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Full Research Article

Macro and Micronutrient Contents of 25 Woody Trees and Shrubs in Northeast of Mexico

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Abstract

Leaf nutrients play an important role for the growth and development of trees and are sources of nutrients for ruminants in forest. The present study was under taken to estimate six nutrients in the leaves, three macronutrients (K, Mg, P) and three micronutrients (Cu, Fe, Zn) of twenty five woody species in Linares, Northeastern of Mexico. Macronutrients and micronutrient contents (Cu, Fe, Mn, Zn, Ca, K, Mg, P, C and N) of ten native exhibit large variations among species in the contents of the nutrients. K values ranged from round about 6.80 to 75.62 mg g^{-1}; Mg content ranges 0.22 to 5.29 mg g^{-1}. P 0.09 to 2.43 mg g^{-1}. Cu from 0.09 to 2.8 to 30.71 µg gps^{-1}, Fe 66.32 to 276 µg gps^{-1}, Zn 10.23 to 144.86 µg gps^{-1}. *Croton suaveolensi* acquired highest level of P (2.43 mg g^{-1}) and K (75.62 mg g^{-1}), whereas *Parkinsonia aculeata* for Mg (5.29 mg g^{-1}). *Cordia boissieri* for both Cu (30.71 µg gps^{-1}) and Fe (280.55 µg gps^{-1}), on the other hand, *Salix lasiolepis* for Zn (144.86 µg gps^{-1}). These species could serve as excellent sources for ruminants and could adapt and grow well for high nutrient contents. The values of mineral contents were much higher than required by the grazing ruminants.

1. Introduction

The shrubs and trees of Tamaulipan Thornscrubs in the semiarid regions are of great economic importance for various uses such as timber for furniture, fences, firewood and sources of forage for wild grazing animals for possessing macro and macronutrients required by the animals (Ramirez, 2014).

Leaves contribute greatly in plant growth and productivity for photosynthesis and nutrient contents, There are is great diversity among plant species in growth from leaf size, leaf shape and canopy management, in addition, there exist some general relationships across wide range of species in leaf traits which determine the carbon fixation strategy among species. The outer canopy leaves, its specific leaf area (SLA, leaf area $unit^{-1}$ mass) tends to be correlated with leaf nitrogen $unit^{-1}$ dry mass, photosynthesis and dark respiration sites (Wright et al., 2001).

Leaves contain various macro-and micronutrients absorbed by plants by roots from soil horizons, required for plant growth and development and as source of nutrients for grazing animals in the forest ecosystem. A Large variation among species with leaf traits favour nutrient conservation and allow short term rapid growth. Species having nutrient conservation have long life span, high leaf mass $area^{-1}$, low nutrient concentrations and low photosynthetic capacity. The availability of nutrients in leaves is essential for efficient plant function. Chaplin, (1982) review the natures of crop responses to nutrient stress and compare these responses to those of specie that evolved under more natural conditions. He gave emphasis on nutritional studies of nitrogen and phosphorus because these elements most commonly limit plant growth (Chaplin, 1982). The nutrients present in leaves contribute to plant growth and metabolism, Sufficient research activities have been undertaken on nutrient content and metabolism in leaves Leaf nutrient contents depends on the availability of nutrients present in the soil habitat Nutrient-poor habitats tend to be dominated by species by nutrient-conserving species, while fertile habitats tend to be dominated by species with higher short-term productivity $leaf^{-1}$ Mass (Chapman, 1990). Within a given habitat, species with a range of leaf traits can coexist.

With the age of leaves, nutrient resorption occurs when nutrients are withdrawn from leaves prior to abscission and reemployed in the developing tissues (leaves, fruits, seeds. Resorption y occurs throughout a leaf s life particularly when the leaves are shaded (Ackerly and Bizzaz, 1995; Hickosaka, 1996). A major phase of resorption occurs shortly before leaf abscission which is a highly ordered process of leaf senescence occurring in most species (Nooden, 1988). Is recycled via resorption (Around 50% of leaf N and P is recycled via resorption (Aerts, 1996). It is emphasized that the presence of active nutrient sinks has control over resorption (Negi and Singh, 1993).

