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EFFECT OF THE CANOPY COVER ON THE ORGANIC AND INORGANIC CONTENT OF SOIL IN CHOLISTAN DESERT

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Abstract

Present study describes the effect of canopy cover of different shrubs on the physico-chemical parameters of soil. The organic and inorganic content of soil underneath the canopy covers (canopied subhabitat) of four different shrubs viz., *Leptadenia pyrotechnica* (Khip), *Calligonum polygonoides* (Phog), *Capparis decidua* (Karir) and *Acacia jacquemeontii* (Banwali) were analyzed and compared with the barren soil (uncanopied subhabitat). It was found that the pH of the soil was decreased while moisture content was increased under the canopy covers as compared to barren soil. The mineral content including sodium, potassium, calcium, magnesium, chlorides, sulphates and phosphates was found to be higher under the canopy covers as compared to barren soil. As for as the soil organic matter and total nitrogen content is concerned, it was found that the organic matter was increased from 0.630% in the barren soil to 0.726% under the canopy cover. Similar results were observed in case of nitrogen which increased from 0.040% of barren soil to 0.135% under the canopy. The study suggests that plantation in the desert areas can contribute a great towards fertility of the soil.

Introduction

Soil is a mixture of organic and inorganic materials. The organic part consists of living things and their remains while the inorganic part is made up of rocks and minerals. The types of plants present in an area have a great impact on the quality of the soil of that area as the plants and soil are strongly influenced by each other (Kim *et al*., 1995). The characteristics of a soil are undergoing continual changes and the rates of these changes are highly dependant on the type and density of the vegetation (Wasonga *et al*., 2003).

As the roots inhabit chiefly the upper soil layer, and because all materials derived from plant shoots are deposited upon the surface, soils generally show a rapid decrease in organic matter from the surface downwards and away from the canopy cover (Ghuman & Lal, 1983; Noureen *et al*., 2008). Under certain types of vegetation both the litter and duff are present, but elsewhere the duff and even the litter, may be essentially lacking, at least in certain season.

In Pakistan the organic matter content of the soil ranges from 0.69-2.45% (Anon., 2008) in the soils of plains. In the hot dry climates, desert soil is formed which is reddish in color and supports a few grasses and small shrubs resulting in a little humus build up. The plant residue is the most important input to soil which gives rise to the organic and inorganic matter of the soil. So the distribution of these matters in the soil mainly depends upon their origin i.e., the type of the plant and their canopy covers. The organic matter derived from the dead roots of the plants is mainly distributed throughout the soil. On the other hand, the organic matter derived from the dead leaves and shoots is mainly present in the upper horizons of the soil and only under the canopy covers (Spears *et al*., 2006).

The organic matter in soil improves the water holding capacity of soil, especially when the soil mineral matter is coarse textured. Both incorporation and surface mulching may substantially reduce water loss from the soil. Nitrogen is one of the major nutrient elements for plants and generally the most deficient one especially in arid and semi-arid areas. It is almost deficient in the soil of all the areas of Pakistan. The other inorganic minerals such as potassium, magnesium, calcium etc., are also usually deficient in most of the desert soils of Pakistan (Based on our previous observations).

In Pakistan, there are four main deserts viz., Thur, Cholistan, Thal and Kharan.The soil of these areas is of regoseil type. The layer of the soil is thick and is not capable of supporting vegetation due to deficiency of humidity. The area of Cholistan is very vast which is partly irrigated by Sutlej Valley Canals. Its length is 720Km and width 50Km comprising approximately 5566919 acres. In the south of this area, lengthy and very wide mountains of sands are present. Here the color of sand is yellowish and pale brown. In this soil animal and plant matters are abundant but minerals are less. The soil textural class is Loamy sand. Cholistan desert is mainly occupied by Bahawalpur Division constituting districts Bahawalnagar, Bahawalpur and Rahim Yar Khan (Matiullah *et al.,* 2004).

The objective of the present study was to observe the effect of canopy covers of different shrubs on the physico-chemical characteristics of the soil and make some recommendations.

Materials and Methods

Sample collection: The selected sampling areas were divided into three sites:

I. Cholistan Institute for Desert Studies (CHIDS),
II. Islamia University, Bahawalpur.
III. The desert area near the student's hostels (Ali and Usman Hall) at Baghdad-ul-Jadid Campus.

These three sites of sampling were designated as site "A", "B" and "C", respectively. Four plants were selected from each site for sampling purpose i.e., *Leptadenia pyrotechnica* (Khip), *Calligonum polygonoides* (Phog), *Capparis decidua* (Karir) and *Acacia jacquemeontii* (Banwali) and were designated as plant "1", "2", "3" and "4", respectively. Samples of barren soil were also collected for comparison of soil quality from Cholistan desert near the sampling sites. Soil samples were collected at depth of 6 inches and at a distance of 30 cm and 100 cm away from each plant stem during the summer season.

