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ORIGINAL ARTICLE

Floristic Indices, Nutrient Accumulation and Nutrient Uptake Ratios of Various Medicinal Plants along the Altitudinal Gradients of Sand Dunes in the Thal Desert of Pakistan

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ABSTRACT

Background: In deserts, precipitation leads to an uneven distribution of nutrients along the altitudinal gradients of sand dunes. This variation can significantly influence the nutrient uptake and distribution of plant species.

Objective: This project was designed to investigate the concentration of nutrient ions, nutrient uptake ratios, and floristic indices of selected medicinal plants from specific sites in the Muzaffargarh district of the Thal Desert in Pakistan.

Methods: Sites with typical desert vegetation were chosen for this study. Plants of approximately equal size on sand dunes were evaluated with replicates. Data from various dunes were compiled and analyzed statistically. Soil samples were collected and analyzed in a laboratory for electrical conductivity (EC), organic matter, nutrient composition, and bicarbonates, along with their relationship to vegetation.

Results: At the highest altitude, EC, nitrogen, and sodium contents were found to be abundant. In contrast, the maximum levels of bicarbonate, phosphorus, and organic matter were recorded at the lowest altitude of the dunes. For nutrient status, the highest potassium concentration (125.70 mg/g) was observed in the leaves of *Aerva javanica*, while the highest potassium uptake and accumulation percentage (311.26%) was found in the stems of *Aerva javanica*. The maximum phosphorus concentration (5.41 mg/g) was identified in the bark of *Haloxylon stockii*, with the highest phosphorus uptake and accumulation percentage (253.65%) observed in the flowers of *Aerva javanica*. The maximum sodium concentration (13.51 mg/g) was recorded in the stems of *Haloxylon stockii*, with the highest sodium uptake and accumulation percentage (93.81%) found in the stems of *Crotalaria burhia*. Regarding floristic indices, in the topmost altitudinal zone, the highest frequency was exhibited by *Caligonum polygonoides*, *Aerva javanica*, *Crotalaria burhia*, and *Sorghum jawarancusa*. In the second altitude zone, the highest frequency was noted for *Haloxylon stockii*, *Caligonum polygonoides*, *Aerva javanica*, and *Crotalaria burhia*. At the third altitude, the highest frequency was observed in *Aerva javanica* and *Fagonia arabica*. Additionally, the maximum density at the first altitude was recorded for *Sorghum jawarancusa*, while in the second altitude zone, *Crotalaria burhia* exhibited the highest density, and at the third altitude zone, *Asphodelus tenuifolius* displayed the highest density.

Conclusion: This study concludes that altitudinal variations result in diverse patterns of physio-chemical properties in dune soils, which in turn affect the frequency of vegetation.

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INTRODUCTION

The Thal desert is situated between 31° 10' N and 71° 30' E in the Punjab province of Pakistan. The vegetation of desert is mostly dwarf trees with profused branches. The maximal temperature in the Thal desert is recorded upto 45.6°C while minimum range reduces from 5.5 to 1.3°C with a mean annual rainfall of 150 to 350 mm. Desert plants are adapted to arid environment by various mechanisms [1].

Salt stress and drought conditions of desert soil determine the reabsorption and recycling of the nutrients in various groups of the plants [2,3]. Due to low precipitation in deserts, concentration of the carbonates and alkalinity increase while phosphorus and nitrogen are depleted [4]. Salinity and water stress in desert soils check also the nutrient resorption process by leaf [5]. The vegetation type of the desert changes along the modification in soil texture being major factor for water holding and hence moisture in the soil [6]. Maestre *et al*., [7] demonstrated that the fine textured soil retains more water favoring the establishment and survival of plants.

The pH of the soil is an important factor which determines the solubility, concentration, form, mobility and availability of nutrients. Low soil pH favors the solubility and availability of salts, including sulphates, carbonates, and phosphates causing an increase in the electrical conductivity of the soil[8]. Due to low rainfall and topographic variations, desert soil becomes heterogeneous in texture and composition. Plants' responses to temporal and spatial soil heterogeneity have been reported about nutrient distribution [9] and water availability. Soil heterogeneity creates competitive and/or facilitative interactions among the nutrients under semi-arid habitats[10], and finally determines the pattern of distribution of plant communities[11]. The soil heterogeneity is also induced by plants through several other mechanisms like excretion of organic compounds from roots[12]; organic matter decomposition[13]; changes of soil properties [14] and depletion of soil nutrients [15].