Rangel and Marsechner, (2005) studied nutrient availability and management in the rhizosphere showing genotypic differences. Plants exposed to nutrient deficiency Plants exposed to nutrient deficiency activate a range of mechanism that lead to increased nutrient availability in the rhizosphere compared with bulk soil Plant may change teir root morphology, increase affinity of nutrient transporters in the plasma membrane and exude organic compounds (carboxylates phenolics), carbohydrates enzymes etc. Chemical changes in the rhizosphere lead to altered abundance and composition of microbial communities Nutrient efficient genotypes are adapted to environment with low nutrient. Understanding the role of plant-microbe-soil interaction governing the nutrient availability will enhance environmental sustainability.

Wright et al. (2001) established a strategy shifts in leaf physiology, structure and nutrient content between species of high and low-rainfall and high and low-nutrient habitats. Most plants withdraw nutrients from leaves with advance in age; the proportions of nutrient restored and the residual nutrient concentration in senesced leaves are different. A major spectrum of strategic variations occur in plant in species with long life span, high leaf mass unit^{-1} area, low leaf nutrient concentrations and low photosynthetic capacity. Green-leaf and senesced-leaf N and P concentration quantified revealed that leaf nutrient concentrations in green and senesced leaves were positively correlated with LL across all species. And most sites excluding nitrogen fixing species. Proportional respiration did not differ with soil nutrients. The results support the argument that nutrient losses has affected the residual nutrient concentration rather than proportional resorption *per se*.

Plants contain nutrients useful for ruminants and wild animals in which direction research has been undertaken, Lukhele and Van Ryssen (2003) undertook a study on chemical composition and potential value of subtropical tree species of Combreatum in southern Africa for ruminants. It was concluded that the foliage tested would not suitable resources of N to supplement protein deficiencies in low quality herbage.

2. Materials and Methods

2.1. Plant species

The shrubs and trees of 25 species from Tamaulipan Thornscrubs, Mexico were undertaken irrespective of families. The table 1 revealed the details herewith.

2.2. Chemical analysis

Mature leaf samples (1.0 g dry weight) obtained from each plant and shrub species was used for determining the contents of minerals (Cu, Fe, Zn, Ca, Mg, K and P). Mineral content was estimated by incinerating samples in a muffle oven at 550 °C during 5 hours. Ashes were digested in a solution containing HCl and HNO_3, using the wet digestion technique. Concentrations of Ca (oxide nitrous/acetylene flame), Cu, Fe, Zn, K and Mg (air/acetylene flame) were determined by atomic absorption spectrophotometer (Varian, model Spectr AA-200), whereas P was quantified spectrophotometrically using a Perkin Elmer spectrophotometer (Model λ 1A) at 880 nm.

2.3. Statistical analysis

The data collected were analysed by the analysis of variance, and Duncan, New Multiple Range test at 5% level of probability that was used to test the significance of means.

3. Results and Discussion

The data regarding the macro-and micro-mineral; contents of twenty five native shrubs and trees are presented in Table 2 and summary of K wails analysis were made in Table 3. The nutrient analysis of 25 native woody species reveals that all the species contained high amount of both macro and micronutrient required for plant growth and metabolism as well as adaptation to semiarid environments. It is observed that all the macro and micronutrients show significant differences among species. The species show large variability both in macro- and micronutrients which are shown graphically below. The results on micronutrients, K, Mg, P, Cu, Fe and Zn are shown in the Table 1 and represented graphically in Figures 1–6.

3.1. Macronutrients

There is wide variability in the presence of the nutrients in the different plant species. K values ranged from round about 6.80 to 75.62 mg g^{-1}. The average content of K is 26 mg g^{-1} with *Croton suaveolens* scored highest (75.62 mg g^{-1}) followed by *Cordia boissieri* (45.48 mg g^{-1}). *Bumelia celastrina, Prosopis laevigata, Acacia farnesiana, Diospyros texana* and *Acacia rigidula* contain K varies from about 33-38 mg g^{-1}.

