Genotype x Environment Interaction in a Core Collection of the Tropical Cover Crop and Forage Legume *Desmodium ovalifolium*

A Proposal for: Der Bundesminister für Wirtschaftliche Zusammenarbeit (BMZ)

Executing Agency: CIAT
International Center for Tropical Agriculture
Centro Internacional de Agricultura Tropical

Collaborating Partners:

- University of Hohenheim, Germany
- Corporación de Investigación Agropecuaria de Colombia (CORPOICA), Colombia
- Centro Nacional de Investigaciones de Café (CENICAFE), Colombia

August 1994

August 12, 1994

Dr. H. Jochen de Haas
Head, Agricultural and Rural Development
Federal Ministry for Economic Cooperation
BMZ
Friedrich-Ebert-Allee 114-116
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Federal Republic of Germany

Ref.: ***Project Proposals for Special Projects***

Fax: ***(0228) 535202***

Dear Dr. de Haas:

We are pleased to submit for your consideration two proposals (3 copies each for distribution) for Special Project funding. According to your guidelines, each proposal shows differential budgets for CIAT and its German partners.

CIAT's Tropical Forages Program has not only assembled a large genetic resource but also has successfully selected forage cultivars, which increasingly have shown their important role as a component for sustainable production systems in the tropics. The project "Genotype x environment interaction in a core collection of the tropical cover crop and forage legume Desmodium ovalifolium" intends to develop this Southeast Asian legume of high potential for wider utilization as a cover crop and forage. The German collaborative research partner will be the University of Hohenheim.

Halting the degradation of the pastures of the Brazilian Cerrados and encroachment of the rain forest margins forms part of the strategy adopted by the CIAT Tropical Lowlands Program. The proposal on "Sustainable Animal Production for the Agropastoral Systems of the Brazilian Cerrados" will assess the impact of pasture degradation and rehabilitation on biophysical and economic performance of production systems. The German collaborative research partner will be the University of Göttingen.

I look forward to a positive consideration of our requests.

Sincerely yours,

Dr. FRITZ KRAMER
Director General

Attachments

cc. Dr. W.R. Swocroft -CIAT

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Acronyms

BMZ	Der Bundesminister für Wirtschaftliche Zusammenarbeit
CIAT	Centro Internacional de Agricultura Tropical, Cali, Colombia
CENICAFE	Centro Nacional de Investigaciones de Café
CORPOICA	Corporación de Investigación Agropecuaria de Colombia
GIS	Geographic Information System
ICA	Instituto Colombiano Agropecuario
NARI	National Agricultural Research Institution
PAGE	Polyacrylamide Gel Electrophoresis
RIEPT	Red Internacional de Evaluación de Pastos Tropicales

1.0 Summary

Title:

Genotype x environment interaction in a core collection of the tropical cover crop and forage legume *Desmodium ovalifolium*

Short Title:

Genotype x environment interaction in *Desmodium ovalifolium*

Objective of Research:

To determine the effect of contrasting edaphic and climatic environments on productivity, litter and forage quality— including palatability, of genotypes in a core collection of the tropical cover crop and forage legume *Desmodium ovalifolium*. Results of this research will contribute to identify:

(1) germplasm with a potential for pasture improvement and soil conservation in the humid and subhumid tropics.

(2) edaphic and climatic patterns of niches with high potential for the utilization of *Desmodium ovalifolium*. In addition, information generated will assist in the design of efficient future research strategies in the genetic resources area such as further collection of *Desmodium ovalifolium* germplasm in its center of diversity.

Abstract:

The Tropical Forages Program at CIAT aims to identify and develop legume and grass germplasm adapted to acid, low-fertility soils in the humid and subhumid tropics, and thus to contribute to increased livestock production and soil enhancement on marginal lands.

Because of a series of agronomic traits, *D. ovalifolium* has a particularly high potential to contribute not only to reclamation of degraded tropical soils and to soil conservation, but also to persist under heavy grazing. Based on the experience with a commercial *D. ovalifolium* variety which is used as a cover legume in Southeast Asian plantation agriculture, however, livestock performance is frequently poor, mainly because of low acceptability and digestibility of the legume. In *D. ovalifolium*, this low forage quality is associated with high tannin contents which, however, seem to be influenced by

edaphic and climatic factors. Preliminary studies with a limited set of genotypes suggest that the germplasm collection of *D. ovalifolium* is variable in this respect as well as in dry-matter productivity and other agronomic characteristics.

During the past 15 years, CIAT has assembled, through plant exploration in the wild, a significant germplasm collection of about 160 accessions, out of which a core collection of 35 has been selected. In the present project, the characterization and evaluation of this core collection is proposed for four contrasting environments in Colombia, with the aim to clarify and quantify the effect of soil and climate on agronomic attributes, and litter and forage quality factors of the 35 genotypes, and to determine genotype x environment interactions.

Cooperating Partners

(1) Tropical Forages Program, Centro Internacional de Agricultura Tropical (CIAT), Cali, Colombia

(2) Department of Tropical Pastures and Forages, Institute of Plant Production in the Tropics and Subtropics, University of Hohenheim, Stuttgart, Germany

(3) Estación Experimental Macagual, Corporación de Investigación Agropecuaria de Colombia (CORPOICA), Florencia, Caquetá, Colombia

(4) Centro Nacional de Investigaciones de Café (CENICAFE), Chinchiná, Caldas, Colombia

Names of Principal Scientists:

CIAT

- Dr. P.C. Kerridge, Project Leader
- Dr. B.L. Maass
- Dr. C.E. Lascano
- Dr. M.C. Amézquita

PARTNERS

- CORPOICA: Dr. J. Velásquez
- CENICAFE: Dr. S. Suárez
- Univ. of Hohenheim: Prof. R. Schultze-Kraft, Project Co-leader

Staff to be Financed

University of Hohenheim:

- 1 doctoral student (3 person/years)
- 2 diploma (M.Sc.) students (1 person/year)

CIAT (and national partners):

- 4 field laborers (8 person/years)

Budget Total and Breakdown by Activities and Year (Current US$):

The total budget is US$230,400, broken down as follows:

Item	*Year 1*	*Year 2*	*Year 3*	*Total*
CIAT and National Partners				
Personnel	26,000	26,000	-	52,000
Research & Operations	4,000	6,000	2,000	12,000
Materials & operational expenses	-	-	-	-
Training & Inter-Institutional Cooperations	5,500	5,500	2,000	13,000
Vehicle	4,500	5,500	1,000	11,000
Indirect Costs	7,100	7,500	800	15,400
TOTAL CIAT	*47,500*	*50,500*	*5,800*	*103,400*
University of Hohenheim				
Personnel	33000	33,000	30,000	96,000
Materials & operational expenses	6,000	2,000	3,000	11,000
Travel	9,000	7,000	4,000	20,000
Indirect Costs	-	-	-	-
TOTAL CIAT	*48,000*	*42,000*	*37,000*	*127,000*
Grand Total All Partners	***95,100***	***92,500***	***42,800***	***230,400***

2.0 Background and Justification

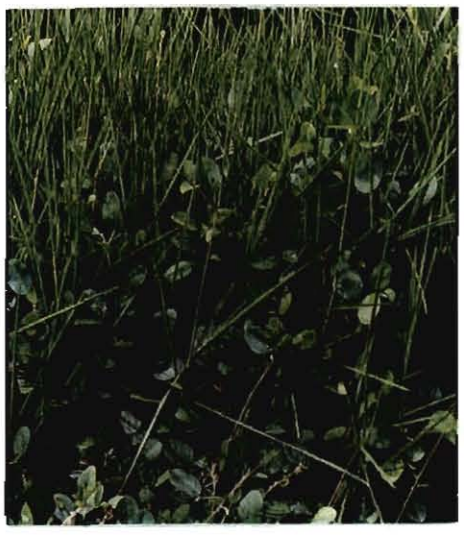
2.1 Introduction

Forage plants in the tropics will concentrate on marginal lands and in agropastoral or silvopastoral systems.

