Performance of *Prosopis* Species in Arid Regions of India

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Introduction

In dry tropical regions of India, woody species have key roles in environmental protection vis-a-vis rural economy. From time immemorial they have been a main energy source in addition to providing food and medicine (Hoking 1993). Despite all developmental efforts, the dependence on woody vegetation is not likely to shift for many years to come, especially for fuelwood and fodder.

To satisfy the need for fuel, fodder, and timber, the local vegetational resources have been exploited ruthlessly in the last four decades. This is primarily because of the tremendous increase in human and livestock populations during this period. Inhospitable climatic conditions do not support much required natural regeneration and subsequent growth of the vegetation. Consequently, vegetation in the area has become sparse and consists of scattered trees, shrubs and grasses (Tewari et al., 1993). The prominent tree species of the region are *Prosopis cineraria*, *Tecomella undulata*, *Capparis decidua*, *Calligonum polygonoides*, *Acacia jaquemontii*, *A . senegal*, etc. (Satyanarayan, 1963)

In view of the availability of limited number of very slow growing woody species and the high requirement of fuel, fodder, and timber, especially in arid tracts of India, we decided to introduce fast-growing exotics from other isoclimatic regions of the world. *Prosopis juliflora* is one of the species which was introduced in India in 1877 (Muthana and Arora, 1983). Owing to its tremendous capacity of seed production and excellent coppicing ability, this species has spread to almost all parts of arid and semiarid tracts of India and, in fact, it has now become naturalised. This species often provides as much as 80% to 90% of the fuel needs of population of arid and semiarid parts of the country (Saxena and Ventakeshwarlu, 1991). *Prosopis* pods have also been processed for use as cattle feed and the gum of the plant has been used in industry (Sharma, 1995). In recent years, due to recurrent droughts in vast stretches of arid and semiarid region, *Prosopis* is gradually becoming an important alternative to annual crops in marginal areas.

Status of *P. juliflora* in Arid Tracts

P. juliflora was introduced in Indian arid tracts about 1877 owing to its fast-growth features and drought hardiness (Muthana and Arora, 1983). Mass-scale aerial seeding of this species was done by the ruler of the erstwhile Marwar state during the 1930s. In 1940, the species was declared a "Royal Tree" and instruction was given to all the officials to plant and protect this tree species (Muthana and Arora, 1983). Due to its rapid colonizing and fast growth, the species has spread over large areas of arid and semiarid tracts.

The ecological amplitude this species is very high. It has been grown in highly saline areas, such as Rann of Kutch in Gujarat State, as well as the sand dunes of the Thar Desert (Saxena and Venkateshwarlu, 1991). In Rann of Kutch, it is the only tree species which has grown naturally and that has been exploited for gum, fuelwood, and fodder (pods). It has been estimated that in the Kutch district more than 200,000 ha are covered with *P. juliflora* (Varshney, 1993). At the moment, *P. juliflora* is the main source of fuelwood in larger parts of arid and semiarid regions of the country (Saxena and Venkateswarlu, 1991).

The Present Study

In view of the wide ecological amplitude and multiple uses of *P. juliflora* , recently, a number of other *Prosopis* species have been introduced into the arid tract of India.

The objective of the introduction was to study the production potential of *Prosopis* , especially in terms of pods and biomass. In 1991, more than 200 accessions of five *Prosopis* species, mainly of Latin American origin were introduced at Central Arid Zone Research Institute at Jodhpur. These *Prosopis* accessions were examined for their adaptability and growth potential in the environmental conditions of the Indian arid tract.

Setting of Trial Region

The Indian arid region, lying between 24° and 29° N latitude and 70° and 76° E longitude, covers an area of 317,909 sq. km and is spread over seven states viz., Rajasthan, Gujarat, Punjab, Haryana, Maharashtra, Karnataka, and Andhra Pradesh. Of these seven states, Rajasthan alone accounts for 61% of the Indian arid tract. The arid tract of western Rajasthan is better known as the Thar Desert, and is located between the Aravalli ranges on east and the Sulaiman Kirthar range on the west (Rode, 1964).

The climate of the regions is characterized by extremes of temperatures ranging from below freezing in winter (mid-December to February) to as high as 48°C in summer (April to June). Rainfall is precarious and erratic, ranging from 150 mm in extreme west (Jaisalmer area) to 375 mm in eastern part (Jodhpur and parts of Pali district). The mean monthly wind speed ranges from 7.3 km/hr (December) to 20 km/hr (May). However, in the summer, the wind often suddenly increases to 100 km/hr, resulting in severe dust storms (Pramanik and Harisharn, 1952).

