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CHARACTERIZATION AND USE OF Desmodium SPECIES IN THE CARIBBEAN TROPICS AND SUBTROPICS

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ABSTRACT

Forage legume research is active and cooperative in the Caribbean Basin/Central America. Large collections of many Desmodium species are available for use. Desmodium intortum and D. uncinatum have been characterized as unadapted to our livestock production sites. Native and exotic browse species (e.g., D. discolor, D. distortum, D. tortuosum, D. nicaraguense, D. strigillosum, D. velutinum and Codariocalyx gyroides (syn. D. gyroides) may be valuable for stock owners with little or no land. Spontaneous species of native pastures (D. incanum, D. uniflorum, D. procumbens, D. scorpiurus, D. adscendens, and D. triflorum) are not presently recommended for commercial development. Desmodium barbatum is untried. Relative adaptation of the wet tropical lowland species D. heterocarpon, D. heterophyllum, and D. ovalifolium varies with site; D. ovalifolium is more widely adapted. Though superior in pasture comportment, D. ovalifolium provides poor animal performance; promising new germplasm is being characterized. An international workshop on D. ovalifolium would be timely.

INTRODUCTION

The following review is the product of research in the CIAT library and the data base of the Red Internacional de Evaluación de Pastos Tropicales (RIEPT). However, it has not been possible to circulate this text among experienced field researchers of our region. As a result, inaccuracies may have crept in without detection. Moreover, very recent results may not be included, because research with pasture legumes in the Caribbean Basin is more active at this time than it has ever been.

Fortunately, this Forage Symposium of the 1990 meeting of the Caribbean Food Crops Society brings together many of the very people best qualified to comment on a review of Desmodium in the Caribbean/Central American region. I present this document as a draft, with the sincere request that my colleagues in attendance will correct or amplify as I proceed, to the end that our understanding of the situation when we leave today will be much better than the one with which I begin.

The genus Desmodium is widely distributed in North, Central, and South America and the Caribbean Islands (Schubert, 1980), and includes many species in all parts of our region (Keoghan, 1980). Some species are restricted to natural habitats, but most of those with forage potential are common in unimproved pastures, road sides, cropped fields, and other disturbed habitats. Several hundred accessions of native Desmodium species have been collected in the Caribbean and Central America by agencies including the University of Florida, CARDI/UWI, the IDRC (Lazier, 1987), and CIAT.

Desmodium species that have received attention from Caribbean Basin forage researchers can be informally divided into four groups. One group includes D. intortum (Mill.) Urb. and D. uncinatum (Jacq.) DC., the first Desmodium species to be investigated in interdisciplinary research programs with continuity and extensive publication of results (Eyles et al., 1985), and therefore the first to receive widespread notice.

Browse Desmodia include the large subshrubs to shrubs D. discolor Vog., D. distortum Macbr., D. tortuosum (Sw.) DC., D. nicaraguense Oerst., D. strigillosum Schind., D. velutinum DC. and Codariocalyx gyroides (Roxb. ex Link) DC. (syn. Desmodium gyroides DC.). A few species of this second group were being cultivated and studied for browse and cut-and-carry systems by the early 1900's (Calvina, 1952). However, early investigators were often isolated and their work was little known.

The third group of Desmodium species includes small, grazing tolerant plants native or spontaneous in many "native pastures" of the Caribbean Basin (Semle, 1962; Meyrat, 1975; Menéndez, 1982a, 1982b; Michaud, 1986). This group includes D. incanum (Sw.) DC. (syn. D. canum (F.J. Gmell) Shinz & Thell.), D. uniflorum (n.c.), D. procumbens (Mill.) Hitchc., D. scorpiurus (Sw.) Desv., D. adscendens (Sw.) DC., and D. triflorum (L.) DC.

The fourth group includes the D. heterocarpon (L.) DC./ovalifolium Wall. group, D. heterophyllum (Willd.) DC., and D. barbatum (L.) Benth. Forage research with these herbaceous species is relatively recent (Grof, 1982).

RIEPT designations will be used for evaluation stages. "A" trials are observations on adaptation of numerous accessions; "B" trials are clipping trials of selections from A trials; "C" trials evaluate response to grazing of the best B entries, and "D" trials measure performance of animals grazing the best C selections (Toledo, 1982).

Ecosystem designations (RIEPT, 1982) are used when known for a site. These include: TRF (tropical rain forest), SESF (semi-evergreen seasonal forest); and WDHS (well-drained isohyperthermic savannahs). Two have been added: EC/D (Eastern

Caribbean Islands/drier); EC/H (Eastern Caribbean Islands/more humid). These are differentiated because "the slight decrease in rainfall north of 17° N Lat ... appropriate to unite the islands between Puerto Rico and Guadeloupe into one [rainfall] regime" (Portig, 1976) and by soil type: many northern islands of the eastern Caribbean have calcareous soil parent material and neutral to basic soils (Portig, 1976). Guadeloupe and islands south are mostly of volcanic origin with a variety of soils. EC/D and EC/H designations are impromptu. Soils and climate of most Caribbean islands are so variable within short distances that agroecological mapping on a regional scale is almost impossible (P. Jones, CIAT/AEU, personal communication, 1990).

