Forest Ecology and Management, 48 (1992) 1–13
Elsevier Science Publishers B.V., Amsterdam

Discovery of thornless, non-browsed, erect tropical *Prosopis* in 3-year-old Haitian progeny trials

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(Accepted 29 January 1991)

ABSTRACT

Lee, S.G., Russell, E.J., Bingham, R.L. and Felker, P., 1992. Discovery of thornless, non-browsed, erect tropical *Prosopis* in 3-year-old Haitian progeny trials. *For. Ecol. Manage.*, 48: 1–13.

Native *Prosopis juliflora* (bayahonde) provides the bulk of the fuelwood for Haiti and provides pods useful for animal feed in the dry season. A country-wide collection of native *Prosopis* was made and compared with tropical *Prosopis* families from Peru and with subtropical *Prosopis* families from the southwestern USA, Argentina and Chile in a progeny/provenance trial with 70 families. The height, form, survival and biomass of these plantings were measured 8 months and 27 months after planting. The overall survival of this non-irrigated planting was 93%. At 27 months the eight tallest families were of Peruvian origin and ranged in mean height from 208 to 235 cm. Some of the Peruvian *Prosopis* were thornless, erect and non-browsed by goats that broke through the exclosure. In contrast thornless *Prosopis alba* and *Leucaena pulverulenta* were severely browsed and experienced high mortality. Although the trees have not yet produced pods, the Peruvian *Prosopis* were collected from trees that provide sweet pods used to make a beverage for human consumption.

INTRODUCTION

A considerable part of northern Haiti is semi-arid as shown by the presence of columnar cactus, *Acacia, Prosopis* and associated thorn scrub vegetation. Owing to the influence of low and erratic rainfall on annual cash crops, Haitians have been forced to generate income from fuelwood sales and production of charcoal (Conway, 1979; Smucker, 1981). In 1979, approximately 85% of Haiti's energy requirements were met with charcoal or fuelwood (Voltaire, 1979). At this time *Prosopis juliflora* (bayahonde in Creole) was the most widely used species for charcoal production (Conway, 1979; Voltaire, 1979). Assuming that wood consumption would increase in proportion to the population growth rate (2.5%), Voltaire (1979) estimated that all wood resources will be depleted by the year 2000, if no reforestation is undertaken.

Not only is there a need to find useful trees that can protect the mountain sides from soil erosion, but there is a need to provide firewood to assist Haiti's poor rural economic condition. To illustrate: "Although there has been moderate growth of the economy during the decade, of about 3.6%/year, income per capita in Haiti ($260/year) remains the lowest in the western Hemisphere and three quarters of its population live in dire poverty with incomes below U.S. $100 (UNDP/World Bank, 1982)".

As *Prosopis* is widely spread throughout Haiti and provides much of the country's fuelwood, it was appropriate to test the growth characteristics of both exotic and indigenous Haitian collections of *Prosopis* germplasm on Haitian soil. We were particularly interested to examine *Prosopis* of Peruvian origin, as Peru may be the center of genetic diversity for tropical *Prosopis* (Felker, 1990). Pods from some of the Peruvian *Prosopis* reach 50 cm in length and are high in sugar (P. Felker, unpublished observation, 1982).

MATERIALS AND METHODS

A randomized complete block design with four replicates was used. Each replicate consisted of a row of five trees. The trees were planted on a 3.0 m in-row by 4.5 m between-row spacing. There were 44 Haitian and 26 North and South American accessions. The North and South American open-pollinated progenies were chosen on the basis of previously demonstrated superior production of either pods or biomass (Felker et al., 1983a, 1984). The thornless *Prosopis alba* clone B2V50 was also included. As *Leucaena pulverulenta* is more adapted to lower rainfall sites than *Leucaena leucocephala*, a previously identified fast-growing family of *L. pulverulenta* 999 (Glumac et al., 1987) was also included in this trial.

The Haitian material was maintained as individual tree collections. The seeds were obtained on a collection trip of the *Prosopis* regions in Haiti with the notable exception of La Gonave. Collections were made in the Cul-de-Sac area en route to the Dominican border, at selected villages along the route from Port-au-Prince to Gonaives, and in northern Haiti from Bombardopolis, Jean Rabel, Bassin Bleu and Gos Marne (Table 1). Attempts were made to collect seeds from trees with superior form, height or pod characters. The 44 open-pollinated progenies included in this trial were selected from the entire collection to represent the major geographical *Prosopis* regions in Haiti.