Mg content ranges 0.22 to 5.29 mg g^{-1} with Parkinsonia aculeata contained highest level (5.29 mg g^{-1}). The plants contain Mg levels more than 2 mg g^{-1} are *Celtis laevigata, Salix lasiolepis, Berberis chococo, Diospyros texana, Quercus virginiana, Amyris texana, Acacia berlandieri, Leucophyllum frutescens, Cordia boissieri, Prosopis laevigata, Cercidium macrum, Acacia wrightii, Havardia pallens, Celtis pallida,*

Table 1: Plants species under study

Name common	Name scientific	Family	type	Leaf type	Name common	Name scientific	Family	type	Leaf type
Barretilla	*Amyris texana*	Rutaceae	Shrub	Compound	Huizache	*Acacia farnesiana*	Fabaceae	Shrub	Compound
Cenizo	*Leucophyllum frutescens*	Scrophulariaceae	Shrub	simple	Lantana	*Lantana macropoda*	Verbenaceae	Shrub	simple
Granjeno	*Celtis pallida*	Ulmaceae	Shrub	simple	Palo amarillo	*Berberis chococo*	Berberidaceae	Shrub	Compound
Oreja de ratón	*Bernardia myricifolia*	Euphrobiaceae	Shrub	simple	Chapote prieto	*Diospyros texana*	Ebenaceae	Tree	simple
Panalero	*Forestiera angustifolia*	Oleaceae	Shrub	simple	Huajillo	*Acacia berlandieri*	Fabaceae	Tree	Compound
Salvia	*Croton suaveolens*	Euphrobiaceae	Shrub	simple	Barreta china	*Fraxinus greggii*	Oleaceae	Tree	Compound
Anacahuita	*Cordia boissieri*	Boraginaceae	Tree	Simple	Encino	*Quercus virginiana*	Fabaceae	Tree	simple
Coma	*Bumelia celastrina*	Sapotacee	Tree	simple	Sauce	*Salix lasiolepis*	Salicaceae	Tree	simple
Palo blanco	*Celtis laevigata*	Ulmaceae	Tree	simple	Huizache chino	*Acacia shaffneri*	Fabaceae	Tree	Compound
Palo verde	*Cercidium macrum*	Fabaceae	Tree	Compound	Mezquite	*Prosopis laevigata*	Fabaceae	Tree	Compound
Tenaza	*Harvadia pallens*	Fabaceae	Tree	compuesta	Retama	*Parkinsonia aculeata*	Fabaceae	Tree	Compound
Chaparro prieto	*Acacia rigidula*	Fabaceae	Shrub	Compound	Uña de gato	*Acacia wrightt*	Mimosaceae	Tree	Compound
Tatalencho	*Gymnosperma glutinosum*	Asteraceae	Shrub	simple					

Bernardia myricifolia, Lantana macropoda, Parkinsonia aculeata.

P level varies from 0.09 to 2.43 mg g^{-1}. *Croton suaveolens* has highest (2.43 mg g^{-1} level of P and Bumelia celastrina has the lowest (0.09 mg g^{-1}). *Amyris texana, Bernardia myricifolia, Cercidium macrum, Havardia pallens, Acacia wrightii, Celtis pallida, Acacia rigidula , Lantana macropoda, Gymnosperma glutinosum, Cordia boissieri, Acacia schaffneri, Salix lasiolepis, Acacia farnesiana, Parkinsonia aculeata, Celtis laevigata, Prosopis laevigata* are having P levels more than 1 mg g^{-1}.

3.2. Micronutrients

Cu from 0.09 to 2.8 to 30.71 µg gps^{-1} where average content exists about 5.01 µg gps^{-1}. *Cordia boissieri* has highest (30.71 µg gps^{-1}) value followed by *Croton suaveolens* (26.87 µg gps^{-1}). Only *Acacia farnesiana, Bumelia celastrina, Celtis pallida, Croton suaveolens and Cordia boissieri* contain more than 24 µg gps^{-1}. Fe content in the plants vary from 66.32 to 276 µg gps^{-1} being highest scored by *Cordia boissieri.* Plants contains more than 225 µg gps^{-1} are *Croton suaveolens, Bumelia celastrina, Acacia rigidula, Celtis laevigata, Acacia farnesiana, Celtis pallida and Cordia boissieri*. Zn content also varies from 10.23 to 144.86 µg gps^{-1} with an average 31.3 mg g^{-1}. Salix lasiolepis contains highest level of Zn of about 144.86 µg gps^{-1}, almost nearly 5 times than average concentration. *Diospyros texana, Celtis laevigata, Acacia schaffneri, Prosopis laevigata, Forestiera angustifolia, Berberis chococo, Parkinsonia aculeate, Cordia boissieri* and *Salix lasiolepis* contains more than 40 µg gps^{-1}.