Plants of the deserts have been used as sources of food, food additives, medicine, flavors, fragrance ingredients, agricultural tools, and forage etc. A considerable rural population relies using desert plants as medicine due to easy access and affordability. As an estimate, 60% of synthetic medicines owe their origin to plants and only 20% of desert flora has been studied so far. To address this substantial research gap, folk knowledge, and modern scientific queries can serve the purpose. Such joint ventures can be utilized for powerful remedies to eradicate the diseases [16]. This study aimed to explore the nutrient concentrations and uptake ratio of the medicinal plants from the Thal desert (Pakistan). The selection of species was based on arid environmental conditions of desert habitat which accumulate ions as osmioicum for adaptation to stressful environments.

MATERIALS AND METHOD

Field Survey and Work

A preliminary survey of the Thal desert in the Muzaffar Garh district of Pakistan was carried out for the study. Typical desert sites with uniform heights of dunes were selected for study. The medicinal uses and local names of plants were collected from local folks. Plant identification was carried out by coordinating with them and scientific names were confirmed by herbarium examples lying in Dr. Mumtaz Bukhari herbarium of the Bahauddine Zakariya University, Multan, Pakistan. The identification of the plants was cross-checked with the literature [17].

Collection of Data for Floristic Indices

The quadrate method was used for floristic indices studies. Sand dunes were altitudinally divided into three zones. Three quadrates were applied in each zone and data of three dunes were analyzed using the following parameters.

Frequency

The frequency was calculated using the following formula.

$$\text{Frequency(\%)} = \frac{\text{Number of quadrates in species that occurred}}{\text{Total number of quadrates}} \times 100$$

Relative Frequency

The relative frequency of species in all of the quadrates was calculated using the formula.

$$\text{Relative frequency(\%)} = \frac{\text{Frequency of one species}}{\text{Total frequency of all species}} \times 100$$

Density

The density has been used to describe the characteristics of the communities. However, comparison can only be based on similar life forms. Basically, density is the number of individuals in a unit area. Using the following formula, the density was calculated.

$$\text{Density} = \frac{\text{Number individual of a species}}{\text{Number of quadrate}} \times 100$$

Relative Density

The following formula was used to calculate the relative density of species in all of the quadrates.

$$\text{Relative density (\%)} = \frac{\text{Density of one species}}{\text{Density of all species in all of the quadrate}} \times 100$$

Laboratory Work

Considering the consistency among the age and size of the plants and their parts, the specimen was gathered by a proper system [18]. Further, preparation of the collected material for further use was done in the research laboratory. All vegetative samples were shade-dried and finely ground to prepare a fine powder.

Digestion

Ground material of 0.1 g of each the soil and plant were taken in digestion tubes and added 5 ml of the concentrated H_2SO_4 and incubated it overnight at room temperature. Placed the digestion tubes in a digestion block and heated at 350°C until the brownish color appeared. Added 2 ml of H_2O_2 (35-40%) in it. Repeated the procedure until the cooled digested material became colorless. The volume of the extract was maintained up to 50 ml in volumetric flasks. The aliquot was filtered and used for the estimation of sodium, potassium, and phosphorus.

Nutrient Ions Analysis

Determination of Potassium Contents

The potassium constituents were analyzed by flame photometer. A graded series of standards in the 10 to 100 ppm range was prepared. Standard curves from the values were drawn. The values of potassium in the flame photometer were compared with the standard curve and total quantities were computed. The percentage of uptake of ions was calculated from the concentration present in soil and plant.

Determination of Sodium Contents

Sodium ion contents were determined by flame photometer method after five times dilution of the material. The percentage of sodium uptake was calculated from the concentration present in the soil and the plant.