The experimental trial was established on a 2 ha area, 4 km east of the village of Thomazeau, about 700 m from the shore of L'Etang Saumatre (30 km east of Port-au-Prince).

Site description

The site appeared to be a larval extrusion. The soil was a clayey-skeletal montmorillonite, isohyperthermic lithic haplustall. The surface 0–23 cm was very dark brown (Munsell colorchart 10YR 2/2) with a pH of 7.0 and 30% stones 5–25 cm in diameter. The 23–35 cm depth had a pH of 6.1 with 60% stones 10–50 cm in diameter. The texture was a silty clay loam.

Rainfall was recorded about 300 m from the plantation: 1176 mm in 1986 and 763 mm in 1987. From the time of initial herbicide application (April 1987), to planting (September 1987), 203 mm fell on the site. From the time of planting to the first measurement in May 1988, the site received 344 mm rainfall.

In January 1987, the site was occupied by thorn scrub containing native *Prosopis*, *Acacia*s and 5 m tall unidentified columnar cacti as major components. This vegetation was removed with hand implements.

After the woody vegetation was removed, the herbaceous vegetation was killed before the spring rainy season to increase the stored soil water for a fall planting. Thus, in April 1987, a glyphosate application was made, followed 1 week later by the pre-emergence herbicide diuron at 1.6 kg a.i. ha^{-1}. The herbicides were applied with a low volume (60 l ha^{-1}), pressure-regulated Solo backpack sprayer, using a 1.5 m wide boom with four 8001 TeeJet nozzles. The low-volume application was most helpful as water had to be carried to the site. One day prior to planting, oryzalin was applied at 1.6 kg a.i. ha^{-1}.

The seedlings were germinated in 3.8 cm × 3.8 cm × 30 cm long cardboard plant bands in May 1987, at a nursery established on site. A rhizobium strain previously shown to effectively nodulate 12 *Prosopis* species was used on the seedlings (Felker and Clark, 1980). Nodules were frequently observed on the seedlings during transplanting.

The seedlings were planted on 27–29 August 1987. At nearly every planting hole, rocks 5–30 cm in diameter were encountered in the surface 40 cm. Picks and shovels were used to make holes deep enough to plant the entire 30 cm long cardboard plant band. The seedlings were watered before planting and the plant bands were left on at transplant as this has been shown to yield a 25% survival advantage over similarly sized bare root seedlings (Felker et al., 1988). The seedlings were planted within 10 min of the holes having been dug. No water was applied after transplanting.

The study site was surrounded by fencing electrified by a solar charger. In spite of the electrification goats still penetrated the fence.

Political turbulence in Haiti prevented the determination of survival counts, height, number of main stems, and stem form until April 1988, 8 months after planting. An analysis of variance was conducted to determine differences among all 70 open-pollinated progenies for height, form and number of branches. A *t*-test was also conducted using the general linear model to deter-

TABLE 1

Prosopis accessions listed in ascending order of mean form, measured 8 months after outplanting in field trials near Thomazeau, Haiti[1]