In the future, the use of forage plants in the tropics will increasingly concentrate in two main areas: (1) marginal lands that, due to climatic, edaphic, and/or topographic constraints, do not allow crop production and where extensive, low-input pasture production is the only viable option of land use; and (2) production systems with an integration of livestock into cropping or tree plantations (agropastoral or silvopastoral systems).

Low input requirements, tolerance of excessive grazing, and the ability to contribute to soil conservation and soil improvement, are considered to be key features in the development process of a forage cultivar for these main areas. Because of their ability to fix atmospheric nitrogen, their deep rooting, and their high nutritive value, legumes play a significant role both for livestock production and soil enhancement (Schultze-Kraft et al., 1993).

Legumes play a significant role both for livestock production and soil enhancement.



2.2 The target species

Desmodium ovalifolium Wall.—a species which taxonomically has recently been accepted as *D. heterocarpon* DC. subsp. *ovalifolium* Ohashi (Ohashi, 1991)—is a legume native to the subhumid and humid tropics of Southeast Asia. It combines a series of agronomic characteristics that are important in either of the aforementioned areas: It is one of the very few tropical legumes that has a strong stoloniferous, creeping growth habit. Thus, it provides not only a very effective, erosion-preventing soil cover, which is tolerant to excessive grazing, but also forms persistent mixtures with aggressive grasses of similarly stoloniferous growth habits, e.g., *Brachiaria* species.

Desmodium ovalifolium shows no specificity for *Bradyrhizobium* strains In exploratory trials it fixed the equivalent of almost 90 kg atmospheric N/ha (CIAT, 1981) In addition, it is one of the few legumes available, that are shade tolerant. Adaptation to acid, infertile soils and low nutrient requirements are particularly important features of this species (Grof, 1982). Because of these traits, *D. ovalifolium* is considered to be a legume with a particularly high potential to reclaim degraded lands in the tropics.

D. ovalifolium *is well adapted to acid, infertile soils.*

Mainly because of its shade tolerance (Wong, 1991) and non-climbing growth habit, *D. ovalifolium* has, since many years, been successfully used as a cover-crop legume in Southeast Asian plantation agriculture, e.g., rubber, oilpalm. Within the RIEPT network (Red Internacional de Evaluación de Pastos Tropicales), the only commercial, yet unnamed, cover crop variety has been tested agronomically over a wide range of sites in tropical America. There, it has also shown considerable promise as a pasture legume, and was released for pasture improvement in the humid tropics of Bahia, Brazil, as cv. Itabela (CEPLAC-CEPEC, 1990).

2.3 The problem

D. ovalifolium *has not been widely used for pasture improvement because high tannin contents lead to low palatability for cattle.*

This commercial cover-crop cultivar, however, has not been widely utilized as a pasture legume, because under grazing it proved to be of low palatability to cattle (Schultze-Kraft et al., 1989); so did a few other experimental lines. As a result, pastures tend to become legume-dominant with time (e.g., CIAT, 1990), and livestock performance is subsequently poor. Condensed tannins have been associated with this low acceptability, and with low protein and cell wall digestibilities (Carulla, 1994; Lascano et al., 1994a).

The correspondingly slow rate of litter decomposition, however,however, may well be an advantage for more effective soil cover as demonstrated by Budelman (1988) for *Flemingia macrophylla*, which has very high tannin contents. Nevertheless, for *D. ovalifolium* to fulfill its

role as a legume that enhances soil fertility and animal production, lower tannin levels and higher digestibility are important criteria for cultivar development in this species.

2.4 The genetic resources base

Preliminary studies with a limited set of genotypes suggested that tannin levels in *D. ovalifolium* are influenced by soil fertility and season (Sobrinho, 1982; Salinas and Lascano, 1983). Observations made in the humid tropical lowlands, suggest that *D. ovalifolium* is palatable and well accepted by cattle in that environment, e.g., in Caquetá, Colombia, and also in the humid tropics of Bahia, Brazil, (CIAT, 1990). In addition, tannin levels seem to vary among genotypes like a range of other plant characteristics (Schultze-Kraft and Benavides, 1988).

CIAT has assembled a large germplasm collection through plant exploration in Southeast Asia during the past 15 years.

This, however, needs to be clarified and quantified, making efficient use of the collection of about 160 accessions, that CIAT has assembled during the past 15 years through plant exploration in the wild in Southeast Asia, the center of diversity of the species. This collection represents a unique genetic resource that has not been tapped as yet.

A core collection has been selected, based on origin and on a series of germplasm characterization parameters.

To reduce the total collection to a manageable size, a core collection composed of 35 genotypes has been selected, based on origin and collection site descriptors, and on a series of germplasm characterization parameters including flowering time and seeding, and preliminary quality assessment.

2.5 Project outline

The core collection will be established at four locations in Colombia, with soil and climate characteristics as follows. Rainfall patterns of the four locations are shown in Figure 1.

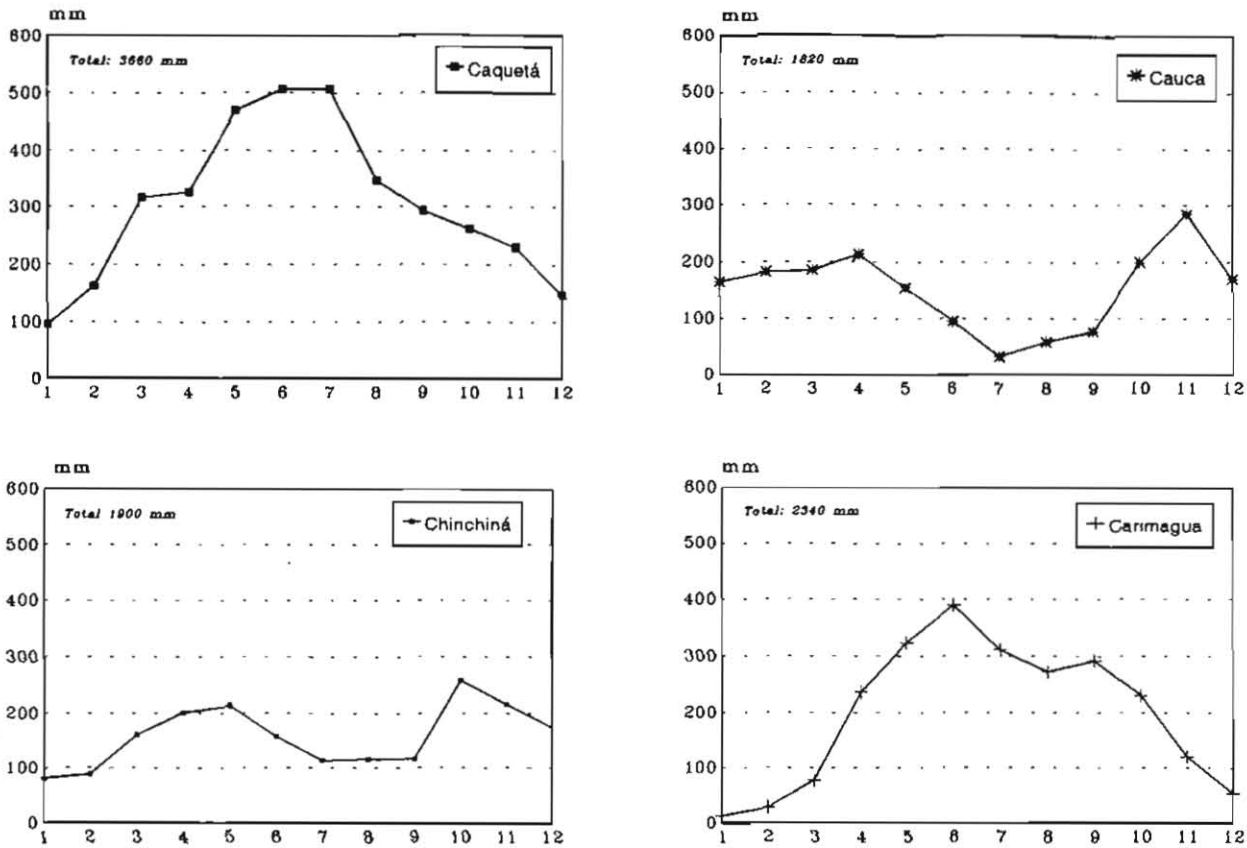


Figure 1: Annual Rainfall pattern at four experimental sites selected
(from January = 1 to December = 12)

The core collection will be evaluated at four locations in Colombia.

