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Desmodium *heterocarpon* (L.) DC. subsp. *ovalifolium* (Prain) Ohashi

Leguminosae

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Synonyms

- Desmodium polycarpum DC. var. *ovalifolium* Wallich ex Prain (1897)
- *Desmodium ovalifolium* Wallich ex Merrill (1910)
- *Desmodium heterocarpon* (L.) DC. ssp. *heterocarpon* var. *ovalifolium* (Wallich ex Prain) Rugayah (1987)

Common names

Desmodium ovalifolium, desmodium, desmodio, khonthi din (Thailand), tràng qua xoan (Vietnam)

Description

The following species description is taken from Schultze-Kraft (1992): A creeping, stoloniferous herb, in dense stands or under competition ascending up to 1 m. Stems many-branched, glabrous except for silky pubescence on young (apical) portions; old stems woody at the base. Leaves 1- and 3-foliolate, in young plants always 1-foliolate; leaflets variable, mostly ovate or broad-elliptical, sometimes round or obovate; terminal leaflet larger than laterals; 1-foliolate leaves and terminal leaflets on adult plants on average 3-4.5 cm x 1.5-3 cm; leaflets coriaceous and without any markings, glabrous and glossy on upper surface, whitish pubescent on lower surface, sometimes only along the central vein. Inflorescence a densely flowered raceme, 2-5 cm x 1-2 cm; flower papilionaceous, small, with an obovoid standard about 6 mm x 4 mm, purple to dark-pink during anthesis, bluish when wilting. Pod erect or falcate, mostly densely pubescent, dehiscent, comprising 2-8 almost quadrate articles 2.5-3.5 mm long. Seeds yellow when ripe.

Taxonomy

"*Desmodium ovalifolium*" is the abbreviated name (used in non-botanical literature) for a distinct, taxonomic *Desmodium* entity which earlier had been recognized at the species level (Merrill, 1910: *D. ovalifolium* Wall.), then rejected as an independent taxon and considered rather as part of *D. heterocarpon* (L.) DC. (Ohashi, 1973), subsequently recognized as a botanical variety (Rugayah, 1987: *D. heterocarpon* subsp. *heterocarpon* var. *ovalifolium* (Wall. ex Prain) Rugayah), and finally recognized at the sub-species level. The taxonomically valid name is at present *Desmodium heterocarpon* (L.) DC. subsp. *ovalifolium* (Prain) Ohashi (Ohashi, 1991). *Desmodium ovalifolium* belongs to the tribe Desmodieae of the Fabaceae subfamily Papilionoideae.

Because of plant morphological characteristics, *D. ovalifolium* is easily distinguishabl from the typical *D. heterocarpon* subsp. *heterocarpon.* However, overlapping betweer the two taxa occurs, and there are indications of some degree of cross-pollination in thi: mainly self-pollinated species (Schultze-Kraft & Benavides, 1988; Ohashi, 1991). Thi: is supported by successful hybridisation within the *D. heterocarpon* - *D. ovalifoliun* species complex whose chromosome number is 2n = 22 (Quesenberry *et al.*, 1989).

Geographic distribution and genetic resources

The geographic distribution of *D. ovalifolium* extends over moist-subhumid to humic (1200-4500 mm rainfall a^{-1}) Southeast Asia: Thailand, Cambodia, Laos, Vietnam Malaysia, Indonesia (Sumatra, East Kalimantan, Sulawesi, Java) and the Philippine: (Ohashi, 1991). The species occurs generally at low elevations. Noteworthy exception: occur between latitudes 20°30' N and 04° S in environments that are frequentl characterized by some degree of shade. As a result of a number of collecting mission: under the auspices of the Centro Internacional de Agricultura Tropical (CIAT), Cali Colombia, between 1979 and 1992 a total of 123 germplasm accessions were collectec in Indonesia, Malaysia, Thailand and Vietnam (Schultze-Kraft *et al.*, 1989, 1993). A present, a collection of 160 accessions is maintained in the CIAT genebank; basic passport data of accessions can be accessed on the Internet (http://singer.cgiar.org/).

The collected germplasm has shown little morphological variation in small-plot fielc nurseries but considerable diversity regarding establishment vigour, flowering time, dr matter and seed production, drought tolerance, and forage quality (Schultze-Kraft & Benavides, 1988). Prospects for further describing the genetic diversity (and eventuall identify accession duplicates) by means of polyacrylamide gel electrophoresis (PAGE were initially promising (Hussain *et al.*, 1987). Several suitable isozymes were identifiec but at the genotype level they were subsequently not sufficiently discriminatory (Klein 1997).