The soils in the region are generally sandy to sandy loam in texture. The consistency and depth vary according to topographic features of the area. In general, they are poor in organic matter (0.04-0.02%) and low to medium in phosphorus content (0.05 to 0.10%). The nitrogen content is mostly low, ranging between 0.02% and 0.07%. The infiltration rate is very high (7 to 15 cm/hr) (Kaul, 1965; Gupta, 1968).

Materials and Methods

The experimental site was located in silvatum of CAZRI, Jodhpur. The seeds of more than 200 single tree selections of five *Prosopis* species, mainly of Latin American origin, were procured from Texas A&M University-Kingsville, USA. The *Prosopis alba, P. chilensis, P. flexuosa,* and *P. nigra* accessions were collected by E. Marmillion of Cordoba, Argentina. The Peruvian *Prosopis* were collected by A. Sagastegui of the Universidad Nacional de Trujillo, Peru. They were selected on the basis of earlier performance. The seeds were sown in 10" x 4" polyethylene bags perforated at the base in February 1991. Of these, more than 200 accessions seedlings of only 106 accessions were obtained in numbers to conduct a replicated field trial. These 106 accessions of five *Prosopis* species were out-planted in the field during July 1991. These included: *P. nigra* (12), *P. flexuosa* (23), *P. alba* (30), *P. chilensis* (19) and *Prosopis* spp.-Peruvian (22). One accession of local *P. juliflora* was taken as a control.

To establish the experiment on the field, a block design with four replicates was employed. Each replicate consisted of a row of five trees with a spacing of 4.0 x 2.5 m. Seedlings were planted in pits of 45 x 45 x 45 cm size. After planting, each seedling was irrigated with 10 liters of water at monthly intervals during first year of establishment. Percentage survival, height increment, and collar diameter was recorded at the beginning of winter season, i.e., at the end of growing season each year up to 1994 (in the month of December). The diameter at 30 cm above the ground of the single largest stem

was taken to be the collar diameter. For computation of biomass from multistemmed trees, all stems originating below 30 cm in height were measured. The biomass of individual stems was estimated from basal diameter measurements using the regression equation described below. The biomass of all these stems were summed to obtain biomass per tree.. The biomass was estimated in the third year using the prediction equation (Felker et al.,1989):

$$\log_{10} \text{Dry Weight (kg)} = 2.1905\,[\log_{10} \text{stem diameter (cm)}] - 0.9811$$

after verifying it by selective destructive sampling. Biomass data were also subjected to Duncan's multiple-range analysis following the procedure as given in Gomez and Gomez (1983). Pod production during the study period was also measured. The pods were subjected to nutritive-value analysis (carbohydrate determinations where conducted according to Yemn and Willis (1954) and protein content was measured by the Kjeldahl technique). Vegetative propagation studies on some of these introduced species were also conducted.

Results and Discussion

Field out-planting and survival

Nursery-raised seedlings of 106 accessions of procured exotic *Prosopis* species and one accession of local *P . juliflora* (total 107) were out-planted in the field after the first effective monsoon rain, i.e., in July 1991. Species survival after five months was maximum (95%) in case of *P. nigra*, followed by *P. juliflora* (91%). The species varied from 87% to 88% survival.

The percentage survival was again recorded in March 1992 (8 months after initial out-planting).The survival among the species ranged from 74% to 90%, maximum being for *P. nigra* and minimum for *P. flexuosa*.

Within the species, great variation in survival percentage was noticed for different accessions. Accessions 158, 161, and 219 of *P. nigra*, and accession 144 of *P. alba* had 100% survival. The greatest survival in the other species were 94% for accessions 51 and 195 of *P. flexuosa*, and 94% for accession 30 of *P. chilensis*. Accession 421 of the Peruvian species had maximum survival for this group. Early results indicated that although all the introduced species/accessions were fairly adaptable to environmental conditions of the Indian arid tract, *P. nigra* had better survival than the other species.

General growth performance of different Prosopis species

A wide range of variability for plant height and collar diameter was found among species and in different accessions of same species. Only few accessions within species have shown consistently better performance across all four years.

Among species, the best performance for plant was noticed for *Prosopis* spp.-Peruvian(276 cm/plant) followed by *P . alba* (251 cm/plant) and *P. chilensis* (238 cm/plant) (Table.1). In contrast, for growth in collar diameter, *P. alba* (4.13 cm/plant) was found best, followed by *Prosopis* spp.-Peruvian (3.80 cm/plant) and *P. chilensis* (3.55 cm/plant).The mean annual increment (MAI) for collar diameter was maximum in *P . alba* (1.09 cm/tree) followed *Prosopis* spp. - Peruvian and *P. chilensis*. *P. nigra* had the lowest MAI among all the species.

