# Evaluation of a Collection of *Calopogonium mucunoides* Desv. for the Cerrado Ecosystem, Brazil

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## ABSTRACT

**An agronomic evaluation of the tropical forage legume *Calopogonium mucunoides* Desv. was made by growing 215 accessions for two years at two levels of fertility on a red-yellow latosol in the Brazilian Cerrado. Annual dry matter yield (DMY) for the 12 clusters ranged from 1-3.6 t ha$^{-1}$, the highest being in clusters 1, 3, 7 and 9. These four clusters contained 47 accessions (22 % of the collection), with medium-low seed yield. Groups 1, 3 and 6 with clusters 11, 10, 4, 5, 8, 2 and 6 were 56 % of the collection, with intermediate DMY and variable seed yield, ranging from high to low. Seed yield during the first year was high only in group one (clusters 10 and 11) which was only 10 % of the collection. The collection presented two other important differences. Leaflets varied in size (normal, as the commercial *C. mucunoides* cv. Común, and small) and in the number of hairs mm$^{-2}$. Also, a negative relationship between the degree of pilosity and in vitro dry matter digestibility was found. Hairs were impregnated with lignin and cutin, both of which impede digestibility of intact tissue. Seventeen accessions were selected for further evaluation in larger plots. Two accessions, CIAT 822 and 20709, were outstanding for their leaf retention during the dry season in the Cerrado ecosystem.**

***Additional index words*: Cerrado, *C. mucunoides*, forage yield, seed yield, cutin, digestibility.**

## INTRODUCTION

The Brazilian Cerrado, covering 205 Mha, has contributed significantly to the livestock economy of Brazil during the last three decades. However, native and cultivated pastures are declining in both productivity and stability as a result of intensive use. Incorporation of a legume component may halt and revert the process of degradation (Peralta and Toledo, 1991).

*Calopogonium mucunoides* Desv., although not widely used (like any other pasture legume today in Brazil), is the most popular forage legume amongst farmers and is the legume seed produced in the greatest volume in Brazil (600 - 800 t year$^{-1}$).

*C. mucunoides* has some limitations, in particular its rather low palatability. It is a vigorous, short-lived perennial, naturalised in many countries (Davies and Hutton, 1975) and is of South American origin (Davies and Hutton, 1975; Cóser, 1981). It is an aggressive climbing legume that dominates most weeds. Its role is more as a reliable basic feed, green cover or green manure, rather than as a high quality forage producing rapid cattle growth. Because it is a very productive legume (Mattos and Pedreira 1984), it can provide companion grasses with nitrogen (Seiffert and Zimmer 1988), and the grasses, in turn, can provide good feed.

It is a myth that at all times cattle dislike grazing *C. mucunoides*. Young seedlings are quite palatable (Wesley-Smith, 1980) and the species is grazed during the dry season (Seiffert and Zimmer, 1988). The low intake of *C. mucunoides* is not due to any toxic effects of the plant, but probably to factors that affect "acceptability". This is supported by the work of McSweeney and Wesley-Smith (1986), where supplementation with 500 g day$^{-1}$ of ground *C. mucunoides* via the ruminal fistula did not depress voluntary consumption of *Medicago sativa* L. hay more than when an equivalent amount of *Macroptilium atropurpureum* (DC.) Urb. was given. It has been suggested that the density of epidermal hairs on *C. mucunoides* may deter animals from eating the plant (Davies and Hutton, 1975).

The broad objectives of this preliminary germplasm evaluation were the characterisation and agronomic assessment of a collection of 215 accessions. A particular objective was to identify high yielding accessions tolerant of the long dry season, and with higher *in vitro* dry matter digestibility and seed yield than the commercial cultivar, to provide new options for use in short-duration ley-farming systems or as green manure.

## MATERIALS AND METHODS

A small plot clipping trial was carried out over two consecutive years at the Cerrados Agricultural Research Centre (EMBRAPA-CERRADOS), located 40 km NE of Brasilia (15° 35' S, 47° 42' W; 1000 m altitude). The soil is an infertile well drained red-yellow latosol, pH 4.9 (in $H_2O$). P fixation and Al saturation are high, whilst available nutrients such as Ca, Mg, S and Zn are in low supply. The average rainfall is 1580 mm, of which 90% falls between October and March. Average year-round temperature is 21°C.

