CHAPTER 1

INTRODUCTION

The Indonesian archipelago is located in the tropics between 6°N and 11°S and between 94°E to 140°E longitude, and consists of some 13,667 islands. Geologically, the chain of the Indonesian islands are divided into three areas. These are:

a) Eastern Sumatera, Northern Java and Kalimantan, which are situated on the Sunda shelf.

b) Southern parts of Irian Jaya, including the islands of the Arafura sea which are located on the Sahul shelf.

c) Western Sumatera, most of Java, Madura, Bali, Sulawesi through the islands of Nusa Tenggara, which are situated in an unstable volcanic area (Birowo and Hansen, 1979).

In certain areas of Java there are soils of high fertility as a consequence of volcanic activity, whereas very poor soils are found in large areas of Eastern Sumatera, Sulawesi, Kalimantan, Irian Jaya which are formed from limestone originating from coral reefs.

The topographical features of Indonesia have been classified into three categories by Birowo and Hansen (1979). They are:

Category 1 : mountainous land at least 200m above sea level.
Category 2 : undulating to hilly land, less than 200m above sea level
Category 3 : swampy land
Details of the soil types in these categories are given in Table 1.1

Table 1.1. Soil types in Indonesia according to Birowo and Hansen (1979).

Category	Soil types	Percentage of total land
1	Mainly lithosols and andosols	66
2	Mainly red-yellow podzolics, terrasols, red-brown mediterranean soils and regosols	32
3	Mainly organic soils and alluvials	27

Forty percent of the land in Category 2 is suitable for agriculture. This markedly exceeds the proportion suitable in Categories 1 and 3.

Schwaar (1973) estimated the area of land used for various forms of production in major regions of Indonesia and this is presented in table 1.2.

Table 1.2. Land use (million hectare) in major regions of Indonesia.

Regions	Irrigated Cropping	Dryland Cropping	Grassland	Estate	Mangrove Swamp, Brush & Forest
Sumatera	1.26	0.12	7.20	3.03	35.75
Kalimantan	0.49	-	5.53	0.08	47.85
Java and Madura	4.49	5.01	0.40	0.46	2.26
Bali	0.12	-	0.24	0.10	0.10
Sulawesi	0.80	0.49	3.96	0.80	13.59
Nusa Tenggara	0.13	0.02	2.52	-	2.26
Maluku	-	-	0.81	-	0.10
Irian Jaya	-	-	0.44	-	41.76
Indonesia	7.29	5.64	21.09	3.75	144.72

Because the island and the territories of Indonesia lie along the equator, the climate is tropical with high humidity, slight changes in temperature and heavy rainfall. Except at higher elevation, temperatures generally range from 20° to 30°C, while humidity ranges from 60% to 90%. Approximately 90% of Indonesia receives an annual rainfall of more than 1250 mm. In general, total rainfall decreases from west to east and in Eastern Indonesia there is marked dry season from approximately May to November.

There are 14.4 million agriculture holdings in Indonesia which are primarily concerned with crop production. They form an important economic and social function in the life to the people in the various areas. In the intensive agricultural areas the rice fields are normally occupied by crops throughout the year, sometimes with three crops a year. This increase in crop area and cropping intensity has meant that there are fewer opportunities for farmers to graze their livestock after harvesting rice, which was the common practice for village people prior to new and improved methods of farming being introduced in these areas. The effects of this has been a marked limitation of sources of forage for village animals, thus inhibiting animal production.

In less intensive areas, not all the ricefields are occupied by crops throughout the year. Sometimes only one or two crops a year are grown. After harvesting the rice, fields are left fallow until the onset of the rainy season. Such a method of growing rice is practiced in the drier regions of Indonesia and in the upland areas.

In upland areas in Indonesia, cropping systems are diverse with cropping most often carried out on fields without bunding and irrigation. The major food crops grown under this system are rice, corn, sorghum, cassava and beans.

The utilisation of the area under cultivation in Indonesia has been estimated by the Indonesian Central Bureau of Statistics (1983) as shown in Table 1.3.

Table 1.3. The area under cultivation in Indonesia estimated by I.C.B.S. (1983).

Crop	Area cultivated (ha)	Yield kg/ha
Wetland rice	7,940,691	4180
Dryland rice	1,161,583	1750
Corn	3,017,746	1690
Cassava	1,242,163	9800
Sweet potato	260,761	7800
Peanuts	483,747	980
Soybeans	633,259	900

From table 1.3, it can be seen that the areas used for the cultivation of rice are by far the most extensive of all crops with a corresponding high volume of production. Because of the green revolution and improved irrigation practices there has been an increase in land under cultivation. As a consequence, the pressure on land utilization has increased so that marginal areas, for example on hill and mountain sides, have been brought under cultivation. The extent of this may be seen in what is known as upland cropping. Because of the lack of irrigation or at most some simple but limited form of irrigation the farmers have to rely on rain only for their crops. In this regard, rice is planted when the rainy season occurs and after that, while there is still moisture in the soil, other crops are planted e.g. corn, cassava, sweet potato, peanuts or soybean. Other areas which are not irrigated and rely on natural rainfall are where plantations may be found.

There are more than 6.69 million hectares of various plantation crops in Indonesia. The major crops growing in these plantations are: tea, limes and fruit in the higher altitudes in west Java, and sugar cane on the lowland plains of East Java. In the larger islands of Sumatera, Sulawesi, Kalimantan and also in the archipelago of the Maluku, tea plantations have been established many years ago, but in some of these areas sugar cane, kapok and cotton have replaced them.

In the mountainous areas of Sulawesi, cloves, coconut, cocoa, coffee and fruits are grown. In areas in North and South Sumatera extensive plantations of rubber, palm oil, tobacco, sugar cane are to be found. In the islands of Maluku and Nusa Tenggara sago, spices, and coconut are the main plantation crops.

There are approximately 21 million hectares of grassland area in various parts of Indonesia (Schwaar, 1973). Especially in the drier parts such as Nusa Tenggara and Sulawesi, native pastures are the main feed source for livestock. Native pasture areas of Sulawesi, Kalimantan and Sumatera are dominated by *Imperata cylindrica* grown with some native or naturalized legume species.

In West Java where improved forages such as *Pennisetum purpureum, Setaria splendida* and *Brachiaria brizantha* (Siregar *et al.* 1985) are grown along the bunds of the rivers it has been suggested that they could contribute to increased production of dairy cattle, sheep and goats. Other improved pastures are dominated by *Brachiaria decumbens, Panicum maximum* var. trichoglume, *Macroptilium atropurpureum,* cv siratro, and *Centrosema pubescens* (Rika *et al.* 1981).

There are many feeding systems within Indonesia and throughout the region. In Java, where the livestock are owned by farmers with very small holdings (0.5-1.0 ha) these differences are apparent (Siregar *et al.* 1985). Because holdings are usually small, there is very little space for the growth of forage plants. As a consequence, in those areas where intensive cropping takes place the farmers utilize crop residues such as leaves and stalks as fodder for their animals.

In other parts of Java, farmers already plant improved grasses on the edge of their terraced fields such as *Brachiaria brizantha* and *Setaria splendida.* They form the main forage source in the cut and carry system (Siregar, 1985). The Indonesian Forest Company has interplanted trees with *Pennisetum purpureum* in teak forest areas (Narsum, 1983).

It has been reported that the various grassland areas of Sulawesi, Kalimantan, Sumatera, Irian Jaya and Nusa Tenggara are dominated by native grasses with low nutritive value (Bonnemaison, 1961; Prawirasaputra *et al.* 1979; Siregar, 1972). Farmers in drier areas have used naturalized leucaena mixed with such residues as banana leaves, jackfruit leaves, and coconut leaves as the main source of forage and some farmers plant small areas of forage crops or cultivated food crops to support their livestock. The grassland areas are considered a potential resource for increased animal production provided that legume species are introduced into the native pastures.

This thesis sets out to assess the potential of native and introduced herbaceous legumes as forages in animal production systems, in particular their suitability for incorporation into pastures, in Eastern Indonesia. Persistence of legumes in grass/legumes mixtures is a major problem, and careful management is often necessary to ensure their survival. Such management cannot be expected in many parts of Indonesia since pastures are generally used as communal grazing areas. In the evaluation of herbaceous legumes emphasis is therefore placed on attributes which can be associated with persistence. Cluster analysis data has been combined with observation and experience to select accessions for sward evaluation.

CHAPTER 2

LITERATURE REVIEW

2.1. IMPORTANCE OF LEGUMES IN FORAGE PRODUCTION

By including a legume component in improved pastures, the farmer can increase the value of animal feeds, raise the level of fertility of his land, and prevent soil erosion (Mardiono and Hardjono, 1984).

Nitrogen deficiency is a major limitation to pasture productivity in the tropics. With the increasing cost of fertilizers, the importance of legume based pastures has been much emphasized by many researchers.

For small-holders who want to increase soil fertility the alternative to artificial fertilizers is the use of animal manure and legumes, which improve soil N levels. Using leguminous green manure some six weeks before planting sugarcane not only protects the soil but reduces the amount of artificial fertilizer needed (Pushparajah and Chellopah 1969). Not only do the legumes assist in adding nitrogen to the soil but they also provide a rich source of protein for the animals. One major advantage of using manure and legumes to increase soil fertility and to provide fodder is that the farmer does not have to spend money to purchase them. Often they may be the only low-cost systems which the farmer can use to improve forage production (Suntraporu, 1980; Manidool, 1985). Native grasses are generally low in protein and this often restricts the growth of ruminants in the tropics (Norman, 1963; Playne and Haydock, 1972; Siebert and Hunter, 1977). The provision of sown legume could overcome the effects of the low protein content of the native pastures.

Le Houerou (1978) and Minson (1981) suggested that legumes complement grasses as the premier feedstuffs for all herbivores, notably by increasing animal intake levels of protein.

The nutritional requirements needed for milk production are greater than that needed for growth, particularly in terms of digestible energy. In this case Stobbs (1973) suggested that in the diets of lactating animals the inclusion of legumes is essential for improving milk production without the use of other supplements. According to Davies and Hutton (1970), legumes provide the most economic source of protein as a means of increasing the production of beef and milk.

Takahashi (1952) reported that *Desmanthus virgatus, Leucaena leucocephala* and *Cajanus cajan* were used in cut and carry systems in Hawaii. Over the past 20 years research using improved forage species in Southeast Asia and the Pacific has shown that the dry matter production from the shrub legume *Leucaena leucocephala* may be as high as 20 t/ha (Mendoza and Javier, 1980; Wong, 1982; Hassan and Izham, 1984; Ivory and Siregar, 1984; Chen, 1985). The few legume species in Southeast Asia which have been identified as having potential for commercial use are: *Centrosema pubescens, Desmodium ovalifolium, Macroptilium atropurpureum, Pueraria phaseoloides, Stylosanthes guianensis, Stylosanthes hamata, Stylosanthes humilis* and *Stylosanthes scabra* (Hassan and Izham, 1984; Topark-Ngarm, 1984).

A great deal of research has placed much emphasis on the contribution of forage legumes to improve feed supplies. This is appropriate when one considers the nutritional differences between legumes and grasses in terms of animal requirements. From this fact, the following parameters relating to legumes are important:

a) Legume are the major source of protein for animals

b) The rate of decline in digestibility with age is slower for legumes than tropical grasses and legumes retain relatively high digestibility at maturity

c) The voluntary intake of legumes is higher than grasses of similar digestibility

d) Legumes have generally a higher mineral concentration than grasses except for sodium in some species (Milford and Minson, 1966; Thornton and Minson, 1973; Evans, 1985)

Multipurpose legume trees that can serve both as fodder and fuelwood are increasingly valued in the tropics (Brewbaker *et al.* 1984; Burley and Van Carlowitz, 1984). Fodder should be viewed as an economically important co-product with fuelwood and timber.

Some legume trees and shrubs have achieved means, such as thorns, of protecting themselves from browsing and these are less useful (Gray, 1969; Rosenthal and Janzen, 1979).

In 1981, the ruminant livestock population of Indonesia was estimated to be 6.5 million cattle, 2.5 million buffaloes and 12.0 million sheep and goats (Directorate General of Animal Husbandry, 1984). The total number of cattle and buffalo in South Sulawesi have increased each year (Table 2.1) and young cattle are exported to other islands in Indonesia and to foreign countries (Anonymous, 1973; 1980).

Table 2.1. Population of cattle and buffalo in South Sulawesi from 1969 to 1976 (Anonymous, 1973;1980).

Animals	Year				
	1969	1970	1971	1972	1976
Cattle	236,506	248,604	282,226	302,909	491,300
Buffalo	329,466	340,416	334,252	332,580	335,100

South Sulawesi appears to have great potential for animal production. This view is reinforced by the availability of approximately 450,000 ha of natural grassland (Anonymous, 1980) which may be used to increase animal production. The exploitation of this potential has been planned by the Government of Indonesia which has designated South Sulawesi as the centre of beef cattle, especially Bali cattle, for meat and animal production. In this area a number of problems have arisen for the farmers in relation to the rearing of animals, the most important of which are:

a) The low nutritive value of the natural grasses

b) The seasonality of growth of fodder.

Moog (1974) and Ashari and Petheram (1983) define the animal feed resources as those which may be obtained from natural herbage on non-cultivated land, roadside verges, bank and rice fields, crop residues and crop by-products, or cut from under plantation crops or when stock are grazed on communal grazing lands.

Generally livestock in Indonesia are fed on a range of native grasses. Leaves of trees, farm wastes, by-products such as crop residues, and also fodder cut from waste plants in rice fields, from the roadsides, from mixed food gardens, and from between trees in plantations (Ivory and Siregar 1984; Siregar, 1985).

On the basis of the above it may be safely assumed that the erratic quantity and quality of fodder results in the slow growth and often in seasonal weight loss, erratic fertility and heavy mortality of calves and lactating cows in Indonesia.

In the outer islands of Indonesia (Sumatera, Sulawesi, Kalimantan and the eastern islands such as Flores, Sumba and Timor) it is possible that legume-based pastures may, through the nitrogen fixed by legumes, and the return of nutrients from animals, restore some fertility to the soil and permit crops to be grown in rotation with the pasture system (Mahadevan and Devendra, 1985). Such a system would be most beneficial to areas like South Sulawesi where most fields lie idle during the dry season.

2.2. ORIGIN AND DISTRIBUTION OF LEGUMES

2.2.1 General

The family *Leguminoseae* contains three sub families. These are: *Caesalpiniodeae, Mimosoideae* and *Papilionoideae* (Williams, 1983). These, in turn, contain a number of tribes, genera, and species (table 2.2).

Table 2.2. The number of tribes, genera and species in the Leguminoseae sub families[A].

Sub Family	Tribes	Genera	Species
Caesalpinioideae	8	174	2859
Mimosoideae	6	56	2832
Papilionoideae	33	456	11271
Total	47	686	16962

[A](Polhill and Raven, 1981; Williams, 1983).

The *Mimosoideae* and the *Caesalpinioideae* have an almost entirely tropical distribution. The *Papilionoideae* on the other hand extends from the tropics into the temperate zones (Humphrey, 1981).

Atkinson (1970) has listed the genera of tropical legumes in the following groups in relation to latitude.

a) The legumes with a wide latitudinal range in both Northern and Southern Subtropics are: *Rhyncosia, Stylosanthes, Trifolium repens, Trifolium, Vicia, Lupinus, Phaseolus, Medicago, Delilotus, Cassia* and *Desmodium.*

b) An intermediate group with a distribution North and South of the respective tropics, but with an apparent equatorial "gap" of 10° to 20° latitude across the equator are: *Zornia, Galactia, Indigofera, Crotalaria, Aeschynomene* and *Astragalus.*

c) An obligatory equatorial group: *Alysicarpus, Calopogonium, Centrosema, Canavalia, Pueraria* and *Teramnus.*

Hutton (1970); Mehra and Magoon (1974) have suggested that there are four main gene centers of tropical and subtropical pasture legumes. These are:

(a) Tropical America

(b) Africa

(c) India, and

(d) East Asia

Williams (1983), in a comprehensive survey of tropical legumes, listed 68 genera in *Papilionoideae* whose natural distribution extends to tropical Asia. Within this groups are: *Pueraria phaseoloides, Desmodium heterocarpon, D. heterophyllum* and *D. ovalifolium.*

South East Asia is generally considered to be only a minor centre for the origin of forage plants and because of this it has been generally overlooked (Harlan, 1981).

Over a period of 6 years, commencing in 1979, scientists collected legumes from a number of countries in South East Asia and from China. Examples of legumes collected from these countries are shown in table 2.3.

Table 2.3. Native legumes collected in South East Asia.

Year	Country	Principal genera collected
1979	Thailand	*Desmodium*
1982	Thailand	*Desmodium, Dendrolobium, Phyllodium*
	Malaysia	*Pueraria, Tadehagi*
1983	Indonesia	*Desmodium, Uraria, Alysicarpus*
	P. New Guinea	*Desmodium, Codariocalyx, Flemingia, Pueraria, Pycnospora, Uraria*
1984	China	*Desmodium, Phyllodium, Tadehagi, Pueraria, Alysicarpus*
	Thailand	*Desmodium, Dendrolobium, Phyllodium, Tadehagi, Pueraria*
	Indonesia	*Desmodium, Aeschynomene, Alysicarpus, Calopogonium, Centrosema, Pseudarthria, Pueraria, Uraria.*

Source: Reid and Ivory (1983); B. Pengelly (pers. comm.) and Schultze-Kraft *et al.* (1984); Ivory and Yuhaeni (1984); Mehra and Magoon (1974), Pattanavibul and Schultze-Kraft (1985).

Alysicarpus, Desmodium, Dolichos, Mucuna, Phaseolus and *Pueraria* are prevalent in South East Asia. *Alysicarpus vaginalis* is a legume which has become widely naturalized throughout the humid tropics and is found in South East Asian countries and also in India. *Pueraria sp.* is also found in the Eastern parts of Asia and the South Pacific (Skerman, 1977).

Schultze-Kraft (1985) has suggested that the following South East Asian legume species have potential as forage plants:

a) Traditional species of known potential: *Pueraria phaseoloides, Desmodium ovalifolium, D. heterocarpon, D. heterophyllum.*

b) Unknown or little known species of suggested potential: *Desmodium strigillosum, D. styracifolium, D. gangeticum, D. sequax, D. velutinum, Codariocalyx gyroides, Dendrolobium sp., Dicerma biarticulatum, Henera obordata, Phyllodium sp., Tadehagi spp.*

c) *Little known species of unknown potential Uraria spp., Dunbaria sp. Flemingia sp.* (Schultze-Kraft, 1985).