In general, the coefficient of variation for collar diameter was greater than for plant height in all the *Prosopis* species under study. It was also observed that within accessions of same species, there was a great deal of variation in height and collar diameter. The variability for any character is determined to a great extent by the natural and human selection sieves through which population had passed during its phylogenetic history (Swaminathan, 1969).

The *P. nigra* , accessions were not significantly different from each other for plant height for all four years. In contrast, they were significantly different for collar diameter in first two years. Different accessions showed variable growth pattern and accession 219 from San Javier, north of Cordoba, exhibited comparatively better performance(over means i.e., means of all the accessions)across all the four years for both plant height and collar diameter (Table 2). The maximum plant height was recorded in accession 222 from Guemes in Salta Province, accession 119 from Villa Angela in Chaco Province 179 and 219 (each having 218 cm/plant), while maximum collar diameter was found in accession 179 (3.63 cm/plant). While accession 219 had a smaller collar diameter than 179, it had nearly twice the biomass of 179.

The collar diameter was measured from the single largest stem at 30 cm height while the biomass was computed by summing all the stems below 30 cm in height. Because accession 179 had more and larger stems, it had the greatest biomass. The parent trees for these accessions were located at the points of a triangle, each more than 500 km distant from the other. Thus, there was no apparent good geographical source for *P. nigra*.

The *P. flexuosa,* accessions were significantly different for plant height in the second and third year. Collar diameter was not significantly different among the accessions for any of the years. Accessions 51 (La Puntilla, Catamarca), 64 (Anilaco, Catamarca), 181 (Catamarca)and 197 (from Valle Calcha in Salta Province) have shown consistently better performance across all four years (Table 3). Plant height and collar diameter maximum in accession 64 (plant height 329 cm/plant; collar diameter 4.87 cm/plant) followed by accession 52 (plant height 322 cm/plant; collar diameter 4.80 cm/plant).

The *P. chilensis* , accessions were significantly different for plant height in years 1, 3, and 4 (Table 4). For collar diameter, they were significantly different only in the fourth year. *P. chilensis* accessions 30, 85, 100, 105, 108 and 118 had consistently better performance for all four years (Table 4). The maximum plant height (305 cm/plant) was recorded in accession 108, followed by accession 105 (297 cm/plant). The maximum collar diameter was in accession 30 (5.03 cm/plant),followed by accession 105 (4.86 cm/plant). Accessions 108, 105, and 30 were from Catamarca Province.

In *P. alba* , the accessions were significantly different for plant height in all four years (Table 5). However, for diameter they did not show any significant differences. Accessions 28, 65, 78, 120, 147, and 151 performed consistently better for all four years (Table 5). Plant height was maximum in accession 67 (386 cm/plant), followed by accession 73 (339 cm/plant), both from La Rioja Province, while collar diameter was maximum in accession 78 (5.55 cm/plant), a special tree whose seed was supplied by Ula Karlin, closely followed by accession 73 (5.31 cm/plant).

In *Prosopis* spp. - Peruvian, the accessions were significantly different in the first two years for both plant height and collar diameter. Accessions 418, 420, and 424 had consistently good growth rates across all four years (Table 6). Plant height was maximum in accession 442 (387 cm/plant), followed by accession 424 (373 cm/plant). The collar diameter was maximum in accession 424 (6.05 cm/plant), followed by accession 442 (5.35 cm/plant). Accessions 418 and 420 were collected in the Procedencia El Nino and Procedencia Porota of Departmento La Libertad of the province of Trujillo. Accession 424 was collected in Procedencia Algorrobal (Distro San Benito) Departmento Cajamarca of Province Contumaza. Accession 442 was collected in Procedencia Huancaco (Viru). Departmento La Libertad in Province of Trujillo.

It is significant that the Argentine trees with the greatest height and collar diameter originated from the most arid (western) provinces of La Rioja, Catamarca, and Salta.

Provenance trials conducted on native *P. cineraria* by Kackar (1988) in Indian arid tracts found similar trends in growth behaviour of provenances collected from different locations. Jindal et al. (1991) also

reported similar genetic variation in a progeny trial of Tecomella undulata , an important arid-zone timber species of India.

Fuelwood production

The fuel production from all 107 accessions of all the *Prosopis* spp. under study was estimated approximately at four year's age.