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The 215 accessions were planted in single row plots (5.5 m long), 2 m apart and with 0.50 m between plants, with two levels of fertiliser and two replications, using a split-plot design. Low (L) and high (H) fertiliser levels were: $P_2O_5$ (L=80, H=200); $K_2O$ (L=60, H=100); FTE (L=30, H=60); Lime (L=1700, H=3000) kg $ha^{-1}$.

In each plot, ground cover percentage and accumulated dry matter yield (DMY) were estimated. Composite samples of all plant parts for the whole collection were analysed for *in vitro* dry matter digestibility (IVDMD). For some selected accessions, IVDMD was carried out on all plant components (whole leaf, leaf without vein, vein, stems and green pods).

Epidermal hairs were counted on 10 leaflets from each accession using a microscope. Hairs are expressed in number $mm^{-2}$. Lignin and cutin concentration in the commercial *C. mucunoides* and in two selected accessions with low hair counts (CIAT 729 and 17887) were determined according to the technique described by Metcalfe and Chalk (1965).

Statistical analysis showed that fertility levels had no significant effect on DMY. Data presented are therefore the average of four measurements. Cluster analysis was applied to a data-matrix of the following four agronomic attributes for the 215 accessions:

- accumulated dry matter yield (kg $ha^{-1}$);
- nutritive value ( IVDMD, %);
- pure seed yield (kg $ha^{-1}$); and
- natural habitat (collecting site).

A higher weight (2:1) was given for nutritive value and pure seed yield. Data were analysed according to SAS software, version 6.0 (SAS, 1989).

Analysis of variance was performed on seed yield data in relation to flowering cycle, time (first and second year), hairiness and hairiness *vs.* IVDMD. Other agronomic attributes recorded during the evaluation were, growth habit, days to seed maturity, density of epidermal hairs ($mm^{-2}$), rooted nodes ($m^{-2}$), and pests and diseases (scale 1-5).

# RESULTS AND DISCUSSION

## Cluster analysis

The data-matrix of agronomic attributes determined for four variables was truncated at the 12 clusters that could be grouped in six main groups (Table 1). The 12 clusters explained 80 % of the variation. The main variables used for discrimination were seed yield and DMY.

*Group 1.* Containing clusters 10 and 11. Seed yield was higher, with a range from 40 - 140 kg $ha^{-1}$ during the first year. DMY ranged from 1 - 4 t $ha^{-1}$, with medium IVDMD (37 - 45 %). This group contained only 10 % of the *C. mucunoides* collection, mainly collected in Panama, Indonesia and Mexico.

*Group 2.* Containing clusters 7 and 9 representing 21 % of the collection. The main agronomic attributes were medium seed yield (0 - 53 kg $ha^{-1}$) and IVDMD (32 - 47 %). Most

**Table 1. Main discriminatory attributes and distribution of accessions of *C. mucunoides* among six main groups and 12 clusters.**

| Group | Cluster No. | Description | | No of accessions/ cluster | Mean | | | Main centre of origin in each group |
|---|---|---|---|---|---|---|---|---|
| | | Seed Yield | DMY[1] | | Seed (kg $ha^{-1}$) | DMY (kg $ha^{-1}$) | IVDMD[2] (%) | |
| 1 | 10 | High | Medium | 6 | 51 | 2200 | 38 | Panama |
| | 11 | | | 14 | 85 | 2600 | 43 | Indonesia Mexico |
| 2 | 7 | Medium | High | 32 | 28 | 3000 | 43 | Colombia |
| | 9 | | | 13 | 14 | 3600 | 36 | Brazil |
| 3 | 4 | | | 25 | 28 | 2000 | 45 | Venezuela |
| | 5 | Medium | Medium | 19 | 40 | 1700 | 42 | Panama |
| | 8 | | | 22 | 13 | 1900 | 40 | |
| 4 | 12 | Medium | Low | 3 | 28 | 900 | 50 | Venezuela - Colombia |
| 5 | 1 | Low | High | 22 | 3 | 3500 | 45 | Brazil |
| | 3 | | | 25 | 2 | 3000 | 41 | Colombia |
| 6 | 2 | Low | Medium | 19 | 0.2 | 2000 | 47 | Colombia |
| | 6 | | | 15 | 3 | 2500 | 41 | Venezuela |

[1] *dry matter yield*
[2] in vitro *dry matter digestibility*

of the accessions originated from Colombia or Brazil. Within this group, the accession CIAT 20709 from Colombia was outstanding for its leaf retention up to the end of the dry season.