The commercial herbaceous forage legumes which have potential in South East Asia and South Pacific region have originated from tropical America (Schultze-Kraft 1985). These are:

a) Traditional species of known potential : *Calopogonium mucunoides, Centrosema pubescens, Macroptilium atropurpureum, Stylosanthes guianensis, S. hamata, S. humilis, S. scabra.*

b) Promising non-traditional species : *Arachis pintoi, Centrosema brasilianum, C. macrocarpum, Centrosema spp., Zornia glabra, Z. latifolia, Stylosanthes capitata, S. guianensis var pauciflora, S. macrocephala.*

Bogdan (1977); Skerman (1977) estimated that *Alysicarpus* originates from India while *Lotononis bainesii* and *Lab lab purpureus* are found widely in Africa but so far they have had somewhat limited use. *Neonotonia wightii* is an important African legumes as is *Vigna unguiculata.* These three legumes were provided from African centres as commercial forage legumes (Williams, 1983). The east African legume concentration are located in the moister areas of Kenya, Tanzania and Uganda and contain *Marcotyloma, Cajanus, Vigna* and *Glycine* (Mehra and Magoon, 1974). Parts of tropical Africa are well known for the existence of the legume *Vigna* (Hartley, 1954).

Ceratonia siliqua, Medicago arborea and *Prosopis cineraria* are legumes represented in writings over 2000 years ago as trees and shrubs which have provided valuable fodder for grazing animals. At least 75% of the shrubs and trees of Africa serve as browse plants to some extent, and many of these are nitrogen fixing (Skerman, 1977).

Tropical America is also generally regarded as a major center of diversity of tropical legumes and most of the cultivated species are of tropical American origin (Williams, 1983). *Stylosanthes sp., Centrosema sp., Macroptilium atropurpureum* (Siratro), *Desmodium sp., Calopogonium sp.,* and *Leucaena sp.* are the most important tropical legumes which have been exploited from tropical

America (Bogdan, 1977; Skerman, 1977). *Stylosanthes* and *Centrosema* originated from Southern Brazil (Burt and Reid, 1974).

Hartley (1954) has described the distribution of the tropical genera *Desmodium* and *Phaseolus,* both of which contain important pasture species which are found in the Southern American countries of Bolivia, Paraguay, and Southern Brazil. Parts of Central and South America are rich in species of *Centrosema, Stylosanthes* and *Arachis.*

The main advances in pasture improvement in Latin America, Africa and Australia have come from the introduction and exploitation of a germplasm to a new area of naturalization or acclimatisation. For example Australia has been entirely dependent on the introduction of legume species from overseas (Whiteman, 1980) and Latin American legumes have provided the base for developments in Asia, Oceania and Africa.

According to Brewbaker (1985) many non-nodulated trees of natural forests can serve as excellent sources of fodder for the browsing animal e.g.: *Artocarpus, Azidirachta, Brocineum, Ficus* and others. These species can be used economically as a high protein fodder without the necessity of having to use N fertilizer which is more productive if allocated directly to grasses.

Skerman (1977) has summarized the best known forage legumes which are available as cultivars (Table 2.4).

Table 2.4. Origin of principal forage legumes (Skerman, 1977).

Genus	Species	Origin	No. Species In Genus	Distribution
Aeschynomene	*americana*	U.S.A	250	America
	falcata	Paraguay		
Alysicarpus	*vaginalis*	U.S.A.	30	Pantropics
Arachis	*glabrata*	Paraguay	20-30	S. America
Calopogonium	*mucunoides*	Tropical America	4	Tropical America
Centrosema	*plumieri*	Tropical America	30-40	Tropical America
	pubescens	Tropical America		
	schiedeanum	Central America		
Desmodium	*canum*	Tropical America	350	Pantropics
	heterophyllum	Tropical America		
	intortum	Central America		
	uncinatum	Brasil		
Lab lab	*purpureus*	E.Africa	2	Africa, India
Lotononis	*bainesii*	S.Africa	100	Africa, India
Macroptilium	*atropurpureum*	Mexico	10	Tropical America
	lathyroides	Tropical America		
Neonotonia	*wightii*	E.Africa	2	Africa, India
Pueraria	*javanica*	S.E.Asia	15	S.E. Asia
Stylosanthes	*guianensis*	Tropical America	30	Tropical America
	hamata	Venezuela Tropical America		
Cajanus	*cajan*	S. Asia	1	S.Asia
Leucaena	*leucocephala*	Central America	40	Tropical

2.2.2 Indonesia

The vast archipelago of Indonesia is the home of a large variety of living plants. This is certainly due, in part, to the variation in rainfall and the variety of physical relief, but it is also the outcome of having a position between two very major continental realms namely Asia and Australia. Some of the plants which evolved in South-East Asia, and in Australia in very different conditions, have spread naturally to Indonesia.

Many new pasture plants, both native and introduced, have entered farming practices in Indonesia in the past. The wider use of these, and earlier selected cultivars, are gradually changing the levels of livestock performance and the nature of farming practices in some parts of Indonesia. The release of new kinds of pasture plants has led to some confusion about the specific environmental conditions to which particular plants are best adapted and the performance characteristics which should be sought.

In the past, sources of forage for animal production have received very little attention because of the farmers' preoccupation with growing food crops. Promising herbaceous legumes have been introduced into plantation crops and in watershed development areas as cultivated forages.

Bonnemaison (1961) observed that in the botanical composition of savannah areas the grazing lands on the large islands are dominated by a few legumes such as *Desmodium heterophyllum.*

Pueraria or *Puero* is a perennial legume native to Indonesia. It appears to have been used in Java first as a green manure crop in coffee and rubber plantations before 1914 (Burkill, 1935) and is now used both as green manure and cover crop in Java (Whyte *et al.* 1953). *Centrosema pubescens* was introduced from tropical South America to Indonesia, probably during the 19th century. It has been used as a green manure or cover crop in rubber, coconut and oil palm plantations during the late 1920's and early 1930's, and was used in preference to *Centrosema plumieri* for this purpose in Indonesia (Burkill, 1935).

Mehra (1984, unpubl.) conducted two surveys on the islands of Nusa Tenggara (Lombok, Sumbawa, Rote, Timor, Flores) and collected the following species: *Aeschynomene americana, Alysicarpus spp, C. pubescens, D. gangeticum, D. heterocarpon, D. laxiflorum, D. styracifolium, Pseudarthria viscida, Pueraria phaseoloides* and *Uraria lagopodoides.* Mehra (1984, unpubl.) found *A. americana, Aeschynomene sp., C. pubescens, D. heterophyllum, D. styracifolium, P. viscida, P.phaseoloides* growing in Southeast Sulawesi as native and naturalized legumes.

2.3. COLLECTION AND EVALUATION OF GERMPLASM

2.3.1. Collection of germplasm

The most important reasons for undertaking plant collection are to seek new forage germplasm and to preserve endangered species. In addition, collection provides native species for exchange and for the improvement of native pastures of low quality (Strickland *et al.* 1980). It has been suggested by Isbell and Burt (1980) that the aims of plant collection missions are to collect and observe plants in their native habitats and to record their edaphic, climate, and ecological relationships.

Prior planning, sampling the variation between and within species; collecting, temporarily storing and maintaining plants and seeds; collecting root nodules; collecting herbarium specimens and characterizing the environments are all important practical considerations in undertaking collecting missions (Burt *et al.* 1979). Evaluation of new plant accessions begins at the moment of collection by an ecological study of the accession in its native habitat (Burt *et al.* 1979).

Large germplasm collections of tropical legumes are held by a few research centres, i.e.: Commonwealth Scientific and Industrial Research Organization (CSIRO); Australia; Centre International de Agricultura Tropical (CIAT). Colombia, Empresa Brasileira de Pesquisa Agropecuaria (EMBRAPA), Brazil (Williams, 1983) and International Board For Plant Genetic Resources (IBPGR), Asia; and Lembaga Biologi Nasional Bogor, Indonesia.

A number of tropical germplasm collection have been made since 1970. A reconnaissance legume collection mission was undertaken to Southern Africa and Madagascar in the period February to June 1970 by Staples (1970). The following genera were collected. *Alysicarpus, Atylosia, Dolichos, Macrotyloma, Vigna, Rhynchosia, Stylosanthes,* and *Zornia*. Reid (1977) collected *Centrosema virginianum, C. plumieri, Calopogonium mucunoides, Alysicarpus vaginalis, Stylosanthes hamata, Neonotonia wightii* and *Vigna sp.* in Cuba, *Stylosanthes guianensis, Centrosema virginianum, Macroptilium lathyroides* and *Zornia latifolia* in *Argentina* and *Stylosanthes capitata, S. guianensis, S. humilis, S. viscosa, Desmodium barbatum, Centrosema pubescens, C. plumieri, Zornia diphylla* and *Arachis sp.* were collected in Brasil.

In another collection mission about 1250 accessions of genera such as *Acacia, Aeschynomene, Centrosema, Desmodium, Macroptilium* and *Stylosanthes* were assembled in Mexico by Reid (1982).

Germplasm collection expeditions have been carried out in South East Asia since 1979 (Schultze-Kraft, 1985), the best known native accessions collected were *Pueraria phaseoloides, Desmodium heterocarpon, D. heterophyllum* and *D. ovalifolium.*

Winter *et al.* (1985) reported that approximately 5000 accessions have been collected specifically for the semi-arid tropics in Australia and that less than half of these have been so far been evaluated. Details of some important collection expeditions are listed in Table 2.5.

Table 2.5. Details of major collections of pasture plants that have contained material suitable for the semi-arid tropics of North West Australia which may also be suitable for East Indonesia.

Collector	Year	Organization	Principal countries	Principal genera	Collection
Hartley, W.	1947-48	CSIRO	Brazil, Paraguay and Argentina	*Arachis,Paspalum,* Stylosanthes	Mainly sub tropical
Miles, J.F.	1952	CSIRO	East and Southern Africa	*Pennisetum, Panicum*	Mainly subtropical
McKee, H.S.	1963-64	CSIRO	Central America	*Stylsanthes, Desmodium*	Mainly tropical
Norris, D.O.	1964-65	CSIRO	Brazil, West Indies	*Stylosanthes, Desmodium*	Mainly subtropical
Atkinson, W.	1965	NSW Dept Agriculture	South America	*Desmodium, Phaseolus, Stylosanthes*	Mainly subtropical
Williams, R.J	1965	CSIRO	Brazil, Bolivia. Paraguay	*Desmodium, Stylosanthes Phaseolus, Paspalum, Centrosema*	Mainly subtropical
Grof, B.	1966	Qld Dept Primary Ind.	Central S. America	*Stylosanthes, Centrosema*	Mainly tropical
Skerman, P.J.	1968	Univ of. Queensland	Tanzania	*Cenchrus, Neonotonia*	Mainly tropical
Staples, I.B.	1970	Qld dept Primary Ind	East/Central South Africa	*Macrotyloma, Vigna*	Mainly subtropical
Miller, I.	1971	N.T.Admin	Mexico/Venezuela, Colombia	*Desmodium, Macroptilium, Stylosanthes, Centrosema*	Mainly tropical
Burt, R.L.	1973	CSIRO	Brazil, Venezuela, Panama	*Desmodium, Macroptilium, Stylosanthes, Centrosema*	Mainly tropical
Strickland, R.	1971	CSIRO	East/Central/South Africa	*Cenchrus, Panicum, Digitaria, Vigna*	Mainly subtropical
Reid, R.	1977	CSIRO	Cuba, Argentina, Brazil	*Stylosanthes, Desmodium, Macroptilium*	Mainly subtropical
Cameron,D.F.	1980	CSIRO	Brazil	*Stylosanthes, Centrosema*	Mainly tropical
Reid, R.	1979-81	CSIRO	Mexico, Colombia	*Leucaena, Macroptilium Desmanthus, Stylosanthes, Centrosema*	Mainly subtropical

2.3.2. Evaluation of germplasm

Ivory (1985) has suggested that the primary objective of forage plant evaluation is to identify forages which under defined management can increase animal productivity when introduced into an existing farming system.

Ivory (1985) has presented a general scheme for evaluation of forage species in a new environment as shown in Figure 2.1.

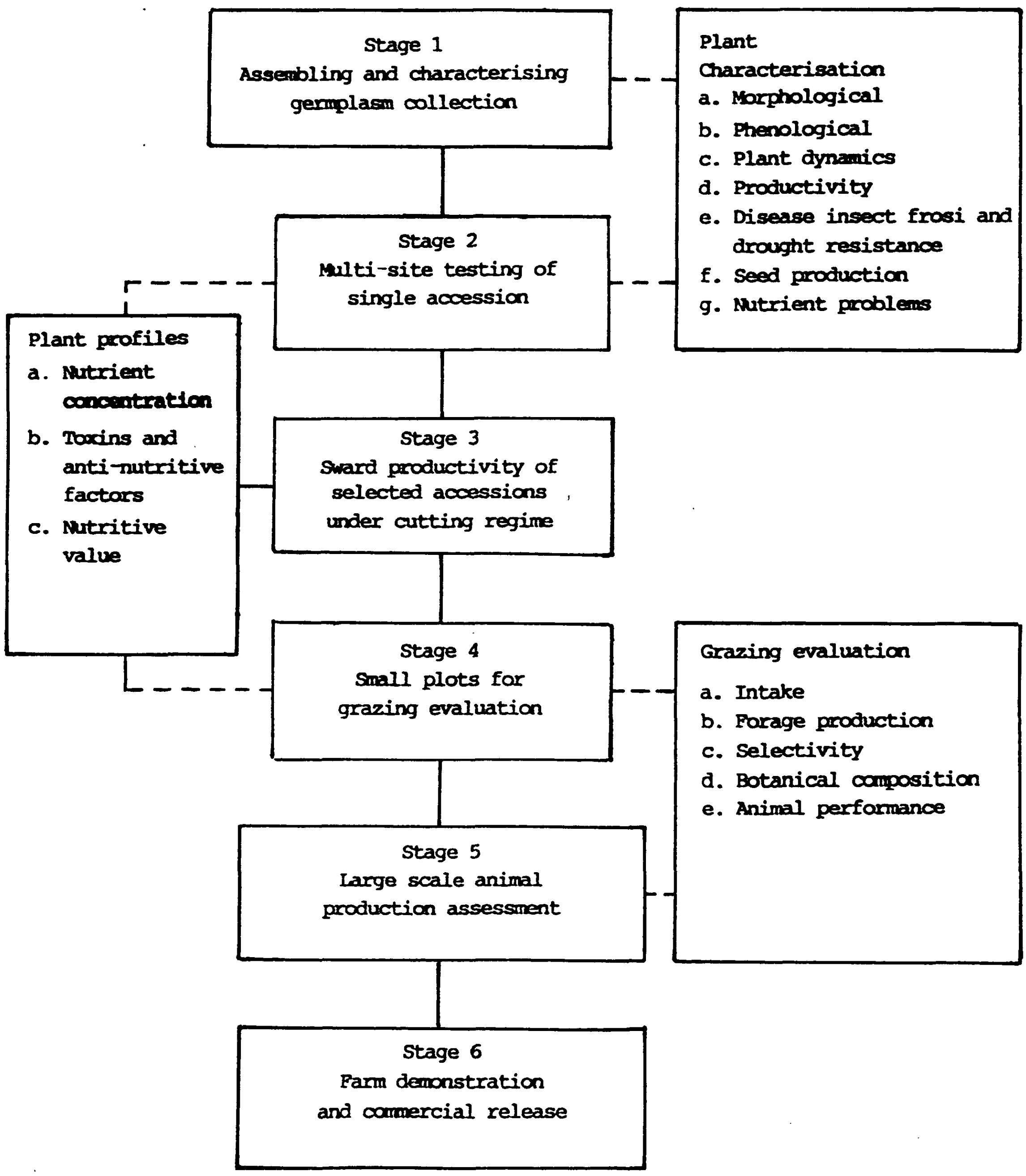

Figure 2.1. General scheme for evaluation of forage species in a new environment (Ivory 1985).

The aims of plant introduction are to provide species for direct use in sown pasture or for use in breeding programmes (Whiteman, 1980).

The evaluation of new species may be divided into four phases; initial assessment (nursery rows); determination of areas of adaptation (observation plots); evaluation in areas of adaptation (quantitative experiments); and final assessment (grazing or cutting experiments) (Cameron and Mc Ivor, 1980). Ivory (1985) noted that the important methods of evaluation are glasshouse, nursery, small sward and grazing.

2.3.3. Glasshouse evaluation

Evaluation in the glasshouse is useful for studying both the variation in mineral nutrient requirements within and between legume species and the variation in affinities between legume accessions and Rhizobium strains (Edye *et al.* 1974). Also the morphological and agronomic characters can be measured with a view to reducing the total population to a few like groups (Burt and Williams, 1979).

2.3.4. Nursery evaluation

The objective of this type of evaluation is to reduce a large number of plant accessions to a small group of superior species which have some potential for use as commercial forage plants (Ivory, 1985), it may be possible also to study factors of special importance e.g. establishment requirements, fertiliser responses (Cameron and Mc Ivor, 1980). In these studies it is important to evaluate the accessions under soil fertility conditions similar to those used by farmers.

2.3.5. Small sward evaluation

Cutting trials are useful for measuring potential herbage yield, season of growth, and for providing samples for estimates of forage quality (Cameron and Mc Ivor, 1980). This evaluation aims to assess the productivity of a select group from nursery evaluation (Ivory, 1985).

2.3.6. Grazing evaluation

The objective of this evaluation is to provide additional information on the productivity, persistence and intake of a small group of elite accessions under grazing (Ivory, 1985). One method of evaluation used is to sow individual swards of all accession within one paddock and rotationally graze to replicate paddocks (Monzote *et al.* 1979).

Legume evaluation work has been conducted in a range of environments in Columbia and other countries of Tropical America and within the International Tropical Pasture Evaluation Network (RIEPT) and several new legumes have shown promise (CIAT, 1980-1984) includes *Arachis pintoi, Centrosema brasilianum, C. macrocarpum, Centrosema spp, Zornia glabra, Z. latifolia, Stylosanthes capitata, S. macrocephala* and *S. guianensis*.