Adaptation

D. ovalifolium is adapted to acid, low-fertility soils and has low nutrient requirement: (e.g. Sánchez & Salinas, 1981; Suárez *et al.*, 1985; Urdaneta *et al.*, 1985; Ahmad, 1986 Silva del A., 1986; Costa *et al.*, 1988). The species showed also good adaptation tc water-saturated and periodically flooded savannas (CIAT, 1986a, 1989a) and wa: generally considered suitable for high rainfall regions (moist-subhumid to humic tropics) with some drought tolerance (Dutra *et al.*, 1980; Spain, 1981; CIAT, 1987a Miles & Lapointe, 1992; Rao *et al.*, 1992). For more detailed and location specific information on the adaptation potential of *D. ovalifolium* (mainly accession CIAT 350 in different agro-ecological zones, the reader is referred to the publications of Franco *e al.* (1990, 1992a, 1992b).

Through its aggressive, stoloniferous growth habit, *D. ovalifolium* is one of the fev legumes compatible with mat-forming grasses like *Brachiaria decumbens* (Grof, 1982 and was reported to depress weeds effectively in pastures and plantations (CIAT, 1989b 2000). In contrast to numerous reports mentioning good persistence of the legume (e.g CIAT, 1985a; Villarreal & Chávez, 1991; Ortega & Samudio, 1997), even under sever animal trampling conditions (García, 1990), *D. ovalifolium* seems to be affected by soi compaction due to high stocking rates under high rainfall conditions and short regrowtl periods (Maldonado & Velásquez, 1990; Reátegui *et al.*, 1990). Furthermore, it was found sensitive to burning (Grof, 1980). To what extent its shallow root system (Ayarza, 1988) has negative impact on persistence is not clear, but Bishop (1983) regards this as an advantage for using the species in silvopastoral systems. Experiments in West Africa suggest the unsuitability of the legume for most of this region (Hairiah & Noordwijk, 1989; RABAOC, 1995; Smith, 1995). This lack of adaptation to drier environments was confirmed by a study using information of origin analysed with FLORAMAP (Jones & Gladkov, 1999). The study identified potential collection sites in South-East Asia and sites for long-term survival (Jones *et al.*, 2000).

Establishment

Ferguson (1992) regards *D. ovalifolium* as easy to establish and highly persistent. Spot-sowing without major soil preparation is possible (CIAT, 1984a); this is particularly important for fragile soils (Suárez & Cardona, 1993). An additional way of seed distribution can be through animal faeces when seeds are mixed with mineral salt supplementation. Furthermore, *D. ovalifolium* was found suitable for establishment via mixed cropping with upland rice in the Llanos Orientales (Eastern lowlands) of Colombia (Schultze-Kraft & Cárdenas, 1993). In case of seed shortage, it can be propagated vegetatively; adequate techniques are described by Grof *et al.* (1981). Surface-sowing of *D. ovalifolium* macro-pellets into burnt savanna is another possible method of establishment (Ogawa *et al.*, 1990; Nada *et al.*, 1992). Recommended seeding rates range from 0.5 kg ha^{-1} for pasture associations to 5 kg ha^{-1} for cover crop purposes (Spain, 1982; Bishop, 1983; Aguila, 1992); trials to define optimal seeding rates in rubber and oil palm plantations are underway, initial results indicating seeding rates of 1-2 kg ha^{-1} as suitable (M. Peters, unpublished). A general disadvantage of the legume is the repeatedly reported slow germination and establishment (e.g. Ridzwan & Sariam, 1982; López & Silva del A., 1986; Domínguez-Valenzuela, 1990). A summary of various establishment aspects of pasture legumes, including *D. ovalifolium*, can be found in Lascano & Spain (1991).

Agronomic performance

In regard to dry matter production, Grof (1984) recorded at Carimagua, Llanos Orientales of Colombia, legume yields of 7.3, 7.2 and 3.98 t ha^{-1} a^{-1} in associations of *D. ovalifolium* with *Brachiaria humidicola*, *B. decumbens* and *Andropogon gayanus*, respectively. In RIEPT network evaluation experiments, legume dry matter production (12 week regrowth) of accession CIAT 350 varied from 0.5-6.5 t ha^{-1}. The respective location specific results are compiled in the proceedings of various RIEPT meetings (Pizarro, 1983, 1985, 1988, 1992; Keller-Grein, 1990). More aggregated information is also available in Franco *et al.* (1990, 1992a, 1992b). In general, *D. ovalifolium* can be considered as a productive legume in high-rainfall areas; it is highly compatible in associations with important tropical grasses.