Desmodium intortum and D. uncinatum

These are species of Central (Desmodium intortum) and South (D. uncinatum) American uplands, first collected in the 1950's (Bryan, 1969). They are adapted to high rainfall zones (1,100 mm or more) but unsuited to hot wet lowland tropics. They have little drought tolerance. D. intortum is better adapted to lighter soils and D. intortum to heavier soils. For persistence, both require high soil fertility; both are tolerant or moderate soil acidity. Bryan (1969) and Imrie et al. (1983) have provided reviews of these species and the two released cultivars, 'Silverleaf' (D. uncinatum) and 'Greenleaf' (D. intortum).

Hybridization research followed the identification of the forage value of D. intortum and D. uncinatum (Rotar and Chow, 1971; Stobbs and Imrie, 1976; Chow and Crowder, 1973). However, many resarchers later concluded that hybridization is efficient for plant improvement only after naturally-occurring germplasm has been thoroughly evaluated, if needed genotypes are not found (Cameron, 1983). In consequence, resources were shifted from hybridization of Desmodium to germplasm research with many legume species (Eyles et al., 1985).

Desmodium intortum in the Caribbean Basin. Positive results with D. intortum in Caribbean and Central America have been mostly at high elevations or high latitudes. Rattray (1972), working in Panama, found that D. intortum was not as well adapted at Gualaca (TRF) as D. ovalifolium, but made good pasture with P. maximum on black soils at cool high altitude sites. In Louisiana and Florida, USA, Greenleaf is a high yielding summer legume (Kretschmer, 1970; Thro et al. In press). It has persisted four years in clipping trials on fertile sites in Louisiana, dormant during winter (-13°C) (Thro and Shock, 1987).

Desmodium intortum was considered "promising" in Costa Rica (Orozco, 1939; Pacheco, 1957), but at a time when few other species were recognized alternatives. In a palatability trial in Puerto Rico with 11 other legumes, it was moderately palatable

(Warmke et al., 1952). In north Andros Island, Bahamas, D. intortum was used with Macroptilium atropurpureum (DC.) Urb. cv. Siratro and Neonotonia wightii (Lackey) in a study of nutrition levels of grazing sheep (Dorsett et al., 1980), but the authors made no comment on the relative values of the legumes. In a one-year trial in Jalisco, Mexico, D. intortum and D. uncinatum yielded less than three N. wightii cultivars but more than Siratro (Sánchez, 1985). In the Isla de la Juventud (WDHS), Cuba, D. intortum and M. atropurpureum were the highest yielding legumes and responded to Ca, P, and K fertilization with 200 to 400% yield incrases on these sandy soils (López et al., 1978).

At Central Farm, Belize (TRF), D. intortum died out in the dry season (Lazier, 1980). It was unadapted in Bayamo and San José de las Lajas (WDHS), Cuba (López et al., 1978; Monzote et al., 1982); and in Guadeloupe (Xande, 1985). In College Station (upland) and Beeville (Gulf coast), Texas, USA (Holt and Allison, 1979/80), D. intortum did not survive the first winter to -7^{o} C), though it has survived similar winters in Louisiana.

Desmodium uncinatum in the Caribbean Basin. In Louisiana, USA, Silverleaf has persisted on eroded soils with pH 4.5, and on fertile, neutral soils in association with Cynodon dactylon (L.) Pers. cv. Alicia, for eight years (Thro, personal observation; Thro and Shock, 1987). In Belize (TRF) (Lazier, 1980), Guadeloupe (EC/H) (Xande, 1985), Antigua (EC/D) (CARDI, 1980), Panama (Rattray, 1972), and Texas (Holt and Allison, 1979/80), D. uncinatum has succumed to drought, competition, cold stress, and unspecified causes. It was the highest yielding of four Desmodium species (D. incanum and two unspecified) during the wet season on a heavy clay site in Antigua (EC/D) (Keoghan and Devers, 1977), but yielded far less than Teramnus labialis (L.F.) Spreng., M. atropurpureum, Centrosema pubescens Benth., and Stylosanthes hamata (L.) Taub.

Commercial usefulness of D. intortum and D. uncinatum in high latitudes is limited. They are in competition for fertile, moist, cool environments where food crops and high-value cash crops can be grown. Their best use in such naturally favored locations may be in soil-building rotations (Lazier, 1980), i.e., sugarcane land rotated to pasture in Louisiana. Also, these late-flowering, short day plants do not set seed before frost (Kretschmer and Snyder, 1979; Thro, pers. obs.). In the absence of a regional seed production site, imported seed is prohibitively expensive.