It is important to recognize that substantial differences in ranking of biomass and collar diameter are attributable to the fact that the collar diameter is the diameter of the single largest stem at 30 cm height, while the biomass is the sum of all the branches. Thus multistemmed trees had greater biomass than single-stemmed trees of the same collar diameter. The mean biomass production for the species (across the accessions) was greatest in *P. alba* (4.34 kg/individual) (Table 5) followed closely by *P. chilensis* (4.11 kg/individual) (Table 6). Minimum biomass occurred (1.90 kg/individual) in *P. nigra* . In the case of local *P. juliflora* (control species) the biomass accumulation during the study period was 1.47 kg/plant. Although *Prosopis* spp.-Peruvian, attained the maximum height during this period, its mean biomass production as a group ranked third, primarily due to straight-bole characteristic of the species. Only very few branches originated from the base or from the lower part of tree trunk of the Peruvian species accessions. The straight-bole characteristic of the Peruvian species may be of greater economic significance than use as fuel because it can be used in high-value timber applications.

The production of fuelwood within the different accession of same species was also assessed. The early results revealed considerable variation in fuelwood production among different accessions of the same species.

In *P. nigra*, accession 219 of this species gave maximum (3.01 kg/individual) average dry fuelwood per plant (Table 2). The minimum (0.99 kg/individual) fuelwood production was recorded in accession 42. The multiple-range analysis of fuelwood production data showed that accessions 168, 165, and 159 belonged to the same group, while accessions 158, 43, and 167 belonged in another distinctive group. In the rest of the accessions, no clear trends were observed, rather, they exhibited overlapping.

There was significant variation in dry fuelwood production among different accessions of *P. flexuosa*. The average wood production was maximum im accession 197 (3.67 kg/individual) and minimum in accession 183 (0.73 kg/individual) (Table 3). The multiple-range analysis of fuelwood production data of different accessions exhibited presence of three distinctive groups. Accessions 198, 183, 119, 194, 103, 133, 195, 111, 180, 196, 52, and 51 belonged to the same group. Similarly, accessions 186, 192, 112, and 117 belonged to another group. Further, accessions 106, 107, and 110 belonged to a third group showing similarity in fuelwood production. In the remaining accessions, viz., 181, 64, and 197, no clear trend was discernible.

Of the 19 accessions of *P. chilensis*, accession 257 gave average maximum (7.81 kg/individual) fuelwood production, followed closely by accession 30 (7.63 kg/individual) (Table 4). The minimum average fuelwood (1.34 kg/individual)was recorded in the accession 226. The fuelwood production in different accessions varied significantly. The multiple-range analysis of the data revealed the presence of two distinctive groups as far as fuelwood production is concerned. Accessions 100, 228, 108, 29, and 118 belonged to one group, while accessions 95, 99, and 241 belonged to another group. In the remaining accessions, the patterns were not as distinct.

Of the 30 total accessions of *P. alba* introduced, the maximum fuelwood production (7.84 kg/individual) was recorded in accession 146 and minimum (1.84 kg/individual) in accession 74 (Table 5). Statistically, the variation in values was quite significant. On the basis of multiple-range analysis, three distinct groups were identified. Accessions 74, 153, and 152 belonged to the first group, showing similar range biomass production in terms of fuelwood yield. Similarly, accessions 149, 233, 67, 135, 120, and 144 belonged to the second group. In accessions 128, 66, 28, 147, 126, 71, 151, 65, and 72, the values exhibited more or less similar trends, but these accessions also exhibited overlapping of values and, thus, it roughly forms a fourth distinctive homogeneous group. In the remaining accessions, trends were not clear.

In the different accessions of *Prosopis* spp.-Peruvian, the fuelwood yield ranged between 8.77 kg/individual (accession 424) to 1.17 kg/individual (accession 432) (Table 6). On the basis of multiple-range analysis, three groups can be identified. While accessions 420, 431, 440, and 439 belonged to the first homogeneous group, accessions 442, 435, and 438 formed the second homogeneous group. Accessions 430, 446, 428, 434, 441, and 443 also form more or less one homogeneous group, but the trend was not as distinctive as in the case of earlier two groups.

Pod production and their nutritive value

Pod production of the introduced species/accessions was initiated in the fourth year after initial field transplantation. In *Prosopis* spp.-Peruvian, 6 of 22 accessions exhibited flowering and produced pods. Only one accession of each *P. chilensis* (105), *P. flexuosa* (69), *P. alba* (70), and *P. nigra* (158) produced pods. The maximum quantity of pods occurred in accession 423 of *Prosopis* spp.-Peruvian (2.059 kg/plant). The minimum was produced by *P. chilensis* (7.8 g/plant).

