Makara Journal of Science

Volume 27
Issue 2 *June*

Article 1

6-25-2023

# Nutrients Ions Indices of Some Medicinal Flora of Cholistan Desert of Pakistan

Ghulam Yasin
*Institute of Botany, Bahauddin Zakariya University, Multan 60800, Pakistan*, yasingmn_bzu@yahoo.com

Adeela Altaf
*Department of Environmental Science, Bahauddin Zakariya University, Multan 60800, Pakistan*

Ikram ul Haq
*Institute of Biotechnology and Genetic Engineering, University of Sindh, Jamshoro 76080, Pakistan*

Samra Nazeer
*Institute of Botany, Bahauddin Zakariya University, Multan 60800, Pakistan*

Mubasharah Sabir
*Institute of Biotechnology and Genetic Engineering, University of Sindh, Jamshoro 76080, Pakistan*

Makara Journal of Science, 27/2 (2023), 81–88
doi: 10.7454/mss.v27i2.1444

# Nutrients Ions Indices of Some Medicinal Flora of Cholistan Desert of Pakistan

Ghulam Yasin[1*], Adeela Altaf [2], Ikram ul Haq[3], Samra Nazeer[1], and Mubashrah Sabir[1]

1. Institute of Botany, Bahauddin Zakariya University, Multan 60800, Pakistan
2. Department of Environmental Science, Bahauddin Zakariya University, Multan 60800, Pakistan
3. Institute of Biotechnology and Genetic Engineering, University of Sindh, Jamshoro 76080, Pakistan

*E-mail: yasingmn_bzu@yahoo.com*

Received October 16, 2022 | Accepted February 25, 2023

## Abstract

By knowing the nutritional status of a plant, one can better manage and use it for ethnobotanical purposes. Various nutrients are accumulated as osmotica in plants of stressful environments. The type and quantity of nutrients present in plants also determine the effectivity of medicine obtained from that plant. Hence, practical utilization of these plants as food or medicines needs to explore the exact nature and presence of the nutrient ions for discrimination of their toxic or medicinal nature. In the present study, some important nutrients in a number of xerophytic plants from Cholistan desert of Pakistan were quantified. Leave, stem and root specimens of seasonally available herbs, shrubs and trees were collected and analyzed for sodium, potassium and phosphorus contents. Each sample was replicated thrice. Obtained data were statistically analyzed and presented as Means ± standard deviations. Among the shrubs, maximum concentration of sodium was observed in leaves of *Salsola imbricata* (269.99 mg/g). The highest concentration of potassium was recorded in stem of *Calotropis procera* (67.78 mg/g) while maximum phosphorus was found in stem of *Pseuda fruticosa* (7.051 mg/g). Among the herbs, maximum sodium was found in stem of *Orobanche aegyptiaca* (234.95 mg/g), maximum potassium in leaves of *O. aegyptiaca* (270.71 mg.g) and the maximum phosphorus in root of *Citrullus colocynthis* (9.34 mg/g). For trees, maximum concentration of sodium, potassium and phosphorus were recorded in leaves of *Tamarix aphylla* (305.40 mg/g), stem of *Capparis decidua* (132.6 mg/g) and stem of *Acacia nilotica* (5.90 mg/g) respectively.

*Keywords: cholistan, desert, medicinal plants, nutrients, Pakistan*

## Introduction

Plant kingdom comprises genetically a diverse array of members which are important for not only human food, shelter and existence but also play role in human health care. Studies about medicinal potential of plants used in complementary, traditional and alternative ailments have attained much attention in recent years [1–3]. A known nutritional and ionic status of medicinal plants can help in knowing the palatability of the various plant parts which could be useful in its better management and conservation for ethnobotanical findings. It may contribute to its pharmacological uses in treatment of various diseases [4].

The land of Pakistan has a wide array of topographic features including diversified plains, hilly peaks, coastal areas, snowy mountains and deserts of extreme temperatures [5]. The Cholistan is a desert in Pakistan which lies between 69º 52' and 75º 24' East and 27º 42' and 29º 45' North coving an area of 26,000 km square [6]. Long drought, less rain fall and hot summer are the climatic characters of Cholistan desert which have significant influence on health of vegetation in this locality [7].