Accession number	Species	Location of origin	Form	Stems/tree	% survival
			Mean ± CI	Mean ± CI	
B2V50	*P. alba*	California	1.0±0.0	1.0±0.0	25
419	*Prosopis* spp.	Trujillo, Peru	1.0±0.0	1.2±0.2	100
420	*Prosopis* spp.	Trujillo, Peru	1.0±0.0	1.2±0.2	95
425	*Prosopis* spp.	Trujillo, Peru	1.0±0.0	1.0±0.0	67
436	*Prosopis* spp.	Trujillo, Peru	1.0±0.0	1.0±0.0	69
999	*L. pulverulenta*	Kingsville, Texas	1.0±0.0	1.0±0.0	42
1117	*P. alba/flexuosa*	Atacama Desert, Chile	1.0±0.0	2.4±0.6	70
559	*Prosopis* spp.	Alredores de Piura, Peru	1.1±0.1	1.7±0.4	100
422	*Prosopis* spp.	Contumaza, Peru	1.1±0.1	1.9±0.2	90
544	*Prosopis* spp.	La Union, Peru	1.1±0.2	1.7±0.6	87
538	*Prosopis* spp.	La Union, Peru	1.1±0.2	1.2±0.3	100
552	*Prosopis* spp.	Alredores de Piura, Peru	1.2±0.2	1.7±0.4	
1134	*P. alba* var. *panta*	Argentina	1.2±0.3	1.5±0.5	79
423	*Prosopis* spp.	Contumaza, Peru	1.1±0.2	1.3±0.3	80
475	*P. glandulosa* var. *torreyana*	UC Riverside, California	1.2±0.3	1.4±0.3	91
545	*Prosopis* spp.	Sullana, Peru	1.2±0.2	2.3±0.9	94
537	*Prosopis* spp.	Sullana, Peru	1.3±0.3	1.7±0.6	100
591	*P. alba* (0039)	Imperial Valley, California	1.3±0.3	1.2±0.6	91
H38	*P. juliflora*	Croix de Bouquette–Thomazeau	1.4±0.3	1.8±0.5	92
1012	*P. flexuosa*	Parquet Factory: Catamarca, Argentina	1.4±0.3	2.6±0.2	71
457	*P. velutina* (0025)	UC Riverside, California	1.5±0.3	1.9±0.5	85
H03	*P. juliflora*	Passe Catabois	1.5±0.3	1.5±0.5	93
1135	*P. nigra*	Argentina	1.5±0.3	1.5±0.5	93
H50	*P. juliflora*	Molle St. Nicholas	1.5±0.3	1.5±1.4	88
H06	*P. juliflora*	Passe Catabois	1.5±0.4	1.4±0.3	94
H49	*P. juliflora*	Molle St. Nicholas	1.5±0.3	1.9±0.5	100
166	*P. alba*	Thermal–Coachella, California	1.5±1.0	1.5±1.0	50
450	*P. velutina* (0032)	UC Riverside, California	1.5±0.3	1.9±0.5	90
901	*P. alba* (0037)	UC Riverside, California	1.5±0.3	1.6±0.5	88
H20	*P. juliflora*	Croix de Bouquette–Dom. Rep.	1.5±0.3	1.9±0.6	95
H44	*P. juliflora*	South Anse Rouge	1.5±0.3	1.7±0.5	100
H24	*P. juliflora*	Croix de Bouquette–Dom. Rep.	1.6±0.3	1.9±0.4	100
1111	*P. glandulosa* var. *glandulosa*	Kingsville, Texas	1.5±0.2	1.7±0.4	100
H35	*P. juliflora*	Port-au-Prince–St. Marc	1.6±0.3	1.9±0.7	89
H54	*P. juliflora*	Jean Rabel	1.6±0.2	2.1±0.5	95
H26	*P. juliflora*	Port-au-Prince–St. Marc	1.6±0.3	2.3±0.5	85
H14	*P. juliflora*	Gonaive	1.6±0.3	1.7±0.4	100
H30	*P. juliflora*	Port-au-Prince–St. Marc	1.7±0.3	2.1±0.5	95
H43	*P. juliflora*	Downtown Port-au-Prince	1.7±0.3	2.2±0.7	95
H15	*P. juliflora*	Gonaive–Anse Rouge	1.7±0.3	1.7±0.6	100

TABLE 1 (continued)