2.4. CHARACTERISTICS OF IMPORTANT NATIVE AND INTRODUCED LEGUMES

Each legume species has its own characteristic and survival mechanisms which are important if the plant is to succeed under variable climate and management conditions. In the following section these characteristics are discussed for a selection of native and introduced legumes.

2.4.1. Native species

As the best known native species, *Desmodium sp.* has a variety of characteristics which are exhibited in plants such as *Desmodium heterophyllum* which is native to the tropics of the eastern hemisphere. It's stoloniferous growth habit and shade tolerance makes it well adapted to the humid tropics of Indonesia. Schultze-Kraft (1985) has suggested that *D. heterophyllum* has high productivity and low drought tolerance and requires high soil fertility. This species is tolerant of short term flooding but has no tolerance of salinity. It appears that this species may be a suitable plant for fallowed rice fields.

Desmodium heterocarpon is a slowly establishing perennial with trailing growth and can thrive even under dense shade. It is drought resistant with a deep root system and adapted to poor soils (Rijkebusch, 1967). In Panama this is one of the best wet season legumes which survives the dry season well. It is a heavy seeder but seed collection is difficult.

Desmodium triflorum is a prostrate legume commonly found growing in native pastures in grazing area of Indonesia. It is resistant to drought (Farinas, 1966) and grazing.

Pueraria phaseoloides is a vigorous native species well known as a "traditional" species. Schultze-Kraft (1985) has suggested that in less humid environments, lack of drought tolerance is a major constraint to commercialization of this species. He found that in an area with 2000 mm annual rainfall in Columbia *P. phaseoloides* defoliates completely when the dry season extends beyond 2.5 months. This species has also been reported to have higher K and Mg requirements which could be a constraint in poorer oxisol and ultisol soils.

Alysicarpus vaginalis is a prostrate legume which is often found growing in public grazing areas of Indonesia. Skerman (1977) reports that it does not tolerate wetlands and adequate drainage is a requirement for good growth. It prefers sandy loams, but is very susceptible to nematodes and so is often grown on clay soils. It grows commonly on coral sand in Tanzania and Tahiti and in clay loams on basaltic slopes in Fiji (Payne, 1955). *A. vaginalis* responded well to nitrogen on the Cununurra clay in Northern Australia, but nitrogen depressed its growth in the Cockatoo sand (Parbery, 1967).

Calopogonium mucunoides is a versatile and adaptable native legume which has spread very widely in Indonesia. It will grow up to 2000 m in Colombia (Crowder, 1960) but prefers lower elevations. This species is adapted to the hotter and wetter tropics (Skerman, 1977) with generally at least 1125 mm to 1500 mm rainfall (Verdcourt, 1979). It is adapted to a wide range of soil textures and grows well at pH 4.5-5.0 and gives marked response in leaf size to application of superphosphate (Skerman, 1977) Calopo tolerates flooding, establishes easily and is very quick growing under suitable conditions where it will form a dense cover within months of sowing (Bryant and Slater, 1974).

Aeschynomene americana is the most widely adapted of the native legumes in public grazing area of Indonesia. Hodges *et al.* (1982) reported that this legumes is well adapted as a warm season annual legume in Florida. It is a self-regenerating annual tolerant of waterlogging which can persist under prolonged wet soil conditions. It grows well in areas with more than 1250 mm annual rainfall and establishes easily on prepared seedbeds.

Centrosema pubescens grows as a naturalized legume in Indonesia. It will grow on a wide range of soils, from sandy loams to clay, grows vigorously on alluvial soils and hill soils of Fiji (Skerman, 1977) but is rather slow to establish due to low seedling vigour.

2.4.2. Introduced legumes

Clitoria ternatea is a perennial legume which grows in Indonesia as an introduced legume. It grows as an ornamental in the warmer parts of the word. Rainfall requirement ranges from a low of 400 mm but the best performance is in the areas of 1500 mm. It performs well under irrigation but has been found to be fairly drought tolerant in Zambia (Parbery, 1967; Van Rensburg, 1967). It adapts to a wide range of soil conditions from sand to deep alluvial loams and heavy black cracking clays (Lee, 1954). It has good seedling vigour producing a dense cover 4 to 6 months after seeding (Skerman, 1977).

Vigna unguiculata is one of the legumes most tolerant to drought conditions and is used as a grazing and food crop down to 400 mm annual rainfall. It has a vigorous seedling (Skerman, 1977) and it adapts to a wide range of soil pH but prefers slightly acid to slightly alkaline soils. It has little salinity tolerance (Johnson, 1970).

Nyoku (1958) has stated that it requires a day length of less than 12 1/2 hours for flowering in Nigeria, where it can produce from 760 to 2800 kg/ha of seed yield.

Vigna vexillata has been reported as an annual legume with good seedling vigour which grows well in the wet season and is effective in weed suppression (Skerman, 1977). Skerman (1977) reports that it produces seed in 91 days on sandy soil up to 126 days on clay soils. Van Rensburg (1967) found that *V. vexillata* can produce 1.442 kg DM/ha, but made no regrowth after cutting.

Macrotyloma axillare has a wide tolerance from sands to clays in well drained soils but requires a pH in excess of 5.5 (Skerman, 1977). It is not tolerant to waterlogging (Farinas, 1966) and will grow from cuttings.

Calopogonium mucunoides can be cut at intervals of 8 weeks (Crowder, 1960). Grazing should not begin until the plants begin to grow erect; then rotationally at intervals of 8 to 12 weeks (Skerman, 1977).

Macroptilium lathyroides is adapted to a wide range of climates with rainfall from 375 to 3000 mm and is fairly tolerant of waterlogging (Skerman, 1977). It does not persist under continuous or heavy grazing and dry matter yield of 5439 kg/ha in a mixed pasture with *Paspalum commersonii* has been recorded (Crowder, 1960) as well as a yield of 15 t/ha green material when cut at a height of 1.25 to 1.5 m in Colombia.

Lab lab purpureus grows well on a wide range of soils under rainfall as low as 500 mm (Verdcourt, 1979). Diatloff (1967) reported that it had poor growth on poor sandy soils, where uninoculated plants yielded 203 kg/ha of dry matter compared with 1611 kg/ha when inoculated. It does not stand heavy defoliation but if only the leaf is taken it will provide two to three grazings in a season (Skerman, 1977). Neme (1970, unpublished) advised that it should not be cut below 25 cm.

Stylosanthes guianensis is both a perennial and an annual in the subtropics. It is commonly grown on sandy soils derived from granite, sandstone or coral, of low phosphorus status and occurs from sea level to 1800 m (Skerman, 1977), in rainfall areas of 284 mm to 1000 mm. *Stylosanthes guianensis* tolerates highly acid soils and nodulates at pH 4.0 (Davies and Hutton, 1970) but it is not tolerant of salinity. It is slow to establish (Risopoulos, 1966), with slow growth up to 6 weeks (Oke, 1967). It requires a day length of less than 12 hours for flowering with best results at 10 hours, 't Mannetje (1965).

2.5. MANAGEMENT OF FORAGE LEGUMES

2.5.1. Persistence

Persistence is an essential character in maintaining high yields of forage legumes. Williams (1968) has suggested that the following characteristics may be required (1) seedling vigour; (2) resistance to grazing; (3) survival through drought or cold; (4) disease resistance, and (5) regeneration from seed. In this regard he suggested that the frequent failure of legumes like *Centrosema pubescens* and *Neonotonia wightii* can often be attributed to poor seedling vigour. Serpa (1966) has shown that germination is hindered by an impermeable seed coat, which can act as survival mechanism.

Resistance to grazing is particularly important. Williams *et al.* (1976) have suggested that perennials, like *Calopogonium mucunoides* and *Pueraria javanica*, rarely persist in the subtropics because of frosts. *Centrosema pubescens*, while perennating as spaced plants and in spaced row conditions in Southern Queensland has only a short active growing season there and persists poorly in pastures.

The twining or tall growth habit of many herbaceous tropical legumes may reduce their capacity to regenerate after grazing. It has been shown that frequent severe defoliation of twinning legumes will seriously reduce their vigour and may kill them (Jones, 1967, 1974, Whiteman, 1969). For this reason rotational grazing is prescribed for them. The prostrate rooted stems of *Lotononis bainesii* and the tuberous and rhizomatous habit of some perennial *Arachis sp.* may contribute to their persistence.

Centro is highly persistent in grazed swards, but its value is limited by its sensitivity to low temperatures when growth and nitrogen fixation decline and by the susceptibility to plant pathogens and insects (Bryant and Slater, 1974).

Neonotonia sp. is preferentially grazed and should be frequently rested to allow regrowth (Skerman, 1977).

Desmodium sp. is not preferentially grazed in short grazing periods with *Setaria spp* and *Pueraria phaseoloides* has poor persistence under grazing in the humid tropics (Williams, 1968).

Clitoria ternatea has good seedling vigour and grows well with tall grasses. Furthermore, Van Rensburg (1967) obtained good yield of *C. ternatea* in Zambia in the first year but thereafter yields declined.

Aeschynomene americana forms leafy swards which can produce ample seed for regeneration. Hopkinson (1983) found that a mid season flowering type under grazing can produce seed yields of between 1500-2800 kg/ha.

Desmodium heterophyllum shows best performance in mixtures with short grass types (Skerman, 1977). *Macrotyloma axillare* has a fairly strong seedling (Skerman, 1977), and it grows well in mixtures with *Setaria, Paspalum,* and *Panicum sp.* and with *Chloris gayana*. It has also been found to produce well with *Desmodium sp., Neonotonia* and Siratro (Luck and Douglas, 1966) and has excellent ability to compete with weeds (Tutt and Luck, 1969).

Lab lab purpureus is usually sown alone or in widely spaced maize or sorghum rows because of its slow early growth and short life and so it should not be subject to weed competition (Skerman, 1977).

This review of literature has highlighted the wide range of legume germplasm that has been collected and evaluated in many parts of the world. Although Indonesia is a centre of diversity of some important genera, few systematic collection and evaluation missions have been undertaken. Because of the importance of such species in ruminant production systems in Indonesia, such a study is warranted and this is the subject of this thesis.

CHAPTER 3

COLLECTION OF NATIVE LEGUMES IN SOUTH SULAWESI

3.1. INTRODUCTION

South Sulawesi is one of the areas of Indonesia which is relatively rich in native and naturalized forage legume genetic resources. Two genera which frequently occur in native grasslands are *Desmodium* and *Uraria*. Only a few germplasm collections of forage legumes have been assembled in Indonesia. Species of *Desmodium* were collected in S. Sulawesi, while *Dolichos, Aeschynomene* and *Vigna* were collected in W. Java (Lawn, 1975). *Desmodium heterophyllum* has been collected from grazing areas in Nusa Tenggara (Bonnemaison, 1961). One recent collection trip was made by Mehra (1986, unpublished) who collected species of *Desmodium, Aeschynomene, Alisycarpus, Centrosema, Pseudarthria, Pueraria, Teramnus* and *Uraria,* from the region of Nusa Tenggara, South East, Central and North Sulawesi.

3.2. COLLECTION TOUR

South Sulawesi lies between 0°12' N and 8°S latitude and between 116° 48' to 122° 36' E longitude. A collection survey was undertaken in South Sulawesi during the period of April to May 1983. The main objective of the survey was to collect germplasm of indigenous legume species. The collection tour was undertaken by the author and Dr. D.A. Ivory.

The sampling sites were selected in different edaphic and climate zones so as to sample both macro and micro geographic components of variation. The sampling strategy consisted of the selection of a collection site every 15-20 km. These sites included abandoned land, edges of agricultural fields, teak plantations, grasslands and roadsides.

The location of these collection sites is presented in Figure 3.1. Details of the collection sites are presented in Table 3.2.

3.3. RESULTS

The most interesting genera collected were *Alysicarpus, Desmodium, Smithia* and *Uraria.* A total of 29 accessions from 6 genera were collected (table 3.1).

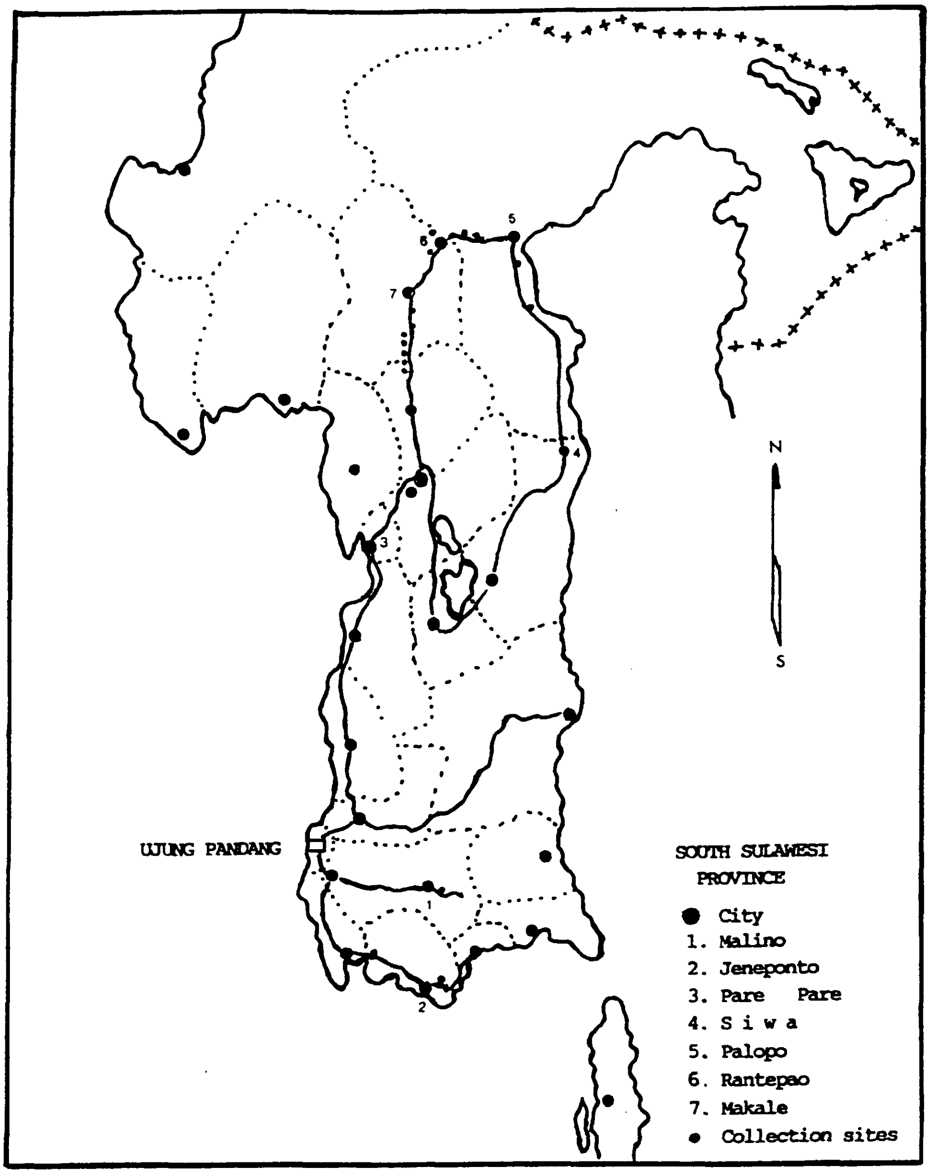

Figure 3.1. The route taken on the legume collection trips in South Sulawesi.

Table 3.1. Genera, species and number of accession collected in South Sulawesi.

	Genera	Species	Number Collected
	Alysicarpus	*A. vaginalis*	6
	Atylosia	*A. scarabaeoides*	1
	Desmodium	*Desmodium spp.*	6
		D. heterocarpon	6
		D. heterophyllum	2
	Smithia	*S. conferta*	1
	Uraria	*U. lagopodoides*	6
	Vigna	*V. triloba*	1
Total:	6	8	29

Table 3.2. Collection location, soil, climate and species collected in South Sulawesi.

Site No.	Collection Site	Species Collected	Soil	Climate*
1.	5 km Malino	-*Desmodium sp*	-	-
2.	29 km West Jeneponto	- *Alysicarpus vaginalis*	-	D-4
3.	56 km South Ujung Pandang	- *Alycarpus vaginalis*	-	D-3
4.	215 km N.E. Ujung Pandang	- *Desmodium heterocarpon*	pH 4.5	D-2
		- *Alysicarpus vaginalis*	pH 6.0	D-2
5.	212 km N.E. Ujung Pandang	-*Desmodium sp*	Clay loam pH 4.0	D-2
		-*Desmodium.sp*		
6.	204 km N.E. Ujung Pandang	- *Uraria lagopodoides*	Clay loam pH 4.0	D-2
		- *Uraria lagopodoides*	Sandy loam pH 5.0	D-2
		- *Uraria lagopodoides*	pH 5.0	C-2
		- *Desmodium heterocarpon*	pH 4.0	C-2
7.	201 km N.E. Ujung Pandang	- *Alysicarpus vaginalis*	pH 5.0	C-2
		- *Desmodium sp*	Alluvial	C-2
8.	147 km N.E. Ujung Pandang	- *Uraria lagopodoides*	Lime stone Clay loam pH 7.5	C-2
		- *Atylosia scarabaeoides*	Lime stone Clay loam pH 7.5	C-2
9.	23 km S. Makale	- *Uraria lagopodoides*	Clay loam pH 6.0	D-2
		- *Alysicarpus vaginalis*	Clay loam pH 6.0	D-2
		- *Vigna triloba*	Clay loam pH 6.0	D-2
10.	33 km S. Makale	- *Desmodium sp*	-	D-2
11.	4 km N. Rantepao	- *Desmodium heterophyllum*	-	B-1
12.	12 km N. Rantepao	- *Smithia conferta*	-	-
		- *Desmodium heterocarpon*	-	B-1
13.	12 km S. Rantepao	- *Desmodium heterocarpon*	-	B-1
14.	29 km E. Rantepao	- *Desmodium heterocarpon*	-	B-1
		- *Desmodium sp*	-	B-1

Site No.	Collection Site	Species Collected	Soil	Climate*
15.	31 km E. Rantepao	- *Desmodium heterophyllum*	-	B-1
16.	16 km S. Palopo	- *Desmodium heterocarpon*	-	C-1
		- *Uraria lagopodoides*	-	C-1
17.	73 km S. Palopo	- *Alysicarpus vaginalis*	-	C-1

*) According to Oldeman and Sjarifuddin (1977):

	No. of months			No. of months	
	wet	dry		wet	dry
B1=	7-9	<2	D2=	3-4	2-3
C1=	5-6	<2	D3=	3-4	3-5
C2=	5-6	2-3	D4=	3-4	>5

3.3.1. Desmodium

Desmodium sp. was found in most of the collection areas. It was found growing from sea level up to 1250 m at Malino in areas that receive between 2200 and 2500 mm of rainfall annually. It was observed to grow well in a wide range of soils ranging from sands to clay with a pH range from 4 to 8. *D. heterocarpon* and *D. heterophyllum* were collected in grasslands in the South West. These two species were also found in areas where flooding occurs. A number of *Desmodium sp.* were collected from roadsides extending from Makale to east of Rantepao in the North, and to Malino in the South.