Soils of an area are important factors which determine communities structure of vegetation [8, 9]. In Cholistan, different types of soils, with respect to types of ions present, have associations with particular plant communities [10]. The vegetations of Cholistan comprise many medicinal plants. The inhabitants of remote areas of desert have less adequate health facilities and the peoples rely on local plant ingredients for their health care. Several ingredients and nutrients of these plants validate the importance of these plants for disease cure [11]. Additionally, in desert areas, these medicinal plants are also source of income for the inhabitants [12, 13]. The knowledge of use of such plants for health care is verbally transferred from generation to generation instead of written documentation [14]. Minerals and nutritive compounds in these desert plants are also the bases for evaluation of their uses as food and fodder [15]. The presence and nature of mineral elements in these plants are essential for synthesis of secondary metabolites. It is estimated that more than 100,000

metabolites are reported for such role [16]. Such metabolites protect plants from pathogens, herbivores, predators and have medicinal and antiviral properties [17]. Some ancient Chinese plants which were used as antiviral agents are documented to have 18000 types of secondary metabolites as alkaloids [18]. The competition among various ions for uptake can mutually influence their absorption by plants. The knowledge about ionic concentration in different organs can be a base for judgment of metabolites synthesized in presence or absence of particular ion. The presence of phosphorus is essential for synthesis of some amino acids and nucleic acids. Similarly, the potassium ion acts as cofactor for various enzymes in addition to playing role in cell signaling and cell turgidity. Sodium ion concentration, in soil, can outcompete the uptake of phosphorus and potassium ion causing drastic effect on plant metabolism. Although much research has been conducted on various aspects of medicinal plant yet sufficient work has to be done [19]. Keeping in view the all above aspects, the present studies were conducted with objective to explore the ionic composition of medicinal plants from Cholistan desert of Pakistan. These findings will discriminate the medicinal potential of plant by assessing their nutrional ions status. The selection of plants was based on arid environmental condition of habitat due to which plant can accumulate minerals ions as osmotica or to synthesis metabolites for adaptation to stressful environment.

## Materials and Methods

**Field survey and samples collection.** Plants of the Din Garh place of Cholistan desert of Pakistan were chosen for study. An initial survey of the site was carried and gatherings with groups of nearby people were organized to know the topographical status of the site and neighborhood plant names. Plants identification was performed by coordinating with them and with the herbarium examples lying in the departmental herbarium (Dr. Mumtaz Bukhari Herbarium) of Botany Department Bahauddin Zakaryia University, Multan, Pakistan and additionally by available literatures [20]. Specimens were sampled in the month of March (spring season) by a proper system keeping in mind the consistency among age and size of plants and their parts. Three replicates of each sample were collected. Further processing of material was done in research laboratory. Estimation of $Na^+$, $K^+$ and P was carried out by the process referring to cited description [22, 23]. Plant samples were first digested and aliquot was prepared for ions determination.

**Digestion of samples.** A concentration of 0.1 g of dried ground material was taken in digestion tubes. Added 5 mL of concentrated $H_2SO_4$, and incubated it overnight at room temperature. Placed the digestion tubes in a digestion block and heated at 350ºC until the fumes were produced and continued to heat for another 30 minutes. Removed the digestion tubes from the digestion block and cooled. Slowly added 1/2 mL of $H_2O_2$ and placed the digestion tubes again into the digestion block. Repeated the procedure until the cooled digested material became colorless. The volume was maintained up to 50 mL in volumetric flasks by adding distilled water. The extract was filtered and used for estimation of $Na^+$, $K^+$ and Phosphorus. All chemicals were of analytical grade manufactured by Sigma Aldric, Japan company.

**Determination of potassium ($K^+$) and sodium ($Na^+$).** The potassium ($K^+$) and sodium ($Na^+$) were estimated by using Jenway PFP-7 flame photometer. A series of standards (ranging from 10.0-100.0 ppm with each escalation of 10) of potassium and sodium were prepared and standard curves from the values were drawn. The values of potassium and sodium from flame photometer were compared separately for standard curve and total quantities were computed.

**Phosphorous contents determination.** The aliquot (2 mL) was taken in measuring cylinder. Barton reagent (2 mL) was added and volume was made up to 50 mL with distilled water. These samples were kept for half an hour before the estimation of phosphorus. The phosphorus (P) was analyzed by using spectrophotometer (Hitachi Model-U 2001 Japan). The values of phosphorus were calculated by using standard curve. For preparation of Barton Reagent, 25 g of Ammonium molybdate was dissolved in 400 mL of distilled water. A concentration of 1.25 g of Ammonium metavandate was dissolved in 300 mL of boiling water. Cooled it and added in it 250 mL of concentrated $HNO_3$ at room temperature. The solutions were mixed and volume was maintained up to one liter and stored at room temperature.

**Statistical analysis.** Data for sodium, potassium and phosphorus of trees, shrubs and herbs were analyzed by using one way ANOVA (Analysis of Variance). The level of statistical significance was set at 5%. Means were separated by Duncan's Multiple Range (DMR) test for significant level as referred by Khalid *et al*. [23]. Data were presented as means and standard deviation (Mean ± SD).