Fertilization

The species responds readily to fertilization. Application of lime and sulphur increased dry matter yields (Pinzón *et al.*, 1980; Yaringaño, 1983). Amounts of 500 kg ha^{-1} lime and 20 kg ha^{-1} sulphur are recommended for pasture establishment (Sánchez & Salinas, 1981). A dramatic response to magnesium was recorded by Spain (1982). Boron anc phosphorus application also had a positive effect on dry matter production (Salinas *e. al.*, 1987). Phosphorus requirements of *D. ovalifolium* are classified as intermediate (Costa, 1988). For more detailed reading, Pérez (1997) provides a summary of fertilize effects on yields of *D. ovalifolium* on different soils in the Llanos of Colombia.

Nutritive value

In contrast to the remarkable agronomic performance of *D. ovalifolium* in high rainfal areas, the nutritive value of the species falls behind other tropical pasture legumes sucl as *Centrosema* spp. (Lascano *et al.*, 1990) or *Arachis pintoi* (Lascano, 1994). This is mainly attributed to the high condensed tannin (CT) content of the legume witl subsequently reduced *in vitro* digestibility (IVDMD), low palatability and animal intake (Carulla, 1994; Lascano *et al.*, 1995). Data on CT contents of *D. ovalifolium*, however are limited. Abaunza *et al.* (1991) reported a CT content of 17% in *D. ovalifolium* accession CIAT 350 at Quilichao, Colombia. This value is lower than those observed ir former collection screenings at the same location where CT contents ranged from 19-43% (CIAT, 1984b; Schultze-Kraft & Benavides, 1988). Leaf tissue analysis from Carimagua revealed CT contents which varied within and between seasons (16-25%) (CIAT, 1984b). These data were obtained through the vanillin-HCl method (catechir standard) (Price *et al.*, 1978) and are difficult to compare with more recent studies using different tannin analysis methods. Carulla (1994) reported CT contents of 4-7% using the butanol-HCl method and *D. ovalifolium* tannins as standards (Asquith & Butler 1985; Terrill *et al.*, 1992). Furthermore, it is unclear if all results were obtained witl adequate sample preservation methods. Valerio (1990) and Cano *et al.* (1994) founc differences in tannin contents in relationship to sample preservation and recommendec freeze-drying as appropriate for legumes containing tannins.

Published information on IVDMD of *D. ovalifolium* (CIAT 350) shows also a large variability across locations (Table 1). Values range from 29-56%, which is below the mean value for tropical legumes (56.6%) reported by Minson & Wilson (1980) Schultze-Kraft & Benavides (1988) likewise found high variability in nutritive value among accessions of *D. ovalifolium* under the same environmental conditions. Crude protein contents ranged from 12-20%, phosphorus and calcium concentrations from 0.10-0.16% and 0.27-0.57%, respectively. Although these values are low compared tc other tropical legumes (Ara, 1987), they are well in the range of results reported ir literature for *D. ovalifolium* accession CIAT 350 from different locations (e.g. Giraldo *e. al.*, 1989; Abaunza *et al.*, 1991). Laredo (1985) reported fibre contents (acid and neutra detergent fibre) in the range of 40-50% for material from the Llanos of Colombia.

Table 1. *In vitro* dry matter digestibility (IVDMD) values of *Desmodium ovalifolium* CIAT 350 from different locations in tropical America and Southeast Asia.

Location	IVDMD (%)	Observations	Source
Carimagua, Colombia	40-56	Range over wet season	Cajas, 1984
Quilichao, Colombia	29-50	Values of associations with *Brachiaria* spp.	Maeno, 1985; Cárdenas,

			1987; CIAT, 1988a
Macagual, Colombia	72	Value of association with Bh, 10% lower than *Bh+Ap*	Gil *et al.*, 1991
Turrialba, Costa Rica	30-50	Range of values from 6 and 12 week regrowth	CATIE, 1989a
San Carlos, Costa Rica	42-48	Range of values from regrowth during the season of minimum precipitation	Villarreal, 1994
Pucallpa, Peru	49	Value of association with *Bdic*	Aguila, 1992
Yurimaguas, Peru	40	Wet season	Reátegui *et al.*, 1985
French Guyana	44	Wet season	Béreau, 1995
Leyte, Philippines	51	10% lower than *Pp*	Bestil & Espina, 1991

Bdic = Brachiaria dictyoneura; Bh = Brachiaria humidicola; Ap = Arachis pintoi; Pp = Pueraria phaseoloides

The variability in nutritive value and especially in CT content among genotypes locations and seasons indicate the existence of pronounced genotype x environment interactions in *D. ovalifolium* determining forage quality. This is further supported by the work of Salinas & Lascano (1983) who observed reduced CT contents in *D. ovalifolium* under increased fertilizer application, especially sulphur, at Carimagua.

