysia, Thailand
Pithecellobium dulce	Tree	Fodder, shade	Philippines, Thailand
Prosopis spp. (mesquite)	Tree	Shade, fodder, lumber	Central America, Indonesia, South Africa, USA
Subfamily *Papilionoideae*			
Arachis hypogaea (peanut, groundnut)	Herb	Food	Many tropical countries
Astragalus cicer (cicer milkvetch)	Herb	Forage, erosion control	Canada, USA, Asia, Europe
Cajanus cajan (pigeon pea)	Shrub/tree	Food, green manure, fuelwood	India, Africa, Southeast Asia
Calopogonium mucunoides (calopo, frisolila)	Herb	Erosion control, soil improvement	Java, Malaysia, Sri Lanka, India, Burma
Canavalia ensiformis (jack bean)	Herb	Erosion control, green manure, food	Indonesia, Mexico, Tropical Africa
Cicer arietinum (chickpea, gram, garbanzo)	Herb	Food	Middle East, India, Mexico, Chile, Peru
Crotalaria juncea (sun hemp, Indian hemp)	Herb	Fiber, green manure	India, Pakistan, Bangladesh, brazil
Cyamopsis tetragonoloba (guar, cluster bean)	Herb	Gum, green manure, cover crop, forage	India, Pakistan, USA, Africa

Species (common name)	Habit	Main Uses	Distribution
Dalbergia sissoo (sissoo, shisham)	Tree	Lumber, fodder	India, Pakistan, Nepal
Desmodium spp. (tick clovers)	Herb	Forage	Tropical America, Asia, Africa
Erythrina spp. (coral tree(	Tree	Shade, fodder, green manure, ornamental	All tropical regions
Gliricidia sepium	Tree	Shade, green manure	All tropical regions
Glycine max (soybean)	Herb	Food, fodder	Worldwide
Lens culinaris (lentil, masur dhal)	Herb	Food	Middle East, India, warm temperate regions
Lotus spp. (trefoils)	Herb	Forage	Europe, Middle East, Central Asia, Australia, South America
Lupinus spp. (lupines)	Herb	Forage, green manure, soil improvement	Europe, USA, Mediterranean
Macroptilium spp. (siratro)	Herb	Forage	Central and South America, USA
Macrotyloma uniflorum (horesgram)	Herb	Fodder	India
Medicago spp. (alfalfa, lucerne, medic, burclover)	Herb	Forage	Temperate regions
Melilotus spp. (sweet clover)	Herb	Forage	Worldwide
Pachyrhizus erosus (yam bean, jicama, sen kuang)	Herb	Food	Mexico, Southeast Asia, China
Phaseolus coccineus (scarlet runner bean)	Herb	Food	Europe, Central America
Phaseolus lunatus (lima bean, butter bean)	Herb	Food	Indonesia, Burma, USA, Central America, Africa
Phaseolus vulgaris (bean, common bean)	Herb	Food	Most temperate and subtropical regions
Pisum sativum (common	Herb	Food, fodder	Most temperate and

Species (common name)	Habit	Main Uses	Distribution
or garden pea)			subtropical regions
Psophocarpus tetragonolobus (winged bean)	Herb	Food	Indonesia, New Guinea, Burma, Thailand, Malaysia
Pueraria phaseoloides (kudzu, puero)	Herb	Forage, erosion control	Southeast Asia
Sesbania grandiflora	Tree	Green manure, food	Indonesia, Philippines, Malaysia, India
Sesbania rostrata	Tree	Green manure, food	West Africa, Philippines, Tropical Americas, Australia, Southeast Asia
Stylosanthes spp. (stylo)	Herb	Forage	Tropical Americas, Australia, Southeast Asia
Trifolium spp. (clovers)	Herb	Forage	USA, Canada, Australia, Mediterranean region
Vicia faba (broadbean, faba bean)	Herb	Food	USA, Canada, Middle East, South America
Vigna mungo (urdbean, black gram)	Herb	Food	India, Pakistan
Vigna radiata (gram, mungbean)	Herb	Food	India, China, Indonesia, Thailand, USA
Vigna subterranea (syn. *voandzeia subterranea*) (bambara groundnut)	Herb	Food	Africa, Southeast Asia
Vigna umbellata (rice bean)	Herb	Food	Africa, Asia, USA
Vigna unguiculata (kacang, cowpea)	Herb	Food	Africa, Asia, USA
Subfamily *Caesalpinoideae* (none of the species listed fixes nitrogen)			
Bauhinia spp.	Tree/shrub	Forage, fodder, ornamental	southeast Asia, Tropical Africa

Species (common name)	Habit	Main Uses	Distribution
Cassia alata	Herb	Medicine, tannin	West Africa
Cassia senna	Herb	Cosmetic	North Africa, Egypt
Ceratonia siliqua (carob, locust)	Tree	Food, gum	Mediterranean region
Senna occidentalis (syn. *Cassia occidentalis*)	Herb	Medicine	Indonesia, Africa, Sri Lanka
Tamarindus indicus (tamarind)	Tree	Food, medicine, wood	Southeast Asia, India, Africa

REVIEW AND DISCUSSION

- List the legumes commonly used in agriculture in your country. Can you identify them by their scientific names and assign them to their subfamilies?
- What are the forage legumes in your country? Which animals feed on these forages?
- Which tree legumes are used in land reclamation and agroforestry in your country?
- Which grain legumes are used to produce edible oils in your country?
- Identify as many legumes as you can from plant specimen. Find out their scientific and common names. Are these legumes introduced or native to your country?