BROWSE OR CUT-AND-CARRY SPECIES

Because much livestock in some countries is owned by producers with little or no land who use incidental areas such as roadsides for grazing (Paterson, 1986), high-yielding, N-fixing, cut-and-carry legumes may have greater value in some situations than legumes for improved grazed pastures. Some interesting species are native, including D. tortuosum (Lasseigne, 1973; Schubert, 1980) and D. distortum (CARDI, 1980; Schubert, 1980). Others are of Old World origin, e.g., C. gyroides, D. strigillosum and D. velutinum (Ohashi, 1973).

In a study in which D. uncinatum, D. intortum, and D. ovalifolium had tannin content in the range of 3.5 to 4% and protein content from 15 to 21%, some browse Desmodia had less tannin and more protein: D. distortum (tannin, 1.7 - 2.2%; protein, 21.8 - 26.1%); D. nicaraguense (tannin, 1.9%; protein (24.7%); D. tortuosum (tannin, 2.0 - 3.3%; protein 16.0 - 29.8%), and C. gyroides (tannin, 2.8 - 3.2%; protein, 22.0 - 23.6%). On the other hand, D. discolor had high tannin (3.4%) and medium protein (21.9%) (Rotar, 1965). Surprisingly, D. nicaraguense was less palatable to cattle than D. intortum in a trial in Puerto Rico (Warmke et al., 1952). In a trial in Colombia, browse species D. velutinum and D. strigillosum were both moderately palatable in the dry season; in the wet season, D. strigillosum was highly palatable and D. velutinum was unpalatable (Schultze-Kraft et al., 1989). Work is needed to sort out palatability differences and nutritional value in Desmodium.

Browse or Cut and Carry Species in the Caribbean Basin. Desmodium nicaraguense. The earliest recorded cultivator of Desmodium in the Caribbean Basin was Francisco Giusti in Guatemala (Calvina, 1952), who planted Meibomia rensoni Paynter (syn. D. nicaraguense) for his horses. Local farmers called it "engorda caballo" (horse fattener). Razeta (1932) stated that it was used by farmers in Nicaragua and had more protein and less fiber than alfalfa. Later workers in El Salvador found that D. nicaraguense had outstanding drought tolerance, with dry season yields superior to Lablab purpureus (L.) Sweet, Cajanus cajan (L.) Millsp., and Pueraria phaseoloides (Roxb.) Benth., and proposed it as a protein source (Choussey, 1943; Watkins and Chavez Viaud, 1950; Watkins and Lewy-van Severen, 1951). It did not persist in trials on an extremely poor soil in Belize (Valencia, 1989).

Desmodium discolor. This species, also relished by horses, has been known as "marmelada de caballo" (horse marmalade). Calvina (1952) regarded it highly in Mexico (1908 to 1914) and Cuba (1914 to 1922). Razeta (1932) considered D. discolor less valuable in Nicaragua than D. nicaraguense.

Desmodium distortum. This legume looked promising in grazed mixtures with P. maximum in Jamaica (Jamaica Dept. of Agr., 1953). In Antigua (EC/D), CARDI evaluated D. distortum CIAT 335 in grazed plots between 1977 and 1980 (CARDI, 1980). Keoghan (1980) recommended it for clay, calcareous, and volcanic soils of dryer parts of the Caribbean, when short term pasture with high early productivity is required. To facilitate testing and commercial use of D. distortum, CARDI included its seed production projects in Antigua (EC/D), Trinidad (EC/H or TRF) (CARDI, 1980), and Guyana (CARDI, 1984/85). In Dominica (EC/H) (CARDI 1983/84), Trinidad (EC/H or TRF) (CARDI, 1980; Ahmad and Huggins, 1986; Ahmad, 1986), and French Guyana (Bereau, 1986), D. distortum established rapidly and gave high early yields. In Dominica (EC/H), D. distortum was second in productivity after an unspecified Stylosanthes in cut-and-carry plots with Pennisetum purpureum (CARDI, 1987).

At Central Farm (TRF), Belize, Valencia (1989) cited "high performance" of D. distortum in introduction trials of 40 legumes. However, in TRF sites at Centeno, Trinidad, and Nueva Guinea, Nicaragua, D. distortum rated only "fair" after 18 and 17 months of evaluation (CARDI, 1980; RIEPT, Unpublished data, 1981-82).

Desmodium tortuosum. This species has been outstanding for early production both at Central Farm, Belize (TRF) (Lazier, 1981a) and in Antigua (EC/D) (CARDI, 1980). In Antigua (EC/D), D. tortuosum behaved as an annual and was recommended only for short term pastures (CARDI, 1980). In the Zona Huenequenera (WDHS), Yucatán, Mexico, "D. purpureum" (syn. D. tortuosum) was rated "very good" but data is available only from the first 12 weeks of the trial (RIEPT, 1988).

Desmodium dichotomum and D. virgatum. Accession CPI 47186 of D. dichotomum did not persist and was not recommended after testing in Antigua (EC/D) (CARDI, 1980). In Trinidad, D. virgatum was more productive than Leucaena leucocephala (Lam.) de Wit, T. labialis, C. pubescens, Stylosanthes guianensis (Aubl.) Sw., S. hamata, and Centrosema pascuorum Mart. ex Benth. on sandy soils (Ahmad and Huggins, 1986). However, it was less persistent than Siratro and Desmanthus virgatus (L.) Willd.