The importance of plant nutrients as sources of forage for ruminants and for the growth and development was emphasized by various authors. Plants with nutrient conservation have long life and high leaf mass $area^{-1}$, low nutrient concentrations and low photosynthetic capacity. The availability of nutrients in leaves is essential for efficient plant function. Chaplin (1982) mentioned the importance the nutritional studies of nitrogen and phosphorus for plant growth (Chaplin, 1982). Leaf nutrient contents depends on the availability of nutrients present in the soil habitat Nutrient-poor habitats tend to be dominated by species by nutrient-conserving species, while fertile habitats tend to be dominated by species with higher short-term productivity leaf Mass^{-1} (Chapman, 1990). Within a given habitat, species with a range of leaf traits can coexist. The nutrient contents of leaves vary with the age of leaves. With the age of leaves, nutrient resorption occurs when nutrients are withdrawn from leaves prior to abscission and reemployed in the developing tissues (leaves, fruits, seeds. Resorption and occurs throughout a leaf s life particularly when the leaves are shaded (Ackerly and Bizzaz, 1995; Hickosaka, 1996).

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Table 2: Macro-and micro-mineral contents of twenty five native shrubs and trees

Species	K (mg g^{-1})	Mg (mg g^{-1})	P (mg g^{-1})	Cu (µg gps^{-1})	Fe (µg gps^{-1})	Zn (µg gps^{-1})
Amyris texana	19.56	2.67	1.09	9.18	99.88	17.40
Leucophyllum frutescens	13.69	2.69	0.80	6.45	118.12	27.23
Celtis pallida	42.60	3.20	1.24	25.98	276.88	12.42
Bernardia myricifolia	11.54	3.61	1.09	8.03	139.73	16.17
Forestiera angustifolia	28.32	1.27	0.89	4.03	70.10	48.56
Croton suaveolens	75.62	0.22	2.43	26.87	229.13	34.55
Cordia boissieri	45.58	2.72	1.42	30.71	280.55	51.87
Bumelia celastrina	33.02	0.68	0.09	25.24	249.00	14.10
Celtis laevigata	20.67	2.19	1.57	8.88	254.09	42.28
Cercidium macrum	14.50	2.95	1.10	5.97	96.08	25.29
Havardia pallens	22.86	3.15	1.11	3.51	109.87	29.57
Acacia rigidula	38.75	0.43	1.25	7.09	252.33	10.23
Gymnosperma glutinosum	21.49	1.90	1.40	8.93	167.40	12.16
Acacia farnesiana	34.72	0.22	1.54	24.62	259.76	15.47
Lantana macropoda	26.04	3.71	1.37	13.00	145.81	28.29
Berberis chococo	12.42	2.35	0.90	5.12	58.79	50.68
Diospyros texana	36.55	2.59	0.98	2.80	72.47	41.45
Acacia berlandieri	6.80	2.69	0.78	3.52	73.46	15.08
Fraxinus greggii	23.07	1.55	0.88	8.16	125.13	30.94
Quercus virginiana	15.04	2.60	0.91	3.63	66.32	39.25
Salix lasiolepis	23.57	2.34	1.51	8.49	95.49	144.86
Acacia schaffneri	19.86	1.72	1.44	3.18	138.93	44.60
Prosopis laevigata	34.04	2.88	1.65	5.17	128.92	48.47
Parkinsonia aculeata	24.93	5.29	1.56	7.44	165.63	51.66
Acacia wrightii	20.50	3.03	1.22	8.11	99.04	28.14