SUGGESTED LESSON PLAN FOR MODULE 2.

TIME: One hour +

OBJECTIVES:

Knowing what plants are legumes, i.e., how to identify them. Knowing the many uses of legumes. Knowing that most legumes form nodules.

MATERIALS:

Samples of native legumes for display -nodulated and non-nodulated

Training aids for Module 2

STEPS:

1. Display key concepts and other appropriate training aids. Gather legume samples yourself or, if appropriate, have the group go out and gather samples.

2. Explain some of the identifying characteristics of legumes, i.e., shape of flowers and. leaves, presence of pods, and nodules on roots. This step is done very well in the field where the whole plant can be examined in place.

3. Again, use questions regarding the types of legumes the audience is familiar with, their uses, etc. This leads into the lecture which can be quite short.

KEY CONCEPTS

Legumes are among the three largest families of flowering plants and have a long history of use in agriculture.

Not all legumes are nodulated.

Legumes belong to the family Leguminosae which consists of four subfamilies, the Papilionoideae, Caesalpinoideae, Mimosoideae, and Swartzioideae.

Examining the reproductive structure is the most dependable way to identify and recognize the legume subfamilies.

Legumes have multiple uses.

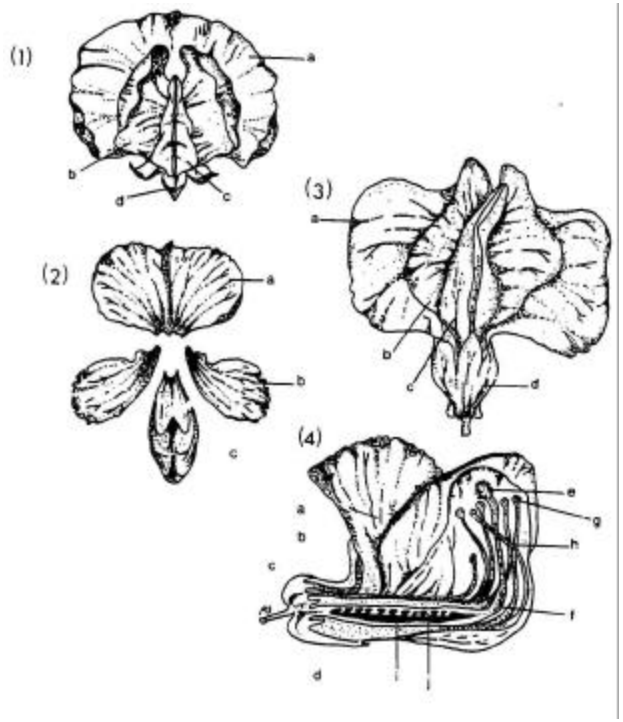


Figure 2-1. SubfamilyPapilionoideae. 1. front view of flower of *Pisum sativum* (pea); 2. petals of *P. sativum*; 3. flower of *Psophocarpus tetragonolobus* (winged bean); 4. flower of *P. tetragonolobus* in longitudinal section. a-posterior or standard petal; b-lateral petal; c-keel petals (carina); d-sepals; e-stigma; f-style; g-anther; h-filament; i-ovary wall; j-ovule.

Figure 2-2. Subfamily Caesalpinoideae.
1. bud of *Cassia* sp.; 2. flower of *Cassia* sp.; and 3. longitudinal section through flower of *Delonix regia* (Flame of the Forest or Poinciana). a-petal; b-sepal;c-stigma; d-style; e-filament; f-anther; g-anther of staminoid; h-posterior or standard petal; i-ovary wall; j-ovule.