*Group 3.* This was the largest group, containing clusters 4, 5 and 8, representing 31 % of the collection. The group had medium values in seed yield and DMY $ha^{-1}$. Also, the agronomic adaptation in this group was the lowest, indicating poor adaptive characteristics. Most accessions originated from Venezuela and Panama.

*Group 4.* This small group had poor seed production, and also poor DMY. Only three accessions belonged to this group, one from Guarico, Venezuela (CIAT 7290) and two from Casanare, Colombia (CIAT 8120 and 8131). The outstanding feature in these accessions was their high IVDMD, which ranged from 48 - 54 %.

*Group 5.* Containing clusters 1 and 3, representing 22 % of the collection. The main distinguishing agronomic attributes were low seed yield and high DMY (ranging from 2 - 4 t $ha^{-1}$). Most of the accessions in this group were rated from good to very good. This group also contained an accession (CIAT 822) with high leaf retention during the dry season. This late-flowering accession was collected in Bahia, Brazil.

*Group 6.* This group contained clusters 2 and 6, representing 16 % of the collection. Accessions had very low seed yield, medium DMY (1 - 3 t $ha^{-1}$) and medium IVDMD with a range from 42 - 51 %. The accessions in this group received a moderate agronomic rating.

## Seed yield

There were significant differences ($P < 0.05$) in seed yield within accessions, between the two flowering cycles estimated and also between years (Table 2).

Days to the start of flowering (counted from planting in year one and from defoliation by hand cutting at the end of the dry season in year two) ranged from 95 - 150 days. Some of the late flowering accessions (75% of non-flowering accessions were the ones with low epidermal hair density) failed to produce seed. Seed yields also varied widely among accessions ($P<0.01$), ranging from 0 - 80 kg $ha^{-1}$ during the first year and from 0 - 450 kg $ha^{-1}$ during the second harvest year.

Although most of the non-flowering accessions had higher IVDMD, these are of little agronomic value for the moderate rainfall areas of the Central plateau region due to their difficulties in reproduction in this environment.

The commercial *C. mucunoides* cv. Común (CIAT 9901) produced 65 kg $ha^{-1}$ of pure seed. Within the evaluated collection, 20 % of the accessions tested produced 2 - 6 times more seed (130 - 450 kg seed $ha^{-1}$).

## Rooted nodes

At 15 months after establishment, the number of rooted nodes ranged from 8 - 150 $m^{-2}$. Six well defined groups were found (Table 3). Sixty percent of the collection had a mean number of rooted nodes ranging from 50 - 150 nodes $m^{-2}$.

The range and number of rooted nodes in the *C. mucunoides* collection was higher than those for comparable collections of *Centrosema acutifolium* Benth (27 - 70 nodes $m^{-2}$) and *Pueraria phaseoloides* (Roxb.) Benth. (4 - 44 nodes $m^{-2}$) evaluated in the same ecosystem (E. A. Pizarro, unpublished data).

## Pilosity

The size of the leaflets and the number of hairs per leaflet produced two different groups within the collection: accessions with low pilosity (< 10 hairs $mm^{-2}$, which were

**Table 2. Days to flowering and seed yield in the *C. mucunoides* collection during the first and second year.**

| Flowering cycle | Days to flowering | No. of pods/plant | Pure seed yield (kg $ha^{-1}$) Year 1 | Year 2 |
|---|---|---|---|---|
| Early flowering | 95 | 35 a[2] | 50 a | 210 a |
| Intermediate [1] | 123 | 39 a | 22 b | 165 b |
| Late flowering | 150 | 32 a | 3 c | 100 c |

[1] *Commercial control is in this group.*
[2] *Means within columns followed by the same letter are not significantly different ($P < 0.05$).*

**Table 3. Mean number of rooted nodes in the *C. mucunoides* collection.**

| Groups | Rooted nodes (No. $m^{-2}$) | Accessions per group (%) |
|---|---|---|
| 1 | 70 - 150 | 35 |
| 2 | 50 - 69 | 28 |
| 3 | 36 - 49 | 18 |
| 4 | 31 - 35 | 7 |
| 5 | 20 - 30 | 5 |
| 6 | 8 - 16 | 7 |

22 % of the collection) and the remaining 78 % with 34 ± 5 hairs $mm^{-2}$.

Another important characteristic detected was that 75 % of the non-flowering accessions with low pilosity (< 10 hairs $mm^{-2}$) were from South America (Brazil 16%, Colombia 66 %, and Peru 11 %). The other 7 % of the remaining accessions evaluated did not have the collecting site identified.