Animal production

Animal production data provide evidence for an even more complex interaction situation including the factors associated grass species and pasture management. Table 2 shows a large variability in cattle liveweight gains (LWG) at different locations in South America under a range of stocking rates and associated grasses. Mixtures with *Brachiaria humidicola* seem to be particularly productive. The contrast between very high and very low LWG is noteworthy. This is corroborated with additional reports on both good performance of *D. ovalifolium*/grass associations and very low or even negative LWG: While, for example, Lascano *et al.* (1982) report a 400% daily LWG increase in a *B. humidicola-D. ovalifolium* association compared to the pure grass pasture (400-100 g an^{-1} d^{-1}, respectively), Gareca (1986) measured LWG of the same association on farms in the Llanos Orientales of Colombia which were even lower than those of native savanna. Data obtained earlier at CIAT (1984c) indicate cattle LWG of -21 g an^{-1} d^{-1} in an association with *Andropogon gayanus* at Carimagua.

Table 2. Animal production (liveweight gain, LWG) from *Desmodium ovalifolium* CIAT 350 in associations with different grasses in tropica

America.

Location	Grass component in mixture	Cattle stocking rate (an ha^{-1})	LWG (g an^{-1} d^{-1})	LWG (kg ha^{-1} a^{-1})	Source
Carimagua, Colombia	*Brachiaria humidicola*	1-1.5	298	510	CIAT, 1985b
	B. humidicola	2.5	434	258	CIAT, 1984d
	B. humidicola [2]	2-4 (160) [1]	92-227		Toro, 1990
	B. decumbens	2.3	460	379	CIAT, 1984d
	Andropogon gayanus	1-1.5	147-268		Spain *et al.*, 1984
Quilichao, Colombia	*B. dictyoneura*	2.6-6.7 (400)	168-489	411-861	CIAT, 1988a
	B. decumbens	4.5 (400)	662	1.009	Maeno, 1985
Pucallpa, Peru	*B. decumbens*	4.4-5.5 (160-190)	135-308	231-433	Castilla *et al.*, 1991
	B. humidicola	4.4-5.5 (160-190)	423-493	548-782	Castilla *et al.*, 1991
Yurimaguas, Peru	*B. decumbens*	4.4 (350)	379	640	Reátegui *et al.*, 1985; Ayarza *et al.*, 1987
	B. humidicola	4.4 (350)	430 [3]	692	Reátegui *et al.*, 1985
	B. dictyoneura	- (350)	101 [4]	131	Reátegui, 1987
Macagual, Colombia	*B. humidicola*	1.2-2.7 (250)	377-533		Maldonado & Velásquez, 1990
Chipiriri, Bolivia	*B. decumbens*	3 (120)	182	66	Siles *et al.*, 1995
Napo,	*B. humidicola*	3	600-700		Caballero &

Ecuador					Costales, 1992
Bahia, Brazil	*B. humidicola*	2-4	351-515		CIAT, 1991a; Boddey *et al.*, 1995
On-farm, Llanos of Colombia	Various			264	Ferguson, 1992

[1] Values in parentheses are initial animal weights; [2] In association with *D. ovalifolium* accession CIAT 13089; [3] Highest LWG of all associations at this location; [4] High proportion of *D. ovalifolium* in mixture (52%)

Milk production is regarded as more sensitive to forage quality. A review of the respective data reveals a similar contrasting picture to that for cattle LWG. Sanabria & Pabón (1999) measured a 10% increase in milk production when cows grazed a *B. decumbens-D. ovalifolium* mixture as compared with pure grass in the Amazon region of Colombia. The data of Heurck (1990), however, indicate slightly lower milk production on *D. ovalifolium* in association with *Cynodon nlemfuensis* compared to the pure grass pasture in Costa Rica. Compared to other legumes (e.g. *Stylosanthes guianensis*, *Centrosema macrocarpum* or *Arachis pintoi*), there is evidence that the milk production potential of *D. ovalifolium*-grass associations is inferior (Heurck, 1990; González Chau, 1992; Caruzo & Vela, 1995).

