Foliar Analysis of Species of the Genus *Prosopis* in the Brazilian Semi-Arid Region

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Introduction

Many species have been recommended for afforestation in the Northeast's semi-arid region, with a view to timber and fodder production (Silva *et al.*, 1979). This region is characterized by marked water deficit and edaphic constraints such as low fertitility and shallow soils. *P. juliflora* is one of the species suitable for this purpose, on account of its multiple use possibilities.

Several parameters must be considered when selecting potential species for afforestation in any given ecologic region, including the plant's nutrition requirements. Generally, foliar analysis is used for this purpose, as the leaves are a relatively sensitive indicator of nutrient supply variations (Kramer and Kozlowski, 1976).

Haag *et al.* (1976), analyzing leaves of five species of the genus *Eucalyptus,* observed that nutrient content differed significantly among species, while Bellote (1979) found that N and P concentrations in *E. grandis* decrease with age.

Mergen and Worral (1964) found that N, P, and K content in *Pinus bankisiana* was associated with provenance, that the capacity to export soil minerals varies among individuals of the same species, and that it could vary with seed provenance and environment. Hoyle and Mader (1964), studying *P. resinosa,* observed that different growth characteristics seem to be correlated with the tree's nutritional status, height being stronlgy related to calcium levels; basal area with potassium levels and volume with soil moisture.

Research conducted by CORFO (1985) to determine the chemical composition of *P. tamarugo* and *P. chilensis* foliage showed, in general terms, a strong mineral imbalance, with deficit in some cases: phosphorus, 0.03 and 0.05%, respectively; calcium, 1.39 and 1.27%; sodium, 0.27 and 0.18%; and excess in others: magnesium, 5.8 and 4.8%, respectively; copper, 70 and 45 ppm.

Sharma (1984), working with *P. juliflora,* found correlations between foliar nutrient content and cationic exchange capacity with the soil. The analyses evidenced the capacity of the plant to tolerate salinity.

This paper presents foliar nutrient concentrations in species of the genus *Prosopis,* as well as a regression equation for productivity as a function of nutrient content.

Material and Methods

This research evolved from a competition trial among 24-month-old *Prosopis* species, provenances and progenies, spaced at 6.0 × 6.0 m, established on red-yellow latosol, at the experimental field of the Agriculture and Livestock Research Center for the Semir-Arid Tropic (CPATSA), Petrolina, Pernambuco. Mean annual temperature and rainfall were, respectively, 24° C and 500 mm.

Leaf samples were taken from the canopy's intermediate section of ten trees each of *P. alba* (Chile provenance), *P. chilensis* (Chile provenance), *P. glandulosa* var. *torreyana* (U.S.A. provenance), *P. juliflora* (local provenance), *P. pallida* (Peru provenance) and *P. velutina* (U.S.A. provenance), corresponding to the North, South, East and West points of the canopy, as suggested by Young and Carpenter (undated). At planting, the trees had received 5:14:3 NPK at a dosage of 100 g/pit.

The samples were oven-dried with forced ventilation, at 65 ± 5° C, until they achieved constant weight. This material was then crushed in a Willey-type mill, sifted with mesh 20, and assayed in laboratory. The concentration of the nutrients K, Ca, Mg, Na, Fe, Zn, Cu, and Mn was measured with an atomic absorption spectrophotometer; phosphorus, by the vanadium ammonium molybdate method, and nitrogen by the microkjeldahl method, according to Sarruge and Haag (1976).

To determine the cylindrical volume of the species, for each tree, the volumes of each forking occurring below 1.30 height were added together.

The data were fed to a computer and regression equations were derived to express timber output as a function of foliar nutrient content for each species.