(1) Well drained savanna, Llanos of Colombia (CORPOICA-CIAT, Carimagua research station). Soils: Oxisol, very acid (pH ≥4.0), high Al saturation (>80%), low fertility, well drained. Climate: Hot and 2300 mm annual rainfall with 4 months dry season.

(2) Humid tropics, Florencia, Caquetá (CORPOICA, Macagual research station). Soils: Ultisol, acid (pH ≥5.0), high Al saturation (>70%), low fertility, moderate drainage. Climate: Hot and 3600 mm annual rainfall with little dry season stress.

(3) Hillsides-dry, Mondomo, Cauca (farmers field). Soils: Moderately acid (pH ≥5.5), low Al saturation (≥20%), moderate fertility, well drained. Climate: Cool because of altitude (1400 m.a.s.l.) and 1800 mm annual rainfall with bimodal distribution and dry season stress.

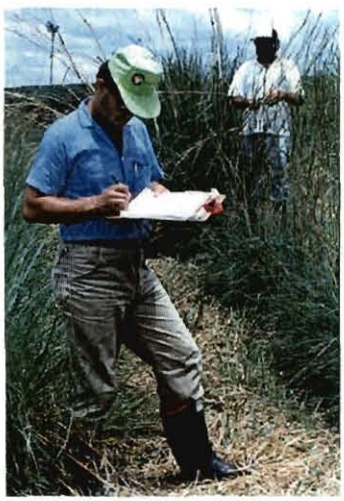
(4) Hillsides-wet, Chinchiná, Caldas (CENICAFE research station). Soils: Moderately acid (pH ≥5.5), low Al saturation (≥30%), moderate fertility. Climate: Cool because of altitude (1400 m.a.s.l.) and 1900 mm annual rainfall with bimodal distribution and little dry season stress.

As in the locations selected the factor "temperature" (hot vs. cool) is confounded with soil "acidity/fertility" (acid/low fertility vs. moderately acid/moderate fertility), a fertilization treatment with two levels will be applied (low and high) in order to eliminate this confounding effect: The low fertilization represents a minimum input level and will be adjusted for the two low-fertility locations "Llanos" and "Caquetá" in order to assure that plants do establish and produce. The high level will be adjusted at each location to remove soil fertility stress completely and thus to promote growth near maximum.

The experiment will last for two and a half years and measurements will be carried out in the establishment phase (first 6 months) and during one rainy and one dry season of the subsequent production phase (24 months). Measurements will concentrate on standard agronomic parameters, including dry matter and seed production,

resistance to pests, diseases and drought, and on litter and forage quality factors related to tannin contents and digestibility, including palatability under grazing.

Results will be subjected to multivariate statistical analyses, and will consider relations between agronomic and quality measurements, and the effects of location, season, fertilization, genotype, and genotype x location interaction.

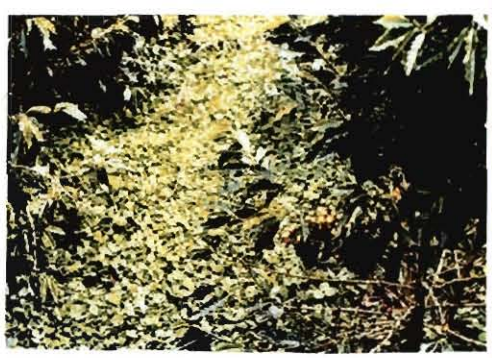


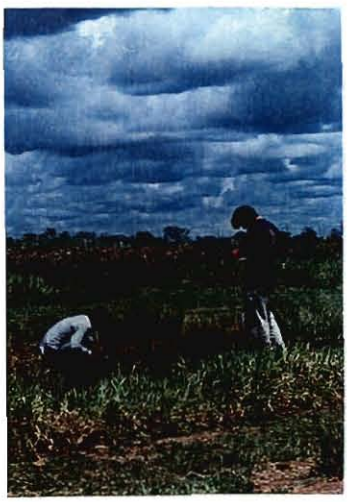
2.6 Ability of organizations and individuals to undertake the research

The project's principal CIAT scientists Drs. P.C. Kerridge (project leader), B.L. Maass, C.E. Lascano, and M.C. Amézquita have long-term experience in the evaluation of tropical forage germplasm, namely in the areas of plant nutrition/soil fertility, genetic variability/ agronomy, forage quality/animal nutrition, and statistical analysis, respectively. They will be able to provide the required local supervision to the doctoral student and the eventual M.Sc. and B.Sc. students.

Since many years, the CIAT Tropical Forages Program (formerly Tropical Pastures Program) has been cooperating closely with the Colombian NARI's CORPOICA (formerly ICA) and CENICAFE, and with local universities, that have faculties of agriculture and biology. The CIAT scientists will therefore be able to maintain the necessary links for an active participation of the national partners in the project. Drs Jaime Velásquez (CORPOICA) and Senén Suárez (CENICAFE) used to be staff member and visiting researcher, respectively, of the former CIAT Tropical Pastures Program. The collaboration of CORPOICA-Macagual and CENICAFE will essentially consist of providing the required experimental area and the corresponding logistics, along with active participation in the periodic measurements, and eventual supervision of a B.Sc. student. Operational costs will be borne by the project funds that are administered by CIAT.

Colombian NARI's and local universities will collaborate in the project.





The German project partner also contributes with a longterm experience in collection and evaluation of tropical forage genetic resources (Prof. R. Schultze-Kraft, project co-leader). The doctoral student is Mr. Axel Schmidt who has an 8-month field-work experience with tropical forage legume evaluation in Colombia; he speaks Spanish fluently.

2.7 Agricultural development and ecology implications of the project

In either aspect the project is highly relevant: Varieties of *Desmodium ovalifolium* varieties that combine productivity and an acceptable level of forage quality with the ability to thrive and produce on marginal lands with infertile soils, will contribute to increased livestock production.

In addition, they will provide building blocks for developing sustainable land use systems in the humid and subhumid tropics through their ability of soil conservation and soil enhancement. They may even be used in reclaming areas with degraded soils.

3.0 Project Objectives

The project has a clear goal, which complements and integrates into the research of the CIAT Tropical Forages Program.

Goal

To contribute to sustainable agricultural production on acid soils in the humid and subhumid tropics through appropriate use of available plant genetic resources of the cover crop and forage legume *Desmodium ovalifolium*.

Project Purpose

To assess the agronomic and forage quality potential of *D. ovalifolium* based on a core collection, at representative high-rainfall locations in Colombia.

The specific objectives are:

(i) To characterize and evaluate the collection in terms of important agronomic characteristics and litter/forage quality, the latter with emphasis on tannin contents, degradability/digestibility, and palatability to cattle.

(ii) To determine the effect of soil fertility and climate on agronomic characteristics and litter/forage quality.