Table 3: Summary of K wails analysis of macro (K, Mg, P) and micronutrients (Cu, Fe, Zn) of 25 species of native woody plants

Variable	χ2	Value *p*
K (mg g^{-1})	113.91	<0.001
Mg (mg g^{-1})	90.56	<0.001
P (mg g^{-1})	106.46	<0.001
Cu (µg gps^{-1})	113.41	<0.001
Fe (µg gps^{-1})	105.84	<0.001
Zn (µg gps^{-1})	115.86	<0.001

Wright et al. (2001) established a strategy shifts in leaf physiology, structure and nutrient content between species of high and low-rainfall and high and low-nutrient habitats. Most plants withdraw nutrients from leaves with advance in age; Green-leaf and senesced-leaf N and P concentration quantified revealed that leaf nutrient concentrations in green and senesced leaves were positively correlated with LL across all species. And most sites excluding nitrogen fixing species. Proportional respiration did not differ with soil nutrients. The

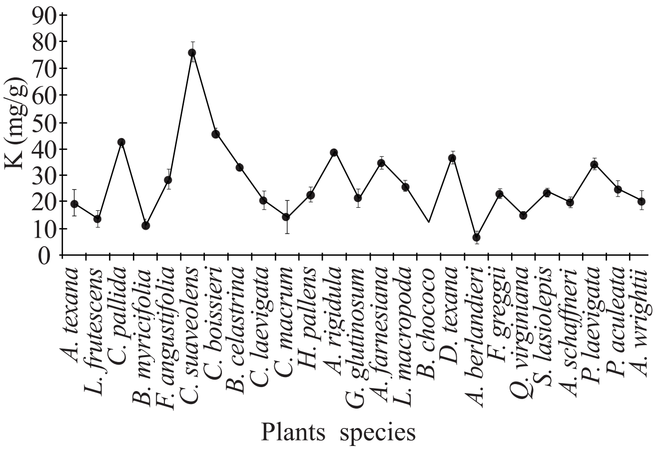

Figure 1: K content in trees and shrubs

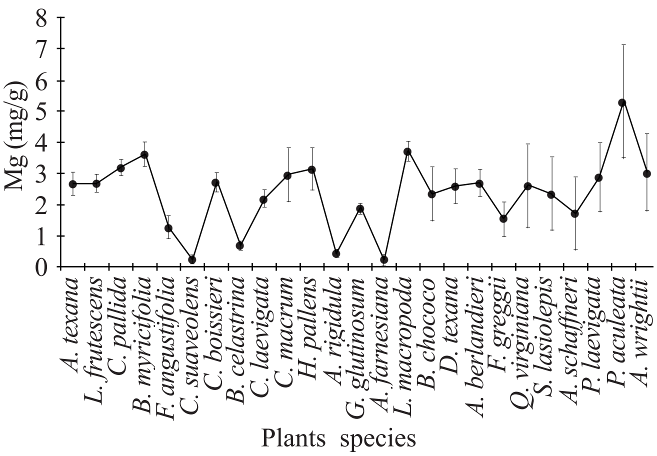

Figure 2: Mg content in trees and shrubs

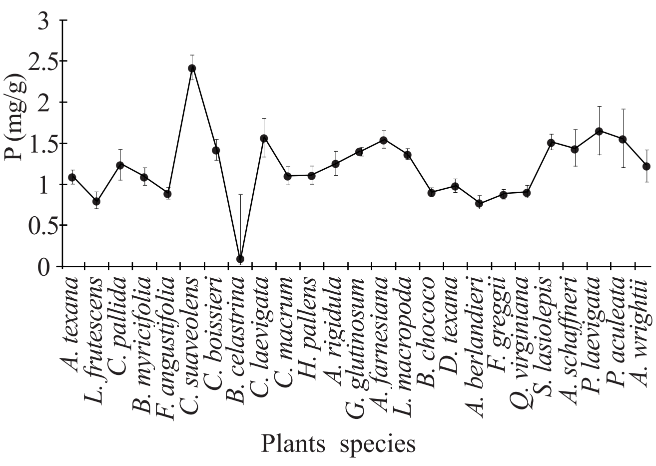

