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The contribution of *Acacia* Species to the Soil Nitrogen in South-western Saudi Arabia

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Abstract. The study revealed higher content of total soil nitrogen beneath the canopy compared to that outside the canopy of each *Acacia* sp., at different sites in the south-western region of Saudi Arabia, between 250 and 2500 m. Total soil nitrogen beneath and outside the canopy of *A. ehrenbergiana*, *A. irageusis* (syn *A. gerrardii*) and *A. origena* (syn. *A. negrii*) gave the following pairs of readings: 0.59, 0.54; 0.56, 0.52; 0.52, and 0.48 meq N per 100 g of air-dry soil, respectively. Lower soil pH and higher moisture content were recorded beneath the canopy compared with those recorded outside the canopy, for each of the *Acacia* species. No significant differences in soil nitrogen, pH, and moisture content were observed when comparing their values in lowlands (250 – 1500 m) and highlands (1750 – 2500 m).

Introduction

Various biological processes are responsible for the rise of nitrogen level in the soil. Leguminous plants contribute significantly to increased soil nitrogen. Nodulation is common in the family leguminosae. Various genera of the subfamilies Caesalpinoideae, Mimosoideae and Papilionoideae produce nodules containing nitrogen-fixing bacteria [1]. The roots of many *Acacia* species show nitrogen-fixing potential [1; 2]. Rhizobial populations can be found at different soil depths under many *Acacia* trees and contribate variably to soil nitrogen [3]. Soil in the south-western region of Saudi Arabia proved to maintain appreciable populations of nitrogen-fixing bacteria of the following genera: *Azotobacter, Clostridium, Pseudomonas, Bacillus, Arthrobacter, Streptomyces* and *Rhizobium* [4]. *Acacia* litter also contributes greatly to the soil nitrogen [5]. In arid and semi-arid areas the soil beneath the *Acacia* canopy is usually better developed than that outside the canopy, containing higher nitrogen

and water contents [3; 6]. Plant growth is greatest under the canopy compared with that outside the canopy [7]. Grazing animals such as goats and sheep play a beneficial role in raising soil nitrogen [8].

In the present study an attempt was made to assess the role of the three most common *Acacia* species in raising soil nitrogen and moisture and reducing pH levels in the soil and to establish the levels of these characteristics in relation to altitudinal gradient in the Asir region in south-western Saudi Arabia.

Materials and Methods

Soil samples were collected during January 1991, at elevations ranging between 250 – 2500 m, in the south-western region of Saudi Arabia, between 17° 30′ – 19° N Latitude and 42° – 43° E Longitude. Soils associated with three common *Acacia* species, distributed along an elevation gradient, were studied. These species were: *Acacia ehrenbergiana* at 250 – 1500 m, *A. iragensis* (syn. *A. gerrardii*) at 1750 – 2000 m and *A. origena* (syn. *A. negrii*) at 1750 – 2500 m. For each species of *Acacia* twenty pairs of random soil samples were collected. One of each pair of the samples was collected from beneath the canopy of a particular *Acacia* species and the other member of the pair from the open areas around the individual tree concerned. These samples were taken from the upper 15 cm of the soil profile, at various places within the range of distribution of each species.

Total soil nitrogen content was determined according to the standard method given by Faniran and Areola [9, p.278], using air-dry soil samples in the analysis. Percentage of soil moisture was determined by oven drying soil samples at 100 °C and then calculating the percentage of soil water. Soil pH was determined by a pH meter in 1:1 soil : water extract. Plants were identified according to Chaudhary [10, p.87], Abulfatih [11] and the Natural History Museum in London.

Statistical analysis was based upon a t-test, using SPSS software, release 5, for windows.

Results and Discussion

Acacia spp. are widely distributed in the south-western region of Saudi Arabia [12, p. 282; 13; 14]. There are seven well-known species of *Acacia* in the region [12]; they are:
A. ehrenbergiana, A. iragensis, A. origena, A. asak, A. tortilis, A. etbaica and *A. oerfota*. Temperature is considered to be the main factor controlling the distribution of these species along the altitudinal gradient between sea level and 2500 m [14; 15]. These species are common on flat areas and rocky slopes [16].

The statistical analysis clearly indicates that soil nitrogen is significantly different ($p < 0.001$) between samples taken under the canopy and those taken outside the canopy, for each *Acacia* species (Table 1 and Fig. 1).

Mean total soil nitrogen contents under the canopy of *A. ehrenbergiana, A. iragensis* and *A. origena* were 0.59, 0.56 and 0.52, and in the open areas outside the canopy related to the same species were 0.54, 0.52 and 0.48 meq N per 100 g air-dry soil, respectively (Table 1).

The differences between soil nitrogen under and outside the canopy were 0.05, 0.04 and 0.04 meq N per 100 g with respect to *A. ehrenbergiana, A. iragensis,* and *A. origena* respectively. These results indicate that the contribution of *A. ehrenbergiana* to the soil nitrogen is the highest (Table 1).

A wide range of total soil nitrogen was recorded for each *Acacia* species. Absolute minimum and maximum of total soil nitrogen content under the canopy were 0.35, 0.85; 0.39, 0.71 and 0.28, 0.75 with regard to *A. ehrenbergiana, A. iragensis* and *A. origena* respectively. In contrast, outside the canopy the readings were 0.32, 0.78; 0.35, 0.68 and 0.25, 0.69, respectively (Fig. 1)

Table 1. Total soil nitrogen content, soil moisture and pH under canopy and in open areas outside the canopy, in the natural habitats of the most common species, in south-western Saudi Arabia.