Preparation of soil extract: One hundred milliliter of bi-distilled water was added to a 250ml Erlenmeyer flask which contained 25g of the soil sample. The flask was shaken with the help of mechanical shaker for two hours and the suspension was left for 36 hours to saturate. The suspension was filtered using the Buckner funnel with the help of suction pump to get the clear sample extract. The extract was used for the estimation of soluble cations and anions i.e., sodium, potassium, calcium, magnesium, chlorides, phosphates and sulphates.

Analytical procedures

Reagents and standard solutions: Analytical grade reagents were used throughout the studies. The standard solutions (1000 mg/L) of Na, K, Ca and Mg were procured from Merck Chemicals, Germany. These solutions were diluted with suitable amount of bi-distilled water to get desired working standard solutions.

Moisture content: Moisture contents in soil samples were measured with the help of ScalTec Moisture analyzer at 110ºC.

Sodium and potassium: Sodium and Potassium were estimated with the help of flame photometer (Rhoades, 1982).

Calcium and magnesium: In the present study, Calcium and Magnesium ions of soil samples were estimated by using the method of complexometric titration with disodium salt of ethylenediamine tetra acetic acid (EDTA) (Rhoades, 1982).

Chlorides: Chlorides in the samples were estimated by Flow Injection Analyzer method (Diamond, 2001). In this method, thiocyanate ion was liberated from mercuric thiocyanate by the formation of soluble mercuric chloride. In the presence of ferric ion, free thiocyanate ion forms the highly colored ferric thiocyanate, of which the absorbance was proportional to the chloride concentration. The absorbance of the ferric thiocyanate was read at 480 nm (Cecil 7000, UK).

Organic carbon: The organic matter was oxidized with a known amount of chromate in the presence of sulphuric acid and the remaining chromate was determined spectrophotometrically at 600 nm wavelength. The calculation of organic matter was based on organic matter containing 58% carbon (Nelson & Sommers, 1982).

Sulphate: Sulphate in soil extracts was determined by gravimetric method (Smittenberg *et al*., 1951). Barium sulphate was precipitated in hydrochloric acid using Barium chloride. The barium sulphate was filtered, dried and weighed.

Phosphate: The phosphate content of the soil samples was analyzed using spectrophotometric method (Olsen & Sommers, 1982). The phosphate was reacted with Sodium molybdate and Potassium pyrosulfate in acidic solution to form phosphomolybdic acid, which was reduced to a blue compound in the presence of ascorbic acid. The absorption was measured at wavelength of 565 nm.

Total nitrogen: Nitrogen in soil samples was analyzed by Kjeldahl Method (Bremner & Mulvaney, 1982, Isaac & Jhonson, 1976).

Results and Discussion

pH of the soil: The pH of soil samples collected from three sites “A”, “B”, and “C” ranged from 7.35-7.72, 7.20-7.52 and 7.21 to 7.63, respectively (Tables 1, 2 and 3). The lowest and highest values of above pH range were representative of samples collected at distance of 30 cm and 100 cm, respectively. These results showed that the soil is more acidic in character near the plant stem. This can be explained with a fact that as we move away from main stem of shrub, the organic matter due to fallen leaves is decreased as compared to organic matter present near stem. Hence pH is increased near stem and decreased as we move away from the stem. The organic matter is decomposed under bacterial action and acidic species are produced which are responsible for the decrease of pH near stem (Noureen *et al*., 2008).

Moisture content: The moisture content in the soil samples taken from under the four experimental plants ranged from 3 to 5.4% being minimum (3.0%) under *A. jacquenmeontii* (Banwali) at site "A" and "B" and maximum (5.4%) under *C. polygonoides* (Phog) and *C. decidua* (Karir) at site "C" (Table 1, 2 & 3). The moisture content in soil samples collected from site "C" was found higher as compared to site "A" and "B". The higher moisture contents are due to reason that the area of site "C" is closer to the cultivated land. However moisture contents of soil collected under canopy cover were higher as compared to barren land (2.60%) which indicates that canopy cover decreases the rate of evaporation of water from soil and water holding capacity of soil is increased. But this effect is greatly pronounced in dry weather as compared to wet as also reported by Wasonga *et al*., (2003).

Sodium & potassium: The potassium is regarded as macronutrient while sodium is considered as a toxic element at higher concentrations. The percentage of sodium in soil samples collected under different plants from all the three sites ranged from 0.024 to 0.062% being minimum (0.024%) under *C. decidua* (Karir) at site A and maximum (0.062%) under *C. polygonoides* at site "B" and *C. decidua* (Karir) at site C. Similarly, the percentage of potassium in the soil samples of different experimental plants from all the three sites ranged from 0.016 to 0.071%. The minimum percentage (0.016) of potassium was recorded in the soil sample collected under *A. jacquemeontii* (Banwali) at site "A" while the maximum amount (0.071%) was found in samples collected under *C. polygonoides* at site "C". The percentage of sodium and potassium in the samples collected from barren area was found to be 0.039% and 0.061% respectively.