Accession number	Species	Location of origin	Form	Stems/tree	% survival
			Mean ± CI	Mean ± CI	
H22	*P. juliflora*	Croix de Bouquette–Dom. Rep.	1.7 ± 0.3	2.3 ± 0.7	85
H32	*P. juliflora*	Port-au-Prince–St. Marc	1.7 ± 0.4	2.6 ± 0.7	93
H40	*P. juliflora*	Croix de Bouquette–Thomazeau	1.7 ± 0.3	1.9 ± 0.6	100
H39	*P. juliflora*	Croix de Bouquette–Thomazeau	1.7 ± 0.3	2.1 ± 0.5	100
H34	*P. juliflora*	Port-au-Prince–St. Marc	1.7 ± 0.3	1.8 ± 0.4	95
H23	*P. juliflora*	Croix de Bouquette–Dom. Rep.	1.7 ± 0.3	2.1 ± 0.4	100
H55	*P. juliflora*	South of Jean Rabel	1.8 ± 0.3	2.6 ± 1.0	93
H18	*P. juliflora*	Port-au-Prince	1.8 ± 0.5	2.7 ± 0.6	90
H41	*P. juliflora*	Croix de Bouquette–Thomazeau	1.8 ± 0.2	2.0 ± 0.4	95
H37	*P. juliflora*	Croix de Bouquette–Thomazeau	1.8 ± 0.3	2.1 ± 0.6	100
H02	*P. juliflora*	Passe Catabois	1.8 ± 0.4	2.8 ± 0.9	100
H45	*P. juliflora*	Baie de Heine	1.8 ± 0.3	2.8 ± 0.5	
H04	*P. juliflora*	Passe Catabois	1.9 ± 0.4	1.9 ± 0.7	88
H11	*P. juliflora*	Bassin Bleu–Gros Marne	1.9 ± 0.3	1.4 ± 0.4	94
H28	*P. juliflora*	Port-au-Prince–St. Marc	1.9 ± 0.3	1.9 ± 0.5	95
H16	*P. juliflora*	Gonaive	1.9 ± 0.3	2.8 ± 0.7	100
H10	*P. juliflora*	North Bassin Bleu	1.9 ± 0.3	2.2 ± 0.5	90
H31	*P. juliflora*	Port-au-Prince	1.9 ± 0.2	2.4 ± 0.4	95
1015	*P. tamarugo*	Atacama Desert, Chile	2.0	1.0	25
H07	*P. juliflora*	Passe Catabois–Bassin Bleu	2.0 ± 0.4	2.8 ± 0.8	100
H12	*P. juliflora*	South of Gros Marne	2.0 ± 0.2	2.7 ± 0.7	90
H21	*P. juliflora*	Croix de Bouquette–Dom. Rep.	2.1 ± 0.3	2.4 ± 0.5	85
H08	*P. juliflora*	North Bassin Bleu	2.1 ± 0.3	2.6 ± 0.5	95
H25	*P. juliflora*	Croix de Bouquette–Dom. Rep.	2.2 ± 0.4	2.6 ± 0.7	85
H09	*P. juliflora*	North Bassin Bleu	2.2 ± 0.3	2.2 ± 0.5	100
H19	*P. juliflora*	Port-au-Prince	2.2 ± 0.3	3.1 ± 0.6	95
H01	*P. juliflora*	Passe Catabois	2.2 ± 0.4	2.9 ± 0.5	82
H36	*P. juliflora*	Croix de Bouquette–Thomazeau	2.3 ± 0.4	3.4 ± 0.6	90
H05	*P. juliflora*	Gonaive	2.4 ± 0.3	3.4 ± 0.8	100
H13	*P. juliflora*	Gonaive	2.4 ± 0.3	2.8 ± 0.5	100

[1]Block means were used to calculate mean form with the exception of accession 1015, which represents measurement on a single tree. Stem form ranking based on the angle of main stem/stems with the ground. Thus, form ratings of 1, 2 and 3 represent stem angles of 60–90° (fully erect), 30–60°, and 0–30° from horizontal, respectively.

mine differences between three major *Prosopis* groups, i.e. progenies originating from Haiti, the Trujillo–Contumaza region of Peru, and the Piura region of Peru.

A rating scheme was devised to compare the vastly differing forms of *Prosopis*. As the *Prosopis* with the best form is inferior to the average commercial pine selection, a very broad rating scale was devised. The angle of the main stem and/or stems with the ground was rated as being 0–30°, 30–60°, or 60–90° from horizontal. The most upright (60–90° from horizontal) stems received a rating of 1, and the most prostrate (0–30° from horizontal) received a rating of 3.

A second measurement of height and basal diameter was made 27 months after planting. Biomass was estimated from basal diameters using previously established regression equations (Felker et al., 1983b).

RESULTS

The overall survival for the field trial was 93% despite a complete absence of watering and no rain for 3 weeks after planting (the ANOVA for difference in arcsine survival was significant at $P=0.0001$). We attribute this high survival to soilwater recharge resulting from effective weed control the season prior to planting, and to the long (30 cm) cardboard plant bands.

Four Peruvian, 15 Haitian, and one Texas native *Prosopis* achieved 100% survival (Table 1). Nearly all Haitian and Peruvian progenies had survivals of 80% or more, and 82% of all Haitian *Prosopis* in the trial achieved at least a 90% survival rate. Open-pollinated progenies exhibiting very low survivals were of the thornless type (*P. alba, L. pulverulenta*), owing to herbivory by goats. These goats broke through an electrified fence surrounding the growth trial during the dry season.

Prosopis tamarugo, that is thorny, from the salt deserts of northern Chile, was the least promising in this field trial, with one seedling surviving at the 8 month evaluation and no surviving seedlings at the 27 month evaluation. This species has performed poorly in California (Felker et al., 1983a) and many other parts of Africa (H.N. LeHouerou, personal communication, 1986). The very arid Chilean desert rarely achieves temperatures of 33°C and it appears that this species poorly tolerates temperatures over 35°C.