3.3.2. Alysicarpus

Alysicarpus vaginalis is well represented in the area as a common constituent of roadside vegetation. It occurs throughout the 2180 to 2430 mm rainfall zone on clay loam soils. It was observed growing commonly in limestone derived soils in areas such as Jeneponto which is only 10 m above sea level and which has an annual rainfall of 900 mm. It was also found in heavily grazed areas. *A. vaginalis* was found in rice fields which had been harvested and it often dominated the bunds.

This species was also collected at an altitude of 800 m at Makale. It is most prevalent in the South West where it often forms the major part of swards.

3.3.3. Uraria

Uraria lagopodoides was collected from grassland areas and on disturbed sites in clay as well as sandy loam soils. This species was observed to grow well at two sites at Palopo at an altitude of 10 m above sea level and as high as 800 m at Makale. The rainfall at these two collection sites is 2180 mm, and 2780 mm.

3.3.4. Smithia

Smithia conferta was found in soaks and swamps in the Makale area. It was collected from an area of high rainfall (4015 mm). It was recorded growing at altitudes from sea level to 700 m. It was observed that it grew well in limestone derived soils.

3.3.5. Vigna

Vigna triloba was the one twining species collected. It appeared to spread by rooting from nodes which came in contact with moist soil. It was collected at an altitude of 800 m near Makale. It was found in disturbed areas in a wide range of soil textures.

3.3.6. Atylosia

From observations *Atylosia scarabaeoides* appears to be a widespread plant. It was found at sea level and at an altitude of 500 m near Makale. If seemed to grow well in a limestone derived clay loam. It was collected in heavily grazed areas but it seemed that animals were avoiding this species.

3.4. DISCUSSION

As suggested by Strickland *et al.* (1980) there are only two methods of assembling a plant collection i.e: correspondence (seed exchange) and field collection. There are several reasons for conducting forage plant collection trips, the most important of which is the observation of native species for the purpose of obtaining information about morphological and agronomic characteristics of these species.

According to Isbell and Burt (1980) observing plants in their native habitats and noting their edaphic, climate, and ecological relationships is important in the search for plants which could be useful in areas other than their place of origin. Therefore the correct procedures need to be employed when surveying. These procedures include detail to prior planning, sampling and collecting methods.

Desmodium sp. were found during the collection trip. This genus has a very wide distribution and well represented throughout South Sulawesi, but is most commonly found in the wet regions. Two of the most common species collected were. *D. heterocarpon* and *D. heterophyllum*. Both of these species were also found by Ivory *et al.* (1984, unpublished). in South to West Sumatera growing vigorously in sand to clay soils with pH 4.7 to 7.2 at altitudes of 50 to 2200 m above sea level. They were also collected in North Sulawesi at altitudes of between 5 to 700 m with an annual rainfall of 1349 to 2325 mm (Reid *et al.* 1986 unpublished). Williams (1983) has suggested that these legumes have been listed as the best known species whose natural distributions extends throughout tropical Asia.

Other legumes which may prove useful include the annuals *A. vaginalis* and *U. lagopodoides.* Both of these grow well at a range of altitudes ranging from 10 to 800 m with an annual rainfall of from 2180 to 2780 mm. These legumes occurred in nearly all sites observed, usually in sands to loams with pH 4 to 7.5. In a lower rainfall area of Jeneponto, with an annual rainfall of about 900 to 1200 mm some accessions of *A. vaginalis* were collected. Some accessions were found in swards in areas protected from continuous grazing whilst others were from areas heavily grazed by goats and buffaloes. This legumes was also collected by Mehra (1986, unpublished) in a similar climatic area in the Nusa Tenggara region and he also found that *A. vaginalis* is native to S.E. Asia (Mehra and Magoon, 1974), and also grown as a cover crops in rubber plantations in Malaysia (Martin and Torrsell, 1974).

Collection of the species *Smithia conferta, Vigna triloba* and *Atylosia scarabaeoides* were made. These species are uncommon throughout S. Sulawesi and were found in the humid tropical areas of the mountainous zone (about 500 at 800 m) in the Makale area which has a high annual rainfall of 2200-4000 mm. Generally these species grown vigorously in limestone derived clay loams.

There is little information about the legumes collected from other parts of Indonesia and only *Smithia conferta* was collected by Reid *et al.* (1986 unpubl.) from a loam soil of pH 7 in Central Sulawesi at an altitude of about 200 m with 1500 mm annual rainfall. *A. scarabaeoides* was collected by Ivory *et al.* (1984 unpubl.) at a lower altitude in South Sumatera in sandy soils with pH 8.9 and at a similar altitude in West Timor on a yellow podzolic loam (Robert, 1985).

It is difficult to determine the origin of the *Alysicarpus, Centrosema, Pseudarthria, Pueraria, Teramnus* with certainty but Arora and Chandel (1972) have identified India as a rich source of humid tropical legumes.

The 29 accessions which have been collected illustrated the variety of legumes present in South Sulawesi and suggests that this area may be a source of potentially important forage legumes.

CHAPTER 4

EVALUATION OF INTRODUCED HERBACEOUS LEGUMES

4.1. INTRODUCTION

Indonesia, like many other developing countries where ruminants are a major component of economic development needs to find ways to increase animal production. Successful livestock production principally depends on the availability of good quality forages. South Sulawesi has the potential to greatly increase its livestock production provided that productive pastures can be established and maintained on a large scale.

In this connection there is a need to develop pasture legumes for the tropics (Hutton, 1965). The different soil types, climates and management systems encountered in the tropics provide a wide range of ecological environments, and each of the agroecological zone requires adapted pasture species.

Therefore there is a need to evaluate introduced as well as native germplasm. This chapter reports on a two year evaluation of introduced herbaceous legumes at Gowa, South Sulawesi.

4.2. MATERIALS AND METHODS

4.2.1. Treatment and Design

A total of 62 herbaceous legume accessions representing 16 genera and 50 species (Table 4.1.) were evaluated between February 1983 and February 1985 at the Animal Husbandry Research Institute, Sub Station at Gowa, South Sulawesi. The accessions were selected from the CSIRO collection. The average annual rainfall at Gowa is 2080 mm with five to six months dry season (Rainfall <100 mm/month). The soil is Alluvial of pH 6 and low in available sulfur (MacLeod, 1984 unpublished).

Seed was planted in February 1983, in a single row 5 m in length with 3 m between rows. Seeds were classified as small (S); small medium (SM); medium (M) and large (L) as listed in Table 4.1. and seeding rate was determined by seed size. The seeding rate of the four seed size classes were 0.5, 1, 2 and 4 g/plot respectively. Each accession was replicated twice giving total of 170 plots. Before planting, basal fertilizer was applied at the rate (kg/ha) of 45 S and 33 P as sulfur fortified single superphosphate. Half of each plot was fertilized with 50 kg N/ha as Urea to enable assessment of the effectiveness of nodulation. Seed was inoculated with the appropriate rhizobium strain as listed in Table 4.1. immediately prior to planting.

Table 4.1. Herbaceous legume accessions included in the experiment, inoculant used and seed size class of accessions.

Acc. Number	Species	Introduction Number	Rhizobium Strain	Seed size Class
003	*Aeschynomene indica*	26709	CB 756	SM
007	*Alysicarpus longifolius*	79603	CB 278	S
008	*Alysicarpus monilifer*	52359	CB 278	S
009	*Alysicarpus ovalifolium*	CQ 512	CB 278	S
010	*Alysicarpus procumbens*	60619	CB 278	S
011	*Alysicarpus vaginalis*	33216	CB 278	S
112	*Arachis sp.*	ex Maiwa	CB 756	L
013	*Arachis monticola*	CQ 990	CB 756	L
014	*Arachis pusilla*	58116	CB 756	L
015	*Arachis pintoi*	58113	CB 3036	L
016	*Colopogonium mucunoides*	'calopo'	CB 75	M
017	*Cassia rotundifolia*	34721	CB 1483	S
018	*Cassia rotundifolia*	49713	CB 1483	S
020	*Cassia pilosa*	57503	CB 1483	S
021	*Centrosema pubescens*	cv belalto	CB 1923	SM
022	*Centrosema pubescens*	58575	CB 1923	SM
023	*Centrosema schiedeanum*	cv belalto	CB 1923	M
024	*Centrosema pascuorum*	55697	CB 1923	M
054	*Centrosema pascuorum*	cross 2/2	CB 1923	SM
025	*Centrosema schottii*	55705	CB 1923	M
026	*Centrosema acutifolium*	94303	CB 1923	M
027	*Centrosema virginianum*	40057	CB 1923	SM
028	*Centrosema plumieri*	58568	CB 1923	M
029	*Centrosema sagittatum*	82277	CB 1923	M
030	*Clitoria ternatea*	50973	CB 1024	M
043	*Desmodium sp.* (type A)	92555	CB 627	S
044	*Desmodium adscendens*	67221	CB 627	S
045	*Desmodium barbatum*	87818	CB 627	S
046	*Desmodium barbatum*	76072	CB 627	S
049	*Desmodium heterocarpon*	86277	CB 2085	S
104	*Desmodium heterophyllum*	cv Johnstone	CB 627	S
051	*Desmodium uncinatum*	cv Silverleaf	CB 627	S
056	*Lab lab purpureus*	cv Rongai	CB 1024	L
062	*Macroptilium atropurpureum*	cv Siratro	CB 756	SM
063	*Macroptilium atropurpureum*	CQ 1382	CB 756	SM
064	*Macroptilium lathyroides*	cv Murray	CB 756	SM

Table 4.1 Continued

Acc. Number	Species	Introduction Number	Rhizobium Strain	Seed size Class
065	*Macroptilium lathyroides*	27766	CB 756	SM
066	*Macroptilium bracteatum*	49747	CB 756	SM
067	*Macroptilium martii*	55786	CB 1717	SM
068	*Macroptilium sp.*	78451	CB 756	S
069	*Macroptilium sp.*	78453	CB 756	S
071	*Macrotyloma axillare*	cv Archer	CB 1024	SM
072	*Macrotyloma uniflorum*	cv Leichardt	CB 1024	M
073	*Macrotyloma africanum*	24972	CB 1024	SM
074	*Macrotyloma daltonii*	60303	CB 1024	M
075	*Neonotonia wightii*	cv Clarence	CB 1913/1918	SM
076	*Neonotonia wightii*	cv Cooper	CB 1913/1918	SM
077	*Neonotonia wightii*	cv Tinaroo	CB 1913/1918	SM
078	*Neonotonia wightii*	cv Malawi	CB 1913/1918	SM
079	*Rhynchosia minima*	36696	CB 1024	SM
080	*Rhynchosia minima*	71865	CB 1024	SM
081	*Rhynchosia hondurensis*	76218	CB 1024	SM
085	*Stylosanthes guianensis*	cv Cook	CB 756	S
088	*Stylosanthes guianensis*	cv Schofield	CB 756	SM
092	*Teramnus uncinatus*	52803	CB 756	SM
094	*Teramnus labialis*	52794	CB 756	SM
097	*Vigna triloba*	50749	CB 756	SM
098	*Vigna oblongifolia*	60430	CB 756	SM
099	*Vigna unguiculata*	60452	CB 756	SM
100	*Vigna vexillata*	17457	CB 756	S
101	*Vigna vexillata*	52908	CB 756	SM
102	*Vigna vexillata*	60454	CB 756	SM

4.2.2. Management

Hand weeding was conducted periodically to ensure purity of plots. All plots were left uncut until the end of November 1983 to allow full expression of growth and reproductive performance of plants and the setting of seed. At the beginning of the rainy season in late November 1983 plots were cut to a height of 10 cm and ratings continued. Because of problems with drying facilities, yield data was unreliable and is not included in this thesis.

4.2.3. Measurements

In order to avoid any confounding due to poor nodulation all measurements were made on the +N half of the plots. Germination counts were conducted on 15th March 1983 and 5th April 1983. Ratings of phenological and agronomic characters were assessed by a visual ranking procedure (Table 4.2). These ratings commenced on 25th April 1983 and subsequently at 4 to 6 weekly intervals. The ratings provided a detailed assessment of plant establishment/ persistence, plant health/vigour, plant yield, disease/pest resistance, drought resistance and reproductive capacity. The methods used here have been described by Ivory *et al.* (1985) and is detailed in Table 4.2.

Multivariate (cluster) analysis was used to categorize the accessions and this analysis was based on morphological and agronomic characteristics of the accessions as recorded in the visual rating. Cluster analyses had previously been applied successfully to group accession performance within species (Edye *et al.*, 1975; Burt *et al.*, 1971; Edye *et al.*, 1976) and had been used extensively in the Forage Research Project to group forage species in plant evaluations (Siregar and Ivory, 1986; Yuhaeni *et al.* 1986).

There are two strategies within classification programs, namely the divisive and agglomerative methods. Ivory *et al.* (1985) compared the two methods and recommended the divisive program for species evaluation. The Eucledian polythetic divisive program (DIPCOM, previously Polidiv) was used in this evaluation and the analysis was undertaken at CSIRO Armidale by Mr. David Hedges. Not all attributes recorded at each rating were used in the analysis since some were repetitive and did not add additional information in respect of the performance of the accessions. For example, data for the same attribute recorded at different observation times could often be described adequately by the mean value or a single value for selected periods of time. The attributes used in the cluster analysis were mean of number of plants established in the first and second year (i.e. seedling recruitment), number of mature plants present at the end of year 2/number present at the end of year 1, in the second year (perenniality index), maximum colour rating, yield performance in the wet and dry seasons in both years and mean yield, mean and maximum disease rating, mean and maximum seed rating, drought susceptibility, mean flowering and mature seed, mean and maximum seed yield (Table 4.3).

Table 4.2. Agronomic parameters, plant attributes and measurement criteria used in the visual ratings.

Agronomic parameter	Plant attributes	Numerical range	Criteria
Plant establishment/ survival	Number of seedlings	0 - 99	
	Number of young plants	0 - 99	Total number of plants in row
	Number of perennial plants	0 - 99	
	Number of dead plants	0 - 99	
Plant health/ vigour	Colour rating	1 - 5	1) Dark green 2) Light green 3) Green yellow 4) Yellow green 5) Yellow
Plant yield	Yield rating	1 - 10	1)Lowest to 10)Highest
	Leaf yield	1 - 10	1)10% leaf to 9) 90 % leaf
Disease/pest	Disease rating	0 - 4	0)Unaffected 1)Evidence 2)Moderate 3)Severe 4)Total
	Disease vector	1 -	Number given for each vector
	Insect rating	0 - 4	0)Unaffected 1)Evidence 2)Moderate 3)Severe 4)Total
	Insect vector	1 - 4	1)Leaf 2)Stem 3)Root 4)Pod
Plant habit	Plant height	0 -	Average for row (cm)
	Plant width	0 -	
Drought	Drought rating	0 - 5	0)Unaffected 1)Wilting
		2-5	Little Moderate Severe or Total leaf senescence
Productive capacity	Flowering	0 or 1	0) No 1) Yes
	Immature seed	0 or 1	0) No 1) Yes
	Mature seed	0 or 1	0) No 1) Yes
	Seed yield rating	0 - 5	0) Nil 1) Very, poor 2) Poor 3) Fair 4) Good 5) Excellent

Table 4.3. The 20 attributes used in the cluster analysis of the introduced herbaceous legume evaluation at Gowa.

No.	Rating attributes
1.	No seedling 1st year
2.	No seedling 2nd year
3.	Perenniality index
4.	Maximum colour
5.	Yield early 1st year
6.	Yield late 1st year
7.	Yield early 2nd year
8.	Yield late 2nd year
9.	Yield early 3rd year
10.	Mean yield
11.	Mean disease
12.	Maximum disease
13.	Mean insect
14.	Maximum insect
15.	Early drought
16.	Late drought
17.	Mean flowering
18.	Mean mature seed
19.	Mean seed yield
20.	Maximum seed yield

During the evaluation, several legumes failed to establish and therefore they were not included in the cluster analysis. A matrix containing 62 legume accessions by 20 agronomic attributes was devised for cluster analysis.

4.3. RESULTS

The mean monthly rainfall recorded at the experimental site is presented in Table 4.4.

Table 4.4. Monthly rainfall (mm) recorded at the experimental site.

	1983		1984	
Month	Rainfall (mm)	No. rain (days)	Rainfall (mm)	No. rain (days)
January	146.1	15	621.6	19
February	81.0	85	95.5	21
March	171.0	13	362.3	18
April	386.4	19	361.6	19
May	127.0	13	54.0	7
June	34.0	7	36.3	4
July	48.0	8	90.2	3
August	0.0	0	79.2	4
September	3.0	1	163.6	6
October	78.0	9	188.8	9
November	303.1	15	253.7	21
December	204.8	15	563.5	20
Total	1582.6	123	3370.3	151

4.3.1. Division of Collection Into Groups

First Division

The first split divided the accessions into groups 2 and 3, reducing the heterogeneity of the population considerably (Figure 4.1). This split was made mainly on the basis of maximum seed yield, mean seed yield and mean plot yield (Table 4.5), and divided the accession into those with a high seed yield and high mean plant yield (group 2) and those with a low seed yield and a low mean plant yield (group 3).

Second Division

Group 2 was further divided into groups 4 and 5 on the basis of mean yield, yield late in the 2nd year (dry season), and yield early in the 3rd year (wet season). Group 5 represents accessions with very high yield, while group 4 has yields intermediate between groups 3 and 5.

Group 3, had low seed and plant yields. Group 7 represents accessions with higher mean seed yield and higher mature seed rating than group 6 while group 6 has less insect damage than group 7.