Phosphorous Content Determination

The sample aliquot (2ml) and Barton reagent were mixed in equal quantity and volume was made to 50ml by adding distilled water. The samples were kept for half an hour before analyzing the phosphorus concentration followed by spectrophotometric analysis. The percentage of phosphorus uptake was calculated from the concentration present in soil and plant. For the preparation of Barton reagent, solution A was prepared by dissolving 25 gm of ammonium molybdate in 400 ml of distilled H_2O. Solution B was prepared by dissolving ammonium metavanadate (125 gm) in 300 ml of boiling water then cooled and 250 ml of conc. HNO_3 was added and again cooled at room temperature. Solution A and solution B were mixed and volume was maintained up to 1000ml and stored at room temperature. Then took 0.11gm of KH_2PO_4 in a 250 ml flask and added 250ml distilled water. Different concentrations (0.2, 0.4, 0.6, and 0.8) of standards were prepared. A 2ml Barton reagent and 2ml from each of these standards were taken and marked up to 50ml with the distilled water.

Statistical Analysis

The data collected were analyzed for analysis of variance for all the parameters using the COSTAT computer package (CoHort Software, Berkeley, CA). To compare means, Duncan's New Multiple Range test at a 5% level of probability was used [19]. Significant F values were tested by LSD tests at a 0.05% significance level, by using the MSTAT-C Computer Statistical Program (MSTAT Development Team, 1989).

Table 1. Mean Values for Properties of Thal Desert Soil Along Altitudinal Gradients of Sand Dunes (n=3).

	EC	OM	N	HCO_3	Na	P
Treatment	Mean LSD= 3.3589	Mean LSD=0.543	Mean LSD=0.0150	Mean LSD=3.1058	Mean LSD= 5.78	Mean LSD=0.017
Elevation 1	5.46±1.322 b	0.637±0.468 a	0.046±0.002 a	14.0±1.0 b	59.7±2.56 a	0.170±0.010 a
Elevation 2	4.32±2.270 a	0.517±0.832 a	0.041±0.004 a	15.0±2.0 b	49.9±3.25 b	0.144±0.009 b
Elevation 3	4.33±1.26 b	0.827±0.47 a	0.025±0.002 b	20.0±1.5a	43.2± 2.99 c	0.173±0.006 a

LSD= least Standard Deviation; values represent mean ±standard deviation; Values sharing the different letters represent significance difference in respective column.

Table 2. Floristic Indices of Plants of Thal.

Elevation	Name of Species	F	R.F	D	R.D
1	*Caligonum polygonoides*	100.00	18.75	11.33	21.94
	Arva jawanica	100.00	18.75	2.33	4.52
	Haloxylane stocksii	33.33	6.24	1.00	0.645
	Crotollaria burhia	100.00	18.75	11.67	22.58
	Symbopogon jawarancusa	100.00	18.75	16.67	32.25
	Orobanki aegyptica	66.67	12.50	6.00	3.87
	Tamarix aphylla	33.34	6.25	5.00	3.22
2	*Haloxylane stocksii*	100.00	25.00	9.00	25.47
	Caligonum polygonoides	100.00	25.00	10.33	29.24
	Arva jawanica	100.00	25.00	5.00	14.15
	Crotollaria burhia	100.00	25.00	11.00	31.13
3	*Arva jawanica*	100.00	20.00	3.00	7.20
	Caligonum polygonoides	66.67	13.34	5.00	12.00
	Symbopogon jawarancusa	100.00	20.00	7.67	18.40
	Mullogo cerviana	33.34	6.67	1.00	2.40
	Aesphodalus tenuifolius	66.67	13.34	19.00	45.60
	Fogonia Arabica	100.00	20.00	4.67	11.20
	Metha longifera	33.34	6.67	4.00	3.20