As might be expected with as many as 70 open-pollinated progenies, the ANOVA was significantly different ($P=0.0001$) for height, number of main stems ($P=0.0001$) and form ($P=0.0001$) (data not presented). To facilitate pairwise comparisons between the accessions and to provide some estimate of variability, the 95% confidence intervals are provided for the number of main stems and form in Table 1.

Peruvian provenances, particularly in the 400 series, *L. pulverulenta*, and *P. alba* clone B2V50 had the most erect form. A second group included Peruvian progeny from the 500 series and the *P. alba* (1134 and 591) which also had good form. Most of the Haitian progeny ranged in mean form values of between 1.5 and 2.4. Thus, most of the Haitian *Prosopis* was more multi-stemmed and prostrate in form. The lowest ten open-pollinated progeny in rank for form were Haitian and were nearly prostrate. The Haitian progeny exhibiting the most erect form were H38 and H03. While the progeny of H38 was ranked sixth in height, it had only 2% lower height than the progeny with the second highest growth rate. H38 seeds were collected from a tree approaching 75 cm diameter at breast height near Thomazeau, while H03 seeds were taken from a small tree north of Passe Catabois.

At the 8 month evaluation, 11 of the 12 Peruvian progenies tested were the fastest growing in this field trial (Table 2). The Peruvian progenies also ranked in the top 20 for the least number of main stems (Table 1). At the 27 month evaluation, the eight tallest progenies were of Peruvian origin. However, Peruvian progenies 422, 423, and 436 were overtaken in height by Haitian progenies (Table 2). Only minor changes occurred between the 8 month and 27 month evaluations. Progenies H44 and H24 were the two tallest Haitian progenies at the 8 month evaluation and were first and third among the Haitian progenies at the 27 month evaluation. Progenies H30 and H02 made dramatic increases in ranking to be the second and fourth highest ranking Haitian progenies.

Some of the Haitian seed sources were collected from large trees (over 50 cm DBH and over 10 m tall) with the expectation that seedlings would possess superior growth traits. However, the three tallest Haitian open-pollinated progenies in the trial came from parent trees less than 4 m tall.

The tallest Haitian progenies at the 27 month evaluation H24, came from a 2 m tall tree growing in a roadside ditch. This parent tree, however, was an abundant pod producer. The second tallest progeny H30 came from a small tree near Montrose and the third tallest progeny H44, was collected south of Anse Rouge, from a tree less than 4 m in height. This underscores the wide genetic variability of *Prosopis* and the role of the environment in shaping phenotypic characteristics. There do not appear to be geographical trends in the ranking of height growth among the Haitian sources.

The tallest individual tree at the 8 month evaluation (180 cm) and the 27 month evaluation (335 cm) originated from the Piura region of Peru (Table 2). Mean height across all blocks for this accession was 79.3 cm and was 86% greater than the overall mean height (42.6 cm) of Haitian accessions. Overall, Peruvian open-pollinated progenies had a mean height of 66.6 ± 10.9 cm in contrast to Haitian open-pollinated progenies which had a mean height of 42.6 cm (Table 3). South American progenies including *P. alba/flexuosa* (1117) from the Chilean salt deserts, *P. flexuosa* (1012) from the Argentine salt deserts, *P. alba* var. *panta* (1134) from Argentina, as well as *P. alba* (0166) from southern California and *P. velutina* (450) from the UC Riverside field trials had mean heights of 48–51 cm.

Prosopis nigra (1135) grows slowly in Argentina, and was the shortest of all the *Prosopis* progenies in the Haiti trial. The California native mesquite, *P. glandulosa* var. *torreyana* (475) suffered considerable mortality from stem fungal diseases when grown in Texas near the Gulf of Mexico. We have attributed this to the summertime humidities of 70–90% near the coast vs. 15–35% in its native habitat in the Mojave desert. This susceptibility to fungal disease may be the cause of its slower growth in the Haiti trial.