(iii) To identify genotype x environment interactions with respect to agronomic characteristics and litter/forage quality.

Project Outputs

The expected outputs will help identify the ecological niches for the utilization of D. ovalifolium

The expected outputs from the above objectives are:

- Identification of superior genotypes with a potential for pasture improvement and soil conservation for edaphic and climatic environments as represented by one or more of the four experiment locations.
- Identification of edaphic and climatic environments where the potential of *D. ovalifolium* is particularly high.

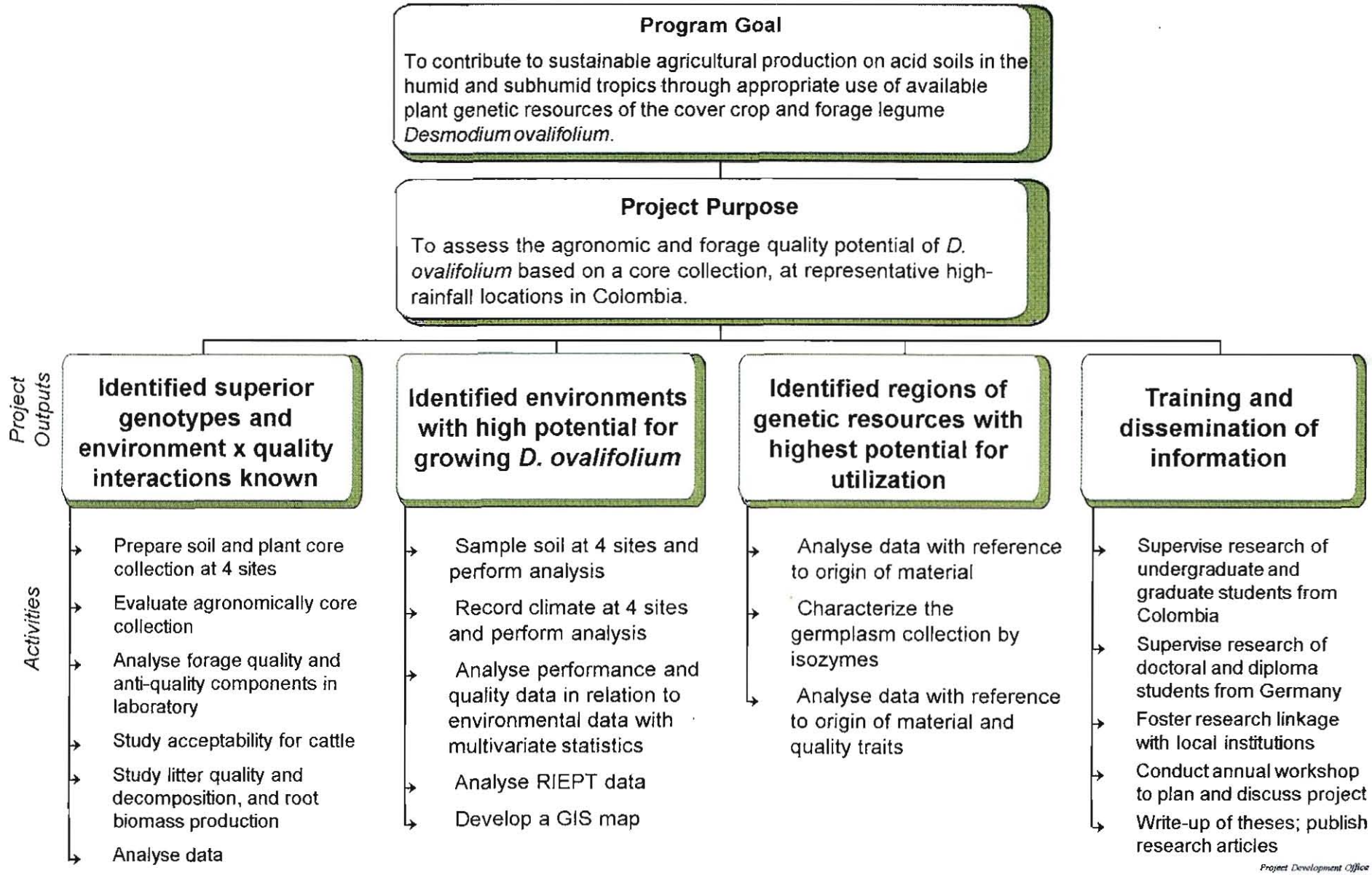
Results on litter and forage quality will assist research in multipurpose trees and shrubs.

- Broadened knowledge about the effect of soil fertility and climate on litter/forage quality of legumes, that contain tannins. This is also highly relevant to the work with multipurpose tree and shrub legumes.
- Identification of regions, in the species' center of diversity, from where most promising genotypes of *D. ovalifolium* originated and where future germplasm collection missions should concentrate, consequently.

Figure 2

Project Description

Work Breakdown Structure Linking Project Activities to Project Outputs



4.0 Work Plan

The project will be coordinated by the Tropical Forages Program, and both Colombian and German students and scientists will carry out the research.

The principal activities and subactivities of the project as they relate to the project's outputs are illustrated in Figure 2. Figure 3 shows the project organization concerning technical reporting and financial management. The implementation schedule, showing the beginning and duration of each main activity, is shown in Figure 4.

The execution of the project will require three years. The project will be coordinated by Dr. P.C. Kerridge, Leader of the Tropical Forages Program, CIAT, with assistance from other scientists from CIAT and staff from the University of Hohenheim, Germany.

The research will be carried out by students and staff of German and Colombian Universities and CIAT scientists (see also 5.0 Training).

Figure 2 shows the breakdown of the project structure with descriptions of the activities. Detailed descriptions of the proposed activities follow.

4.1 Identified superior genotypes of *D. ovalifolium* with a potential for pasture improvement and soil conservation

Core collection

The experiment will involve the evaluation of a core collection (35 genotypes) of the ex situ collection of *Desmodium ovalifolium* maintained in the CIAT germplasm bank. This core collection has been assembled based mainly on origin. However, agronomic and quality data, such as growth habit, flowering pattern, tannin content and relative palatability obtained in previous evaluations have also been taken into account (Table 1).

Presently, seed of the 35 genotypes is being increased to make further evaluation possible.