F=frequency; R. F= relative frequency; D=density; R. D= relative density

RESULTS

Concentration of Potassium in Herbs

The maximum level of potassium was present in *Mentha longifera* leaves (125.53 mg/g) and *Mentha longifera* root (126.50 mg/g) while the minimum level of potassium was shown by *Symbopogon jawarancusa* leaves (14.73 mg/g). A significant difference was shown in *Symbopogon jawarancusa* root (73.30 mg/g), *Symbopogon jawarancusa* stem (30.56 mg/g), *Symbopogon jawarancusa* leaves (14.73 mg/g), *Mentha longifera* leaves (125.53 mg/g), *Citrolus colocynthus* leaves (87.73 mg/g), *Citrolus colocynthus* stem (117.20 mg/g), *Fogonia Arabica* root (35.43 mg/g), *Fogonia Arabica* stem (71.30 mg/g), *Fogonia Arabica* leaves (69.26 mg/g), *Aesphodalus tenuifolius* stem (54.53 mg/g), *Aesphodalus tenuifolius* fruit (57.23 mg/g), *Orobanki aegyptica* flower (49.30 mg/g), *Orobanki aegyptica* stem (64.50 mg/g), and *Mullogo cerviana* fruit (65.20 mg/g). The uptake ratio of potassium from soil was variable. *Mentha longifera* leaves (310.71%), *Mentha longifera* root (313.88%), and *Mullogo cerviana* root (309.50%) exhibited maximum potassium uptake. *Citrolus colocynthus* stem (283.45%) has shown fewer uptakes than before. *Mullogo cerviana* stem (1137.37%) *Mullogo cerviana* leaves (136.32%), and *Symbopogon jawarancusa* root (139.82%) has shown moderate uptake. The *Orobanki aegyptica* flower (61.30%) and *Symbopogon jawarancusa* leaves (52.71%) showed fewer uptakes. Surprisingly, a lower uptake has been shown by *Symbopogon jawarancusa* stem (0.013%).

Concentration of Sodium in Herbs

A higher level of sodium has been shown by *Mullogo cerviana* fruit (97.23 mg/g) and a lower level of sodium has been shown by *Orobanki aegyptica* flower (3.20 mg/g). A significant level of sodium was shown by *Symbopogon jawarancusa* root (9.13 mg/g), *Symbopogon jawarancusa* stem (10.15 mg/g), *Symbopogon jawarancusa* leaves (5.26 mg/g), *Mentha longifera* leaves (5.10 mg/g), *Fogonia Arabica* root (6.90 mg/g), *Fogonia arabica* stem (11.58 mg/g), *Aesphodalus tenuifolius* stem (7.42 mg/g), *Aesphodalus tenuifolius* fruit (8.52 mg/g), *Orobanki aegyptica* flower (3.20 mg/g), *Mullogo cerviana* leaves

(77.22 mg/g), *Mullogo cerviana* root (111 mg/g), *Mullogo cerviana* fruit (97.23 mg/g), and *Mullogo cerviana* stem (123.98 mg/g). Herbs showed variations in the uptake of sodium from soil. *Mullogo cerviana* stem (115.24%) showed maximum uptake of Na ions while a moderate uptake has been shown by *Symbopogon jawarancusa* root (84.14%), *Symbopogon jawarancusa* stem (82.37%), *Symbopogon jawarancusa* leaves (90.86%), *Mentha longifera* leaves (89.23%), *Mentha longifera* root (91.14%), *Citrolus colocynthus* stem (89.23%), *Citrolus colocynthus* leaves (83%), *Citrolus colocynthus* fruit (83.80%), *Fogonia Arabica* stem (79.89%), *Fogonia Arabica* stem (83.92%), *Fogonia Arabica* root (88.02%), *Orobanki aegyptica* flower (94.44%), *Orobanki aegyptica* stem (83.75%), *Mullogo cerviana* root (92.70%), and *Mullogo cerviana* flower (68.80%). A minimum uptake has been shown by *Mullogo cerviana* leaves (34.06%).

Concentration of Phosphorus in Herbs

The maximum quantity of phosphorus has been expressed by *Mentha longifera* leaves (5.55 mg/g). Statistically significant values were shown by *Symbopogon jawarancusa* root (0.15 mg/g), *Symbopogon jawarancusa* stem (0.24 mg/g), *Symbopogon jawarancusa* leaves (0.49 mg/g), *Mentha longifera* leaves (5.55 mg/g), *Mentha longifera* root (0.39 mg/g), *Citrolus colocynthus* leaves (0.36 mg/g), *Citrolus colocynthus* stem (2.33 mg/g), *Fogonia arabica* stem (0.43 mg/g), *Aesphodalus tenuifolius* stem (0.34 mg/g), *Aesphodalus tenuifolius* fruit (0.27 mg/g) and *Orobanki aegyptica* stem (0.12 mg/g). Herbs have revealed variations in the uptake of phosphorous ions. *Mentha longifera* root (3344%). *Citrolus colocynthus* leave (1317%), *Fogonia arabica* root (1257%) have shown maximum uptake. (198.18%) has been shown by *Symbopogon jawarancusa* leaves. *Orobanki aegyptica* flower (137.32%), *Mullogo cerviana* leaves (137.32%), *Citrolus colocynthus* stem (119.07%) have been shown moderate uptake. Surprisingly reduced phosphorus uptake has been shown by *Fogonia arabica* leaves (9.53%) and *Mullogo cerviana* flower (8.72%).