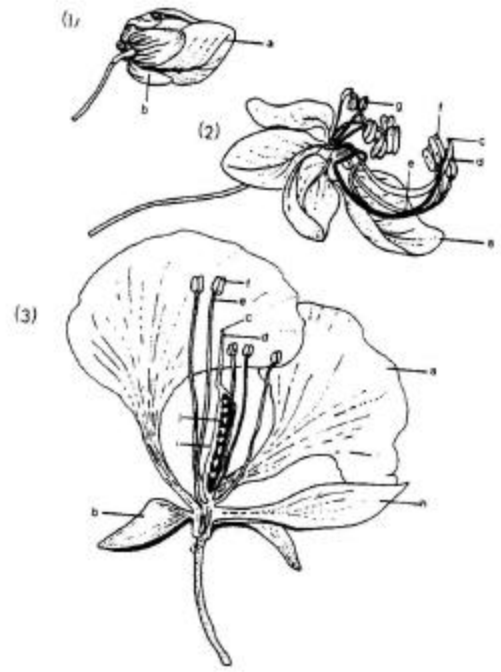


Figure 2-3. Subfamily Mimosoideae.
1. Floret of *Adenanthera pavonina*; 2. in-florescence (globose head) of *Leucaena leucocephala* in longitudinal section showing arrangement of florets on torus; 3. floret of *L. leucocephala* (side view); 4. floret of *L. leucocephala* (top view). a-petal; b-sepal; c-stigma; d-anther; e-filament; f-style; g-ovary

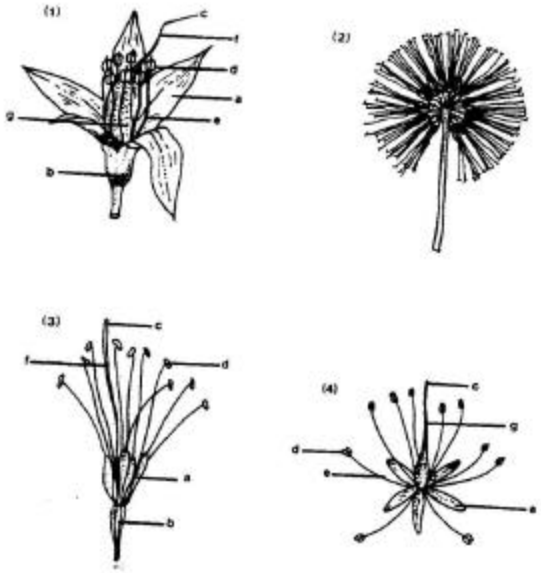


Figure 2-4. Leaves of legumes and associated structures. Leaf shapes: 1. oblong; 2. cuneate; 3. cordate; 4. linear; 5. lanceolate; 6. ovate; 7. oval. Leaf arrangements: 8. bi-pinnate; 9. pinnate; 10. palmate; 11. simple; 12. trifoliate; 13. branch of *Pisum* showing (a) five-branched tendril and (b) stipule; 14. (c) bi-pinnate leaf showing position of pulvinus; 15. *Acacia* seedling showing (d) simple phyllodes, and (e) true compound leaves.

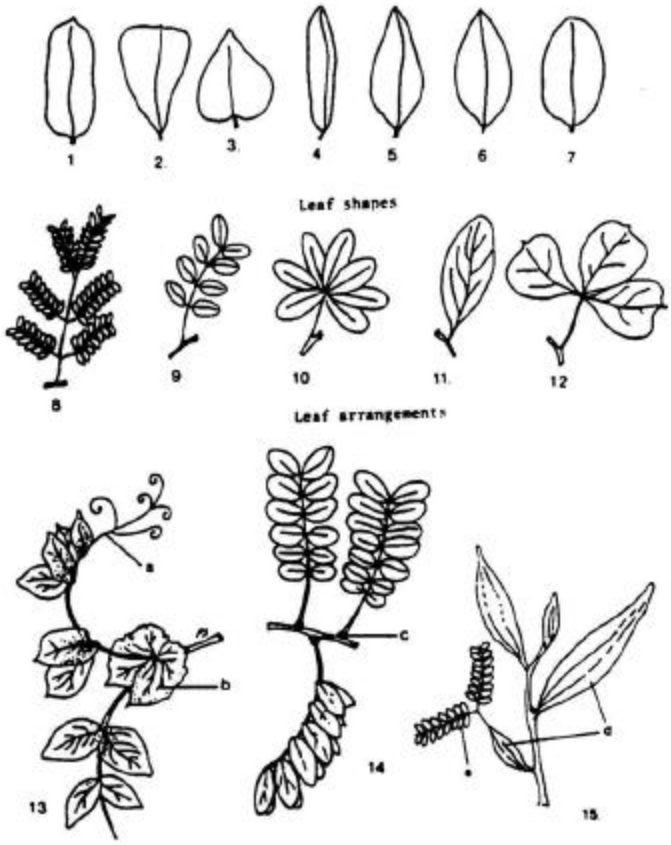


Figure 2-5. Legume pods. 1. *Strongylodon lucidus*; 2. *Tamarindus indica*; 3. *Acacia farnesiana*; 4. *Parkinsonia aculeata*; 5. *Prosopis pallida*; 6. *Lablab purpureus*; 7. *Pisum sativum*; 8. *Psophocarpus tetragonolobus*; 9. *Arachis hypogaea*; 10. *Cicer arietinum*; 11. *Leucaena leucocephala*.