Although thornless *P. alba* progenies have produced the greatest height and biomass when grown in the USA (Felker et al., 1983a,b) goat herbivory in

TABLE 2

Ninety-five percent confidence intervals for mean height growth (cm), and dry weight (kg) at 8 months and 27 months after planting, listed in descending order of 27 month height growth

Accession No. (location)		Height (cm)				Dry weight (kg)
		8 Months		27 Months		27 Months
		Mean ± CI	Max.	Mean ± CI	Max.	Mean ± CI
552	(Peru)	79 ± 14	180	235 ± 32	300	3.3 ± 1.3
545	(Peru)	75 ± 9	110	234 ± 42	335	3.8 ± 1.7
420	(Peru)	79 ± 14	144	224 ± 27	285	2.2 ± 0.8
537	(Peru)	61 ± 6	75	223 ± 41	300	2.3 ± 0.7
559	(Peru)	78 ± 6	108	221 ± 22	280	2.7 ± 0.9
538	(Peru)	57 ± 8	71	211 ± 23	250	2.2 ± 0.6
544	(Peru)	74 ± 18	145	210 ± 55	300	3.2 ± 1.3
419	(Peru)	75 ± 11	123	208 ± 125	300	2.9 ± 3.0
H24	(Haiti)	51 ± 7	95	188 ± 56	280	1.5 ± 0.9
1117	(Chile)	51 ± 8	80	168 ± 12	250	1.9 ± 0.8
H30	(Haiti)	41 ± 6	70	167 ± 38	250	2.2 ± 1.1
H44	(Haiti)	55 ± 4	71	167 ± 38	220	2.3 ± 1.4
H02	(Haiti)	41 ± 8	65	166 ± 25	205	3.2 ± 1.2
422	(Peru)	58 ± 8	91	165 ± 32	205	1.9 ± 0.9
B2V50	(CA)	45 ± 10	60	164 ± 134	275	2.4 ± 2.3
H39	(Haiti)	44 ± 4	55	162 ± 49	220	2.3 ± 1.0
H38	(Haiti)	39 ± 4	49	161 ± 87	280	2.2 ± 1.6
H18	(Haiti)	42 ± 7	75	158 ± 34	230	2.2 ± 0.9
H23	(Haiti)	43 ± 7	87	157 ± 41	240	2.2 ± 0.7
H40	(Haiti)	43 ± 5	63	155 ± 29	210	2.5 ± 1.2
H34	(Haiti)	40 ± 5	65	155 ± 48	240	1.6 ± 1.1
H55	(Haiti)	46 ± 7	71	154 ± 27	215	2.5 ± 1.8
436	(Peru)	57 ± 16	105	154 ± 25	225	1.2 ± 1.4
H54	(Haiti)	38 ± 4	54	153 ± 58	220	2.2 ± 1.8
423	(Peru)	57 ± 9	87	151 ± 46	220	1.9 ± 1.5
425	(Peru)	49 ± 15	66	151 ± 43	195	0.7 ± 0.4
H36	(Haiti)	42 ± 5	61	151 ± 13	190	2.4 ± 0.5
H09	(Haiti)	47 ± 7	72	151 ± 25	205	2.2 ± 1.5
450	(CA)	50 ± 6	72	150 ± 24	220	1.4 ± 0.8
H01	(Haiti)	47 ± 12	107	149 ± 26	220	2.3 ± 1.3
H32	(Haiti)	44 ± 5	65	149 ± 31	220	2.2 ± 1.0
H45	(Haiti)	42 ± 9	100	148 ± 20	205	1.9 ± 1.4
H31	(Haiti)	41 ± 8	75	146 ± 37	200	2.4 ± 1.1
H14	(Haiti)	40 ± 5	61	146 ± 39	240	1.2 ± 0.6
H10	(Haiti)	40 ± 9	91	146 ± 20	240	2.1 ± 0.8
457	(CA)	43 ± 6	71	145 ± 44	215	1.5 ± 1.0
H49	(Haiti)	47 ± 6	65	144 ± 39	195	2.3 ± 1.5
H19	(Haiti)	42 ± 12	125	142 ± 43	205	3.3 ± 2.5
H03	(Haiti)	39 ± 9	87	142 ± 46	215	2.0 ± 1.1
H41	(Haiti)	40 ± 6	84	142 ± 23	200	2.0 ± 0.9
H28	(Haiti)	44 ± 6	70	141 ± 32	185	1.7 ± 0.3
H25	(Haiti)	45 ± 6	70	141 ± 38	235	2.6 ± 1.1

TABLE 2 (continued)