Figure 3

Project Organization Chart

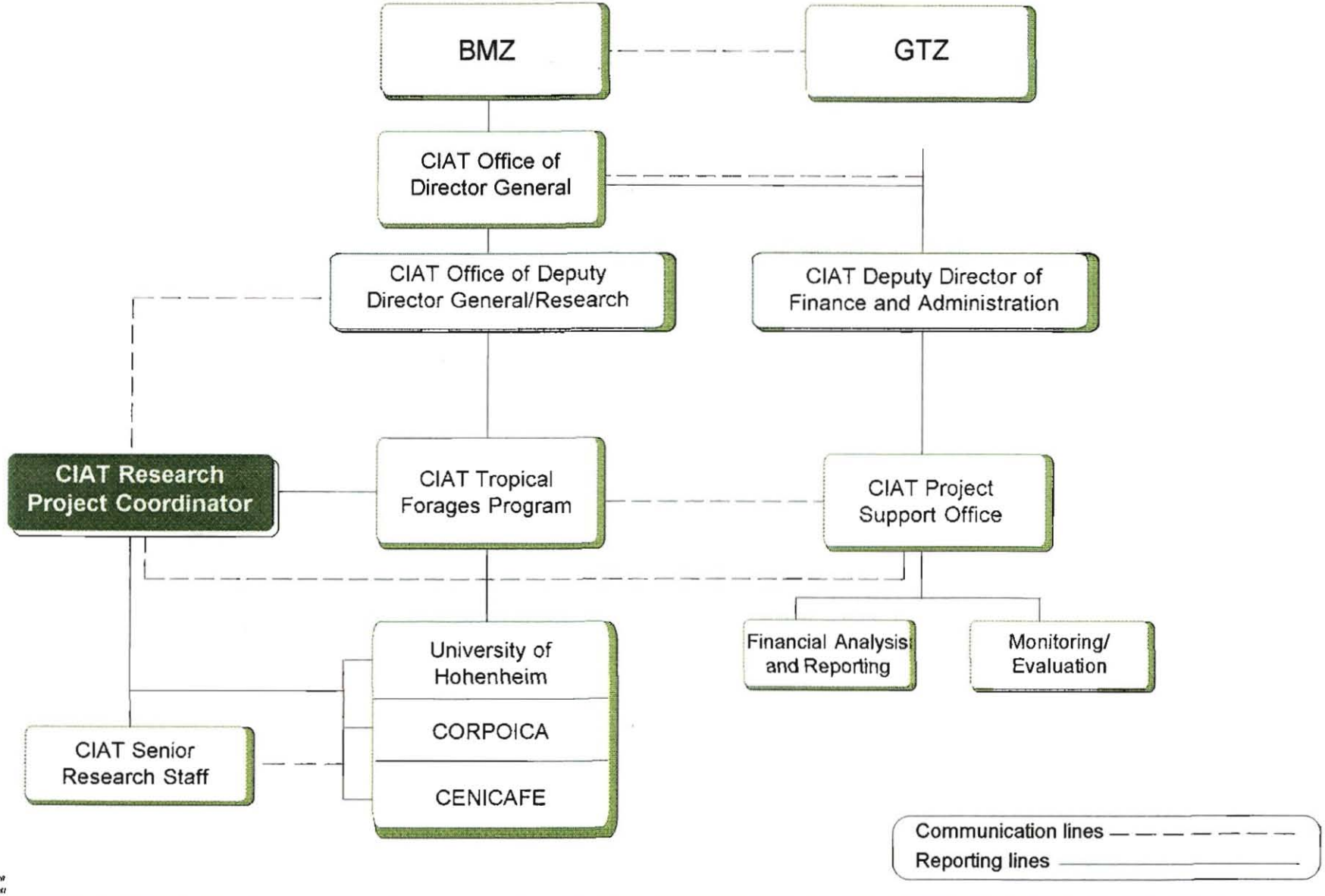


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Figure 4

Implementation Schedule of Activities by Quarter (Q)

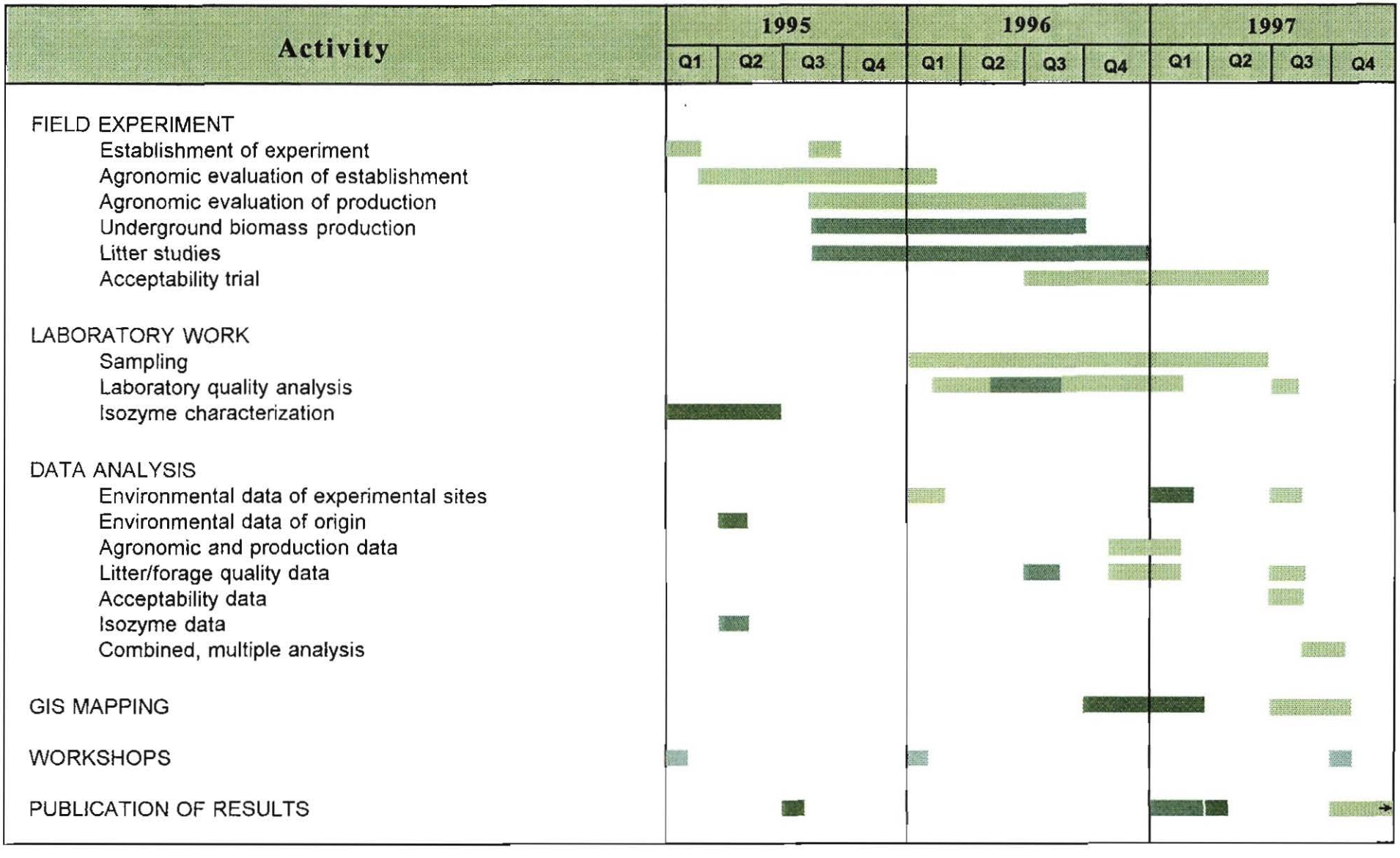


Table 1: Origin of core collection of *Desmodium ovalifolium*

Country of origin	Accessions (No.)	Range of latitudes	Range of altitudes	Range of rainfall
Thailand	21	19N-6N	25-900	1160-4540
Vietnam	3	15N-12N	150-900	1840-2200
Malaysia	5	6N-2N	30-80	2150-2900
Indonesia	4	5N-4S	40-120	1840-3190
Without information	2	-	-	-

Table 2: Summary of characteristics of locations

Location	Acidity	Al saturation	Fertility	Temperature	Dry season stress
Llanos/ Carimagua	H	H	L	Hot	H
Humid Tropics/ Caquetá	H	H	L	Hot	L
Hillsides/ Cauca	M	L	M	Cool	H
Hillsides/ Chinchiná	M	L	M	Cool	L

H = high **M** = moderate **L** = low

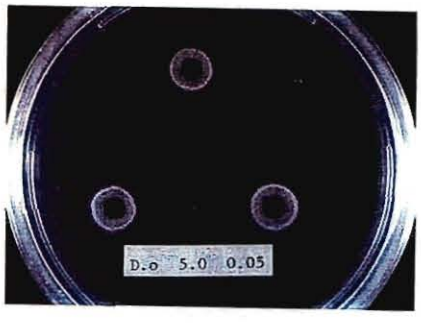
Sites for evaluation

The evaluation will be carried out in different ecoregions in Colombia. The most important features of the four sites selected are mentioned in Section 2.5 and are summarized in Table 2. Each site will be characterized in terms of soil physical and chemical properties. During the duration of the experiment soil moisture will be monitored, and climatic data will be recorded (i.e., day/ night temperature, relative humidity, rainfall).