The maximum carbohydrate content (40%) was found in the pulp of *P. nigra*, followed by *P. alba* (38%), and *P. chilensis* (37.5%). While the average carbohydrate content of *Prosopis* spp.-Peruvian was 30%, its variability between accessions was very high, ranging from 18% to 37%. The crude protein content in *Prosopis* spp.-Peruvian was also quite variable, ranging from 5.11% to 11.55%, with an overall average of 8.44%. The protein content of *P. alba*, *P. chilensis*, and *P. nigra* pods was 8.8%, 4.48%, and 5.99%, respectively. Further investigations in this regard are in progress.

Vegetative propagation

Raising seed orchards through seeds leads to heterogeneity in the population due to out crossing in the species. In order to propagate good germ plasm both for thornlessness and high nutritive value, the cleft grafting technique was followed (Wojtusik et al., 1993).

Nonthorny grafts from superior *Prosopis* spp.-Peruvian were grafted on the local thorny *P. juliflora*, both on one-year-old field-transplanted saplings and five-month-old nursery seedings. About 70% success was obtained on both field-outplanted saplings, as well as in nursery seedlings. The nursery-raised grafted seedlings were supplied to different institutions in India to evaluate their performance in different agroecological zones. Moreover, *P. chilensis, P. alba*, and *P. nigra* have also been grafted successfully on local *P. juliflora*. The success rate with these species of these species was about 50%. In addition to grafting, all five exotic *Prosopis* species have also been propagated using stem cuttings in the mist chamber.

Conclusions

The species of genus *Prosopis* have the capacity for thriving on poor fertility soils and in hot dry climates (Vasquez et al., 1985). Currently, between 36% and 43% of the earth's area is rated as desertic. According to modern historians, the origin of civilization in the Nile, Indus, and Tigris-Euphrates valleys could be linked to the increasing aridity of the surrounding areas, which forced the population of steppes and savannas to move to these valleys where they had to irrigate and cultivate the land (Habit, 1985). Now, vast areas of the world are threatened by desertification. According to conservative estimates, arid zones and their advance affect approximately 384 million people directly or indirectly. This population accounts for 12% of the world's total population, most of which belongs to the Third World (Duhart, 1985).

In India, more than 0.3 million square kilometers are categorised as hot arid and the western part of Rajasthan state, commonly known as the Thar Desert, accounts for 61% of the total arid zone of the country. Beside the native *Prosopis* species, *P. cineraria*, vast stretches of tropical arid and semiarid parts of the country have been covered by *P. juliflora*.

The present study has shown that all the introduced *Prosopis* species are highly adaptable to environmental conditions of the Indian arid tract. The study of Sharma (1995) further substantiated this fact that, although all the newly introduced *Prosopis* species in 1991 have performed well, but among them, *Prosopis* spp.-Peruvian has performed much better. Lee et al., (1992) also reported the excellent performance of this species from Haiti. Harris et al. (This volume) have also found the Peruvian *Prosopis* to have superior biomass and survival. Thus, the Peruvian genetic stock is near the top in evaluations in three distinctly different environments: Haiti, Cape Verde, and the interior deserts of India.

Early results of the present study indicated that the introduced species of multipurpose utility of genus *Prosopis* (mainly of Latin American origin) has tremendous capacity for biomass and pod production in inhospitable soil and climatic conditions of the Indian arid tract. All these features make them highly suitable candidates for plantation and agroforestry activities in arid and semiarid tracts of the country.

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Table 1. Average Performance of *Prosopis* Species in Different Years

Species	Plant Height (cm)				Collar Diameter (cm)			
	1991	1992	1993	1994	1991	1992	1993	1994
P. nigra	39	79	134	188	0.60	1.17	1.79	2.45
P. chilensis	53	100	183	238	0.92	1.79	2.86	3.55
P. flexuosa	58	100	169	229	0.69	1.23	2.22	3.20
P. alba	47	90	189	251	0.92	1.78	3.14	4.13
Prosopis spp.-Peruvian	89	159	210	276	0.88	2.16	3.02	3.80
P. juliflora (check)	40	50	167	204	0.40	0.88	2.82	3.34

Table 2. Mean Values of Plant Height and Collar Diameter of 12 Accessions of *P. nigra* at Four Growth Stages