Accession No. (location)		Height (cm)				Dry weight (kg)
		8 Months		27 Months		27 Months
		Mean ± CI	Max.	Mean ± CI	Max.	Mean ± CI
H50	(Haiti)	13 ± 6	63	139 ± 40	190	3.4 ± 3.3
H26	(Haiti)	48 ± 5	74	139 ± 26	220	2.7 ± 1.2
H08	(Haiti)	41 ± 7	75	135 ± 20	200	2.3 ± 0.5
H21	(Haiti)	37 ± 5	60	133 ± 54	200	2.3 ± 1.5
H22	(Haiti)	42 ± 7	65	133 ± 42	210	1.8 ± 0.9
H43	(Haiti)	45 ± 4	74	132 ± 29	180	1.8 ± 0.3
1111	(TX)	43 ± 8	80	129 ± 34	190	1.8 ± 0.9
1134	(Arg.)	48 ± 6	60	128 ± 10	210	1.8 ± 0.5
H15	(Haiti)	43 ± 7	80	126 ± 18	180	2.2 ± 1.7
H35	(Haiti)	40 ± 5	65	125 ± 60	220	1.3 ± 0.8
H16	(Haiti)	43 ± 6	70	124 ± 24	180	1.5 ± 0.4
H11	(Haiti)	41 ± 7	76	119 ± 44	180	2.2 ± 1.2
H13	(Haiti)	39 ± 6	70	119 ± 38	200	2.0 ± 1.3
H12	(Haiti)	45 ± 6	68	118 ± 38	180	2.1 ± 1.3
H04	(Haiti)	45 ± 8	80	116 ± 41	170	1.7 ± 0.9
H37	(Haiti)	47 ± 6	78	115 ± 16	165	1.2 ± 0.6
H07	(Haiti)	36 ± 6	72	112 ± 55	200	1.4 ± 1.0
H20	(Haiti)	39 ± 5	59	110 ± 34	220	1.2 ± 0.7
H05	(Haiti)	39 ± 6	70	108 ± 40	210	1.7 ± 0.5
591	(CA)	38 ± 9	56	107 ± 79	220	1.2 ± 1.4
475	(CA)	35 ± 11	60	106 ± 29	170	1.0 ± 0.6
901	(CA)	41 ± 3	52	102 ± 20	180	0.9 ± 0.4
H06	(Haiti)	38 ± 7	64	93 ± 48	165	1.3 ± 1.5
166	(CA)	48 ± 7	51	93 ± 50	170	0.9 ± 1.0
1012	(Arg.)	49 ± 8	60	91 ± 59	150	0.4 ± 0.5
1135	(Arg.)	31 ± 6	50	80 ± 18	115	0.4 ± 0.1
999	(TX)	39 ± 5	52	79 ± 52	130	0.1 ± 0.1
1015	(Chile)	31 -	31	- -	-	- -

these Haitian trials reduced their biomass. The thornless *L. pulverulenta* (999) was similarly affected. In contrast, thorny Haitian and Peruvian *Prosopis* suffered negligible browse.

Surprisingly, some of the Peruvian trees in open-pollinated progenies 420 and 419 were found to be thornless but not browsed. We had assumed that the primary deterrent to browse was the presence of thorns. Evidently there is some 'palatibility factor' in these thornless progeny that prevents browse. This is the first time that rapid growing, erect, thornless and non-browsed *Prosopis* have been observed.

The study appeared to contain two types of Peruvian *Prosopis*. In general progenies 538 to 559 had anthocyanin pigmentation in stem tissue, greater secondary branching angles and all trees in these progenies were thorny. Progenies 419 to 436 had no anthocyanin pigmentation and narrow (more

TABLE 3

Height, form and number of branches for two Peruvian populations and the Haitian population at 8 months after transplanting

Origin	N	Height (cm)	Number of branches	Form
		Mean ± SD	Mean ± SD	Mean ± SD
Piura	24	71.4 ± 16.5	1.68 ± 0.69	1.17 ± 0.27
Haiti	176	42.6 ± 7.8	2.24 ± 0.80	1.82 ± 0.40
Trujillo	23	64.3 ± 16.5	1.13 ± 0.17	1.04 ± 0.11

Each N is a mean of five trees in that replicate. As judged by a 't-test' the Peruvian populations were significantly different from each other and the Haitian population ($P=0.05$) for height and number of branches. For form the Peruvian populations were not significantly different from each other but they were different from the Haitian population.

erect) secondary branch angles and some trees in these progenies lacked thorns. Progenies 419 to 436 were collected in the Trujillo and Contumaza areas of Peru, while progenies 538 to 559 originated from the Piura region; approximately 3° further north.

't-tests' conducted pairwise between the two apparent Peruvian provenances (progenies 538 to 559 vs. progenies 419 to 436) and the Haitian progenies found that the three provenances were significantly different ($P=0.05$) for height and number of main branches (Table 3). The differences in form between the two Peruvian provenances were not significant, but the forms of both Peruvian provenances were significantly different from the Haitian group. This is the first report for *Prosopis* where the term provenance is valid, i.e. the variation among progeny within provenances is less than the variation between provenances.