Results and Discussion

The data in Table 1 show significant variations in the mean concentrations of nutrients contained in the leaves of different species of *Prosopis.*

TABLE 1

Mean Foliar Nutrient Concentrations in Species of the Genus *Prosopis* at 24 Months of Age Petrolina, Pernambuco

Nutrients / Species	N	P	K	Ca
	%			
P. alba	3.938 a	0.198 b	1.352 cd	0.837 cd
P. chilensis	4.046 a	0.236 a	1.191 bc	0.602 d
P. glandulosa	3.380 a	0.180 bc	1.327 ab	0.872 c
P. juliflora	3.103 b	0.135 d	1.056 c	1.860 a
P. pallida	3.367 b	0.151 cd	1.225 ab	1.628 b
P. velutina	3.842 a	0.164 bcd	1.190 bc	0.815 cd
F	**15.20**	**9.93**	**4.7**	**41.93**
C.V.	**8.11**	**20.56**	**12.78**	**22.61**

Nutrients / Species	Mg	Na	Cu	Mn	Zn	Fe
			ppm			
P. alba	0.435 bc	120.6 bc	26.7 b	127,1 c	50,0 d	179.9 ab
P. chilensis	0.413 c	149.4 b	41.2 b	59.3 d	89.2 c	105.7 c
P. glandulosa	0.519 b	67.2 cd	87.2 ab	147,3 bc	153.5 a	138.4 ab
P. juliflora	0.744 a	292.0 a	37.4 b	251.9 a	91.4 c	153.7 bc
P. pallida	0.480 bc	69.7 cd	39.5 b	180.9 b	74.0 c	233.5 a
P. velutina	0.447 bc	43.4 d	82.6 a	99.4 cd	125.2 b	224.6 a
F	**16.28**	**18.33**	**15.91**	**15.16**	**21.61**	**5.98**
C.V.	**18.91**	**54.41**	**38.85**	**37.72**	**25.83**	**33.75**

Values followed by the same letter do not differ from each other as per Duncan test at 5% probability level.

With the exception of Ca and Mn, the values found are above those reported by INFOR (Aguirre and Wrann, 1985) for *P. tamarugo* of different ages, and by Lima (1982) for 3-year-old *P. juliflora.*

Among the species studied, stand out the N (4.046%) and P (0.236%) concentrations in *P. chilensis.* As regards calcium, *P. juliflora* and *P. pallida* exhibited concentrations of 1.860% and 1.628%, respectively, higher than that for the other species, but below the mean mentioned by Aguirre and Wrann (1985) for *P. tamarugo.* This element is considered immobile in plant tissue, and it occurs in

considerable amounts in cell wall. Possibly the concentrations of this element are correlated with soil quality.

As regards magnesium, *P. juliflora* presented a concentration significantly higher than that for the other species, with 0.744%, demonstrating great capacity for extracting this element from the soil.

There are few studies concerning the importance and ideal level of micronutrients in plant development. In our research, the 251.9 ppm of manganese found in *P. juliflora* are significantly higher than in the other species. Haag *et al.* (1976) point out that the high Mn level in plants is associated with high soil acidity. As regards copper, minor variations were observed among the species, and only *P. glandulosa* and *P. velutina* differed negatively. *P. chilensis* presented a significantly lower iron concentration (105.7 ppm) compared with the other species and with the value reported for the same species by CORFO (1985).

Table 2 shows the height, crown diameter, stem diameter and cylindrical volume data.

In terms of volume, *P. juliflora* shows good development at two years of age, with 0.03009 m^3/ha/tree, standing out as a species with great potential for the region when compared with the productivity of the remaining species. *P. glandulosa* was the least productive, with 0.00075 m^3/ha/tree.

Comparing Tables 1 and 2, it may be observed that *P. juliflora* presents the lowest contents of N, P, and K, together with the highest productivity in timber volume.

TABLE 2

Dendometric Characteristics of Species of the Genus *Prosopis* at 24 months of age.