The division of the above groups was continued up to 15-group levels (Figure 4.1). However, division beyond the 8 group level did not produce a significant reduction in heterogeneity so they are not presented.

Group means of selected agronomic attributes used in the cluster analysis at the 8 group levels are given in Table 4.5 and accessions in each of the 8 groups are listed in Table 4.6.

Table 4.5. Group mean of selected agronomic attributes used in the cluster analysis at the 8 group level.

Rating	Group							
attributes	I	II	III	IV	V	VI	VII	VIII
	(7)[A]	(4)	(9)	(11)	(9)	(9)	(8)	(5)
Yield late 1st year	4.13	4.00	1.89	8.18	4.44	0.18	2.00	2.80
Yield early 3rd year	3.81	4.13	3.28	7.05	8.22	0.00	0.95	5.90
Perenniality index	0.66	0.05	0.57	0.89	0.45	0.00	0.17	0.44
Mean disease	0.97	1.40	0.73	0.71	0.3	0.09	0.23	0.08
Mean insect	0.40	0.40	0.33	0.46	0.48	0.01	0.27	0.40
Early drought	1.81	2.25	2.06	2.55	1.44	0.00	0.50	1.00
Late drought	2.25	3.13	2.60	2.86	1.56	0.00	1.31	0.10
Mean flowering	0.33	0.97	0.83	0.62	0.56	0.00	0.16	0.02
Mean mature seed	0.43	0.95	0.74	0.54	0.34	0.00	0.12	0.00
Maximum seed yield	2.63	4.00	3.78	3.95	2.50	0.00	1.50	0.00

[A]Number in parenthesis indicate the number of accessions in each group

Table 4.6. List of accessions at the 8 group level.

Group	No of accessions	Species	
I	7	*Centrosema schottii*	CPI 55705
		Centrosema virginianum	CPI 40057
		Macroptilium bracteatum	CPI 49747
		Macroptilium martii	CPI 55786
		Vigna vexillata	CPI 60454
		Arachis monticola	CQ 990
		Macrotyloma uniflorum	cv Leichardt
II	4	*Alysicarpus ovalifolium*	CQ 512
		Arachis pusilla	CPI 58116
		Cassia rotundifolia	CPI 34721
		Macroptilium lathyroides	CPI 27766
III	9	*Alysicarpus longifolius*	CPI 79603
		Macroptilium lathyroides	cv Murray
		Teramnus uncinatus	CPI 52803
		Vigna triloba	CPI 50749
		Alysicarpus monilifer	CPI 52359
		Alysicarpus procumbens	CPI 60619
		Alysicarpus vaginalis	CPI 33216
		Desmodium sp.(type A)	CPI 92555
		Desmodium barbatum	CPI 76072
IV	11	*Calopogonium mucunoides*	Belalto 'calopo'
		Cassia pilosa	CPI 57503
		Centrosema pascuorum	CPI 55697
		Vigna vexillata	CPI 17457
		Centrosema pubescens	Belalto 'centro'
		Centrosema pubescens	CPI 58575
		Clitoria ternatea	CPI 50973
		Centrosema pascuorum	cross 2/2
		Macroptilium atropurpureum	cv Siratro
		Macroptilium atropurpureum	CQ 1382
		Rhynchosia minima	CPI 36696

Table 4.6. continued

Group	No of accessions	Species	
V	9	*Arachis pintoi*	CPI 58113
		Centrosema schiedeanum	cv Belalto
		Centrosema plumieri	CPI 58568
		Vigna vexillata	CPI 52908
		Desmodium heterophyllum	cv Johnstone
		Arachis sp.	ex Maiwa
		Desmodium barbatum	CPI 87818
		Neonotonia wightii	cv Cooper
		Rhynchosia minima	CPI 71865
VI	9	*Desmodium heterocarpon*	CPI 86277
		Macroptilium sp.	CPI 78453
		Macrotyloma axillare	cv Ancher
		Macrotyloma africanum	CPI 24972
		Stylosanthes guianensis	cv Cook
		Stylosanthes guianensis	cv Schofield
		Teramnus labialis	CPI 52794
		Desmodium adscendens	CPI 67221
		Macroptilium sp.	CPI 78451
VII	8	*Aeschynomene indica*	CPI 26709
		Cassia rotundifolia	CPI 49713
		Centrosema acutifolium	CPI 94303
		Macrotyloma daltonii	CPI 60303
		Vigna oblongifolia	CPI 60430
		Vigna unguiculata	CPI 60452
		Desmodium uncinatum	cv Silverleaf
		Rhynchosia hondurensis	CPI 76218
VIII	5	*Centrosema sagittatum*	CPI 82277
		Lab lab purpureus	cv Rongai
		Neonotonia wightii	cv Clarence
		Neonotonia wightii	cv Tinaroo
		Neonotonia wightii	cv Malawi

The main attributes of each group at the 8 group level (I-VIII) are discussed below:

Group I: Accessions in group I which included 2 *Centrosema* species (table 4.6) had moderate to low yields (table 4.5) and a perenniality index lower than the *Centrosema* in group IV and V. Flowering and seed yields were low, with moisture stress symptoms evident at times. The disease rating was high and mean insect damage ratings was intermediate.

Group II: Group II included 4 accessions (Table 4.6) with moderate yields. This group contained mostly annuals (perenniality index 0.05), had frequent flowering and high seed production. All accessions in the group recorded high disease but low insect resistance.

Group III: This group contained 9 accessions of mostly *Alysicarpus* species (Table 4.6). It is a low yielding group with plant yield gradually increasing over time. Plants were moderately perennial with high disease but low insect resistance. Flowering was frequent with good seed production.

Group IV: This group was strongly perennial with the exception of *C.pascuorum* and contained 11 accessions (Table 4.6). This was the highest yielding group but some species showed a yield decline over time. Flowering was frequent but with only moderate seed production. Some insect damage was recorded and disease were recorded at times.

Group V: Some of the *Centrosema and Arachis* species were included in this strongly perennial group (Table 4.6). This group had moderate yields overall but yields increased markedly over time. Flowering occurred frequently but seed production was low. Accessions in the group recorded some insect and disease damage but this was slight.

Group VI: Some accessions of *Macroptilium, Stylosanthes, Desmodium and Macrotyloma* (Table 4.6) were included in this annual group. This was the lowest yielding group with very low seed production and all accessions died within one year.

Group VII: This group had a very low perenniality index (0.17) with low yields recorded. Some *Vigna* accessions (Table 4.6) were included in this group with good disease and insect resistance but very low seed production.

Group VIII: This group contained mostly *Neonotonia* accessions (Table 4.6). Accessions in this group were moderately perennial and yield increased from low to good over time but no seed production was recorded.

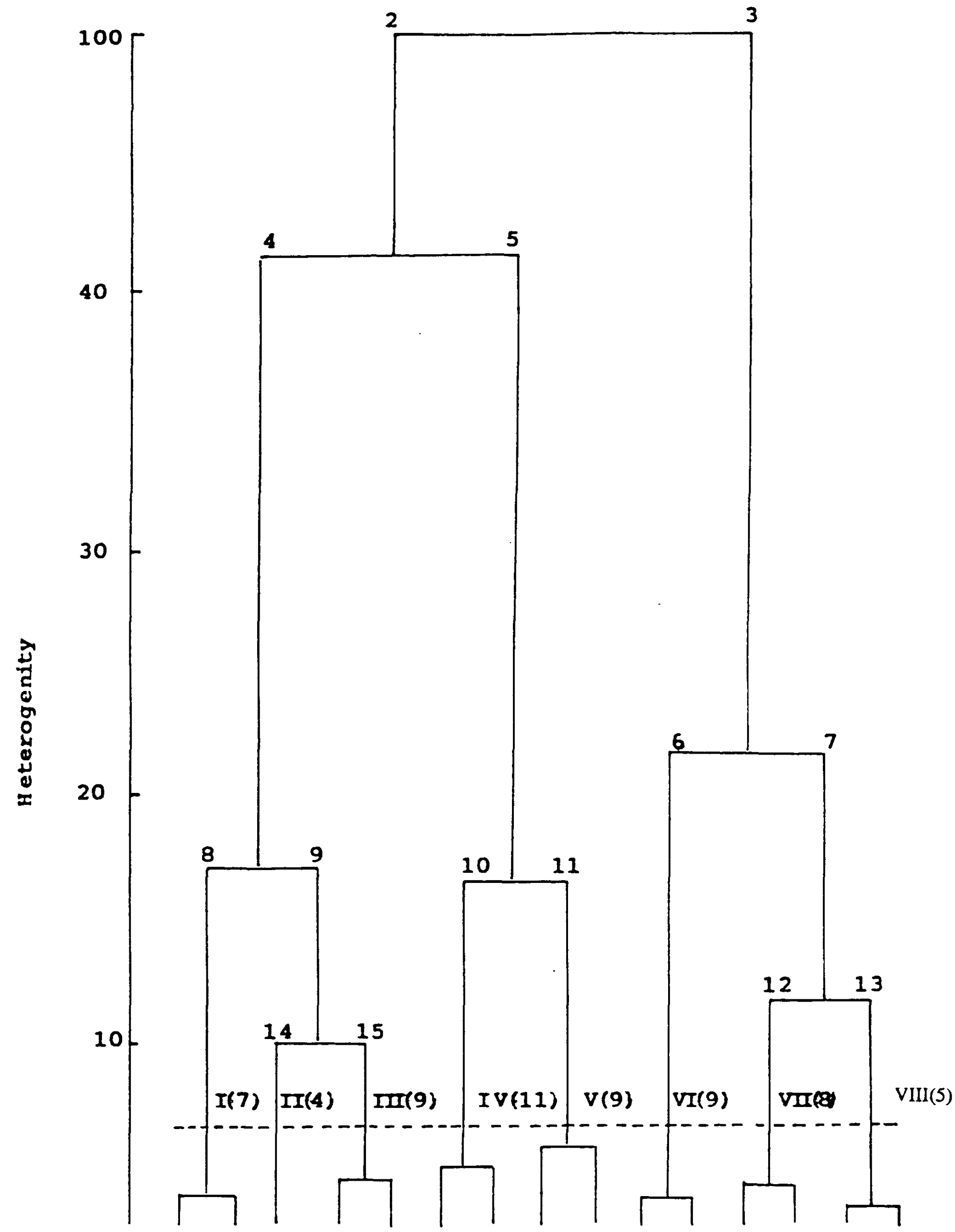

Figure 4.1 Dendrogram of division as defined by cluster analysis (number in parenthesis indicate the number of accessions in each group).

4.4 DISCUSSION

Most accessions of the genus *Centrosema* were assigned to the higher yielding groups (groups I, IV, V, and VIII). *Centrosema pubescens* (group IV) performed well in this evaluation and also in evaluations of the wet tropical lowlands (Bryan, 1968; Barnard, 1969). This plant grows vigorously on alluvial soil (Skerman, 1977). *Centrosema pascuorum* (group IV) has been identified as a tropical legume of considerable promise for the heavy seasonal rainfall areas of Northern Australia (Winter, 1978; Anning, 1982; Clements *et al.* 1984), North Eastern Thailand (Topark-Ngarm and Moolsiri, 1982) and several other countries in Southeast Asia. In the present evaluation it was inferior to *C.pubescens*. Two additional *Centrosema* species from group V (*C.schiedeanum* cv Belalto and *C.plumieri* CPI 58568 are considered worthy of further evaluation. Although yields in these two species were lower than in *C.pubescens* in early assessments they improved markedly with time and are considered to be very compatible with taller grasses.

The two lower growing creeping accessions, *Desmodium heterophyllum* cv Johstone and *Arachis sp* ex Maiwa from group V were both considered to have attributes which combine productivity and persistence and should undergo further testing. The *Arachis sp* evaluated here came from an area in the Northern part of South Sulawesi. It was introduced into observation plots in Indonesia from Australia and, over approximately 10 years between its introduction and this evaluation, it had been spread naturally from the original small plot to an area of approximately $100m^2$.

The plasticity in growth habit of *Cassia pilosa* CPI 57503 (group IV) and its ability to set seed and for the seedlings to re-establish in competition with the parent plant suggests that this accession may fit well into systems with variable management.

Centrosema acutifolium CPI 94303 (group VII) was separated from the successful species of *Centrosema* as it failed to regrow after cutting in November. *Centrosema sagittatum* (group VIII) had low yields in the first year but its yield increased with time and was among the highest yielding at the end of the evaluation.

Neonotonia wightii cv. Cooper formed part of group V while the three other cultivars Clarence, Tinaroo and Malawi belonged to group VIII which was characterized by initial low yields which improved over time. Cultivar 'Cooper' is more drought resistant, more adapted to slightly lower rainfall regions and its seedling vigour is greater than of both 'Clarence' and 'Tinaroo' (Bryant and Slater, 1974) and it is more productive in its first year.

Group IV was the highest yielding group in the first year. Yield was reduced after cutting but had recovered by later scorings. Skerman (1977) suggested that *Centrosema pubescens* was a legume that recovered slowly after defoliation and Crowder (1960) indicated that this legume performed best under at 8 weekly defoliation intervals.

Accessions in group VII had only very low yields which decreased after they were cut in November. Groups I, IV and VII all exhibited a similar pattern of slow regrowth after cutting. This may be attributed the relatively low cutting height of 10 cm used in this study. In an earlier study

Cameron *et al.* (1984) found that *Vigna unguiculata* failed to grow with 1000 mm annual rainfall. Skerman (1977) reported that *Desmodium uncinatum* did not persist on an alluvial soil under an annual rainfall of 2000 mm. *Vigna oblongifolia* which was included in this group failed to produce any regrowth after cutting in the studies of Van Rensburg (1967).

Most of the accessions in the genus *Alysicarpus* showed only moderate yield but they had good seed production. Seedling establishment was high from *Alysicarpus ovalifolium* (group II) in the second year but *Alysicarpus longifolius, Alysicarpus monilifer, Alysicarpus procumbens and Alysicarpus vaginalis* (group III) performed poorly during this experiment. Difficulties in the establishment of *Alysicarpus* can often be attributed to poor seedling vigour.

Accessions in group VI failed to survive the second year of the evaluation. These included *Desmodium heterocarpon* CPI 86277, a species which Van Rensburg (1967) identified as being unproductive and most of the plants in an experiment in Zambia died. The other species in this group is *Stylosanthes guianensis* which has been reported as being a legume slow to establish but grows vigorously to a height of 1 to 1.5m (Skerman, 1977). However, this species does not tolerate cutting lower than 20 cm.

By a process of elimination it has been possible to reduce the total of 62 accessions of introduced legumes tested to a manageable number for further evaluation. Although yield has been a major factor in the elimination process other factors such as seed set, growth habit and disease and insect resistance have also been taken into account. Using this procedure 9 accessions are recommended for further testing:

Calopogonium mucunoides (Calopo)

Centrosema pubescens (Centro)

C. pascuorum CPI 55697

C.schiedeanum cv Belalto

C.plumieri CPI 58568

Macroptilium atropurpureum (cv Siratro)

Cassia pilosa CPI 57568

Desmodium heterophyllum cv Johnstone

Arachis sp ex Maiwa.

CHAPTER 5

EVALUATION OF NATIVE AND SELECTED INTRODUCED LEGUMES IN SOUTH SULAWESI

5.1. INTRODUCTION

Indonesia has the potential to provide a wide range of forages from its native or naturalized legumes. This contention is supported by the collection expedition reported in chapter 3 plus extensive germplasm collections from South, Central and North Sulawesi (Reid and Ivory, 1983) from Sumatera (Ivory and Yuhaeni, 1984) and from Southeast Sulawesi, the islands of Nusa Tenggara and Maluku (Mehra and Magoon, 1974). These collection provided a wide range of material and the evaluation reported in this chapter was undertaken to reduce the large number of accessions to a smaller group of superior accessions under defined management conditions.

5.2. MATERIALS AND METHODS

5.2.1. Location and Climate

A number of native herbaceous legumes, collected from several areas in Indonesia, were evaluated at the Gowa Research Station, South Sulawesi. The site is located 30 km South of Ujung Pandang the capital city of South Sulawesi province (8° 11'S, longitude 119° 29'E). The soil at the site is classified as an alluvial soil of pH 6 with low available sulfur (Mac Leod, 1984 unpublished). Annual rainfall recorded at the experimental site was 3285 mm in 1986 and 1876 mm from January to April in 1987 (Figure 5.1).

5.2.2. Collection

Two hundred and twenty six herbaceous legumes, from 8 genera and 14 species groups (Table 5.1) were selected from the material collected in the expeditions listed in section 5.1.

Information on the legume species was gathered from species collections in the Bogor Herbarium, details of previous plant collection trips, and from books on the leguminous flora of Indonesia. In addition, soils and agroclimatic maps were prepared which were used in the plant collecting trip undertaken in April 1983.