Codariocalyx gyroides. This Desmodium ally is included by tradition. In a trial in Colombia, it had lower tannin content and higher palatability than D. ovalifolium (CIAT/TPP, 1981).

Codariocalyx gyroides in the Caribbean Basin. I. WDHS. In Los Santos, Panama, C. gyroides CIAT 3001 had dry matter yields equal to or higher than all species tested in the first wet season of a "B" trial (RIEPT, 1982). In Isla de la Juventud, Cuba, C. gyroides CIAT 3001 performed well through the second dry season but did poorly the second wet season of a B trial; it was considered "adapted" (RIEPT, 1985). However, in an A trial at Moblissa, Guyana, C. gyroides was judged unadapted (RIEPT, unpubl. data, 1982). At El Chep. Panama, very poor stands of C. gyroides CIAT 3001 increased in yield from very low to low over one cycle (RIEPT, 1982).

II. TRF. At Central Farm, Belize, C. gyroides CF 29 (CIAT 3001) was found to be palatable, productive, and persistent (Lazier, 1981a and 1981b; Neal, 1981; Ahmad, 1986). These trials included an 18-month experiment with intensive rapid grazing every six weeks (Lazier, 1981a). Valencia (1989) found that C. gyroides did well in on-farm trials on cracking black clay soils in Belize, but that C. pubescens, L. leucocephala, and P. phaseoloides were more competitive with volunteer vegetation. In Costa Rica (San Carlos, Turrialba, Guapiles), C. gyroides CIAT 3001 was rated "good" to "excellent" in type A trials reporting observations over periods that ranged from 3 to 28 months (RIEPT Unpublished data, 1981-87).

On the other hand, C. gyroides CIAT 3001 was very low yielding at Calabacito, Panama (first wet season data only) RIEPT, 1982). In Nicaragua, C. gyroides CIAT 3001 was rated good after 17 months of an A trial at Nueva Guinea but produced low yields in a type B trial at the same site (RIEPT, 1982); and at El Recreo was one of the few accessions left by the second wet season, though its yields were far inferior to those of D. ovalifolium CIAT 350 and were declining (RIEPT, 1982). In Honduras (La Ceiba), C. gyroides CIAT 3001 was rated poor after 15 months observation (it had been rated excellent at this site in the first wet season) (RIEPT, Unpublished data, 1982).

III. SESF. In a B trial in San Isidro, Costa Rica, C. gyroides CIAT 3001 was low yielding in its first cycle but by its second dry season had very high yields (RIEPT, 1982). However, it was lower yielding than D. ovalifolium CIAT 350.

Desmodium sp. CIAT 3019. This accession was rated "good" after 14 months in A trials in Guapiles (TRF), Costa Rica (RIEPT, unpub. data, 1982-1984) but "fair" to "poor" in Nueva Guinea (TRF), Nicaragua (RIEPT, Unpublished data, 1981-82).

Desmodium strigillosum and D. velutinum. CIAT accessions 13153, 13155, and 13158 of D. strigillosum and CIAT 13218 D. velutinum were tested in Guapiles (TRF) and San Isidro (SESF), Costa Rica. At both sites, D. strigillosum yielded less than D. ovalifolium but more than D. heterophyllum (CIAT/TPP, 1989). Yield of D. velutinum at Guapiles was higher than all but one of more than 30 accessions of D. ovalifolium.

SPONTANEOUS LEGUMES OF NATIVE PASTURES

American species in this group include Desmodium incanum, D. procumbens, D. scorpiurus and D. adscendens (Schubert, 1980). D. triflorum is pantropic (Verdcourt, 1979). All are small plants that survive grazing by becoming prostrate, an attribute that makes their contribution to pastures difficult to measure (Lazier, 1981a). In some cases they comprise from 10 to 20% (CARDI, 1980; Michaud, 1986) or even one-third (Dirven, 1954) of the plant population and may make a valuable contribution to the to the biotic system. Valencia (1989) noted that animal average daily gain increased in certain heavily-grazed paddocks at Central Farm (TRF), Belize, after D. adscendens and D. heterophyllum volunteered in those paddocks.

Desmodium incanum in the Caribbean Basin. I. TRF. Lazier (1981a, 1981b) found D. incanum persistent at Central Farm, Belize, but selected C. gyroides for further research because of its equal persistence and greater production and animal use. In A trials in Puerto Cabezas (RIEPT, Unpublished data, 1983-85) and Nueva Guinea (RIEPT, unpub. data, 1981-82), Nicaragua, D. incanum accession CIAT 13032 was rated "fair" over 12-17 months of evaluation. In a single early rating of an A trial in El Bongo, Panama, D. incanum "261" was rated "fair" and CIAT 13032 "poor" (RIEPT, unpub. data, 1983). In Calabacito, Panama, "252" and CIAT 13032 were both rated "fair" to "poor" in an A trial; only the first five months of data from this trial are available (RIEPT, unpub. data, 1984). After 15 months of evaluation in an A trial at La Ceiba, Honduras, CIAT 13032 was rated "fair" (RIEPT, unpub. data, 1982-84).