Table 3. Means for Nutrients Concentrations of Some Herbs of Thal Desert.

Name of Species	Plant Part	Potassium LSD=2.188	Potassium (K^+)	Phosphorous LSD= 0.124	Phosphorous (P)	Sodium LSD=2.431	Sodium (Na^+)
Symbopogon jawarancusa	R	73.3±1.4 d	139.8246	0.15±0.01 gh	8.72026	9.13±1.05 efg	84.1493
	S	30.56±0.70 k	0.01309	0.24±0.01 fgh	46.04759	10.15±0.98 ef	82.3785
	L	14.43±0.97 l	52.7876	0.49± 0.09 c	198.1805	5.26±0.60 ij	90.8681
Mentha longifera	L	125.53± 1.60 a	310.7119	5.66±0.10 a	3344.289	6.2±0.96 hi	89.2361
	R	126.5±1.08 a	313.8856	0.39± 0.06 cde	137.3273	5.1±0.95 ij	91.1458
Citrolus colocynthus	L	87.73±2.15 c	187.037	0.36± 0.05 cdef	119.0714	9.36±0.70 efg	83.75
	S	117.2±2.21 b	283.4577	2.33±0.10 b	1317.879	6.2± 0.7 hi	89.2361
	F	14.73±1.15 l	51.806	0.24±0.10 fgh	46.04759	9.33±1.12 efg	83.8021
Fogonia arabica	R	35.43±0.87 j	15.92069	2.23±0.29 b	1257.025	6.90±0.90 ghi	88.0208
	S	71.3±0.96 de	133.281	0.43±0.01 cd	161.6686	11.58±1.45 e	79.8958
	L	69.26±0.80 e	127.4899	0.18±0.01 gh	9.53569	9.26± 1.22 efg	83.9236
Aesphodalus tenuifolius	S	54.53±1.50 h	78.41251	0.34±0.007 def	106.9007	7.42±1.18 fghi	87.1181
	F	57.23±0.90 g	87.24643	0.27±0.009 efg	64.30354	8.52±1.06 fgh	85.2083
Orobanki aegyptica	F	49.3±0.81 i	61.30088	0.39±0.007 cde	137.3273	3.20±0.41 j	94.4444
	S	64.5±1.4 f	111.0326	0.12±0.012 h	26.9762	9.36±0.90 efg	83.75
Mullogo cerviana	R	125.16±1.56 a	309.5014	0.45±0.008 cd	173.8392	111±3.63 b	92.70833
	S	72.66±1.36 k	137.7307	0.24±0.01 fgh	46.04759	123.98±2.66 a	115.2431
	F	65.2±1.38 f	113.3229	0.15±0.008 gh	8.72026	97.23±1.70 c	68.80208
	L	72.23±1.00 d	136.3238	0.39±0.007 cde	137.3273	77.22± 1.85 d	34.0625

R= root; S= stem; L= leaves; F= flower; FR= fruit; values represent mean ±standard deviation; Values sharing the different letters represent significance difference in respective column; LSD= Least Standard Deviation

Table 4. Means for Nutrients Concentrations of Some Shrubs of Thal Desert.