Figure 3: P content in trees and shrubs

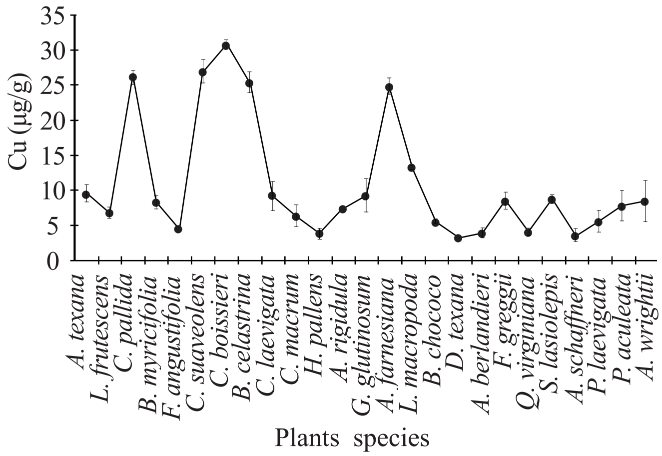

Figure 4: Cu content in trees and shrubs

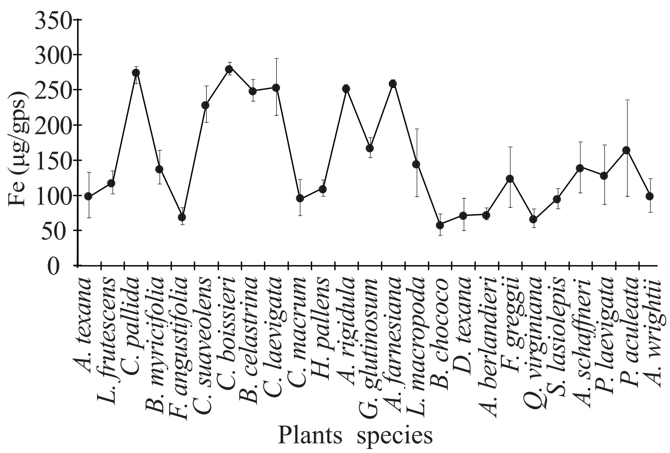

Figure 5: Fe content in trees and shrubs

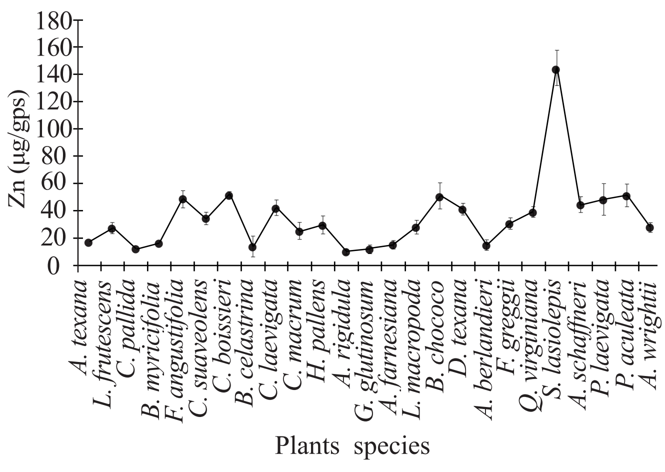

Figure 6: Zn content in trees and shrubs

results support the argument that nutrient losses has affected the residual nutrient concentration rather than proportional resorption *per se*.

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4. Conclusion

Croton suaveolensi acquired highest level of P (2.43 mg g^{-1}) and K (75.62 mg g^{-1}), whereas *Parkinsonia aculeata* for Mg (5.29 mg g^{-1}). *Cordia boissieri* for both Cu (30.71 µg gps^{-1}) and Fe (280.55 µg gps^{-1}), on the other hand, *Salix lasiolepis* for Zn (144.86 µg gps^{-1}). The species containing high level of nutrients could serve as excellent sources for ruminants and could adapt and grow well for high nutrient contents. The values of mineral contents were much higher than required by the grazing ruminants.

5. Acknowledgement

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