II. SESF. In a B trial in La Esperanza, Honduras, D. incanum CIAT 13032 was one of few legumes to persist two years and one of very few to produce any forage in the dry season (RIEPT, 1988). Severe powdery mildew was noted on D. incanum at La Esperanza. In B trials in the Dominican Republic (Pedro Brand, Haras Nacional), CIAT 13032 was relatively very low yielding even in the dry season, over two cycles (RIEPT, 1985).

III. WDHS. In Bauta, Cuba, D. incanum was defoliated, cause unidentified, and disappeared from plots in a B trial (RIEPT, 1988).

IV. EC/D. Keoghan and Devers (1977) reported very low yields for D. incanum on a heavy clay site in Antigua (EC/D), both wet and dry season, relative to yields of 20 legume species. However, D. incanum persisted when planted on a similar Antigua site (heavy clay, high pH soil) in mixtures with T. labialis, the highest-yielding legume in this environment, and after five years made up half of the mixture (CARDI, 1980).

In Louisiana, USA, where D. incanum is neither native or naturalized, CIAT 13032 was not winterhardy (Thro, 1984), but Tifhardy-1, a selection from Georgia, USA (Miller and Wells, 1989), has persisted and spread on a very acid, eroded site with low soil water holding-capacity. D. incanum is a highly persistent legume in Florida, but is not used due to low palatability and low yields.

Desmodium scorpiurus, D. adscendens, and D. triflorum were ubiquitous and well-nodulated in Belizean (TRF) pastures (Llazier, 1981a), and were likely making a nitrogen contribution. However, D. adscendens did not compete well with

Cynodon nlemfuensis Vanderyst, Bothriochloa pertusa, or P. maximum at Central Farm (TRF) in Belize (Valencia, 1989). D. scorpiurus, D. adscendens, and D. triflorum have been considered as "promising" in Costa Rica (Orozco, 1939; Semple, 1962).

Desmodium uniflorum accession "26062" had low productivity in Antigua (EC/D) (CARDI, 1980). Desmodium procumbens behaved as a transitory annual in Antigua (CARDI, 1980), and was not considered useful.

Desmodium heterocarpun/qualifolium, D. heterophyllum, AND D. barbatum

The first three species are Asian legumes considered by Ohashi (1973) to be one species with several botanical varieties. However, forage researchers have found consistent morphological differences between the species (Schultze-Kraft and Benavides, 1988; Quesenberry et al., 1989). All three tolerant shade and heavy soils (Schultze-Kraft, Personal communication, 1990) and were recommended by Keoghan (1980) for long-term pastures in wet regions of the Caribbean. D. barbatum is a pantropical species (Schubert, 1980; Ohashi, 1973). Although it is a distinct species, some accessions of D. barbatum are similar to D. heterocarpon and D. ovalifolium in growth habit.

Desmodium heterocarpon. D. heterocarpon cv. Florida, a selection from USDA PI 217910, is released in southern Florida, USA (Kretschmer et al., 1979), and has been tested by RIEPT as CIAT 365. It has better drought tolerance than D. heterophyllum, better seed production, and good grazing tolerance in spite of an upright growth habit in the absence of grazing, but is susceptible to root knot nematode. Additional collections of D. heterocarpon and D. ovalifolium have been tested in Florida (Kretschmer et al., 1980; Quesenberry and Dunn, 1987; Kretschmer et al., 1990) and accessions have been identified with greater resistance. Root knot nematode-resistant accessions of D. ovalifolium have been crossed with D. heterocarpon (Quesenberry et al., 1989) and advanced generation hybrids from these crosses appear to combine nematode resistance of D. ovalifolium with characteristics of D. heterocarpon such as earlier seed production.

Desmodium heterocarpon in the Caribbean. I. TRF. In Nueva Guinea, Nicaragua, D. heterocarpon CIAT 365 was rated "good" for 17 months (RIEPT, Unpublished data, 1982). In San Carlos, Guapiles, and Turrialba, Costa Rica, CIAT 365 (at Guapiles, CIAT 3787, as well) was rated "good" over observation intervals of 3 to 14 months (RIEPT, Unpublished data, 1982-84). In Belize, D. heterocarpon was recommended for poorly drained soils (Ahmad, 1986). At Central Farm, Belize, D. heterocarpon CF 1037 was one of 12 of 28 legume entries that persisted for three years (Valencia, 1989). In recent work in Costa Rica, D. heterocarpon was outstanding at Guapiles but not at San Isidro (WDHS) (CIAT/TPP, 1989).

II. SESF. In San Ramón, Costa Rica, D. heterocarpon CIAT 3787 was rated "poor" after 14 months of observation (RIEPT, Unpublished data, 1985-87).