Name of Species	Plant Part	Potassium LSD=1.536	Potassium	Phosphorous LSD= 0.028	Phosphorous	Sodium LSD=1.986	Sodium
Aerva javanica	R	26.56± 0.97 h	13.1004	0.24±0.01 g	46.34146	4.4±0.55 fg	92.3611
	F	18.63±1.05 i	39.0459	0.58±0.01 c	253.6585	4.46±0.40 fg	92.2569
	L	31.33±1.15 g	2.5062	0.42± 0.01 d	156.0976	12.07±0.93 bc	79.0451
	S	125.70±1.85 a	311.2682	0.24±0.010 g	46.34146	10.30±0.61 d	82.1181
Caligonum polygonoides	S	42.5±1.11 f	39.05248	0.43±0.08 d	162.1951	8.53±1.02 e	85.191
	L	57.36±1.10 d	87.67177	0.31±0.04 f	89.02439	6.03±0.55 f	89.5313
Haloxylane stockii	B	20.4±1.2 i	33.2548	5.41±0.05 a	3198.78	10.66±0.89 cd	81.4931
	R	15.6±1.08 j	48.9596	0.21±0.01 g	28.04878	9.36±0.61 de	83.75
	S	25.6±1.21 h	16.2413	0.39±0.1 e	137.8049	13.51±1.50 b	76.5451
Crotollaria burhia	R	20.4±1.11 i	33.2548	0.39±0.06 e	137.8049	5.56±0.25 f	90.3472
	S	50.3±0.85 e	64.5727	0.42±0.09 d	156.0976	3.56±0.61 g	93.8194
	F	64.6±1.41 b	111.3598	0.79±0.06 b	381.7073	9.44±0.53 de	83.6111

LSD= Least Standard Deviation; values represent mean ±standard deviation; Values sharing the different letters represent significance difference in respective column; n=3; S=stem; F=flower; B=bark; R=root; L=leave.

Concentration of Potassium in Shrubs

A higher value of potassium was present in *Aerva javanica* stem (125.70 mg /g) while lower K+ was present in *Haloxylone stockii* root (15.60 mg /g). A significant difference is present in *Aerva javanica* stem (125.7 mg /g), *Aerva javanica* root (25.56 mg /g), *Aerva javanica* leaves (31.33 mg /g), *Aerva javanica* flower (18.63 mg /g), *Caligonum polygonoides* stem (42.50 mg /g), *Caligonum polygonoides* leaves (57.36 mg /g), *Haloxylone stockii* root (15.60 mg /g), *Crotollaria burhia* stem (50.30 mg /g) and *Crotollaria burhia* flower (64.60 mg /g). There were variations among shrubs in absorbing potassium from the soil. Some shrubs show high uptake such as *Aerva javanica* stem (311.26%). While some shrubs show relatively low uptake such as *Crotollaria burhia* flower (111.35%) and *Caligonum polygonoides* leaves (87.67%). Some candidates showed low uptake like *Crotollaria burhia* stem (64.7%). *Crotollaria burhia* root (33.25%), *Haloxylone stockii* bark (33.25%), *Haloxylone stockii* root (48.95%), *Caligonum polygonoides* stem (39.05), and *Aerva javanica* flower (39.04%) exhibited moderate uptake. Some shrubs have revealed surprisingly low uptake like *Aerva javanica* leaves (2.50%) and *Aerva javanica* root (13.10%).

Concentration of Sodium in Shrubs

The high value of sodium was present in *Aerva javanica* stem (10.30 mg /g) and a lower value of sodium was present in *Crotollaria burhia* stem (3.56 mg/g). There was a significant difference between *Aerva javanica* root (4.40 mg /g), *Aerva javanica* leaves (12.07 mg /g), *Aerva javanica* stem (10.30 mg /g), *Caligonum polygonoides* stem (8.53 mg /g), *Caligonum polygonoides* leaves (6.03 mg /g), *Haloxylone stockii* bark (10.66 mg /g), *Haloxylone stockii* root (9.36 mg /g), *Haloxylone stockii* stem (13.51mg /g), and *Crotollaria burhia* stem (3.56 mg /g). Variations were present among different shrubs and their parts in the uptake of sodium ions. Some shrubs absorbed maximum sodium from the soil such as *Aerva javanica* root (92.36%), *Aerva javanica* root (92.25%), *Crotollaria burhia* root (90.34%), *Crotollaria burhia* stem (93.81%), and *Caligonum polygonoides* leaves (89.53%). Some shrubs showed moderate uptake *Aerva javanica* stem (82.11%), *Caligonum polygonoides* stem (85.19%), *Haloxylone stockii* bark (81.49%) *Haloxylone stockii* root (83.75%), and *Crotollaria burhia* flower (83.61%). Others exhibited low uptake like *Aerva javanica* leaves (79.04%) and *Haloxylone stockii* stem (76.54%).