US No.	Accession No.	Plant Height (cm)				Collar Diameter (cm)				Biomass (kg)
		1-year	2-year	3-year	4-year	1-year	2-year	3-year	4-year	
42	EC 308027	32	60	99	142	0.61	0.94	1.62	2.14	0.99
43	EC 308028	45	90	121	182	0.71	1.27	1.26	1.58	1.85
44	EC 308029	39	73	147	196	0.56	0.84	1.51	2.34	1.03
158	EC 308034	38	76	114	173	0.47	0.92	1.45	2.25	1.65
159	EC 308035	48	86	126	175	0.71	1.64	1.56	2.19	1.19
161	EC 308037	32	86	152	187	0.63	1.17	2.26	2.67	2.47
165	EC 308041	45	79	98	153	0.53	0.86	0.96	1.66	1.30
167	EC 308043	34	79	140	213	0.58	1.20	2.02	2.39	1.91
168	EC 308044	32	75	109	176	0.53	0.91	1.54	1.99	1.67
179	EC 308045	39	73	171	218	0.60	1.21	2.66	3.63	1.98
219	EC 308046	43	90	164	218	0.67	1.95	2.33	3.08	3.01
222	EC 308047	38	83	166	218	0.55	1.14	2.33	3.45	2.55
	Mean	39	79	134	188	0.60	1.17	1.79	2.45	1.90
	±SE	6.88	9.41	25.94	34.21	0.11	0.22	0.45	0.67	0.63
	Range	32-48	60-90	98-171	142-228	0.47-0.71	0.91-1.95	0.96-2.66	1.58-3.63	0.99-4.16
	CV %	25.1	16.8	27.4	25.7	26.2	26.9	35.2	3.86	46.88
	CD 5%	-	-	-	-	0.45	0.92	-	-	1.28
	CD 1%	-	-	-	-	0.61	-	-	-	1.73

Table 3. Mean values of plant height and collar diameter of 23 accessions of *P. flexuosa* at Four Growth Stages

US No.	Accession No.	Plant Height (cm)				Collar Diameter (cm)				Biomass (kg)
		1-year	2-year	3-year	4-year	1-year	2-year	3-year	4-year	
51	EC 308063	60	108	224	309	0.73	1.28	3.01	3.93	2.99
52	EC 308064	53	85	259	322	0.66	1.21	3.28	4.80	1.27
53	EC 308065	66	94	148	183	0.71	1.27	1.24	1.84	1.58
64	EC 308066	69	131	244	329	0.77	1.81	3.74	4.87	3.03
103	EC 308067	58	93	177	223	0.67	1.45	1.98	2.38	1.68
106	EC 308068	59	95	186	243	0.60	1.05	2.21	3.28	1.28
107	EC 308069	53	99	172	214	0.70	1.37	2.76	2.98	1.16
110	EC 308070	58	98	151	212	0.63	1.21	2.23	3.66	1.11
111	EC 308071	60	100	128	182	0.66	1.18	1.34	2.03	1.55
112	EC 308072	62	113	145	214	0.70	1.35	2.48	3.69	1.25
113	EC 308073	57	103	184	220	0.62	1.12	2.62	3.14	1.25
117	EC 308075	62	90	167	230	0.64	1.12	2.31	3.23	1.46
119	EC 308076	56	93	114	193	0.58	1.36	2.07	3.35	1.19
180	EC 308081	68	114	183	224	0.61	1.46	2.30	3.11	1.62
181	EC 308082	56	103	194	273	0.81	1.40	2.55	3.98	2.50
183	EC 308084	56	94	153	229	0.52	0.85	1.71	3.23	0.73
186	EC 308087	56	96	172	217	0.66	0.97	1.68	2.69	1.22
192	EC 308093	61	98	137	202	0.78	0.90	1.86	2.92	1.27
194	EC 308095	65	119	181	211	0.59	1.46	1.88	2.27	1.79
195	EC 308096	58	91	146	217	0.77	1.29	1.90	2.50	1.86
196	EC 308097	44	76	136	185	0.88	1.37	1.81	3.01	1.60
197	EC 308098	58	117	170	229	0.85	1.73	2.51	3.57	3.67
198	EC 308099	49	93	120	205	0.67	1.27	1.49	2.91	1.21
	Mean	58	100	169	229	0.69	1.23	2.22	3.2	1.66
	±SE	6.6	11.5	38.3	47.4	0.11	0.30	0.76	1.09	0.68
	Range	44-69	76-131	114-259	182-329	0.52-0.88	0.85-1.81	1.24-3.74	1.84-4.87	0.73-3.67
	CV %	16.0	16.3	32.0	29.3	23.1	32.5	48.32	48.30	58.16
	CD 5%	-	23.0	76.20	-	-	-	-	-	1.35