In an adaptation trial in an infertile, acid-soil site in Louisiana, USA, D. heterocarpon cv. Florida was rated "excellent" during the first summer but was killed the first winter (Thro, 1984). In spite of excellent seed set, only isolated seedlings were observed the following year.

Desmodium heterophyllum. The low growth habit of this legume gives it tolerance to grazing and compatibility with such grasses as Brachiaria decumbens Staph (Imrie et al., 1983) but limits seed recovery; fortunately, it can be vegetatively established from stolons. It is tolerant of acid soils and grows well on fertile alluvial soils; it is not drought tolerant. There is one commercial cultivar, Johnstone, released in Australia in 1973 (Imrie et al., 1983), tested by RIEPT as CIAT 349.

Desmodium heterophyllum in the Caribbean Basin. I. TRF. Rattray (1972) cited the ease of vegetative reproduction of this species in Gualaca, Panama. At Central Farm, Belize, D. heterophyllum was recommended for poorly drained soils (Ahmad, 1986). It survived as a reseeding wet season annual at least from 1977 to 1982 (Valencia, 1989). In La Ceiba, Honduras, D. heterophyllum CIAT 349 was rated "good" in the first 15 months of an A trial (RIEPT, 1985), and CIAT 3782 was mentioned as outstanding for persistence, disease resistance, productivity and ease of establishment in a B trial at that site (RIEPT, 1988). In Puerto Cabezas, Nicaragua, CIAT 349 was rated "excellent" during one year of observation (RIEPT, Unpublished data, 1984-85). Type B trials including CIAT 349 and 3782 were established at Guapiles, Costa Rica (RIEPT, 1988), where both accessions were well nodulated at 12 weeks, and A trials including CIAT 349 at Turrialba (RIEPT, Unpublished data, 1983), but later results of these trials were not available.

However, the accession CIAT 349 was not outstanding among entries in an A trial in Sona, Panama (CIAT/TPP, 1987). In Nicaragua, D. heterophyllum CIAT 349 was rated "excellent" in the first year of an A trial in Puerto Cabezas, but in El Recreo (B trial) and Nueva Guinea (A trial), it was rated "poor" to "fair" during 17 months of observation,had low yields, and disappeared from clipped plots by the second wet season (RIEPT 1982; RIEPT, Unpublished data, 1982). In Costa Rica, D. heterophyllum was rated "fair" to "poor" in A trials in San Carlos (RIEPT, Unpublished data, 1983), though CIAT 349 rated "good" during 14 months of observation in Guapiles, Costa Rica (RIEPT, Unpublished data, 1982-84). In Trinidad (location unspec.), Johnstone was one of the least productive of the legumes tested (CARDI, 1978-79; CARDI, 1980). In El Centeno, Trinidad, first year yields were low (RIEPT, 1982).

II. SESF. At San Ramón, Costa Rica, D. heterophyllum was rated "fair" to "poor" (RIEPT, 1985-87). In B trials at San Isidro, Costa Rica, yields of D. heterophyllum CIAT 349 were consistently low for two years (RIEPT, 1982). In later work, D. heterophyllum accessions did poorly at both Gaupiles (TRF) and at San Isidro compared to D. heterocarpon, D. ovalifolium, D. velutinum, and D. strigillosum (CIAT/TPP, 1989). CIAT 349 persisted for two years in infertile, eroded, acid soil in Louisiana, USA), after which it died out (Thro, 1984). However, during two years, D. heterophyllum CIAT 349 was one of the most productive legumes in the cool season in a B trial in Tlapocoyan, Veracruz, Mexico (RIEPT, 1988).

Desmodium ovalifolium. This species has excellent adaptation to high aluminum, highly acid soils of the tropics (Imrie et al., 1983). It is adapted to wet regions with rainfall of 2000 mm or more (Grof, 1982) and with short dry seasons of no more than two or three months (Schultze-Kraft, CIAT/TPP, Personal communication, 1990). A cover crop cultivar from a Singapore-based seed company has been tested as CIAT 350 (Schultze-Kraft and Giacometti, 1979). It was found to have excellent persistence under grazing even with aggressive grasses such as Brachiaria species for which no other companion legumes were available (Grof, 1982). Subsequent studies have revealed shortcomings of this otherwise highly promising legume.

It is susceptible to a stem nematode, Pterotylenchus cecidogenus, found on native Desmodium hosts, and to a false rust disease, causal organism Synchytrium desmodii, an exotic pathogen introduced here by an unknown importer of Asian seed (CIAT/TPP, 1985). When a resistant accession, CIAT 13089, was grown on two soils in mixture with B. humidicola (Rendle) Schwe., its vigorous growth habit, freedom from disease, and low palatability allowed it to dominate the grass, yet its presence did not increase animal production, and in some cases even depressed it (CIAT/TPP, 1989) relative to the grass control.

A collection of 84 accessions of D. ovalifolium contained substantial variation for pest resistance, palatability, tannin content, flowering date, growth habit, forage yield, and protein content. Tannin content and palatability were negatively correlated in this collection (Schultze-Kraft and Benavides, 1988).