Pasture management

Another controversial aspect of *D. ovalifolium*/grass pastures, which has been related to its nutritive value, is the tendency of the legume to dominate pastures over time. Toro (1990) reports legume dominance in pastures with *D. ovalifolium* accession CIAT 13089 at Carimagua. Muñoz & Costales (1985) made similar observations with CIAT 350 in Napo, Ecuador. Additional examples for legume dominance are given by CATIE (1989b) and Campero (1994). Several authors, however, relate this tendency to inadequate pasture management, especially to low stocking rates (e.g. Tergas *et al.*, 1981; CIAT, 1985c; Vela & Flores Mere, 1996). Vela (1994) recommends high stocking rates (4 animals ha^{-1}) for pastures containing *D. ovalifolium* at Pucallpa, Peru, in order to maintain the grass-legume balance. Martins da Silva (1982) sustained an adequate grass-*D. ovalifolium* balance through stocking rates of 3.5 animals ha^{-1} at Carimagua. It was assumed by Bishop *et al.* (1992) that pasture management has to keep *D. ovalifolium* plants in young regrowth stages, since older tissue is not grazed. Maeno (1985) and Ferrufino (1989) associated increased consumption of *D. ovalifolium* with plant renewal at Quilichao, Colombia and Chiripiri, Bolivia, respectively. Higher IVDMD and increased legume intake are reported with high stocking rates by CIAT (1982a, 1986b). High stocking rates are also seen as a way to eradicate the legume from pastures (Cadisch *et al.*, 1996). Fire might be an additional possibility to control the legume, since *D. ovalifolium* is susceptible to fire (Reátegui *et al.*, 1995). Unfortunately only few data on forage quality related to grazing and pasture dominance are available. Such data, however, are needed to review the contrasting observations concerning the relationship between high tannin contents and legume dominance in pastures.

Diseases

The use of *D. ovalifolium* may be limited by several diseases and pests. Pink disease (*Phanerochaete salmonicolor*) is currently restricted to Malaysia where it is serious only on *D. ovalifolium* in rubber plantations. Mostly young branches of the plants are affected and show salmon-pink mycelial encrustation before dying (Lenné & Stanton, 1990). Wart disease or false rust, caused by the fungus *Synchytrium desmodii*, was first recorded in Kalutara district in Sri Lanka in 1952 in rubber plantations (Munasinghe, 1955) and was introduced to South America through the importation of *D. ovalifolium* seed (Lenné, 1985). The disease was recognised for the first time in South America in 1981 in evaluation plots at Carimagua (CIAT, 1982b). Although adult plants generally regrow healthy tissue even after severe attacks of false rust, the fungus decreases herbage and seed production, and may also dramatically reduce seedling survival and thus long-term persistence of the legume. Seed treatment with concentrated hydrochloric acid in order to control further distribution of the disease by seed failed to kill resting spores of the fungus. Control through application of several fungicides was not successful either (Lenné *et al.*, 1990). A geographically widespread disease, which also affects *D. ovalifolium*, is little leaf, caused by polymorphic, mycoplasma-like organisms (MLOs). However, the disease, also known as phyllody or witches' broom, is generally only recorded under experimental conditions and is therefore not a major limitation in production systems (CIAT, 1984e). For an extended and detailed review of diseases of the genus *Desmodium*, the reader is referred to Lenné (1994).

Pests

Due to their widespread distribution, root-knot nematodes are considered by plant pathologists as a serious threat to *D. ovalifolium* in Central and South America (Trutmann, 1994). Infected plants become stunted, chlorotic and wilted, some defoliate and die (Lenné, 1981a). *Meloidogyne javanica, M. incognita, M. arenaria* and *M. hapla* are reported to affect *D. ovalifolium* (Lenné & Stanton, 1990), but there seems to be large variation among locations, years, accessions and the subsequent effect on plant persistence. Lenné *et al.* (1990) considered the role of nematodes as important only for the well-drained savanna ecosystem (such as at Carimagua, Llanos of Colombia). Most reports are based on experiences from germplasm screening sites like Carimagua and Pucallpa, Peru (e.g. CIAT, 1984f, 1988b). There seems to be evidence for a build-up of nematode populations at these sites showing increased plant infection over the years. In 1982, accession CIAT 350 was reported as only slightly affected at Carimagua (CIAT, 1984e) and still characterised as of good resistance in 1983 (CIAT, 1984g). Two years later the same accession was described as severely affected by nematodes at this major germplasm screening site (CIAT, 1986a).