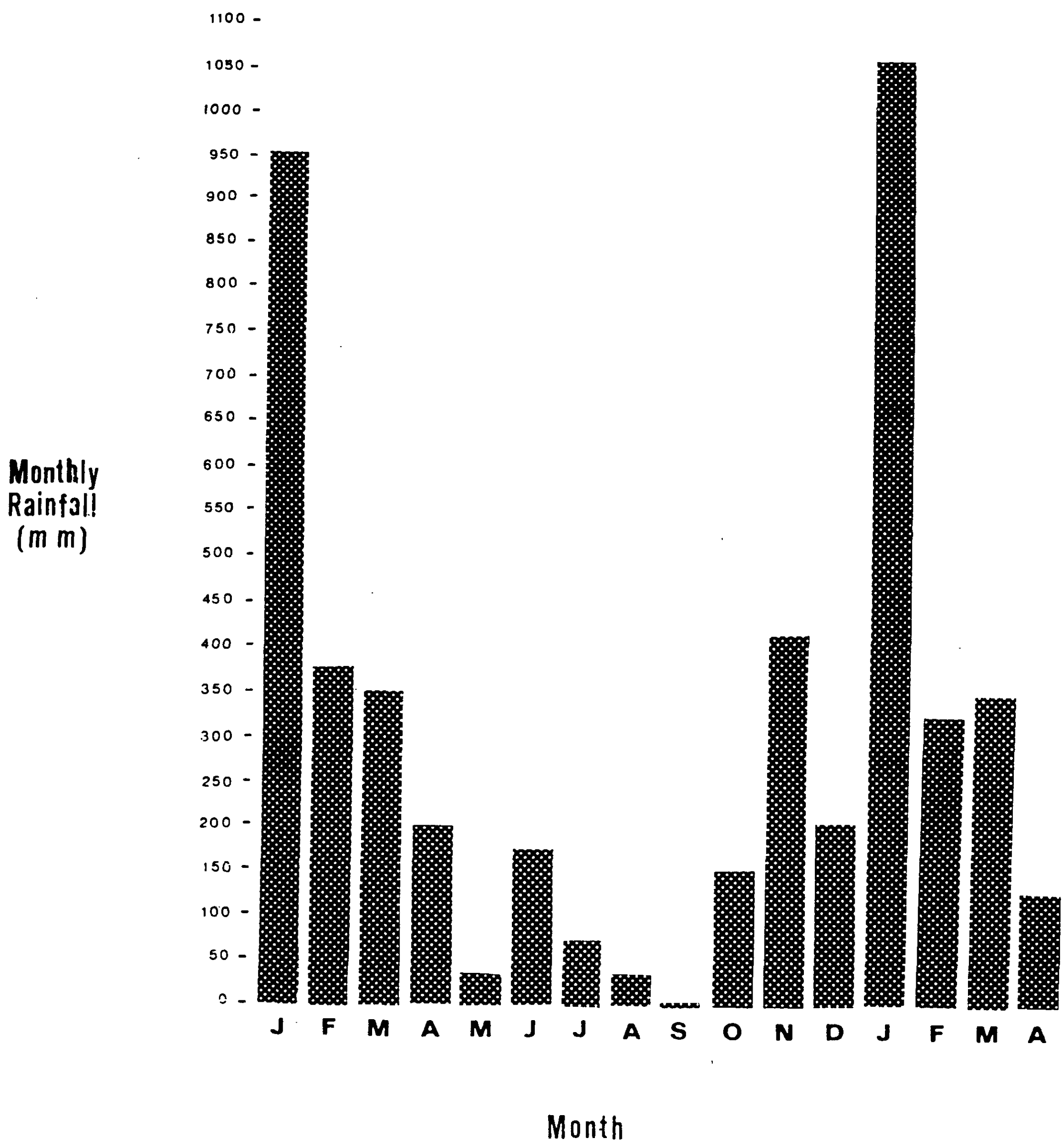

Figure 5.1. The mean monthly rainfall recorded at Gowa station from January 1986 - April 1987.

5.2.3. Nursery

A portion of the seed collected was germinated and planted into plastic bags in a shaded nursery before transplanting to the experimental plots. Seed was germinated in metal trays containing blotting paper soaked in fungicide and enclosed in a plastic bag.

5.2.4. Trial area

When the seedlings were about 10 cm high, they were transplanted in two replicates using single 5 metre rows as plots. The rows were spaced 3 metres apart. Because of the lack of seed for some species the experiment was sown at two different times. The first planting commenced on

February 23, 1986 and contained 62 native accessions plus 8 standards (Table 5.1) and the second planting which contained 164 native accessions, on May 10, 1986. Each plot contained from six to eight plants depending on the availability of seedlings. There were 468 plots in all.

The same fertilisers were applied to the plots as in the experiment reported in Chapter 4.

Table 5.1. Native legume species sown at Gowa Experiment Station.

Species	No. of Accessions Planting 1	Planting 2	Cutting Height (cm)
Aeschynomene americana	13	4	10
Alysicarpus vaginalis	13	1	10
Alysicarpus sp.	0	5	10
Centrosema pubescens	21	13	10
Desmodium gangeticum	15	12	20
Desmodium heterocarpon - short	0	22	7.5
Desmodium heterophyllum	0	6	5
Desmodium laxiflorum	0	13	20
Desmodium styracifolium - short	0	16	7.5
Pseudarthria viscida	0	24	7.5
Pueraria phaseoloides	0	20	10
Pueraria sp.	0	2	10
Teramnus labialis	0	7	10
Uraria lagopodoides	0	19	7.5
Total	**62**	**164**	
Standards			
Neonotonia wightii cv Tinaroo	1	0	10
Macroptilium atropurpureum cv Siratro	1	0	10
Desmodium heterophyllum cv Johnstone	1	0	5
Desmodium triflorum ex Gowa	1	0	5
Centrosema pubescens CPI 58575	1	0	10
Centrosema plumieri CPI 58568	1	0	10
Clitoria ternatea CPI 50973	1	0	20
Arachis sp. ex Maiwa	1	0	5
Total	**70**	**164**	

5.2.5. Rating

A number of agronomic parameters, plant attributes and measurement criteria were used every 3 - 6 weeks throughout the evaluation period to provide a detailed assessment of plant establishment/persistence, plant health/vigour, plant yield, disease pest resistance, drought resistance and reproductive capacity and the criteria used were the same as those for the introduced legumes and are summarized in Table 4.2. The plots were harvested at approximately 5 weekly intervals on 4 occasions between December 1986 and April 1987. The plots were cut to the heights shown in table 5.1. The first rating was made in March 1986 and continued until April 1987.

5.2.6. Data management

All data scored from the experiment was subjected to cluster analysis in the same way as that reported in Chapter 4.

5.3. RESULTS

The mean monthly rainfall at the experimental site is presented in Figure 5.1. Cluster analysis was undertaken separately for each planting and the dendrograms are presented in Figures 5.2 (Planting 1) and 5.4 (Planting 2).

5.3.1. Planting 1

The 16 agronomic attributes used in the cluster analysis were : number of plants established during the evaluation period i.e: seedling establishment, number of mature plants present (perenniality index), drought tolerance, yield rating (harvests on April 17, July 22, September 22, November 11), mean and maximum disease rating, mean and maximum insect rating, mean flowering, mean mature seed, mean and maximum seed yield. These selected attributes were used in cluster analysis to categorize the accessions.

The first dendrogram (planting 1) was truncated at the 10 group level as shown in Figure 5.2. The number of accessions in each group listed in Table 5.2. and a graphical presentation of key attributes presented in figure 5.3.

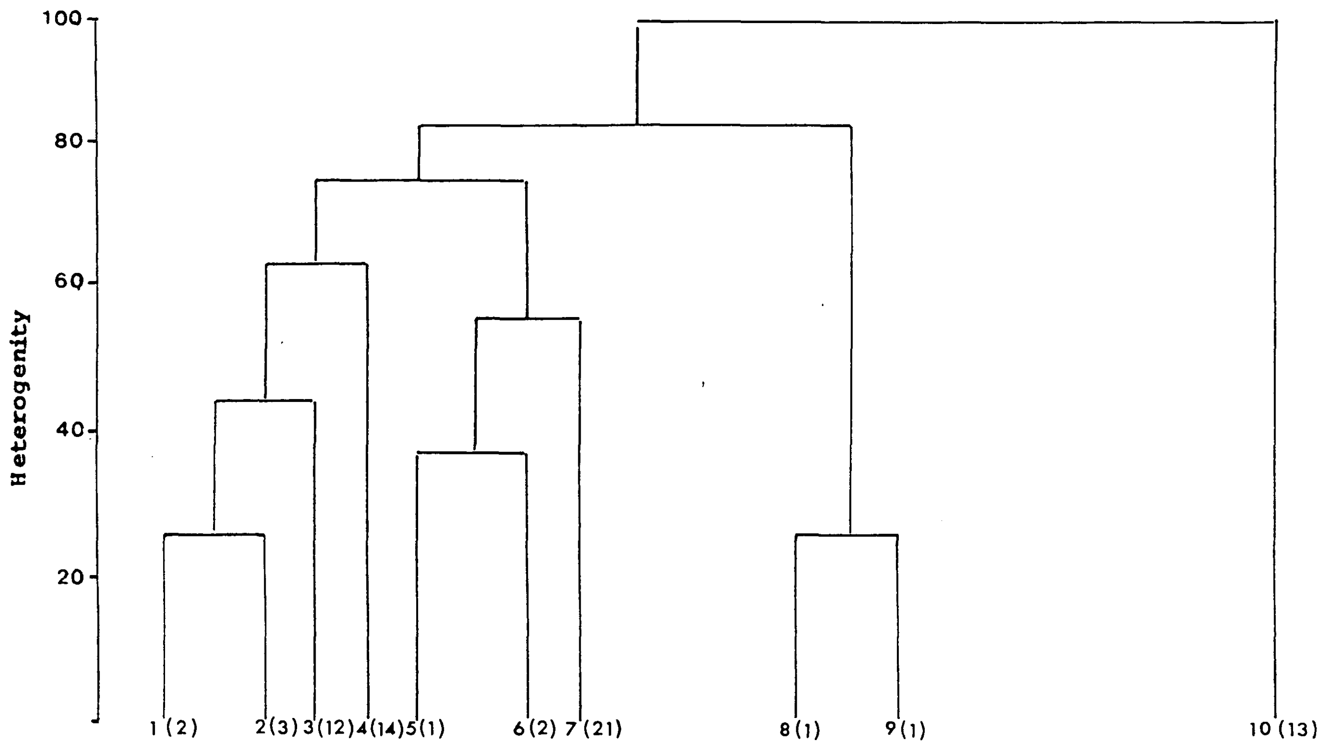

Figure 5.2. Dendrogram of divisions as defined by cluster analysis (planting 1). (Numbers in parenthesis indicate the number of accessions in each group).

Table 5.2. Accessions included in each group at the 10 group level (planting 1).

Group	Accession no.	Species	Introduction No.
1 (2)[A]	22	*Centrosema pubescens*	CPI 58575
	399	*Desmodium triflorum*	ex Gowa
2 (3)	517	*Desmodium gangeticum*	KLM 247
	540	*Desmodium gangeticum*	SUL 019
	541	*Desmodium gangeticum*	SUL 028
3 (12)	512	*Desmodium gangeticum*	KLM 152
	513	*Desmodium gangeticum*	KLM 197
	518	*Desmodium gangeticum*	KLM 254
	521	*Desmodium gangeticum*	KLM 328
	525	*Desmodium gangeticum*	KLM 403
	527	*Desmodium gangeticum*	KLM 429
	528	*Desmodium gangeticum*	KLM 430
	530	*Desmodium gangeticum*	KLM 447
	534	*Desmodium gangeticum*	KLM 481
	535	*Desmodium gangeticum*	KLM 484
	536	*Desmodium gangeticum*	KLM 493
	539	*Desmodium gangeticum*	KLM 538
4 (14)	104	*Desmodium heterophyllum*	cv John stone
	422	*Alysicarpus vaginalis*	KLM 271
	423	*Alysicarpus vaginalis*	KLM 274
	424	*Alysicarpus vaginalis*	KLM 305
	425	*Alysicarpus vaginalis*	KLM 317
	426	*Alysicarpus vaginalis*	KLM 319
	427	*Alysicarpus vaginalis*	KLM 398
	428	*Alysycarpus vaginalis*	KLM 465
	429	*Alysicarpus vaginalis*	SUL 002
	430	*Alysicarpus vaginalis*	SUL 003
	431	*Alysicarpus vaginalis*	SUL 005
	433	*Alysicarpus vaginalis*	SUL 017
	434	*Alysicarpus vaginalis*	SUL 056
	436	*Alysicarpus vaginalis*	SUM 025
5 (1)	28	*Centrosema plumeri*	CPI 58568
6 (2)	30	*Clitoria ternatea*	CPI 50973
	62	*Macroptilium atropurpureum*	cv Siratro
7 (21)	467	*Centrosema pubescens*	KLM 141
	468	*Centrosema pubescens*	KLM 147
	470	*Centrosema pubescens*	KLM 215
	471	*Centrosema pubescens*	KLM 218
	472	*Centrosema pubescens*	KLM 221
	473	*Centrosema pubescens*	KLM 226
	475	*Centrosema pubescens*	KLM 242
	477	*Centrosema pubescens*	KLM 300
	478	*Centrosema pubescens*	KLM 307
	479	*Centrosema pubescens*	KLM 330
	480	*Centrosema pubescens*	KLM 347
	481	*Centrosema pubescens*	KLM 439
	482	*Centrosema pubescens*	KLM 504

Table 5.2. Continued

Group	Accession no.	Species	Introduction No.
	483	*Centrosema pubescens*	KLM 534
	484	*Centrosema pubescens*	KLM 537
	485	*Centrosema pubescens*	KLM 539
	486	*Centrosema pubescens*	KLM 545
	487	*Centrosema pubescens*	KLM 548
	488	*Centrosema pubescens*	KLM 549
	489	*Centrosema pubescens*	KLM 553
	490	*Centrosema pubescens*	KLM 557
8 (1)	77	*Neonotonia wightii*	cv Tinaroo
9 (1)	112	*Arachis sp.*	ex Gowa
10 (13)	401	*Aeschynomene americana*	KLM 033
	407	*Aeschynomene americana*	KLM 276
	408	*Aeschynomene americana*	KLM 281
	409	*Aeschynomene americana*	KLM 302
	410	*Aeschynomene americana*	KIM 315
	411	*Aeschynomene americana*	KLM 323
	412	*Aeschynomene americana*	KLM 336
	413	*Aeschynomene americana*	KLM 428
	414	*Aeschynomene americana*	KLM 436
	415	*Aeschynomene americana*	KLM 474
	417	*Aeschynomene americana*	KLM 566
	419	*Aeschynomene americana*	SUM 008
	420	*Aeschynomene americana*	SUM 022

[A] number of accessions in the group.

The group means for the major attributes responsible for the groupings are presented in Table 5.3. A summary of group characteristics is given namely:

Group 1: This group contained 2 accessions and was a moderate yielding group with plant yield gradually increasing over time (Table 5.3). Flowering in this group was good, but with only moderate seed production. Plants were strongly perennial with good disease and insect resistance. Seedling recruitment after seed set was poor. Group 1 included two of the standard species namely : *Centrosema pubescens* CPI 58575 and *Desmodium triflorum* ex Gowa.

Group 2: This group contains 3 accessions and was a moderate yielding strongly perennial group. The accessions possessed frequent flowering and moderate seed production but no new recruitments after seed set (Table 5.3). The group members have good disease and insect resistance. Group 2 included 3 accessions of *Desmodium gangeticum* (Table 5.2).

Table 5.3. Mean values for agronomic attributes used in the cluster analyses (planting 1).

Agronomic attributes	Group 1	2	3	4	5	6	7	8	9	10
No.Seedlings 2nd year	0.0	0.0	16.8	99.0	26.0	57.5	18.5	0.0	0.0	99.0
Perenniality index	1.0	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	0.0
Yield 17/4	3.3	3.8	3.2	4.1	10.0	7.5	5.0	4.5	4.5	3.7
Yield 22/7	5.3	5.2	3.8	4.4	10.0	7.5	6.6	5.0	4.5	3.7
Yield 22/9	6.0	4.7	3.8	4.4	9.0	7.0	6.5	5.5	5.0	1.1
Yield 11/11	6.5	5.5	4.8	5.6	8.0	7.8	7.4	7.0	6.0	2.8
Mean yield	5.0	4.5	3.7	4.4	9.2	7.4	6.2	5.1	4.5	3.0
Drought	0.3	0.0	0.0	0.6	0.5	0.0	0.0	0.0	0.0	0.6
Mean disease	0.2	0.0	0.0	0.4	0.1	0.1	0.9	0.0	0.0	0.1
Max disease	0.8	0.3	0.2	0.9	0.5	0.5	1.0	0.5	0.0	0.4
Mean insect	0.6	0.8	0.7	0.9	0.6	0.9	0.3	0.5	0.4	0.7
Max insect	1.0	2.0	1.2	1.1	1.5	1.3	1.0	1.0	1.5	1.8
Mean flowering	0.7	0.7	1.0	1.0	0.7	0.9	0.7	0.0	1.0	0.4
Mean mature seed	0.4	0.6	0.9	0.8	0.5	0.7	0.5	0.0	0.1	0.4
Mean seed yield	1.0	1.2	2.3	2.4	1.9	2.5	1.5	0.0	0.2	0.9
Max seed yield	2.8	2.5	3.8	4.1	4.5	4.3	3.5	0.0	1.5	3.0

Group 3: This was a moderate to low yielding group with yield increasing over time (Table 5.3) but to a lesser extent than in group 1. Flowering occurring frequently, with high seed production. Plants were strongly perennial with high disease and insect resistance. Seedling recruitment was low. A total of 12 *Desmodium gangeticum* accessions were included in this group (Table 5.2).

Group 4: This group was strongly perennial with moderate yields, which increased over time (Table 5.3). This group was the second lowest yielding but yield increased with time. Accessions in the group flowered well, produced much seed (Table 5.3). and recruited well in the second year. Accessions in the group recorded some insect and disease damage but this was slight. This is a large group that contained 13 accessions of *Alysicarpus vaginalis* and *Desmodium heterophyllum* cv. Johnstone as a standard species (Table 5.3).

Group 5: There was only 1 accession (*Centrosema plumieri* CPI 58568) in this group (a standard species). This was the highest yielding group and one of only two groups to show a yield decline over time (Figure 5.3). The accession was strongly perennial with flowering occurring frequently and high seed production. Insect damage was moderate and minimal disease resistance recorded.

Group 6: This group was a small group containing 2 standard species : *Clitoria ternatea* CPI 58568 and *Macroptilium atropurpureum* cv. Siratro (Table 5.3). Yields were high throughout the evaluation and accessions had a high perenniality index. Some insect damage was recorded but the resistance to disease was generally low. Flowering was frequent and seed yields good. There was a moderate recruitment of seedlings in the second year.

Group 7: This is the largest group which contains 21 accession of *Centrosema pubescens.* It is a high yielding group with plant yield gradually increasing over time (Table 5.3). This group had frequent flowering and good seed production. All accessions of *Centrosema pubescens* were strongly perennial with a high disease but low insect resistance. Seedling recruitment in the second year was low.

Group 8: This was a moderate yielding group containing only one accession (*Neonotonia wightii* cv Tinaroo) this had a moderate yield which increased over time (Figure 5.3). Plants were strongly perennial with moderate insect damage but were unaffected by disease. The accession did not flower and hence did not produce seed.

Group 9: This group contained only the standard species, *Arachis sp.* ex Maiwa. Yield was moderate which increased over time (Table 5.3). This accession was strongly perennial which flowered frequently, seed production was low and there was no seedling recruitment in the second year. Insect damage was low and there was no disease as shown in Figure 5.3.