Concentration of Phosphorus in Shrubs

The maximum value of phosphorus was present in *Crotollaria burhia* flower (0.79 mg/g) while a lower value was present in *Haloxylone stockii* root (0.21 mg/g). A significant difference was present between *Aerva javanica* root (0.24 mg/g), *Aerva javanica* flower (0.58 mg/g), *Aerva javanica* leaves (0.42 mg/g), *Caligonum polygonoides* leaves (0.31 mg/g), *Haloxylone stockii* bark (5.41 mg/g), *Haloxylone stockii* stem (0.39 mg/g) and *Crotollaria burhia* flower (0.79 mg/g). Maximum uptake of phosphorus has been revealed by the flowers of *Aerva javanica* (46.34%)

and *Crotollaria burhia* (381.07%), *Aerva javanica* leaves (156.09%), *Caligonum polygonoides* leaves (162.19%), *Crotollaria burhia* stem (156.09 mg/kg), *Caligonum polygonoides* stem (162.19%). *Haloxylone stockii* stem (137.80%), and *Crotollaria burhia* root (137.80 mg/g) showed moderate uptake. *Caligonum polygonoides* leaves (89.02%) showed relatively low uptake. *Aerva javanica* stem (46.34%), and *Haloxylone stockii* root (28.04%) showed very low uptake.

Concentration of Potassium in Trees

Among *Cappris decidua* stem (32.26 mg /g), *Tamarix aphylla* stem (18.68 mg /g), and *Acacia nilotica* stem (2.65 mg /g), significant differences in potassium ions were present. However, there was minimal difference of potassium ions found between *Acacia nilotica* root (10.33 mg /g) and *Acacia nilotica* stem (2.65 mg /g). Trees have shown moderate uptake of potassium from the soil. *Acacia nilotica* stem showed maximum uptake (91.62%) from the soil. *Acacia nilotica* root showed moderate uptake of potassium from the soil. *Tamarix aphylla* stem showed (38.88 mg/kg), *Salvadora oleoides* stem (101.54%), *Salvadora oleoides* leaves (35.45%) uptake while minimum uptake was shown by *Capparis decidua* stem (5.54%).

Concentration of Sodium in Trees

Differences in concentration of sodium ions among *Acacia nilotica* stem (4.84 mg /g), *cappris decidua* stem (9.59 mg /g), *Salvadora oleoides* leaves (10.23mg /g) and *Tamarix aphylla* stem (9.99 mg /g) were significant. *Acacia nilotica* stem (172.62%) showed maximum uptake while *Tamarix aphylla* stem showed (155.71%) minimum uptake. *Acacia nilotica* root has shown (162.28%), *Salvadora oleoides* stem (89.93%), *Salvadora oleoides* leaves (82.23%), and *Capparis decidua* stem (157.08%) of sodium ions.

Concentration of Phosphorous in Trees

The statistical difference was present between phosphorus concentrations in *Acacia nilotica* stem (0.42) *Cappris decidua* stem (0.49) *Salvadora oleoides* stem (0.45), *Tamarix aphylla stem* (0.27) *Salvadora oleoides* leaves (0.33), *Acacia nilotica* stem (0.42) and *Acacia nilotica* root (0.58). Some of the selected trees exhibited variation in their phosphorous uptake. *Acacia nilotica* root (1.35%) showed maximum uptake while *Tamarix aphylla* stem showed minimum uptake (0.35). *Salvadora oleoides* leaves (101.21%), *Acacia nilotica* stem (0.83%), *Salvadora oleoides* stem (174.39%) and *Capparis decidua* stem (1.06%) were to name a few.

Soil Properties and Floristic Indices

The chemical properties of Thal desert soil were as EC= 4.70 dS; organic matter= 0.660; N= 0.037; HCO_3= 16.33 Na^+=50.9; and P= 0.162. Considering floristic indices; the maximum frequency in altitude 1 was of *Caligonum polygonoides, Aerva javanica, Crotollaria burhia, and Symbopogon jawarancusa* while the minimum was of *Haloxylone stocksii.* In altitude 2; the maximum frequency was of *Haloxylone stocksii,Caligonum polygonoides, Aerva javanica and Crotollaria burhia* while the minimum was of *Mullogo cerviana.* In altitude 3; the maximum frequencies were of *Aerva javanica and Fogonia arabica* while the minimum was of *Metha longifera.* Similarly, at altitude 1; the maximum density was of *Symbopogon jawarancusa* while the minimum was of *Haloxylone stocksii.* At altitude 2, the maximum density was of *Crotollaria burhia* while minimum was of *Aerva javanica.* At altitude 3 maximum density was of *Aesphodalus tenuifolius* while the minimum was of *Aerva javanica.*

Table 5. Means for Nutrients Concentrations of Some Trees of Thal Desert.