Experimental design

The core collection will be planted at each site in a split-plot arrangement with two replications. The main plot will be fertility level and the subplot genotypes.

The main plot will be the fertility level applied (low and high) and the sub-plot genotypes.



Appropriate statistics will be applied to analyse the complex data sets.

Measurements

Measurements and evaluations will be carried out in the establishment phase (6 months) and during the production phase (18 months) as detailed in Table 3.

Analysis of results

Common descriptive statistics will be applied to explore the data generated. Analysis of variance will be applied for all variables measured or evaluated to determine differences between genotypes, environments, and the interaction of both. Correlation analysis will help understand the interdependence of agronomic and quality factors. Analysis of stability of both data sets, such as the Stability Index of Eberhart and Russell (1966), will be performed to identify superior genotypes across ecoregion, not only in terms of agronomic performance but also concerning litter/forage quality features. For example, Keller-Grein et al. (1993) conducted this kind of analysis of performance across species and accessions in the humid tropics of South America.

Table 3: Evaluation parameters and methods

Establishment phase

Agronomic measurements will be taken monthly.

1. Number of plants
2. Soil cover (%)
3. Incidence of pests and diseases

Production phase

Agronomic measurements will be taken every 6 and 8 weeks in the periods of maximum and minimum rainfall, respectively, following a uniformization cut. The methodology applied will be modified based on Toledo (1982).

1. Plant height and lateral extension (cm)
2. Forage yield (biomass production g/m^2)
3. Leaf:stem proportion (%)
4. Flowering date (days after transplanting)
5. Seed yield (g/plant)
6. Incidence of pests and diseases

Quality measurements will be carried out on leaves of 4-6 weeks-old regrowth which were sampled twice during the period of maximum rainfall and twice during the period of minimum rainfall. Laboratory analyses will be carried out utilizing the same methods as Carulla (1994).

1. Crude protein (%)
2. Indigestible N (N in ADF)
3. Cell wall content (NDF)
4. In vitro digestibility (DM and cell wall)
5. Extractable and bound (fiber and protein) condensed tannins
6. Capacity of tannins to bind protein (radial difussion assay)
7. Relative degree of polymerization of tannins (i.e., type of tannins)

Acceptability measurements as reported by Maass (1988) and Thomas and Schultze-Kraft (1990) and detailed below, are planned on 4-6 weeks-old regrowth, once during the period of maximum rainfall and once during the period of minimum rainfall.

The relative palatability of genotypes of *D. ovalifolium* will be measured in Cafeteria-type trial. Four groups of animals (2-3 animals/group) will be adjusted for 3 days in one of the replications of each fertilizer plot. Following adjustment, each group of animals will graze one of the fertilizer plots for 3 days. On each day the genotype being grazed will be recorded at 10-minutes-intervals. A palatability index will be calculated for each genotype within each fertility level. These palatability indices will be complemented by measurements on forage utilization (i.e., forage on offer before and after grazing).

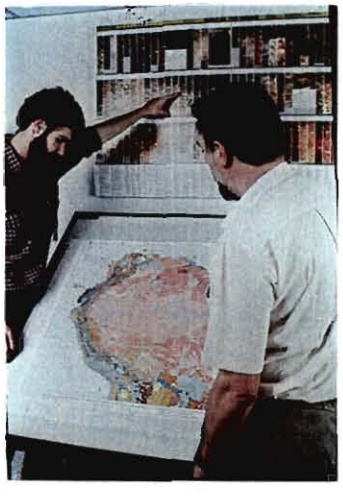
Multivariate statistics help discriminate the most important environmental factors for performance and quality.

4.2 Identified edapho-climatic environments with high potential for growing *D. ovalifolium*

Analysis of trial results

With the purpose of identifying the edapho-climatic pattern for growing *D. ovalifolium*, multivariate statistics will be applied to reduce the climate and soil variables measured to the most important ones. Similar analyses have been performed previously at CIAT with the legume *Stylosanthes guianensis* (Amézquita et al., 1991) and the grass *Andropogon gayanus* (Amézquita et al., 1989), where Principal Component Analysis and Step-wise Multiple Regression Analysis helped discriminate the most important environmental factors. The resulting factors will then be subjected to statistical analysis to estimate the effects of location, fertilizer within location, genotype and genotype x location interaction, through Analysis of Variance.

Response variables of the genotypes such as yield and quality will be related to an "environmental index" which combines edaphic, climatic and biotic indicators, resulting from a Principal Component Analysis on environmental variables that explain the largest proportion of variation among sites.



GIS map

Given the identification of particular environmental factors the basis for a map will be developed in collaboration with the Geographic Information Systems (GIS) Section at CIAT, which will indicate regions of highest potential for growing *Desmodium ovalifolium* as a cover crop and/or for pasture improvement. Data produced within the RIEPT network in the past 15 years, by evaluating the commercial genotype of *D. ovalifolium* (accession CIAT 350) over a wide range of sites in the American tropics, will also be utilized to generate this

map. Recently such a map was produced to determine potential growing areas for *Leucaena leucocephala* in the Americas (Lascano et al., 1994b).

The regions with highest potential for growing D. ovalifolium *will be indicated in a map.*

4.3 Broadened knowledge about the effect of soil fertility and climate on litter and forage quality

Previous exploratory studies at CIAT (unpubl. data) suggest a close relation between litter and forage quality parameters. In the present project, studies of litter decomposition will be carried out at the four locations by applying litter-bag techniques. Litter decomposition determined by percent of organic matter remaining in the litter bag, and the extent of release of N and P from the litter will be measured (e.g., Rao et al., 1992; Sarrantonio, 1991).

The resulting rates of decomposition will be submitted to Correlation Analysis with forage quality parameters, with special emphasis on tannins and cell wall components such as fiber. Soil fertility and climatic differences of the four sites will be taken into account.

4.4 Identified regions in the center of diversity of *D. ovalifolium* with genetic resources of highest potential for utilization

Isozyme characterization

A characterization of the entire germplasm collection of *D. ovalifolium* maintained at CIAT will be carried out by isozyme analysis applying polyacrylamide gel electrophoresis (PAGE). Recent studies, utilizing this technique, revealed considerable diversity in germplasm collections of legumes, such as *Arachis pintoi* (Maass et al., 1993; Bermúdez and Maass, unpubl. data), *Stylosanthes capitata* (Marulanda and Maass, unpubl. data), and *S. guianensis* (Maass and Ocampo, unpubl.

Genetic diversity and its relation with useful traits will be studied through isozyme characterization.

data), and helped stratify genetic diversity. These studies are being developed by undergraduate students of a Colombian university for their theses.

Data analysis

In the subsequent data analysis of banding patterns and single bands, the genetic diversity of the collection and the genetic similarity of accessions will be described. For this purpose, Correspondence Analysis proved to be most useful. Geographic centers of diversity will be identified by relating diversity structure to the origin of the specific accessions. These data will be also related to agronomic performance and quality data. Furthermore, it will be analyzed how well the core collection represents the entire collection, concerning isozyme analysis.

Identification of centers of biodiversity will assist in designing ex situ and in situ conservation strategies of genetic resources.

Finally, correlations of isozyme banding patterns and quality traits, particularly tannins, will be sought for the purpose of identifying a simple marker which may help speed up future germplasm screening for tannin content.

5.0 Training

Students from local universities will be given the opportunity for thesis research. Women are encouraged to participate in the project.

Training of junior researchers is an important component of the project.