Large variation was found by screening *D. ovalifolium* accessions for their tolerance/resistance not only to *Meloidogyne* spp., but also to *Pterotylenchus cecidogenus*, a stem gall nematode (CIAT, 1984g, 1986c, 1989a; Hernández & López, 1985; Sasser *et al.*, 1987; Stanton *et al.*, 1990). This above-ground nematode produces galls on stems, causing disruption of the vascular systems and eventual death of *D. ovalifolium* plants (Siddiqi & Lenné, 1984). It has only been recorded in the Llanos of Colombia and near Porto Velho, Brazil (Stanton & Torres, 1989). Stanton (1994) claims that pure stands of *D. ovalifolium* may be killed by the nematode within two years, while subsequent survival of seedlings and shoot and root growth are also reduced. From several accessions classified as nematode resistant, the high yielding accession CIAT 13089 was selected because of its additional tolerance to *Synchytrium desmodii* and it subsequently replaced CIAT 350 in further on-station and on-farm experiments (CIAT, 1990a). No reports are available on factors determining this resistance. Quesenberry & Moon (1995) used selected *D. heterocarpon* materials to enhance root-knot nematode tolerance. For more extensive information on nematodes in tropical legumes the reader is referred to Stanton (1994).

The potential of chemical control such as pregermination treatment of *D. ovalifolium* seed or application on seedlings was only studied in pot trials and showed mainly short term effects (Stanton & Torres, 1989). Remarkable are reports from agronomists on the good recuperation of *D. ovalifolium* screening plots from soil seed banks after severe nematode and false rust attacks at Carimagua (CIAT, 1985a, 1985d). When grown in mixtures with grasses only slight damage of *M. javanica* on *D. ovalifolium* CIAT 350 was observed (Lenné, 1981b), which, from the agronomic point of view, was considered insignificant, questioning the replacement of this accession by CIAT 13089 (CIAT, 1984a). Nevertheless, since *D. ovalifolium* has to be considered as host for nematodes, its use as cover crop in banana plantations could be limited as nematode populations (e.g. *Radopholus similis*) may be maintained (Ternisien, 1989). Also the larvae of the beetle *Eutheola* sp., commonly known as chiza in the Cauca area in South Colombia, may be seen as a limitation (CIAT, 1989c; Lascano *et al.*, 1991). Although leaf sucking and eating insects were observed in *D. ovalifolium*, they do not constitute a real threat for the species. A summary on insect pests associated with forages in tropical America was given by Calderón & Arango (1985). Except for the controversial issue of nematode importance and the fungus *Synchytrium desmodii*, the legume can be considered as relatively free of diseases and pests (CIAT, 1984e; Béreau, 1986).

Seed production

Since all accessions of *D. ovalifolium* represent undomesticated populations, they retain many wild-plant characteristics, which aid their natural spread but pose difficulties for commercial seed production (Loch & Ferguson, 1999). Very little detailed knowledge is available about their flowering behaviour and the identification of regions suitable for seed production. Table 3 gives an overview of seed yields obtained at different locations. Seed production varied with location, year and genotype, as did the time from flowering to seed harvest. Yields ranged from 0.1-440 kg ha^{-1} a^{-1}. Favourable seed production conditions were found in regions of higher latitude with high moisture availability throughout the year, e.g. in Chimore, Bolivia, 18° S, 226 masl, 21-26 °C, no frost risk, 4000 mm rainfall with 1000 mm in the period of minimum precipitation (Ferguson *et al.*, 1983). The legume is very sensitive to moisture stress which may lead to low, erratic or no flowering at all (Andrade *et al.*, 1983; Thomas, 1986). Flowering may be extended over the whole year, if adequate moisture is available, favouring the legume's self-generation under various climatic conditions, but undesirable for commercial seed production (Sobrinho, 1982).

Table 3. Seed production of *Desmodium ovalifolium* accessions at different locations in Central and South America.

Location	Year	CIAT accession	Seed yields	Source

		No.	(kg ha^{-1} a^{-1})	
Various in Colombia	1977-1985	350	85 (2-380)	CIAT, 1986d
		3784	160 (38-535)	
Planaltina, Brazil	1979-1980	350		Andrade *et al.*, 1983
Carimagua, Colombia	1980	various	0.8-153	CIAT, 1982c
Chimore, Bolivia	1980	350	220	Ferguson *et al.*, 1983
S/Quilichao, Colombia	1980	350	170	
	1982-1983	various	74	CIAT, 1984h
Calzada, Peru	1985	various	40-260	Díaz & Palacios, 1986
Tarapoto, Peru	1984-1985	350	65-86	Pérez *et al.*, 1987
	1986-1987	350	40-60	Silva del A., 1988
Pucallpa, Peru	1987-1988	350	>100	Hidalgo,1988; Salazar *et al.*, 1993
Planaltina, Brazil (várzea)	1988	collection	0.1 -440	CIAT, 1989a
Guápiles, Costa Rica	1988-1989	collection	69-440	Diulgheroff,1990; CIAT,1990b; Diulgheroff *et al.*, 1990
Itabela, Brazil	1989-90	350	197	Pereira, 1994
		13099	289	