Group 10: This was the lowest yielding group containing 13 *Aeschynomene americana* accessions (Table 5.3). In addition to low mean yield the yield declined over time. This group contained mostly annuals (Perenniality index 0). Flowering and seed yields were low but second year seedling recruitment was the highest of the groups. Insect damage was low to moderate and there was no disease resistance.

5.3.2. Planting 2

The same 16 attributes as used in planting 1 were used in the cluster analyses of planting 2 except the yield rating dates were different. The planting 2 dendrogram was truncated at 9 the group level (Figure 5.4).

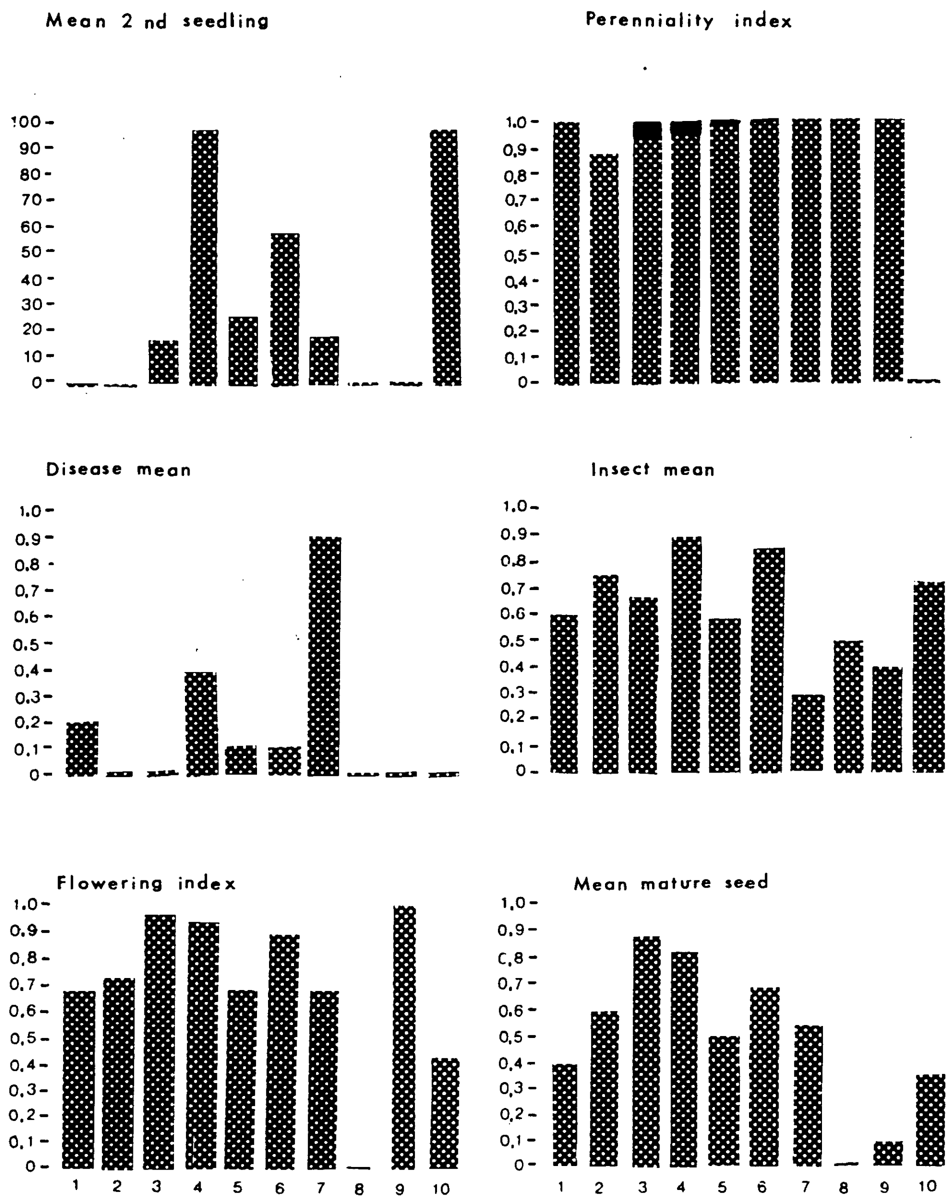

Figure 5.3. Group means for 8 attributes at the 10 group level of native legumes from planting 1.

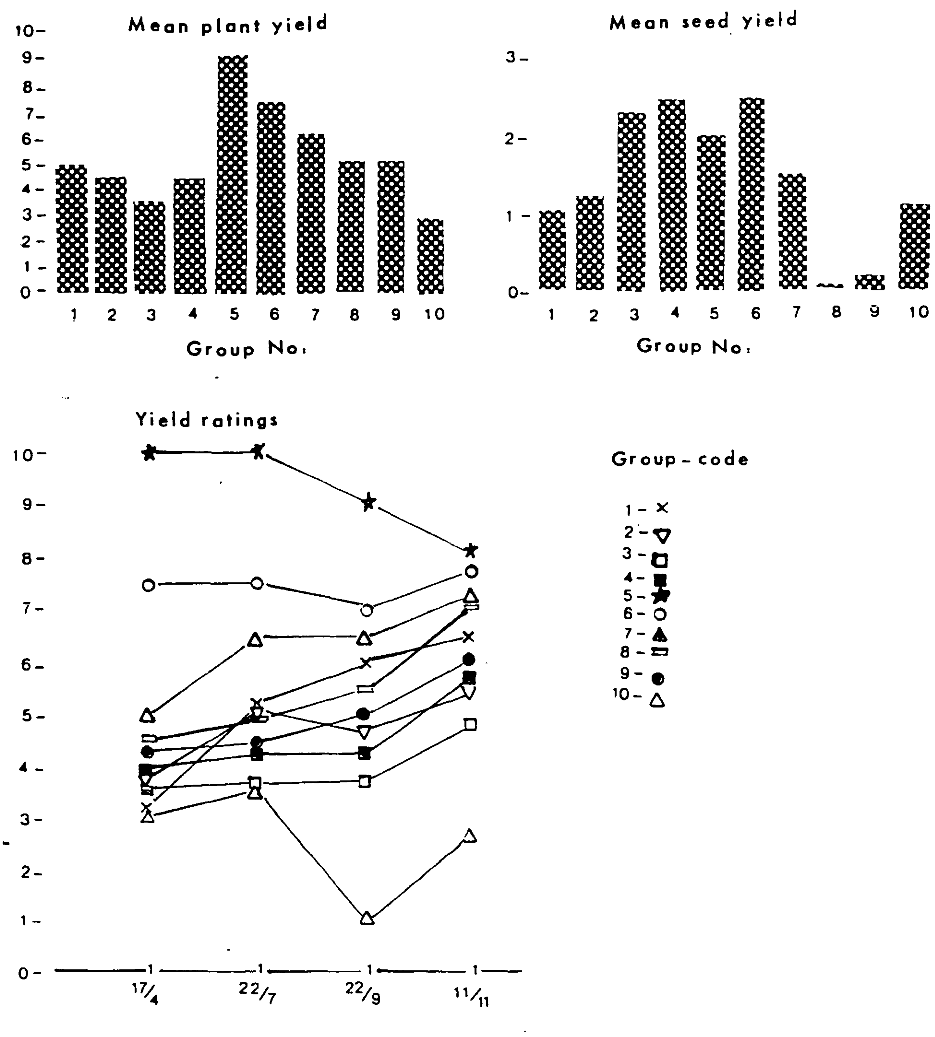

Figure 5.3. Continued

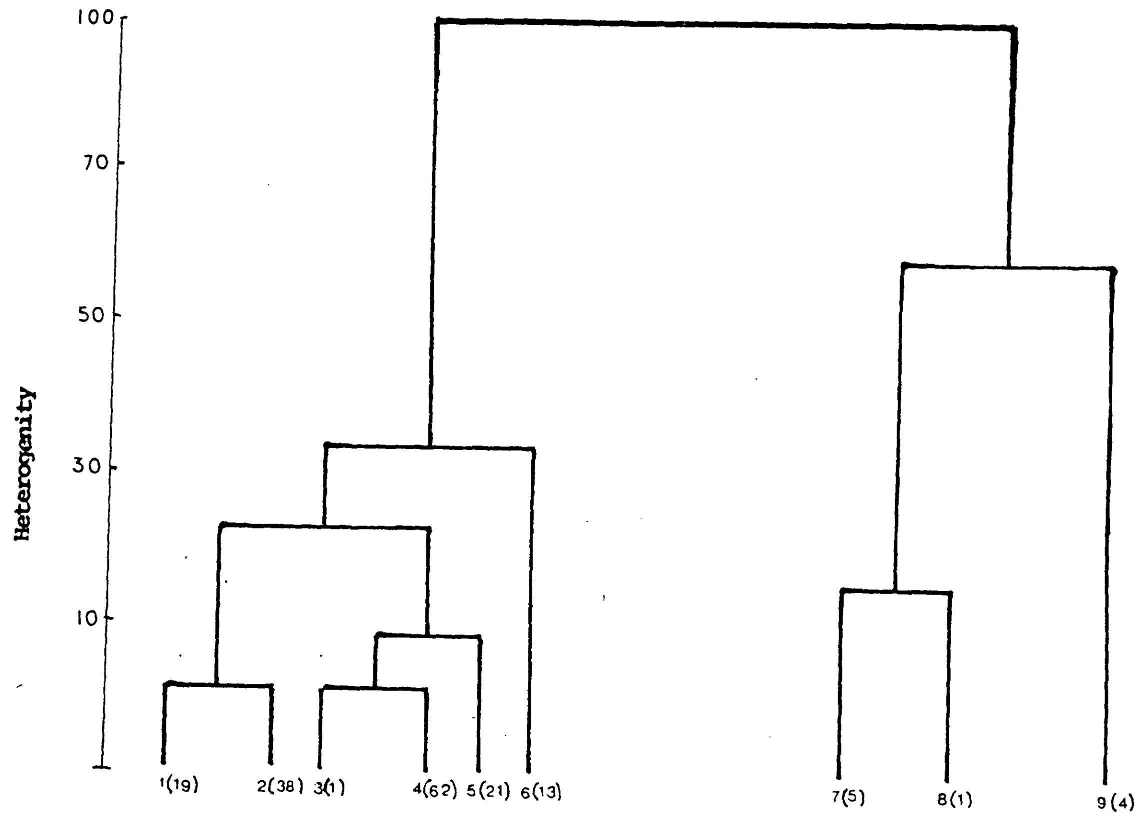

Figure 5.4. Dendrogram of divisions based on 16 agronomic attributes as defined by cluster analysis (planting 2). (Numbers in parenthesis indicate the number of accessions in each group).

Table 5.4. Accessions included in each groups at the 9 group level. (planting 2).

Group	Accession No.	Species	Introduction No.
1 (19[A])	552	*Desmodium heterocarpon*	SUL 042
	554	*Desmodium heterocarpon*	SUL 050
	544	*Desmodium heterocarpon*	SUL 012
	547	*Desmodium heterocarpon*	SUL 028
	551	*Desmodium heterocarpon*	SUL 031
	543	*Desmodium heterocarpon*	SUM 006
	553	*Desmodium heterocarpon*	SUL 049
	555	*Desmodium heterocarpon*	SUL 051
	557	*Desmodium heterocarpon*	SUL 054
	558	*Desmodium heterocarpon*	SUL 059
	601	*Desmodium styracifolium*	KLM 202
	862	*Desmodium gangeticum*	KLM 1023
	664	*Pseudarthria viscida*	KLM 352
	666	*Pseudarthria viscida*	KLM 393
	668	*Pseudarthria viscida*	KLM 420
	670	*Pseudarthria viscida*	KLM 542
	719	*Teramnus labialis*	KLM 427
	720	*Teramnus labialis*	KLM 434
	723	*Teramnus labialis*	KLM 518
2 (38)	850	*Desmodium gangeticum*	KLM 879
	556	*Desmodium heterocarpon*	SUL 052
	724	*Uraria lagopodoides*	SUL 009
	1070	*Uraria lagopodoides*	KLM 1195
	762	*Alysicarpus sp.*	KLM 637
	774	*Alysicarpus vaginalis*	KLM 784
	777	*Alysicarpus sp.*	KLM 815
	788	*Alysicarpus sp.*	KLM 1070
	794	*Alysicarpus sp.*	KLM 1234
	1077	*Uraria lagopodoides*	KLM 1257
	563	*Desmodium heterocarpon*	KLM 288
	846	*Desmodium gangeticum*	KLM 855
	1064	*Uraria lagopodoides*	KLM 1032
	780	*Alysicarpus sp.*	KLM 838
	560	*Desmodium heterocarpon*	KLM 186
	725	*Uraria lagopodoides*	SUL 010
	730	*Uraria lagopodoides*	SUL 055
	735	*Uraria lagopodoides*	KLM 222
	741	*Uraria lagopodoides*	KLM 275
	744	*Uraria lagopodoides*	KLM 472
	726	*Uraria lagopodoides*	SUL 014
	733	*Uraria lagopodoides*	KLM 188
	736	*Uraria lagopodoides*	KLM 230
	737	*Uraria lagopodoides*	KLM 252
	738	*Uraria lagopodoides*	KLM 255
	1039	*Uraria lagopodoides*	KLM 627
	1046	*Uraria lagopodoides*	KLM 718
	1049	*Uraria lagopodoides*	KLM 753
	835	*Desmodium gangeticum*	KLM 678
	837	*Desmodium gangeticum*	KLM 696
	843	*Desmodium gangeticum*	KLM 778

Table 5.4. Continued

Group	Accession No.	Species	Introduction No.
	864	*Desmodium gangeticum*	KLM 1042
	949	*Pseudarthria viscida*	KLM 790
	954	*Pseudarthria viscida*	KLM 585
	948	*Pseudarthria viscida*	KLM 751
	665	*Pseudarthria viscida*	KLM 370
	578	*Desmodium laxiflorum*	SUL 027
	704	*Pueraria sp.*	MAL 15
3 (1)	545	*Desmodium heterocarpon*	SUM 013
4 (62)	585	*Desmodium laxiflorum*	KLM 499
	588	*Desmodium laxiflorum*	KLM 523
	987	*Pseudarthria viscida*	KLM 1289
	586	*Desmodium laxiflorum*	KLM 500
	546	*Desmodium heterocarpon*	SUM 020
	611	*Desmodium styracifolium*	KLM 547
	722	*Teramnus labialis*	KLM 491
	654	*Pseudarthria viscida*	SUL 013
	656	*Pseudarthria viscida*	KLM 220
	603	*Desmodium styracifolium*	KLM 248
	921	*Desmodium laxiflorum*	KLM 1012
	590	*Desmodium laxiflorum*	KLM 532
	857	*Desmodium gangeticum*	KIM 987
	907	*Desmodium heterocarpon*	KLM 1168
	567	*Desmodium heterocarpon*	KLM 309
	600	*Desmodium styracifolium*	KLM 201
	876	*Desmodium gangeticum*	KLM 1200
	886	*Desmodium gangeticum*	KLM 1274
	892	*Desmodium gangeticum*	KLM 1284
	957	*Pseudarthria viscida*	KLM 880
	985	*Pseudarthria viscida*	KLM 1248
	669	*Pseudarthria viscida*	KLM 421
	742	*Uraria lagopodoides*	KLM 426
	1079	*Uraria lagopodoides*	KLM 1299
	597	*Desmodium styracifolium*	KLM 157
	602	*Desmodium styracifolium*	KLM 235
	929	*Desmodium styracifolium*	KLM 1068
	937	*Desmodium styracifolium*	KLM 1212
	917	*Desmodium laxiflorum*	KLM 837
	919	*Desmodium laxiflorum*	KLM 981
	920	*Desmodium laxiflorum*	KLM 986
	926	*Desmodium laxiflorum*	KLM 1207
	928	*Desmodium laxiflorum*	KLM 1305
	662	*Pseudarthria viscida*	KLM 338
	700	*Pueraria phaseoloides*	SUM 016
	1026	*Pueraria phaseoloides*	KLM 1143
	899	*Desmodium heterocarpon*	KLM 912
	902	*Desmodium heterocarpon*	KLM 923
	905	*Desmodium heterocarpon*	KLM 956
	908	*Desmodium heterocarpon*	KLM 1185
	939	*Desmodium styracifolium*	KLM 1236

Table 5.4. Continued

Group	Accession No.	Species	Introduction No.
	605	*Desmodium styracifolium*	KLM 272
	964	*Pseudarthria viscida*	KLM 990
	982	*Psedarthria viscida*	KLM 1216
	607	*Desmodium styracifolium*	KLM 327
	609	*Desmodium styracifolium*	KLM 529
	922	*Desmodium laxiflorum*	KLM 1091
	587	*Desmodium laxiflorum*	KLM 521
	598	*Desmodium styracifolium*	KLM 201
	932	*Desmodium styracifolium*	KLM 1181
	655	*Pseudarthria viscida*	KLM 208
	703	*Pueraria sp.*	MAL 10
	962	*Pseudarthria viscida*	KLM 962
	968	*Pseudarthria viscida*	KLM 1019
	976	*Pseudarthria viscida*	KLM 1130
	657	*Pseudarthria viscida*	KLM 229
	716	*Teramnus labialis*	KLM 261
	714	*Teramnus labialis*	SUL 041
	931	*Desmodium styracifolium*	KLM 1179
	945	*Desmodium styracifolium*	KLM 1301
	659	*Pseudarthria viscida*	KLM 268
	661	*Pseudarthria viscida*	KLM 332
5 (21)	569	*Desmodium heterocarpon*	KLM 561
	677	*Pueraria phaseoloides*	KLM 160
	690	*Pueraria phaseoloides*	KLM 292
	694	*Pueraria phaseoloides*	KLM 329
	702	*Pueraria phaseoloides*	MAL 13
	1018	*Pueraria phaseoloides*	KLM 975
	1021	*Pueraria phaseoloides*	KLM 980
	1037	*Pueraria phaseoloides*	KLM 1297
	859	*Desmodium gangeticum*	KLM 1006
	1038	*Pueraria phaseoloides*	KLM 1302
	680	*Pueraria phaseoloides*	KLM 185
	681	*Pueraria phaseoloides*	KLM 192
	682	*Pueraria phaseoloides*	KLM 212
	684	*Pueraria phaseoloides*	KLM 241
	687	*Pueraria phaseoloides*	KLM 280
	689	*Pueraria phaseoloides*	KLM 284
	691	*Pueraria phaseoloides*	KLM 298
	692	*Pueraria phaseoloides*	KLM 308
	693	*Pueraria phaseoloides*	KLM 312
	696	*Pueraria phaseoloides*	KLM 344
	715	*Teramnus labialis*	KLM 216
6 (13)	798	*Centrosema pubescens*	KLM 849
	823	*Centrosema pubescens*	KLM 1157
	825	*Centrosema pubescens*	KLM 1164
	831	*Centrosema pubescens*	KLM 1294
	807	*Centrosema pubescens*	KLM 1041
	810	*Centrosema pubescens*	KLM 1054
	813	*Centrosema pubescens*	KLM 1062

Table 5.4. Continued

Group	Accession No.	Species	Introduction No.
	814	*Centrosema pubescens*	KLM 1073
	816	*Centrosema pubescens*	KLM 1120
	820	*Centrosema pubescens*	KLM 1141
	826	*Centrosema pubescens*	KLM 1180
	828	*Centrosema pubescens*	KLM 1239
	830	*Centrosema pubescens*	KLM 1285
7 (5)	572	*Desmodium heterophyllum*	SUL 053
	573	*Desmodium heterophyllum*	SUM 001
	577	*Desmodium heterophyllum*	SUM 021
	575	*Desmodium heterophyllum*	SUM 009
	574	*Desmodium heterophyllum*	SUM 007
8 (1)	576	*Desmodium heterophyllum*	SUM 017
9 (4)	754	*Aeschynomene americana*	KLM 837
	756	*Aeschynomene americana*	KLM 869
	757	*Aeschynomene americana*	KLM 1145
	760	*Aeschynomene americana*	KLM 1171

^{A} Number of accessions in the group.