Species	Height (m)	Crown diameter (m)	DBH (cm)	Forkings/ tree	Vol./Treee (m^3)
P. alba	3.82 b	4.60 a	3.6 a	3	0.02182 ab
P. chilensis	2.62 c	1.84 c	1.9 a	4	0.00303 cd
P. glandulosa	1.70 d	2.19 bc	1.0 c	4	0.00075 d
P. juliflora	4.58 a	5.36 a	3.8 a	4	0.03009 a
P. pallida	2.86 c	5.24	3.4 a	3	0.01239 bc
P. velutina	2.48 c	2.86 b	1.7 b	5	0.00272 cd

Figures followed by the same letter do not differ from each other as per Duncan test at 5% probability level.

TABLE 3

Equations Selected for Structure of the Variation in Productivity (Volume, m^3) as a Function of the Foliar Nutrients in Species of the Genus *Prosopis*

Species	Equation	R^2	CV(%)
P. alba	$Y = 0.0275560 + 0.0890406\ Ca - 0.1282150\ Mg - 0.0003234\ Cu - 0.0000881\ Fe$	90.88	35.68
P. chilensis	$Y = 0.0071308 + 0.0012998\ N + 0.0171545\ Ca - 0.0358864\ Mg + 0.0000228\ Na - 0.0001620\ Cu + 0.0001346\ Mn + 0.0000525\ Zn$	98.44	14.68
P. glandulosa	$Y = 0.0004473 - 0.0166759\ Mg - 0.0000320\ Cu + 0.000040\ Mn + 0.0000235\ Zn + 0.0000177\ Fe$	99.38	18.88
P. juliflora	$Y = 0.20635 - 0.0344065\ Ca - 0.0019210\ Cu - 0.0003663\ Mn$	60.85	41.84
P. pallida	$Y = -0.0640687 + 0.0075895\ N + 0.143762\ Mg + 0.0002653\ Na - 0.0001127\ Mn - 0.0000694\ Fe$	83.44	44.99
P. velutina	$Y = 0.00040876 - 0.00474878\ Ca + 0.000019998\ Zn$	44.30	49.36

Y = Wood Volume (m^3)

Haag *et al.* (1976), observing less productivity in *E. microcorys* in timber volume among the various species of *Eucalyptus* studied, concluded that the cause for this low productivity is low foliar

N, P, and K content found in this species. With *P. juliflora,* however, the situation was the opposite, as the lower foliar N, P, and K concentrations are concurrent with a higher productivity, suggesting that this species is more efficient in nutrient utilization than the other species.

Table 3 shows the regression equations derived through the multiple linear regressive model, which explain the variation in productivity as a function of nutrients contained in the leaves of each species. According to this model, the variables Ca, Mg, Cu and Fe account for 90.88% of the productivity variation in *P. alba;* N, Ca, Mg, Na, Cu, Mn, and Zn, for 98.44% of *P. chilensis;* Mg, Cu, Mn, Zn and Fe, for 99.38% of *P. glandulosa;* Ca, Cu and Mn, for 60.85% of *P. juliflora;* N, Mg, Na, Mn and Fe, for 83.44% of *P. pallida,* and Ca and Zn, for 44.30% of *P. velutina* productivity variation. The stepwise increase of the remaining variables would contribute very little to productivity variation.

Conclusions

1. The *Prosopis* species exhibited varying foliar nutrient concentrations;
2. The lowest foliar concentrations of N, P, and K were found in *P. juliflora.*
3. *P. juliflora* is the species presenting highest productivity in terms of timber volume.
4. *P. glandulosa* was the least productive species.
5. The nutrients Ca, Mg, Cu, and Fe account for 90.88% of the productivity variation in *P. alba;* N, Ca, Mg, Na, Cu, Mn and Zn, for 98.44% in *P. chilensis;* Mg, Cu, Mn, Zn and Fe, for 99.38% in *P. glandulosa;* Ca, Cu and Mn, for 60.85% in *P. juliflora;* N, Mg, Na, Mn, and Fe, for 83.44% in *P. pallida,* and Ca and Zn, for 44.30% in *P. velutina.*

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