Thousand-seed weights of *D. ovalifolium* range from 1.7-2.2 g (~500,000 seeds kg^{-1}) (Rotar & Urata, 1966). When dried to low moisture contents of 4-8%, seeds can be stored for long periods. Little loss in germination was observed after storage for 16 years at temperatures as low as -12 °C (Bass, 1984). Similar to other tropical legumes the hardseededness of *D. ovalifolium* seed has to be broken prior to sowing. High temperature treatment with hot water and scarification with sulphuric acid are recommended (Rojas & Herrera, 1989). Crop management guidelines for seed production are not documented, apart from information on chemical weed control (Ferguson & Sánchez, 1984).

Commercial cultivars

Desmodium ovalifolium seed is commercially available, mainly in the form of ar unnamed variety traded in Southeast Asia and known to researchers as accession CIAT 350. From this material, a commercial cultivar (cv. Itabela) was developed and officiall released in Brazil for use as a forage legume in the humid tropics of the state Bahia (CEPLAC, 1990). In Colombia, the release of the same genotype as cultivar "Macagual" is currently being prepared (Velásquez *et al.*, in preparation).

Use as cover crop

The potential of *D. ovalifolium* for integration into tropical production systems is no only based on the already described agronomic characteristics concerning its use as a pasture plant. The legume's attributes favour also its utilization as a cover crop and thus as a multi-purpose legume. The first publications on *D. ovalifolium* dealt exclusivel with its role as soil cover under rubber in Sri Lanka (Changeasfrera, 1954; Munasinghe 1955) and Malaysia (Anon. 1960; John, 1963). Edgar (1958) reports *D. ovalifolium* as part of the traditional cover plant mixtures in Southeast Asia. High persistence througl outstanding adaptation to shade environments and its non-climbing growth habit explair its particular suitability for plantation agriculture (Wong *et al.*, 1985). Wahab & Ahmac (1984) observed even better dry matter production under shade than in full sunlight. *D. ovalifolium* was found the most shade tolerant species producing dry matter of 5 t ha^{-1} a^{-1} in the experiments of Chen & Sariam (1984). Likewise, in South and Central Americ the legume is increasingly used in plantation agriculture because of its good grounc cover potential (Béreau, 1986; CIAT, 1987b) and dry matter production under shade (Achío, 1997). In the southern part of Zulia state, Venezuela, *D. ovalifolium* is used as both cover crop and pasture legume on more than 10,000 ha (I. Urdaneta CORPOZULIA, 1998, pers. communication). In this context, seed production of *D. ovalifolium* in plantations is attracting growing interest among farmers.

Extensive weed suppression through *D. ovalifolium* compensates for the species' slow establishment from seeds (Ferrufino & Ovando, 1988; CIAT, 2000). Due to this latte restriction, *D. ovalifolium* is used in legume mixtures with faster establishing specie like *Centrosema pubescens*, *Calopogonium mucunoides*, *C. caeruleum*, *Mimosa invisc* and *Pueraria phaseoloides* in young plantations. As light penetration through the tree canopy will decrease over time, only *D. ovalifolium* will persist because of its shade tolerance (Watson, 1963; Jayasinghe, 1991). Chee (1982) reports persistence of more than 10 years under rubber. A possibility to shorten the establishment period is vegetative propagation (Herrera, 1996).

Desmodium ovalifolium is not only recommended for oil palm or rubber, but also for a number of other perennial plantations such as coffee, tea, banana or macadamia nuts (e.g. Suárez, 1992; Sánchez, 1993, Humphreys, 1994; Bradshaw & Lanini, 1995) However, the evaluation of the resulting cover plant/main crop interactions is controversial. Pérez *et al.* (1993) observed negative effects on growth and fruit yields o *Bactris gasipaes* (peach palm) at Yurimaguas, Peru, because of alleged competition fo nitrogen. Although *D. ovalifolium* was found to suppress weeds effectively (CIAT 1990c) and serve as a trap crop for nematodes in coffee orchards (Vallejos, 1993), there are neither clear studies on further possible interactions nor large data sets on the economic viability of the technology under different ecological and market conditions