A summary of group characteristics is given below:

Group 1: This was a high yielding, strongly perennial group which contained the 3 genera *Desmodium, Pseudarthria* and *Teramnus* (Table 5.4). This was amongst the highest yielding groups throughout the evaluation. Some evidence of leaf senescence was observed under low moisture conditions. Flowering occurring frequently with good seed yield but very low seedling recruitment. Insect damage was low to moderate and there was no evidence of disease.

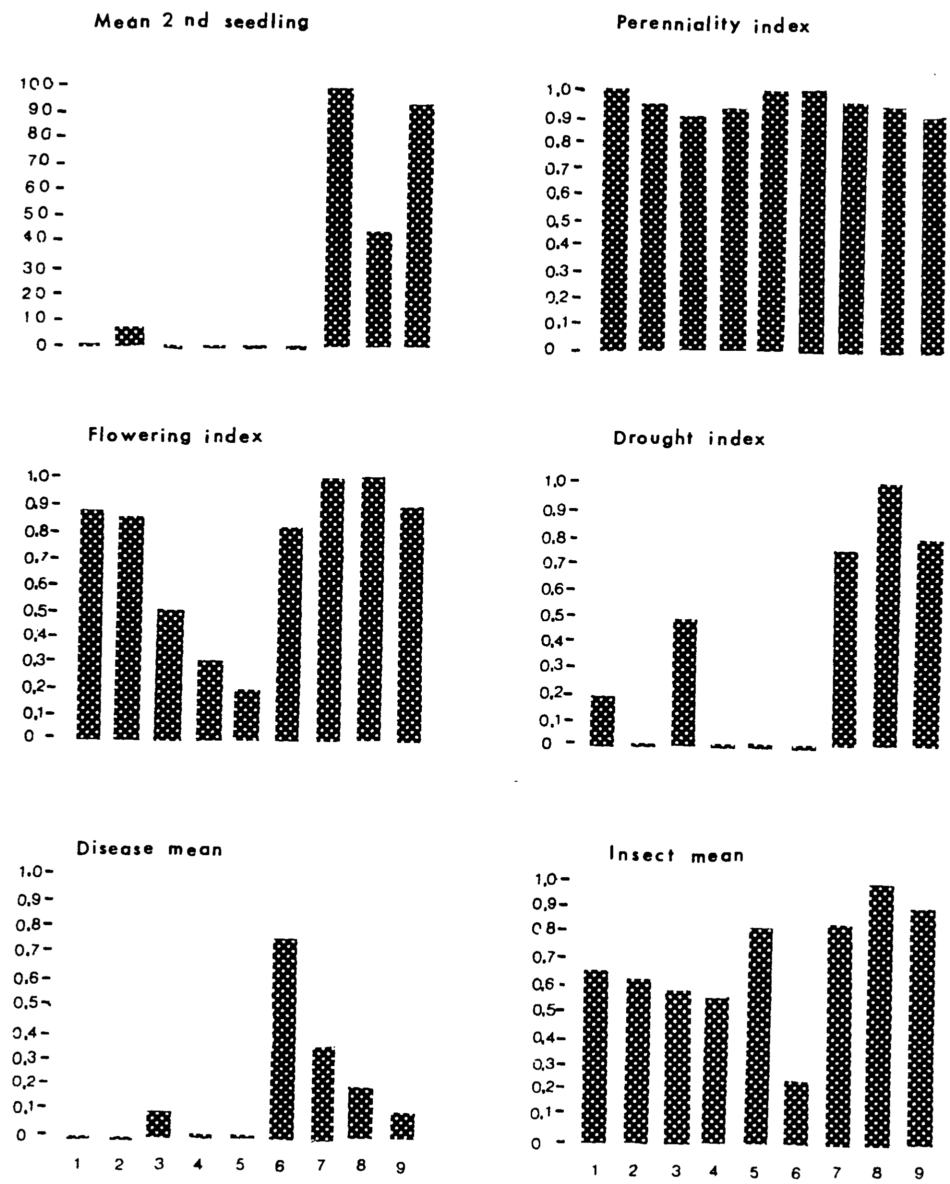

Figure 5.5. Group mean for 10 attributes at 9 group level of native legumes from planting 2.

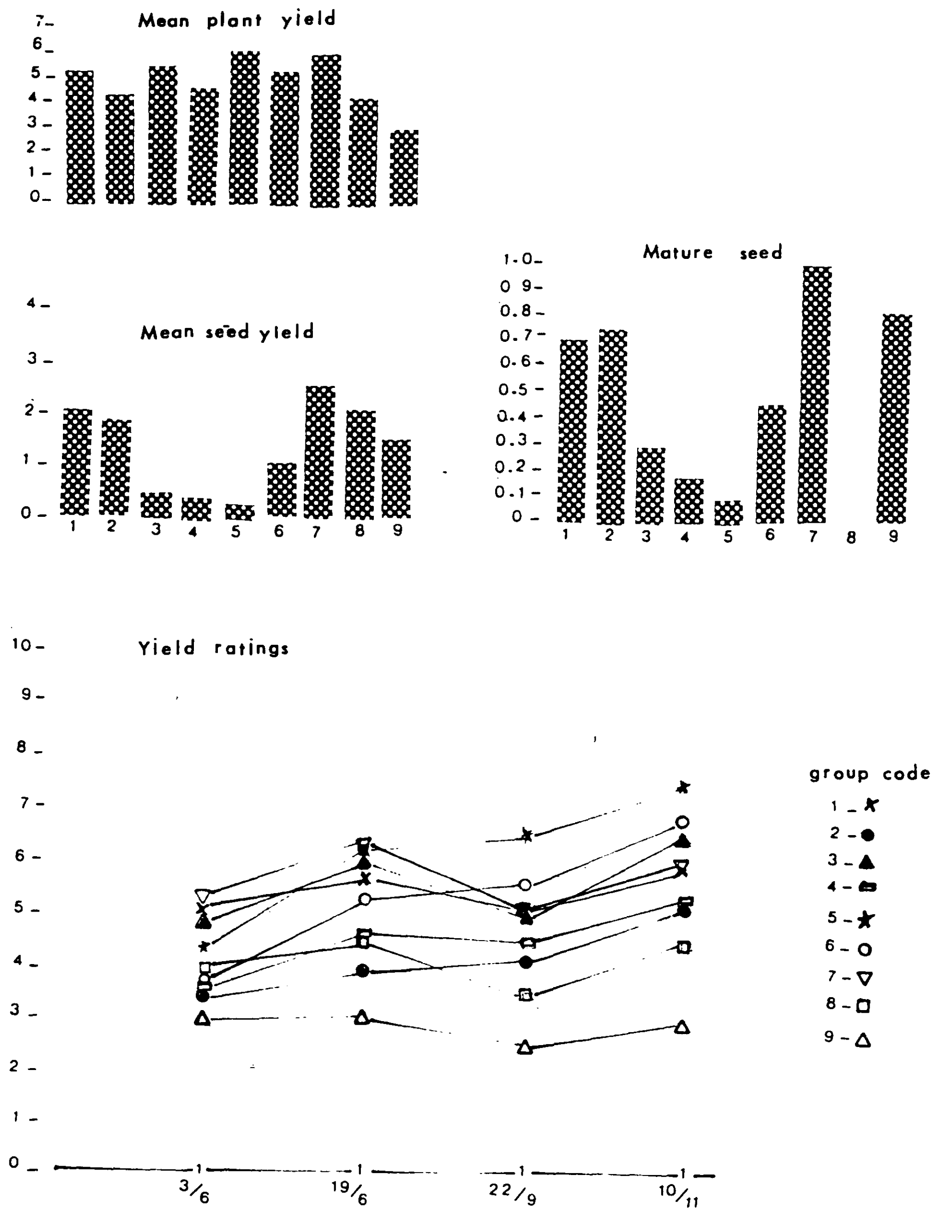

Figure 5.5. Continued

Table 5.5. Mean values for agronomic attributes used in the cluster analysis (planting 2).

Agronomic attributes	Group 1	2	3	4	5	6	7	8	9
Seedling	1.6	7.1	0.0	0.0	0.0	0.0	99.0	45.5	94.1
2nd year									
Perenniality	1.0	1.0	0.9	0.9	1.0	1.0	1.0	0.9	0.9
Yield 3/6	5.0	3.5	5.0	3.5	4.3	3.8	5.3	4.0	3.0
Yield 19/8	5.6	4.0	6.0	4.6	6.2	5.3	6.3	4.5	3.1
Yield 22/9	5.1	4.3	5.0	4.6	6.5	5.6	5.1	3.5	2.6
Yield 10/11	6.0	5.2	6.0	5.4	7.4	6.6	6.5	4.5	3.0
Mean yield	5.2	4.2	5.3	4.4	5.9	5.2	5.9	4.1	2.9
Drought	0.2	0.1	0.5	0.0	0.0	0.0	0.8	1.0	0.8
Mean disease	0.0	0.1	0.1	0.0	0.1	0.8	0.3	0.2	0.1
Max disease	0.0	0.4	0.5	0.0	0.3	1.0	0.9	1.0	0.6
Mean insect	0.7	0.6	0.6	0.5	0.8	0.2	0.9	1.0	0.9
Max insect	1.4	1.2	1.0	1.1	1.4	0.8	1.0	1.5	1.1
Mean flowering	0.9	0.9	0.5	0.3	0.2	0.8	1.0	1.0	0.9
Mean mature seed	0.7	0.7	0.3	0.2	0.1	0.5	1.0	1.0	0.8
Mean seed yield	2.1	1.9	0.5	0.4	0.3	1.1	2.6	2.1	1.5
Max seed yield	3.8	3.4	2.0	1.3	0.8	2.8	3.3	2.5	2.8

Group 2: This is a large group which contained 39 accessions of *Desmodium, Uraria, Alysicarpus*, and *Pseudarthria* (Table 5.4) which maintained moderate yields throughout the evaluation period. Flowering occurred frequently with good seed yield but very low seedling recruitment in the second year. Insect damage was low to moderate and there was little or no evidence of disease.

Group 3: This group was a group containing only one accession of *Desmodium heterocarpon* (Sum 013) which was strongly perennial. Good yields were recorded throughout but flowering occurred infrequently with low seed production and there was low seedling recruitment in the second year. There was no evidence disease and moderate tolerance insects and drought.

Group 4: This was the largest group which contained 62 accessions of *Desmodium, Pseudarthria, Teramnus, Uraria*, and *Pueraria* (Table 5.4). The group had moderate yields with no evidence of drought damage. Accessions in the group flowered infrequently and had low seed production and seedling recruitment. Accessions in the group were strongly perennial with moderate tolerance to insects and no evidence at disease.

Group 5: This was a highest yielding group with yield increasing over time (Table 5.5 and Figure 5.5). The group was dominated by *Pueraria phaseoloides* (Table 5.4). The group was strongly perennial with no seedling recruitment in the second year. Flowering and seed yield was low and insect damage was high the groups exhibited good resistance to disease and drought (Table 5.5).

Group 6: This group contained 13 accessions of perennial *Centrosema pubescens* (Table 5.4) with high yields. Flowering was frequent with moderate seed yields but no seedling recruitment in the second year. Members of the group had good resistance to insects and drought, but had the highest evidence of disease of all groups.

Group 7: This group contained 6 accessions of perennial *Desmodium heterophyllum* (Table 5.4). The accessions in the group had high and stable yields (Table 5.5 and Figure 5.5). The accessions flowered frequently and produced high seed yields. Seedling recruitment in the second year was the highest among the groups. There was frequent evidence of disease and some insect damage was recorded.

Group 8: This was a single accession of perennial *Desmodium heterophyllum* (SUM 017), which had a moderate yield (Table 5.5). Flowering was frequent with good seed yields. This accession exhibited high insect damage, was drought resistant and there was no evidence of disease. Seedling recruitment in the second year was moderate.

Group 9: This group was a lowest yielding group, containing 4 accessions of *Aeschynomene americana* (Table 5.4). Plant yields decreased over time (Figure 5.5) and flowering was frequent and good seed yields were produced. This group contained mostly annuals (perenniality index 0) with high seedling recruitment in the second year. Some insect damage was evident and there was no evidence of disease (Table 5.5).

5.4 DISCUSSION

5.4.1 Native and Naturalized accessions

Planting 1:

The highest yielding species were the introduced standards *C.plumeri, C.ternatea* and *M.atropurpureum* in groups 5 and 6. These accessions had a low incidence of disease and insect problems and seeded well.

The highest yielding native species were in group 7 which contained 21 accessions of prostrate *C.pubescens*. It is of interest to note that these local Centro's performed better than the introduced CPI 58575 which was in group 1. There was some variation in the performance of the members of group 7 and accessions KLM 226 and 539 were selected for further evaluation on the basis of more stable yield and lower disease incidence.

Among the low growing, grazing resistant types studied the native standard *D.triflorum* ex Gowa was the best performer (group 10) and should be further evaluated.

One member of group 2, *D.gangeticum* KLM484 showed good tolerance to cutting and was the best performer of the group. For cut and carry systems this shrub could play a valuable role when grown as a protein bank removed from competition from grasses. This accession requires further evaluation.

Planting 2:

Although group 5 had the highest yield, no members of this group can be recommended for further evaluation because of their poor seed yields. In a developing area like Indonesia the availability of seed is a major determinant of the likely success of a species. The exception would be if the species had some outstanding characters (eg *Gliricidia maculata*). No members of group 5 were in this category.

There was little variation among the 5 *D.heterophyllum* accessions in the moderate yielding group 7. These stoloniferous accessions could possibly have a place in closely grazed situations. Observation suggests that accession SUL053 should be further evaluated.

Although group 1 was only in the moderate yield category it contained 4 accessions of *Pseudarthria viscida* which showed promise. There was little variation among these accessions but accession KLM420 should be further evaluated.

5.4.2 Selection of Introduced and Native Accessions for Further Evaluation.

The rating system developed for use in the Forage Research Project (table 4.2) provides a means of monitoring the changes in performance of forage species over time. The development of small hand-held computers greatly aids in the collection of the large amount of data in an evaluation program as extensive as the one undertaken here. This, together with the availability of powerful cluster analysis programs such as DIPCOM means that the accessions can be classified into like groups to aid selection.

While the above processes assists and formalizes the plant selection process they do not substitute for careful observations and understanding of the system into which the forage will be introduced. These subjective assessments make the final selection process a mixture of science and art. Evaluators must take care not to let bias dominate the data they have obtained so that their "pet species" progress to the higher evaluation stages without good reason.

As outlined in Chapter 1, the persistence of legumes in native grass pastures is a major problem in South Sulawesi and in East Indonesia generally. For this reason the selection process undertaken here took into account not only the anticipated contribution to yield in the pasture but was based on plant characters such as low growth habit and multiple growing points. The ability of the accession to produce seed in the environment in which it is to be used was also carefully considered. None or poor seeding accessions were discounted in value unless this was over-ridden by other exceptional characters e.g. ability to spread from a single planting.

5.4.3 Recommendations for Sward Testing

It is recognised that three types of systems exist in East Indonesia into which forages must be incorporated.

a) Managed grazed sward

b) Mis-managed grazed swards

c) Home gardens which use a cut and carry system

The evaluations indicate that the following accessions should be further evaluated.

a) For managed grazed swards, the native *C. pubescens*, KLM 226 and KLM 539 should be evaluated alongside the commercial Centro from the introduced collection. Also included in this evaluation should be *Centrosema pascuorum, C. mucunoides* (calopo), *C. schiedeanum* cv. Belalto, *C. plumieri* CPI 58568 and *M. atropurpureum* (siratro).

These should be the sown as single legume components in both monocultures and in mixtures with appropriate grasses. In another evaluation in the Forage Research Project, grasses for these managed situations have been identified.

b) For mismanaged areas it is recommended that *D. heterophyllum* cv. Johnstone, *Cassia pilosa* CPI 57503, *Pseudarthria viscida* KLM 420 and *Arachis sp.* be evaluated in mixed grass-legume swards and that the local *D. heterophyllum* (SUL 053) and *D. triflorum* from the native evaluation be included for comparison. The choice of grass for these evaluations requires considerable care. Ideally they must be productive but they must not be so competitive that they compete out the low growing legume. In a parallel evaluation of grasses, the lower growing species *Digitaria milangiana* has been identified as suitable.

c) For home gardens, where space to grow forages is limited and the forage is cut and carried to the animals, the local legume *D. gangeticum* KLM 484 should be evaluated alongside introduced shrub legumes such as *C. gyroides, D. rensonii* and *Cajanus cajan.* These species were selected from the evaluation program of Ella (1987).

If resources permit all these evaluations should be subject to grazing pressure appropriate to the system. If this is not possible then the cutting regimes should be severe enough to put the species under pressure.

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