Name of Species	Plant Part	Potassium LSD=3.95	Potassium (K^+)	Phosphorous LSD=0.01	Phosphorous (P)	Sodium LSD=1.40	Sodium(Na^+)
Acacia nilotica	R	10.33±2.47 e	66.2021	0.58±0.009 a	1.359999	8±0.5 b	162.282
	S	2.65±1.3 f	91.6241	0.42±0.011 d	0.836507	4.84± 0.71 c	172.621
Capparis aphylla	S	32.26±2.35 c	5.549012	0.49±0.005 b	1.065535	9.59±0.83 a	157.08
Tamarix aphylla	S	18.68±2.08 d	38.8823	0.27±0.007 f	0.345734	9.99±0.88 a	155.771
Salvadora oleoides	S	61.6±1.05 a	101.5443	0.45±0.01 c	174.3902	5.8±1.1 c	89.9306
	L	41.4±1.08 b	35.45347	0.33±0.09 e	101.2195	10.23±0.50 a	82.2396

R=root, S=stem, LSD=Least Standard Deviation [values representing the mean±standard deviation; values representing the different letters show significant difference among column].

DISCUSSION

The concentration and uptake percentage of nutrients varied among plant species and their organ (Table **1-5**). This might be due to various factors. The availability of water and nutrients to the plants depends upon the soil texture which is a basic soil property that influences water retention and infiltration property of the soil [6]. Variations in soil texture and composition occur along the altitudinal gradients of dunes of deserts. These differences are reflected in the form of uptake and retention of nutrients in plants and their parts. The presence of salt in the soil also limits the absorption of water from soil [20]. In soil with low moisture content; potassium is accumulated while sodium accumulation is favored in saline soil [21]. Another cause might be that the availability and uptake of one nutrient ion influences the accumulation and uptake of the other nutrient [22]. Drought also influences the absorption of nutrients. Under drought conditions of desert, uptake, and accumulation of mineral elements plays a role in facilitating the plant for osmotic adjustment [23]. The ions uptake and their accumulation in plants depends also on the concentration of ions present in the soil.

Some ions like potassium ions act as osmitica in addition to an essential macronutrient for plant growth and development [24]. More clear discrimination of ionic uptake occurs under low soil moisture [25]. Due to the high uptake of sodium, the other nutrients become deficient in plants [24] since high sodium displaces the membrane-bound Ca^{+2} [26]. The nutrient uptake and status in a plant determine its potential for osmotic adjustment. A species that develops a better root system and growth has more available water and solutes for osmotic adjustment. Therefore, ions are important in maintaining the turgidity of tissues. Variations of nutrients might also be due to the reason that before the onset of senescence, perennial plants shift their nutrients from abscising tissues to healthy ones [27].

Due to low water availability in the desert, nutrient cycling is also insufficient [4]. Topography, texture and composition of desert soil play important role in the distribution of plants. The association of certain plant species to specific soil types is commonly observed in deserts [28]. Different vegetation types correspond to different soil salinity levels and ionic concentrations. Ions and compounds present in the soil had a great impact on the toxicity and medicinal value of the plants and determined the ethnomedicinal potentials of the plant. Natural products from plants having ethnomedicinal potentials have long played an important role in the innovation of drugs [29]. Ethnopharmacological studies of desert plants can greatly contribute to modern medicinal purposes.

CONCLUSION

Physicochemical properties of soil are varied along the altitudinal gradients of sand dunes in the Thal desert. Soil characteristics determine the ionic composition of the plant and its part in addition to the floristic diversity along the altitudinal distance. These altitudinal variations patternise the physio-chemical properties of dune soil and hence frequency of the vegetation.

CONFLICT OF INTEREST

There is no conflict of interest of any kind.

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