Desmodium ovalifolium in the Caribbean Basin. I. TRF. In Honduras (La Ceiba), D. ovalifolium CIAT 350 and 3784 were rated "excellent" in a 15-month A trial (RIEPT, Unpublished data, 1983). In Panama (Sona), D. ovalifolium CIAT 350 had outstanding disease resistance in the wet season and average yields increasing over time (RIEPT, 1985). In Costa Rica (San Carlos), Guapiles, and Turrialba), D. ovalifolium has advanced from A trials in which it rated "good" after 8 months of observation at Turrialba and 14 months at Guapiles, but only "fair" after two dry seasons and one wet season in San Carlos (RIEPT, 1985) to C trials at Turrialba (RIEPT, 1988). CIAT D. ovalifolium accessions 350, 3673 and 3784, were tested in these B trials; CIAT 350 was superior to CIAT 3673 for pest resistance and had better seed production in San Carlos. In the C trials at Turrialba, D. ovalifolium with C. nlemfuensis had lower pasture and legume yield and quality than associations with Arachis pintoi Greg. & Krap. and P. phaseoloides, but only D. ovalifolium increased in the pasture as more animals were added.

Desmodium ovalifolium was rated highly in a B trial at Fray Bartolomeo de las Casas, Guatemala (CIAT 3793) (RIEPT, 1988); another B trial in Seybo el Valle, Dominican Republic (CIAT 350 and 3784) (RIEPT, 1985); an A trial in Puerto Cabezas, Nicaragua (CIAT 3784) (RIEPT, 1982) and B trials in El Recreo and Nueva Guinea, Nicaragua (CIAT 350) (RIEPT, 1982). In the B trial at El Recreo, CIAT 350 was rated "best" and was one of few species left by the second rainy season. In Belize, D. ovalifolium kept a good stand in a C-type grazing trial on a vertic planosol from 1977 to 1989 (Ahmad, 1986) and accession CF 200 (CIAT 350) was rated "best overall performance" on acid, infertile lowland soils in native pastures (Valencia, 1989). However, D. ovalifolium CIAT 350 and 3784 both did equally poorly at Hojancha, Costa Rica (RIEPT, 1985), especially in the dry season.

II. WDHS. In the Dominican Republic (Pedro Brand and Harras Nacional), D. ovalifolium CIAT 3784 yielded near the mean of all B trial entries, less than Zornia latifolia Sm. in Rees. and P. phaseoloides entries (RIEPT, 1985) but was rated highly for its dry season value. In Moblissa, Guyana, D. ovalifolium CIAT 350 is considered adapted (RIEPT, 1985; Cumerbatch, 1986). In Surinam, D. ovalifolium did not respond when pH of a highly acid soil was increased (Simons, 1984). Bereau (1986) reported from French Guyana that D. ovalifolium CIAT 350 was slow to establish, but had excellent persistence and disease resistance. CARDI (1980) included D. ovalifolium in its seed production project.

III. SESF. In a 20-month A trial at San Ramón, Costa Rica, D. ovalifolium CIAT 3781 was rated "good" but CIAT 3376 and CIAT 350 were rated "fair" and CIAT 3782, 3784, and 3787 disappeared before the end of the trial (RIEPT, Unpublished data, 1985-87). In a B trial at Bauta, Cuba, it was defoliated and disappeared from the plots (accession unspecified) (RIEPT, 1988). At Penonome, Panama, there was no visible pest damage to account for the languid performance of CIAT 3784 (RIEPT, 1988). In San Isidro, Costa Rica, CIAT 350 was rated "adapted" but low to average in yield, surpassed by C. gyroides, Aeschynomene histrix Poir, and S. guianensis (RIEPT, Unpublished data, 1983). However, when a large collection of D. ovalifolium (>30 accessions) was tested at two contrasting locations in Costa Rica, Guapiles (TRF) and San Isidro,yield of six accessions common to both sites was not different between the two sites (CIAT/TPP, 1989), and in a Trinidad site with pronounced wet and dry seasons, D. ovalifolium "CV 350" was superior to 8 to 12 other legumes (Davis, 1986).

In Mexico, in B trials in Destierro and Loma Bonita (WDHS), Halapa/El Gusto (TRF), and Jerico (SESF), ranging in length from one dry season to two years, CIAT 350 and two low tannin, pest resistant selections (CIAT 3788 and 3784) were among the best entries for yield and persistence (RIEPT, 1982, 1985, 1988). In Jalapa, CIAT 3784 was higher yielding than CIAT 350; in the other locations there was little difference.

In a D trial at San Jose de las Lajas (WDHS), Cuba, D. ovalifolium CIAT 350 provided poorer animal performance than S. guianensis CIAT 184 in a C. dactylon mixture, and less available forage (RIEPT, 1985).

Desmodium ovalifolium CIAT 350 was rated "good" during the first summer of an adaptation trial in Louisiana, USA, but did not survive the winter (Thro, 1984).