(Bradshaw *et al.*, 1992). A positive example of the use of *D. ovalifolium* in coffee is the adoption of a slash-and-mulch management of accession CIAT 350 to reduce weeding costs (reduction from 4 to 2 cleanings a^{-1}) and to improve soil fertility with robusta coffee production in the Coca region of Ecuador (Peck & Bishop, 1992): Every 6 months *Desmodium* is cut back to ground level and the mulch material left in place to decompose. This forms a layer of organic material favourable for mycorrhizae development, on which coffee growth is strongly dependent, and improves nutrient cycling. The management technique is economically interesting (CIAT, 1991b), and would have been even more adopted by farmers if more palatable genotypes for livestock integration (goats) had been available for the region (Lascano & Pezo, 1994). Nevertheless, Manidool (1985) and Domínguez-Valenzuela (1990) favour the use of *D. ovalifolium* in agroforestry/silvopastoral systems in the humid tropics, either in livestock systems including plantation grazing of grass-legume mixtures, or as a cover crop in plantation agriculture. The use of *D. ovalifolium* in improved fallow systems for crop production is suggested not to be advisable due to the tendency of the legume to weediness in later crop cycles through the build-up of soil seed banks (Staver, 1989). Recently, *D. ovalifolium* was used successfully for the rehabilitation of erosion galleys in South Colombia (Villada *et al.*, 1997).

Nitrogen fixation

Although the species is not considered a particularly efficient N_2 fixer (Cadisch *et al.* 1989; Viera-Vargas *et al.*, 1995), it can contribute >200 kg N ha^{-1} a^{-1} (Boddey *et al.* 1995; Valles *et al.*, 1996), if effectively nodulated by the required specific *Bradyrhizobium* strain (Giller & Wilson, 1991). As a result of extensive evaluations, *D. ovalifolium* CIAT strain 4099 was recommended by CIAT (Franco *et al.*, 1993). Inoculation efficiency can be increased by molybdenum fertilization (Balaguera, 1986) and inoculum application as water solution on young seedlings (CIAT, 1988c). A decrease in BNF of *D. ovalifolium* has been observed under increasing stocking rates (Boddey *et al.*, 1995) and under shade conditions (Reynolds, 1995), but BNF seems to be enhanced through P and K applications (Cadisch *et al.*, 1989).

Nutrient cycling

Nitrogen fixed by *D. ovalifolium* may contribute to the N economy and productivity of agricultural systems mainly in two ways: directly through the consumption of the legume tissue by animals, and indirectly through N transfer to companion crops or pasture grasses. The latter leads to soil fertility improvement and subsequently enhanced crop/grass and animal productivity. N transfer is closely linked to soil organic matter (SOM) dynamics and the decomposition of leaf litter and legume roots (Cadisch *et al.* 1998). Litter production of *D. ovalifolium* can be as high as 6-7 t ha^{-1} a^{-1} (Ara *et al.* 1991). Costa (1995) and Gonçalves & Costa (1994) observed a transfer of 43 and 65% of the BNF derived N (70 and 154 kg ha^{-1} a^{-1}) to *Pennisetum purpureum* and *Brachiaria humidicola*, respectively. At Itaguí, Brazil, N fixation by *D. ovalifolium* was rather low (46-68 kg N ha^{-1} a^{-1}) (Viera-Vargas *et al.*, 1995), in contrast to Porto Velho, Brazil where 137 kg N ha^{-1} a^{-1} were found, but of which only 28% were transferred (Costa 1993). An even lower transfer rate of 4% was found by Gonçalves *et al.* (1992) also in Porto Velho.

Further reading

Entire bibliography on *Desmodium ovalifolium*

Links

- Effect of boron on forage quality of D. ovalifolium
- D. ovalifolium references
- Short CIAT report
- Ush fallow research with D. ovalifolium
- D. ovalifolium under coconuts in Vanuatu
- Early Growth of Young Oil Palm Under Different Leguminous Cover Crops
- Potential nitrogen fixation of five *Desmodium heterocarpon* subsp. *ovalifolium* genotypes
- Drawing of D. heterocarpon

Key References

Aguila, R. del (1992); Bishop, J.P. *et al.* (1992);Cadisch, G. *et al.* (1996);Domínguez-Valenzuela, J.A. (1990);Ferguson, J.E. *et al.* (1983); Gonçalves, C.A. *et al.* (1994);Grof, B. (1982);Grof, B. (1984);Lascano, C.E. *et al.*(1982); Lascano, C.E. *et al.*(1995); Lenné, J.M. (1994); Ohashi, H. (1991); Salinas, J.G. and Lascano, C.E. (1983); Schultze-Kraft, R. (1992); Schultze-Kraft, R. and Benavides, G. (1988); Schultze-Kraft, R. and Cárdenas, E.A. (1993); Wong, C.C. *et al.*(1985)

Other References