Until future measurements reveal more about the Haitian progeny, i.e. pod production characteristics or future growth rates, the best overall Haitian performer is H44, collected south of Anse Rouge. This progeny had a 100% survival rate and was the tallest of all the Haitian material. It was also ranked fifth highest for mean number of main stems (1.69) and seventh in stem form (1.54) out of all Haitian progeny. Other Haitian *Prosopis* nearing H44 in performance include H06, H11, and H50 originating from Passe Catabois, Bassin Bleu, and Molle St. Nicholas, respectively. Open-pollinated progeny H50 and H06 exhibited the best form and fewest number of branches, but were ranked 40 and 63, respectively, for height growth.

DISCUSSION

Tropical *Prosopis* species have become naturalized through many semi-arid regions of the world such as Brazil, Senegal, Sudan, Pakistan, and India where they have been widely used by poor people for fuelwood and animal fodder.

While only anecdotal records describe the introduction of these species to new areas (Anonymous, 1884; Mohan, 1940), the lack of cold tolerance in this group (Felker et al., 1981) and their leaf and pod morphology strongly suggest a central American origin. Burkart (1976) describes the original distribution of *P. juliflora* as being "northern South America (Venezuela and Colombia), Panama, Central America to Mexico and the Antillean Islands". Burkart describes subspecies of *P. juliflora* as being indigenous to Ecuador and Peru.

Taxonomy of the tropical *P. juliflora/P. pallida* complex, has been widely regarded to be most difficult. We have found it particularly difficult to distinguish *P. pallida* from *P. juliflora* in Hawaii, Haiti, Pakistan, Senegal, Brazil and India. We are uncertain as to how these Haitian and Peruvian *Prosopis* relate to naturalized *Prosopis* in other parts of the world.

The tropical *Prosopis* of Peru are known for long sweet pods that have been used to make a syrup-like product for human consumption known as 'algarrobina' (National Academy of Sciences, 1979). In 1942 seeds from the Peruvian *Prosopis* were imported into Brazil for cultivation for the dry northeastern region (Reis, 1982). The longest pods we have ever observed (about 50 cm) were from the Brazilian *Prosopis*. Notes on the collection records state that the pods from Piura accessions (538–559) were used for the manufacture of a molasses type product for human consumption called Algarrobina. Very good height growth coupled with excellent pod production characteristics make these accessions a very promising subject for further study.

Of all the open-pollinated progeny tested, the 400 and 500 series from Peru had the most promising height growth, fewest main stems, and growth form. These trees have also proven to be unpalatable to hungry goats that are an everyday danger to plant life in Haiti and most other semi-arid regions of the world. It remains to be seen whether the Piura trees will produce pods of similar abundance, size, and quality as they do in their native Peru. The 70 different open-pollinated progenies in this trial will provide abundant opportunities for outcrossing to produce individuals with intermediate phenotypic characters. A mist propagation system has been established to asexually propagate eight elite trees selected for cloning. These rooted cuttings could be used to establish seed orchards for Haitian local reforestation programs.

While these results are preliminary, this first progeny trial of a wide range of tropical, open-pollinated *Prosopis* families indicates substantially significant differences in height growth, form and branching. Through this communication we wish to alert others to these possibilities, in the hope that extensive, well-documented collections of the Peruvian *Prosopis* will be made. We have since observed similar *Prosopis* of Peruvian origin in field trials (350 mm annual rainfall) at the Central Arid Zone Research Institute in Jodhpur, India that were provided by the Centre Technique du Forestier Tropicale. In the Indian trials, the Peruvian *Prosopis* was one of the very few entries in a species trial that survived. We hope this Peruvian germplasm will be multiplied and distributed to the tropical regions of the world, i.e. Senegal, Sudan, and India where the introduced *Prosopis* is doing well but has a narrow germplasm base.

ACKNOWLEDGMENTS

The financial assistance of the U.S. Agency for International Development Grant No. DAN-5542-G-SS-2099-03 obtained through courtesy of Michael D. Benge is gratefully acknowledged. This study would not have been possible without excellent local cooperation from Reverend Wally Turnbull, Baptist Haiti Mission, Joel Timyan, International Resources Group, Peter Welle, CARE, and Steven Gronski, Operation Double Harvest.

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