5.1 Training of Colombian scientists

The project will provide the opportunity for four Colombian undergraduate students from the universities at Palmira (Universidad Nacional), Villavicencio (Universidad del Llano), Florencia (Universidad del Amazonas), and Manizales (Universidad de Caldas) to conduct their B.Sc. thesis research at the experiment locations Cauca, Carimagua (Llanos), Macagual (Caquetá), and Chinchiná (Caldas), respectively. According to its gender policy, CIAT will take care that both female and male students will participate in the project if they are equally talented. Their thesis subjects will be in the area of underground biomass production of *D. ovalifolium* genotypes.

A M.Sc. thesis opportunity for a Colombian scientist is also included in the project. The thesis subject will be in the area of evaluation of plant characteristics in *D. ovalifolium* that are relevant for soil reclamation, including litter quality and descomposition.

5.2 Training of German scientists

A German doctoral student from the University of Hohenheim will carry out the main part of the project. He will work under the local supervision of the project leader, Dr. P.C. Kerridge, and Dr. B.L. Maass. His work will be complemented by short-term studies (6 months) of two German diploma students ("MSc students") whose thesis subjects will be in the areas of:

(1) GIS mapping regions with high potential for growing *D. ovalifolium* as a cover crop and/or for pasture improvement; and

(2) biochemical characterization of *D. ovalifolium* genotypes by isozyme electrophoresis.

6.0 Expected Patentable Research Results

CIAT endorses the principle of free access to research results. It supports this through publication of research findings in international journals and in-house documents.

There are no patentable results anticipated in this project.

7.0 Funding Requirements

7.1 Budget

The budgets for CIAT and the University of Hohenheim appear in Table 4. The CIAT budget includes the part of the national partners, that will be administered by CIAT

7.2 Budget notes

Personnel

- The 4 field laborers budgeted for CIAT refer to 1 laborer/ location during 2 years and are the absolute minimum of support personnel required to carry out the project.
- The German doctoral student (budget equivalent to BATII/ 2) will carry out the main part of the project. He will be supported by two German diploma students ("MSc students"): the stipends of the latter (DM 5.000 each) are equivalent to the diploma student scholarships granted by the Eiselen Foundation and include their international travel from and to Germany.

Research and operational expenses

- As the project includes a grazing phase to determine variation in palatability, in addition to common experiment establishment costs, fencing and water supply for cattle is required.
- The project requires frequent travelling between the four locations. Therefore a 4-wheel-drive vehicle needs to be assigned during the two years of measurements in the field.

Table 4

Centro Internacional de Agricultura Tropical – CIAT

BMZ – Genotype X Environment Interaction in the Tropical Cover Crop and Forage Legume *Desmodium ovalifolium*

Proposed Budget in US$ dollars

Line item	Year 1	Year 2	Year 3	Total
CIAT				
Personnel				
Field labourers (4) – 8 Man/Yrs	26,000	26,000	–	52,000
Total personnel	**26,000**	**26,000**	–	52,000
Research and Operations				
Supplies and services: Fencing, land preparation, fertilizer, water supplies	3,000	3,000	–	6,000
Laboratory analysis	1,000	3,000	2,000	6,000
Total research and operations	**4,000**	**6,000**	**2,000**	12,000
Training and Inter–institutional cooperation				
BSc Students (4)	2,000	2,000	–	4,000
MSc Students (1)	1,500	1,500	–	3,000
Workshops	2,000	2,000	2,000	6,000
Total training and Inter–institutional cooperation	**5,500**	**5,500**	**2,000**	13,000
Vehicle lease	**4,500**	**5,500**	**1,000**	11,000
Indirect costs (20% Excluding vehicle)	**7,100**	**7,500**	**800**	15,400
TOTAL CIAT	**47,100**	**50,500**	**5,800**	103,400
HOHENHEIM UNIVERSITY				
Personnel				
Doctoral student (1) 12 mo/yr	30,000	30,000	30,000	90,000
MSc Student (2) 6 mo/yr	3,000	3,000	–	6,000
Total personnel	**33,000**	**33,000**	**30,000**	96,000
Materials and operational expenses				
Literature searches, photocopies, telecommunications, freight expenses, publications	2,000	2,000	3,000	7,000
Portable computer	4,000	–	–	4,000
Total materials and operational expenses	**6,000**	**2,000**	**3,000**	11,000
Travel				
Local (Doctoral Student)	2,000	2,000	2,000	6,000
International (Doctoral Student)	2,000	–	2,000	4,000
(Supervisor)	5,000	5,000	–	10,000
Total Travel	**9,000**	**7,000**	**4,000**	20,000
TOTAL HOHENHEIM UNIVERSITY	**48,000**	**42,000**	**37,000**	127,000
GRAND TOTAL	**95,100**	**92,500**	**42,800**	230,400

p/ E Ramirez

Juan A. Garafulic
Financial Controller

BMZ-GENO
12-Aug-94
PROPOSED

- The doctoral student will need access to computer facilities at each of the four locations. Since this cannot be guaranteed, a portable computer with some basic software is required (Hohenheim budget).

Training and interinstitutional cooperation (CIAT budget)

- Provision is made for training of up to four B.Sc. students from Colombian universities who will receive a small allowance to do his/her thesis research, and for one MSc student also from a Colombian university
- The workshops budgeted refer to 2-day meetings at CIAT with the participation of CIAT scientists, the doctoral student, and the Colombian project partners and their research assistants, at the beginning of years 1 and 2, and at the end of the project, in order to discuss research methodology details of research, project progress, and final results.

Travel (Hohenheim budget)

- The amount budgeted for local travel refers to an absolute minimum necessary for the doctoral student to move between the four locations, incl. petrol for the vehicle.
- The international travel (US$ 14,000 for the supervisor and the doctoral student) includes a provision for an eventual participation in an international congress.

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Keller-Grein, G.; Amézquita, M.C.; Lema, G. and Franco, L.H. 1993. Multilocational testing of grasses and legumes in the humid tropics of South America. Proc. of the XVII Int. Grassl. Congr., New Zealand and Queensland, Australia, Vol I, p. 217-219.

Maass, B.L. 1988. Möglichkeiten der Futterwertfeststellung im frühen Evaluierungsstadium genetischer Ressourcen am Beispiel von *Stylosanthes scabra* Vog. Giessener Beiträge zur Entwicklungsforschung Reihe I. Bd. 17, p. 177-186.

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Appendix A-1

CIAT C.V.

Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

Peter C. Kerridge

Position in Project:

Research Scientist, Forage Agronomist
Project Officer

Managerial Experience:

Centro Internacional de Agricultura Tropical (CIAT)
Cali, Colombia (1992-present)
Leader, Tropical Forages Program. Responsible for supervision of scientists and projects within the Program and liaison with other CIAT Programs and national and donor organizations.

Division of Tropical Crops and Pastures (DTCP) CSIRO
Brisbane, Australia (1978-1992)
Project Leader 'Phosphorus requirements for beef cattle' (1981-90) 'Grazing, legumes and sustainability of savannas' (1990-92)

Malaysian Agricultural Research and Development Institute (MARDI)
Serdang, Malaysia (1973-1978) AIDAB secondment
Responsible for Australian contribution to development of a forage research and development unit within MARDI.

Research Experience:

CIAT, Cali, Colombia (1992-present).
Adaptation of tropical forages to soil and climate.

DTCP-CSIRO (1978-1992)
Nutrient requirements for plants and cattle.
Adaptation of forage legumes to different soils.
Smallholder feeding systems for livestock -Southeast Asia.

MARDI (1973-1978)
Adaptation of tropical forages.
Nutrient and rhizobia requirements of forage legumes.
Productivity of tropical forages for beef and milk production.

DTCP-CSIRO (1968-1973)
Fertilizer requirements of tropical pastures used for milk production.
Molybdenum requirements of legumes.

Oregon State University, Corvallis Ore. USA (1964-78)
Tolerance of aluminium toxicity in wheat.