There was a clear negative relationship between the density of epidermal hairs and quality (IVDMD). The accessions with more hairs per leaflet (34 ± 5 $mm^{-2}$) had significantly (P<0.05) lower IVDMD (Table 4).

## *In vitro* DM digestibility

IVDMD was correlated with the number of epidermal hairs per unit area. In general, IVDMD was low to moderate. The lowest figures were in group one (mean 40 % IVDMD) and the highest (50 % IVDMD) in group four, which had the lowest DMY. In this group, 40% of the accessions were from Venezuela and 28 % from Colombia. The commercial cultivar of *C. mucunoides,* CIAT 9901, is hairy (35 hairs $mm^{-2}$) and with a mean IVDMD of 41 %. This is one of the reasons for its low palatability and intake. IVDMD for the whole collection was similar to the values reported by Cruz *et al.* (1983) in seven populations, but higher than the ones reported by Vasconcelos *et al.* (1974) and Ademosun (1973).

To search for plant parts responsible for quality, whole leaf, leaf without vein, vein, stems and green pods, were analysed for IVDMD in 12 preselected accessions. Within accessions (Table 5) IVDMD was similar for the various plant components, with the exeption of green pods which were more digestible (P<0.05).

The other factor investigated in an effort to understand the effect of density of epidermal hairs on *C. mucunoides* quality (IVDMD) was the chemical composition around the hairs. The commercial *C. mucunoides* cv. Común with 35 hairs $mm^{-2}$ and the two less hairy accessions (CIAT 729 with 9 hairs $mm^{-2}$ and CIAT 17887 with 11 hairs $mm^{-2}$) were analysed for lignin and cutin concentration. Hairs at the base were bicellular and the basal cells were impregnated with lignin and cutin. As indicated by Himmelsbach (1993), cutin, waxes and suberin can influence digestibility. Cutin and waxes are attached only to epidermal cells of aerial parts of plants. Hadley (1981) remarked that cutin appears to be embedded in wax and pectin. All these components present diffusional barriers that impede digestibility of intact tissue. The second component found attached to the hairs was lignin, which is the most important secondary cell wall component that limits digestibility (Van Soest, 1993). Rod-shaped crystals, another component which reduces quality in forages were not found in the epidermal cells of the leaflet. The present results may explain in part the low digestibility and "acceptability" of the forage legume, *C. mucunoides*.

## Pests and diseases

The germplasm tested was basically free of destructive pests and diseases. The main fungal diseases detected were *Leptosphaeria* sp. (leaf spot), *Meliola bicornis* (sooty mould) and *Rhizoctonia solani* (foliar

**Table 4. Relationship between number of epidermal hairs and IVDMD at 23 weeks of age in *C. mucunoides* accessions.**

| Pilosity | IVDMD (%) |
|---|---|
| Low density 10 hairs $mm^{-2}$ | 58 a [1] |
| High density 34 hairs $mm^{-2}$ | 52 b |

[1] *Means followed by the same letter are not significantly different (P < 0.05).*

**Table 5. IVDMD in plant components in 12 preselected accessions of *C. mucunoides*.**

| Plant components | Hairy accessions | Less hairy accessions |
|---|---|---|
| | (IVDMD %) | |
| Whole leaf | 41 a[1] | 52 a |
| Leaf without vein | 41 a | 49 a |
| Vein | 40 a | 50 a |
| Stem | 42 a | 52 a |
| Green pods | 48 b | 60 b |

[1] *Means within accessions followed by the same letter are not significantly different (P < 0.05).*

blight). The level of leaf-eating insects was higher in the less hairy and smaller leaved accessions of *C. mucunoides*.

### Selected germplasm

From the statistical analysis (cluster and Anova tests) and the field agronomic evaluations for two rainy and dry seasons, 17 accessions were selected for future regional evaluations i.e. CIAT 729, 822, 884, 887, 7722, 8404, 8405, 8513, 9111, 9450, 17887, 18065, 18107, 18564, 20676, 20845 and 20709.

## ACKNOWLEDGEMENTS

We thank Mrs. Rita de Cássia C. Condé for her help with the experiment and Dra. T. Paviani from the Universidade Federal de Brasilia-UnB, Brasilia, DF, Brazil for her collaboration on the lignin and cutin determination.

Also, a very sincere appreciation to Gerardo Ramírez, Tropical Forages Program -CIAT/TFP-Statistician, for his help and advice in the cluster analysis.

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