Calcium & magnesium: The availability of Ca & Mg is invariably higher in acidic soils as compared to neutral or alkaline soils. In strongly alkaline soils, sodium is invariably the dominant cation on the exchange site because Ca is precipitated as carbonate. The Ca therefore, has a buffering effect upon pH. It is found that soil with pH value 9 or above is often somewhat deficient in Ca and for similar reason Mg. The calcium and magnesium are regarded as secondary nutrients and are required by plants in moderate amounts.

The Ca content was ranged in all soil samples from 0.048 to 0.092%, whereas the barren soil has only 0.042% of Calcium. The maximum Ca content (0.092%) was found under canopy cover of *L. pyrotechnica* (Khip) at site "B" whereas minimum content (0.048%) were found under *A. jacquemeontii* (Banwali) at site "A" and "B".

The content of magnesium ranged from 0.007 to 0.105% being minimum (0.007%) under *C. deciduas* (Khrir) at sit "A" and maximum (0.105%) under *A. jacquemeontii* (Banwali) at site "C". However, barren soil was found to have magnesium contents of 0.040%. Above stated results are in accordance with the studies of Noureen *et al*., (2008).

Chlorides: Plant requirements of chlorides are generally small because they are classified as micronutrient and inputs from the oceans to the atmosphere and from the atmosphere to the soil are generally sufficient and may be substantial. The highest percentage (0.131%) of chloride ion was found under *A. jacquemeontii* (Banwali) at site "C" whereas the minimum content (0.028%) was found under *C. deciduas* (Karir) at site "A" which were even lower than the barren soil samples (0.042%). The highest percentage of chlorides at site "C" might be due to its nearness to the cultivated area.

Sulphates: Sulphur tends to accumulate as sulphate anion, which is then readily available to plant. The sulphur deficiency is more in soils with pH value above 8. The percentage of sulphate ions ranged from 0.791 to 1.977% being minimum under canopy cover of *L. pyrotechnica* at site "B" and maximum under *L. pyrotechnica* at site "A". The barren soil has only 0.710% of sulphate ions. These results show that sulphates are accumulated under canopy cover and increase nutritional value of the soil.

Phosphates: Phosphorous is regarded as macronutrient and is required by the plants in large amounts. The phosphate content of soil samples ranged from 0.0012 to 0.0036% being maximum under *L. pyrotechnica* (Khip) at site "C" and *A. jacquemeontii* (Banwali) at site "A", while minimum under *C. polygonoides* (Phog) at site "A" and "C". The barren soil contains 0.0018% of phosphates which is higher than minimum content of 0.0012% under canopy cover of *C. polygonoides* (Phog) at site "A" and "C".

Organic matter: Organic matter directly influences the soil fertility and also the water holding capacity of the soil. The organic matter of various soil samples ranged from 0.726 to 2.10%. The maximum organic matter content (2.10%) was found under *C. decidua* (Karir) at site "C" whereas minimum content (0.726%) was found under *C. polygonoides* (Phog) at site "A". The organic matter is contributed to soil only due to fallen leaves and branches of the shrubs. The organic matter content of soil covered with the shrub canopies was found to be higher as compared to barren soil (0.630%). Our finding is also supported by the studies of Wasonga, *et al*., (2003) who have also reported that the soil organic matter in the mid-canopy zone was significantly higher than in the sub-canopy and adjacent open zones during both dry and wet season. Similarly, Noureen *et al*., (2008) has also reported the presence of higher organic content under the canopy cover of *C. polygonoides* in Cholistan desert of Pakistan.

Soil nitrogen: Nitrogen occurs in soil in both cationic and anionic forms. Nitrogen is an essential element for plant growth and is classified as a macronutrient. The amount of nitrogen in soil is influenced by the amount of organic matter present and amount of the canopy cover in addition to the nitrogen cycle (Kim, *et al*., 1995). The percentage of nitrogen in the soil samples ranged from 0.040 to 0.115% being maximum under *C. decidua* (Karir) site "A" and minimum under *L. pyrotechnica* at site "B". However, the nitrogen content of barren land was found to be 0.040%. The nitrogen content of the soil was found highly variable under canopy covers of different shrubs.

Conclusion

The results obtained after analysis of soil samples from all the sites indicate clearly that the canopy cover significantly affects the quality of the soil. The organic matter and the total nitrogen are comparatively higher as compared to barren soil indicating increased fertility of soil under canopy cover. Similarly, the mineral content of the soil is also affected by the canopy cover of these plants. On the basis of present study it is recommended that if the plantation is increased in Cholistan desert, it will improve the quality of soil and land may be used for cultivation, which can overcome the financial crises of the local people and will have good affect on economy of the country as well.

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