Desmodium barbatum. This species is also adapted to acid soils (Imrie et al., 1983; Schultz-Kraft and Giacometti, 1979). Semple (1964) observed it in native pastures in Costa Rica from sea level to above 1000 m. It volunteered in Hyparrhenia rufa (C. G. Nees) Staph pastures at Zamorano, Honduras; in some places these pastures were 40% D. barbatum/60% grass (Semple, 1964). Desmodium barbatum was equally palatable with the grass when pasture height was about 30 cm. Semple reported that D. barbatum needed at least a 6-month wet season; Schultze-Kraft and Giacometti (1979) describe the species as adapted to high rainfall areas. Semple (1964) and Schultze-Kraft and Giacometti (1979) comment on the broad range of morphological diversity in D. barbatum for growth habit, foliage density, and productivity.

Desmodium barbatum in the Caribbean Basin. Locally collected accessions of D. barbatum were planted in trials at Sona (TRF) and Los Santos (WDHS), Panama (CIAT/TPP, 1987); no data are yet available. In Belize (TRF), Valencia (1989) observed good early performance from D. barbatum CF 1024, but it did not persist. In Louisiana, CIAT 363 was rated "excellent" in the first summer of an adaptation trial but did not survive the winter (Thro, 1984).

DISCUSSION

"In areas that cannot be cropped, grazing animals will always have a place, turning plants that humans cannot digest into edible protein" (Keoghan and Devers, 1977). It appears that Desmodium intortum and D. uncinatum are not useful in sites of the type referred to by Keoghan and Devers.

Desmodium shrubs and subshrubs are capable of providing high dry matter yields for browse or cut and carry situations. In the western Caribbean, C. gyroides looks best; and D. distortum has been recommended. For most of these species, there is insufficient data to determine the limits of their adaptation, but C. gyroides is widely adapted and some species (e.g., D. tortuosum) are widespread.

In research to date, the small, spontaneous species widely distributed in native pastures have lacked sufficient advantages to justify commercial development. Desmodium hetercarpon and D. heterophyllum are adapted to grazed pastures in TRF sites, and D. heterocarpon in Florida; there is no data for these species in other ecosystems. In wet, acid-soil regions of the true tropics, D. ovalifolium has been superior to the other two species.

Desmodium ovalifolium has been tested in more places in our region than anything except CocaCola and has been just as widely successful. However, animal performance in D trials with high-tannin CIAT 350 and CIAT 13089 has been disappointing. Low tannin accessions have been identified.

Desmodium barbatum came to the attention of researchers at about the same time as D. ovalifolium (Schultze-Kraft and Giacometti, 1979) and was eclipsed. An enlarged collection of D. barbatum now exists and might reward examination (Schultze-Kraft, CIAT/TPP, Personal communication, 1990).

CONCLUSIONS

Momentum. At this time, there is great momentum in Desmodium research, and legume research in general, in our region. The effects of CATIE, CARDI, and RIEPT, as each has come on the scene, are strikingly evident in continuity and quality of research and availability of information. These coordinators have amplified the value of each local program's contribution and greatly increased the probability that we will, together, successfully complete the first stages in the development of new Desmodium species. This first stage is a huge task: thorough evaluation of a representative sample of natural genetic variation in a representative range of environments, from adaptation trials of many accessions through animal performance trials with a few of the best.

We are in the thick of the job right now. The RIEPT data, for example, show conclusions that are building, not yet formed. Continuity, communication, and cooperation are essential to carrying on from this high-energy point.

What next? One priority at this stage should be what to do about Desmodium ovalifolium, the highly promising legume with the serious drawbacks for animal performance. Study of natural variation in this species has received much effort and may be close to completion, when plant breeding should begin _if needed_. Breeding programs could be location-specific or aimed at broad adaptation, as desired. It may be time for a workshop on this species, to consolidate information and together plan the next steps.

A second priority is to meet the needs of special purpose systems and of environments where _D. ovalifolium_ is not superior, such as the eastern Caribbean. For example, unless other genera provide better legumes for these niches, work should be continued with _C. gyroides_ and _D. distortum_. An enlarged collection of _C. gyroides_ is now available for research (Schultze-Kraft, CIAT/TPP, Personal communication, 1990). Early results with _D. strigillosum_ and _D. velutinum_ should be pursued.

Adoption. Closely integrating our research with on-farm biological, economic, and social conditions, though extremely costly in time as well as funds, maybe improve our chances of developing cultivars that are really in demand. Working with our customers, we will be in a better position to develop legumes to fit common types of management and mismanagement.

Seed availability is also key. Potential seed production environments for promising species should be scouted throughout the region. Technology adoption programs for forage legumes should attempt to integrate seed production and marketing research with development of market demand, so that producers are not frustrated by extension tales of unavailable, unaffordable wonder legumes.

* Let us Keep cooperating.

* It is time for an international strategy session on _Desmodium ovalifolium_.

* Stay close to our customers.

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