Agricultural University, Bogor, Indonesia. (1961-1964)
Adaptation of forage legumes to acid soils.
Use of crop residues for draught animals.

University of Queensland, Brisbane. (1958-61)
Fodder conservation in Western Queensland.
Ecology of a native legume -Psoralea eriantha.

Consultancies:

In areas of research management, review of research and development and project design to Indonesia, Philippines, Thailand, Fiji, Brazil, Colombia and Ethiopia.

Membership in Scientific Societies:

- Tropical Grassland of Australia
- Australian Society of Animal Production
- Australian Society of Soil Science

Education:

Ph.D. Plant Nutrition. Oregon State University, 1978.

B.Agr.Sci. University of Queensland, 1957.

Professional Development Courses (CSIRO and CIAT)
Project Management, Communication.

Languages:

English -Fluent
Indonesian, Spanish -Conversational

Citizenship:

Australian

Country of Residency:

Colombia

Recent Publications:

(Author of 36 articles and 13 book chapters, a representative sample of which appear here)

Kerridge, P.C. 1994. Opportunities for forage research and development in tropical Latin America. ACIAR Conference: Strategic Directions for Tropical Pasture Research in ACIAR. Brisbane November 1993.

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Appendix A-2

CIAT
Centro Internacional de Agricultura Tropical
International Center for Tropical Agriculture

C.V.

Rainer Schultze-Kraft

Position in Project:	German Project Coordinator for University of Hohenheim
Citizenship:	German
Country of Residency:	Germany
Education:	Field work for doctoral thesis **Centro Internacional de Agricultura Tropical** (CIAT) Cali, Colombia, 1976 Dr. agr. degree **Justus Liebig-University Giessen** Thesis subject: Studies on the suitability of the legume genus *Stylosanthes* for pasture improvement in tropical savannas of South America such as the Colombian Llanos Orientales". 1976 Agronomist degree. Dipl.-Ing. Agr. Agricultural science studies, majoring in plant production **Justus Liebig-Univesity Giessen**, Germany Diploma Ing. agr. 1972
Languages:	German, English, Spanish - fluent French, Portuguese - working knowledge
Research Experience:	**University of Hohenheim**, Germany Institute of Plant Production in the Tropics and Subtropics Professor, Tropical Pastures and Forages July, 1991 - present

Centro Internacional de Agricultura Tropical (CIAT),
Cali, Colombia
Tropical Pastures Program (TPP)
Germplasm Agronomist

- Head of the TPP Germplasm section: Collection, introduction, preliminary evaluation and multiplication of tropical forage germplasm. 1976

- Head of the TPP Germplasm Development Unit: Coordination of research activities of seven TPP sections (Germplasm, Breeding, Plant Pathology, Entomology, Regional Trials, Agronomy-Llanos, Agronomy-Cerrados). 1980 - 1985

- Head of the TPP section Pasture Agronomy/RIEPT-Llanos: Species evaluation and selection under cutting and grazing in the Llanos ecosystem, including on-station research at Carimagua and Villavicencio (Meta, Colombia) as well as coordination of RIEPT (Red Internacional de Evaluación de Pastos Tropicales) network trials. 1989 - 1991

Justus Liebig-University, Giessen, Germany
Institute of Plant Production
Scientific Assistant
January, 1973 - April, 1973

Consultant for German Ministry of Economic Cooperation (BMZ), Perú
Agronomist
August, 1972 - September, 1972

Assistant farm manager (bananas, coconuts, citrus, dairy and beef cattle on improved pastures).
Santa Marta, Colombia
May, 1961 - August, 1967

UNIVERSITÄT HOHENHEIM

INSTITUT FÜR PFLANZENPRODUKTION
IN DEN TROPEN UND SUBTROPEN
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Appendix B

Partner Confirmation Letters

Dr. Peter C. Kerridge
Tropical Forages Program
CIAT
Apartado Aéreo 6713
Cali, Colombia

1 August 1994

Dear Dr. Kerridge,

I am writing to confirm my commitment and that of the Department of Tropical Pastures and Forages of this Institute, to the special project entitled "Genotype x environment interaction in a core collection of the tropical cover crop and forage legume *Desmodium ovalifolium*" which will be proposed to BMZ.

Sincerely,

Prof. Dr. R. Schultze-Kraft

Corporación Colombiana de Investigaciones Agropecuarias
CORPOICA - CI MACAGUAL

Macagual, 10 de agosto de 1994 No. 194

Doctora
BRIGITTE MAASS
Programa de Forrajes Tropicales
CIAT, Cali

Estimada Brigitte:

Encontramos interesante la propuesta para el proyecto "Interacción genotipo por medio ambiente de una colección de Desmodium ovalifolium - cultivo de cobertura y leguminosa forrajera tropical".

Como consideramos que este proyecto intenta desarrollar una especie promisoria apropiada a sistemas sostenibles, estamos muy interesados en colaborar con el CIAT y otras instituciones para llevar a cabo las diferentes actividades.

Nosotros contribuiremos con lo que el proyecto requiera en áreas para los experimentos y oficina para el personal investigador, además consideramos necesario poder tener acceso a la información y al germoplasma que se requiera en futuras investigaciones.

Cordial saludo,

SALVADOR ROJAS GONZALEZ
Director CI Macagual

CORPORACION COLOMBIANA
DE INVESTIGACION
AGROPECUARIA
CORPOICA
REGIONAL DIEZ
DIRECTOR CENTRO DE INV. MACAGUAL

Km. 20 Vía a Morelia, Apartado Aereo 337 Teléfono • Fax (95835) 4455 Florencia - Caquetá Colombia

Federación Nacional de Cafeteros de Colombia

Cenicafé

CENTRO NACIONAL DE INVESTIGACIONES DE CAFE " PEDRO URIBE MEJIA "

Chinchiná - Caldas - Colombia

Al contestar
Cítese este número

11 AGO. 1994

DIR 3203

Señores
CENTRO INTERNACIONAL DE AGRICULTURA TROPICAL
PROGRAMA DE PASTOS TROPICALES
Att. Dra. Brigitte L. Maass
Cali
VALLE

Asunto: Genotype x Environment Interaction in the Tropical Cover Crop and Forage Legume **Desmodium ovalifolium**

El Centro Nacional de Investigaciones de Café (CENICAFE) de la Federación Nacional de Cafeteros de Colombia, desea colaborar con CIAT y otras instituciones en el Proyecto sobre **Desmodium ovalifolium.**

Debido a la necesidad de desarrollar esta especie promisoria bajo diferentes condiciones ambientales para un uso apropiado bajo sistemas de producción agropecuaria sostenibles, hay la necesidad de ejecutar el presente trabajo clave para el desarrollo y protección del medio ambiente.

La localidad en Chinchiná, en la Subestación Experimental La Romelia, suelos Melanudans a 1370 m de elevación se localiza dentro de la zona media de la ladera colombiana, entre los 1000 y 2000 m.s.n.m. La zona es diversa en hidrología, suelo y vegetación. De otro lado, es frágil y el suelo y su productividad desaparecen facilmente cuando no reciben el manejo apropiado.

Desmodium ovalifolium es una leguminosa promisoria para la zona media de ladera colombiana y la zona Andina Americana para el aumento de la productividad y en el mejoramiento de la protección del suelo y del medio ambiente, y por lo tanto CENICAFE colaborará en la medida de sus posibilidades para que se lleve a cabo el presente proyecto.

Atentamente,

GABRIEL CADENA GOMEZ
Director

c.c. Programa de Agronomía
Disciplina Química Agrícola

SSV/mlcg.

CIAT has in-house facilities for the production of high-quality training materials and video programs for scientific and extension agricultural activities.

This proposal was produced and published, using CIAT's computer layout and graphic composition facilities and outside low-cost copying services.