Soil Source	Mean total soil nitrogen (meq N per 100 g air-dry soil)	Mean soil moisture (%)	Mean pH	N	Elevation range (m)
A. ehrenbergiana					
Under canopy soil	0.59±0.15	12.5±2.6	7.3+0.1	20	250 – 1500
Open area soil	0.54±0.14	11.0±2.5	7.5±0.1	20	250 1500
A. iragensis					
Under canopy soil	0.56±0.11	11.5±1.8	7.4±0.2	20	1750 – 2000
Open area soil	0.52±0.11	9.5±1.7	7.6+0.2	20	1750 – 2000
A. origena					
Under canopy soil	0.52±0.13	9.7±2.1	7.2±0.1	20	1750 – 2500
Open area soil	0.48±0.12	7.7±2.1	7.5±0.1	20	1750 – 2500
All *Acacia* species					
Under canopy soil	0.56±0.13	11.2±2.4	7.3±0.12	60	250 – 2500
Open area soil	0.51±0.12	9.4±2.4	7.5±0.12	60	250 – 2500

N = Number of cases
± = Standard deviaton

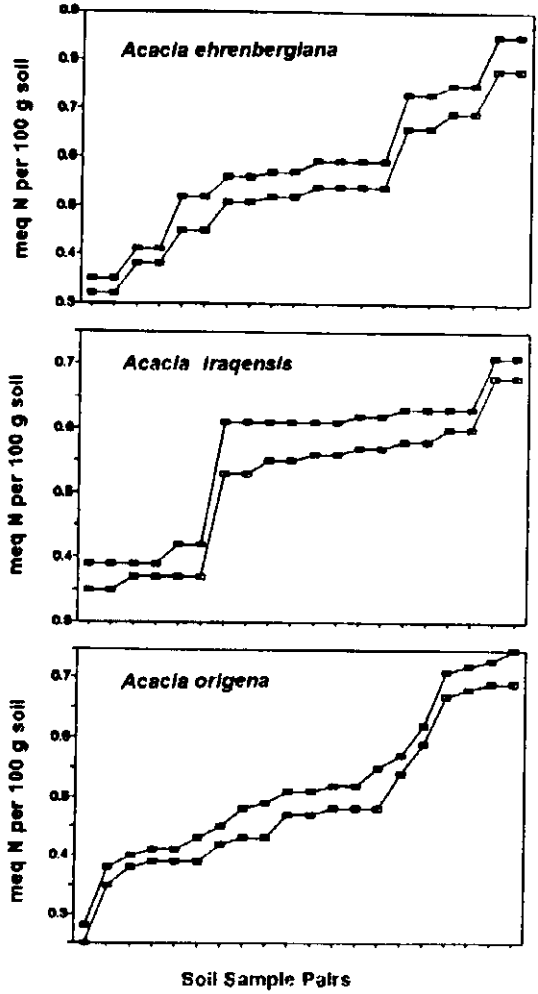

Fig.1. Total soil nitrogen content (meq N per 100g m) in areas occupied by *Acacia ehrenbergiana*, *A. iragensis* and *A. origena*. Soil sample pairs were taken from beneath the canopy (filled rectangles) and outside the canopy (empty rectangles). Values of sample pairs are ranked along the x-axis.

Significantly ($p < 0.001$) lower pH and higher soil moisture were recorded beneath the canopy compared with values outside the canopy of each of the *Acacia* species (Table 1).

Comparing soils beneath the canopy of *Acacia* trees, at lowlands (250 – 1500 m) and at highlands (1750 – 2500 m) showed no significant differences in soil nitrogen ($p = 0.610$), pH ($p = 0.140$) and soil moisture ($p = 0.609$). Comparing soils outside the canopy of *Acacia* trees, at lowlands and highlands showed no significant differences in soil nitrogen ($p = 0.638$), pH ($p = 0.528$) and soil moisture ($p = 0.589$).

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مساهمة أشجار الأكاشيا في رفع كمية نيتروجين التربة في الجنوب الغربي للمملكة العربية السعودية

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ملخص البحث. أوضحت الدراسة ارتفاع كمية النيتروجين في التربة الواقعة تحت الأنواع المختلفة من أشجار الأكاشيا، مقارنة بالتربة عديمة الغطاء النباتي، في الجنوب الغربي للمملكة العربية السعودية، بين ارتفاع ٢٥٠ و ٢٥٠٠ متر فوق سطح البحر.

وسجلت معدّلات كمية النيتروجين، المقاسة تحت الأشجار وفي الأراضي الجرداء البعيدة عن الأشجار، المقادير التالية المبينة إزاء كل نوع من أنواع الأشجار، مقدَّرة بوحدة القياس meq N per 100 g air-dry :

(١) من المنخفضات (acacia ehrenbergiana) (٠,٥٩ و ٠,٥٤)

(٢) من الهضبة (acacia iraqensis) (٠,٥٦ و ٠,٥٢)

(٣) من المرتفعات (acacia origena) (٠,٥٢ و ٠,٤٨)

ومن تحليلات الرطوبة والأس الهيدروجيني للتربة تبين ارتفاع مقدار الرطوبة وانخفاض الأس الهيدروجيني في العيّنات المأخوذة من تحت الأشجار مقارنة بتلك المأخوذة من الأرض الجرداء. وتبين كذلك من الدراسة أنّ مستوى ارتفاع الأرض فوق سطح البحر ليس له تأثير واضح على مقادير النيتروجين، والرطوبة، والأس الهيدروجيني.