Table 4. Mean Values of Plant Height and Collar Diameter of 19 Accessions of *P. chilensis* at Four Growth Stages

US No.	Accession No.	Plant Height (cm)				Collar diameter (cm)				Biomass (kg)
		1-year	2-year	3-year	4-year	1-year	2-year	3-year	4-year	
29	EC 308160	53	92	161	184	0.86	1.87	2.63	2.36	3.84
30	EC 308161	43	110	214	269	1.01	2.32	3.76	5.03	7.63
85	EC 308170	49	102	240	282	0.96	1.89	3.66	4.25	6.35
86	EC 308171	46	99	210	216	0.75	1.84	3.22	3.83	4.70
91	EC 308174	49	81	158	201	0.90	1.25	1.94	2.15	2.48
95	EC 308177	59	93	215	294	0.81	1.43	3.39	3.87	3.58
99	EC 308180	42	94	168	220	0.91	1.65	2.81	3.12	3.08
100	EC 308181	53	102	202	271	1.03	2.14	3.38	4.85	3.28
105	EC 308184	61	129	243	297	0.89	1.86	3.63	4.86	6.62
108	EC 308185	54	106	220	305	0.96	1.92	3.30	4.09	3.75
118	EC 308187	64	112	183	245	1.02	2.05	2.85	3.64	3.59
139	EC 308188	53	89	163	206	0.82	1.38	1.81	2.74	2.61
140	EC 308189	53	96	127	204	1.08	1.78	2.22	3.33	2.88
226	EC 308196	42	67	96	179	0.95	1.50	1.85	2.22	1.34
228	EC 308197	44	90	196	207	0.87	1.67	2.91	2.85	3.13
235	EC 308199	50	90	198	275	0.78	1.71	3.30	4.07	5.48
237	EC 308200	51	77	136	203	0.81	1.40	1.80	2.70	2.03
241	EC 308204	51	95	185	217	0.96	1.80	3.12	2.79	3.98
257	EC 308206	89	166	172	254	1.10	2.63	2.80	3.72	7.81
	Mean	53	100	183	238	0.92	1.79	2.86	3.55	4.11
	±SE	8.73	22.64	32.36	36.52	0.14	0.45	0.78	1.00	1.34
	Range	42-89	67-166	96-243	179-305	0.75-1.10	1.25-2.63	1.80-3.76	2.15-5.03	1.34-7.81
	CV %	23.4	32.2	24.9	21.7	20.9	35.6	38.4	40.0	46.12
	CD 5%	17.5	-	64.7	73.0	-	-	-	2.0	2.68
	CD 1%	23.2	-	86.1	97.2	-	-	-	-	3.56

Table 5. Means of Plant Height and Collar Diameter of 30 Accessions of *P. alba* at Four Growth Stages

US No.	Accession No.	Plant Height (cm)				Collar Diameter (cm)				Biomass (kg)
		1-year	2-year	3-year	4-year	1-year	2-year	3-year	4-year	
28	EC 308109	42	104	215	305	0.95	2.11	3.94	4.99	5.76
57	EC 308112	43	88	186	253	0.88	2.02	3.80	4.30	5.59
65	EC 308119	60	102	225	291	1.06	1.76	4.19	5.09	7.05
66	EC 308120	52	98	192	220	1.06	1.81	2.33	3.04	4.21
67	EC 308121	47	87	259	386	0.79	1.31	3.78	5.22	2.39
68	EC 308122	56	78	169	239	0.88	1.41	3.32	3.84	4.62
70	EC 308123	49	93	185	243	1.01	1.90	2.90	3.81	4.04
71	EC 308124	59	92	181	227	0.95	1.78	2.87	4.02	5.23
72	EC 308125	50	98	173	237	0.90	2.48	3.41	3.76	6.75
73	EC 308126	43	88	249	337	0.63	1.39	3.76	5.31	3.80
74	EC 308127	49	72	126	178	1.13	1.90	1.99	2.99	1.84
75	EC 308128	61	112	186	239	0.92	1.57	2.97	3.82	2.67
78	EC 308129	36	100	224	289	0.97	2.31	4.36	5.55	4.59
120	EC 308130	44	103	261	239	0.93	1.81	3.92	4.84	4.15
122	EC 308132	54	88	167	187	0.95	1.66	2.31	2.54	2.69
126	EC 308133	58	123	231	246	0.94	2.11	3.48	4.02	6.04
128	EC 308135	53	96	184	246	0.82	1.78	2.95	4.39	5.09
135	EC 308141	50	91	168	225	0.87	1.39	2.91	4.07	2.91
144	EC 308142	42	82	198	246	0.98	2.00	2.73	3.72	3.80
145	EC 308143	44	82	179	242	0.97	1.86	3.12	3.76	4.80
146	EC 308144	40	100	154	225	0.81	2.22	2.76	3.84	7.84
147	EC 308145	43	104	220	291	1.09	2.24	4.07	5.24	5.81
148	EC 308146	39	67	141	200	0.79	1.19	2.52	3.38	3.43
149	EC 308147	41	68	151	209	0.89	1.54	2.38	3.79	2.38
150	EC 308148	46	76	202	287	0.94	1.48	3.46	5.87	4.71
151	EC 308149	42	104	208	265	1.01	2.15	3.48	4.82	6.30
152	EC 308150	38	67	160	233	0.87	1.42	2.78	4.36	2.21
153	EC 308151	46	74	153	195	1.14	1.78	2.58	3.86	2.82
230	EC 308154	42	84	179	266	0.84	1.69	2.84	4.05	4.35
233	EC 308156	40	73	133	179	0.66	1.26	2.12	5.31	2.26
	Mean	47	90	189	251	0.92	1.78	3.14	4.13	4.34
	±SE	5.51	12.6	39.16	49.56	0.15	0.39	0.84	1.06	1.59
	Range	36-61	67-123	126-261	178-337	0.63-1.14	1.19-2.48	1.99-4.36	2.54-5.55	1.84-7.84
	CV %	16.62	19.89	29.37	27.95	23.23	31.18	37.74	36.21	52.00
	CD 5%	10.96	25.11	77.93	136.97	-	-	-	-	3.16
	CD 1%	14.49	33.19	-	181.02	-	-	-	-	4.18

Table 6. Mean Values of Plant Height and Collar Diameter of 22 Accessions of *Prosopis* spp.-Peruvian at Four Growth Stages

US No.	Accession No.	Plant height (cm)				Collar diameter (cm)				Biomass (kg)
		1-year	2-year	3-year	4-year	1-year	2-year	3-year	4-year	
417	EC 308207	63	134	209	266	1.01	2.32	3.04	4.53	3.90
418	EC 308208	120	269	280	323	0.94	3.56	3.99	4.65	6.59
420	EC 308210	128	288	222	326	1.22	3.74	3.60	3.85	6.55
421	EC 308211	103	227	216	271	1.13	3.03	3.09	4.38	5.40
423	EC 308213	79	162	213	289	1.03	3.29	4.48	4.46	4.97
424	EC 308214	108	235	264	373	1.08	3.31	5.09	6.05	8.77
428	EC 308218	89	156	245	315	0.81	2.32	3.60	4.57	2.67
429	EC 308219	73	126	161	189	0.67	1.26	1.66	1.99	1.22
430	EC 308220	90	146	144	228	0.90	1.65	1.54	2.81	2.05
431	EC 308221	80	126	181	256	0.77	1.67	3.19	2.52	1.93
432	EC 308222	80	104	178	227	0.77	1.32	1.74	2.58	1.17
433	EC 308223	97	164	230	301	0.85	2.05	3.57	4.10	3.32
434	EC 308224	81	124	187	260	0.81	1.41	2.84	3.31	2.29
435	EC 308225	87	122	230	311	0.88	1.57	3.41	4.62	2.01
437	EC 308227	95	163	204	254	0.88	1.89	2.88	3.56	2.43
438	EC 308228	82	124	166	236	0.75	1.80	2.04	2.80	2.38
439	EC 308229	75	114	191	215	0.78	1.47	2.05	2.90	1.98
440	EC 308230	93	152	191	247	0.68	1.75	2.58	3.34	2.02
441	EC 308231	89	142	187	254	0.91	1.89	2.58	2.89	2.66
442	EC 308232	87	132	292	387	0.75	2.23	3.81	5.35	2.20
443	EC 308233	86	162	234	296	0.96	2.13	2.74	3.78	3.02
446	EC 308236	84	132	196	250	0.70	1.77	2.97	3.54	4.03
	Mean	89	159	210	276	0.88	2.16	3.02	3.8	3.35
	±SE	14.9	28.6	51.4	70.23	0.12	0.38	1.13	1.3	1.47
	Range	63-128	104-288	144-292	-	0.67-1.22	1.26-3.74	1.54-5.09	-	1.17-8.77
	CV %	23.6	25.5	34.6	36.0	19.4	25.2	52.8	47.52	62.04
	CD 5%	29.8	57.30	-	-	0.24	0.76	-	-	2.94