## Results and Discussions

**Concentration of ions in shrubs.** Sodium concentration in shrubs showed significant differences and the mean values are represented in Table 1. Maximum concentration (269.99 mg/g) of sodium was observed in leaves of *S. imbricata* and minimum (16.75 mg/g) concentration in stem of *Calligonum polygonoides.* Non significant difference was shown between stem of *P. fruticosa* (182.87 mg/g) and leaves of *Abutilon indicum* (172.28 mg/g). Similarly, non significant differences were revealed among stem of *Aerva javanica* (128.83 mg/g); leaves of *Haloxylon salicornicum* (115.14 mg/g) and stem of *A. indicum*. Furthermore, leaves of *C.*

*polygonoides* (22.42 mg/g); root of *C. polygonoides* (18.29 mg/g); stem of *C. polygonoides* (36.02 mg/g); stem of *H. salicornicum* (36.02 mg/g); root of *S. imbricata* (36.6 mg/g); leaves of *C. procera* (36.20 mg/g); stem of *C. procera* (39.53 mg/g) and flower of *A. javanica* (24.35 mg/g) did not revealed any significant differences among them. While, significant differences were observed among leaves of *S. imbricata* (269.99 mg/g), stem of *S. imbricata* (82.97 mg/g) and stem of *Leptadenia pyrotechnica* (206.33 mg/g).

Significant difference was observed in potassium concentration of shrubs and the mean values are represented in Table 1. Higher concentration (67.78 mg/g) of potassium was recorded in stem of *C. procera* and minimum (8.8 mg/g) in flower of *A. javanica*. Non significant differences were observed among stem of *C. polygonoides* (11.83 mg/g), stem of *A. javanica* (12.69 mg/g) and stem of *H. salicornicum* (13.45 mg/g). Furthermore, significant differences were recorded among leaves of *C. polygonoides* and root of *C. polygonoides*. A concentration of 27.86 mg/g by leaves of *H. salicornicum* was shown. The concentrations in stem of *S. imbricata* (26.63 mg/g), leaves of *S. imbricata* (33.83 mg/g) and root of *S. imbricata* (42.10 mg/g) were found. Potassium was found as; in leaves of *C. procera* (20.43 mg/g); stem of *L. pyrotechnica* (25.58 mg/g); stem of *P. fruticosa* (35.40 mg/g) and stem of *A. indicum* (12.69 mg/g) and leaves of *A. indicum* (35.90 mg/g).

Significant differences were examined for phosphorus concentrations of shrubs and their mean values are represented in Table 1. Maximum concentration (7.051 mg/g) was revealed in stem of *P. fruticosa* and minimum (3.612 mg/g) concentration in stem of *A. javanica*. Non significant difference was revealed between leaves of *C. polygonoides* (4.185 mg/g) and stem of *C. polygonoides* (4.042 mg/g). Also, root of *C. polygonoides* (5.331 mg/g) and leaves of *H. salicornicum* (5.188 mg/g) did not show any significant difference. Similarly, non significant difference was revealed between leaves of *H. salicornicum* (5.188 mg/g) and leaves of *C. procera* (5.905 mg/g). Non significant difference differences were recorded among leaves of *S. imbricata* (5.905 mg/g); root of *S. imbricata* (5.905 mg/g); stem of *S. imbricata* (5.905 mg/g); flower of *A. javanica* (5.905 mg/g); stem of *A. indicum* (5.905 mg/g).

**Concentration of ions in herbs.** Sodium concentration in herbs showed significant differences and it was shown in Table 2. Maximum concentration (234.95 mg/g) of sodium was observed in stem of *O. aegyptiaca* while minimum (17.34 mg/g) concentration in shoot of *Cressa cretica* (17.34 mg/g). No significant differences were recorded among stem of *C. colocynthis* (18.963 mg/g); shoot of *C. cretica* (17.34 mg/g) and shoot of *Polygonum aviculare* (27.183 mg/g). Significant difference was observed between leaves of *C. colocynthis* (155.627 mg/g) and root of *C. colocynthis* (186.957 mg/g).

**Table 1. Quantitative Estimation of Concentrations of Sodium, Potassium and Phosphorus in Some Shrubs of Cholistan Desert**

| Species | Parts | Sodium ($Na^+$) (mg/g) LSD=(23.44) | Potassium ($K^+$) (mg/g) LSD=(8.06) | Phosphorus (P)(mg/g) LSD=(1.38) |
|---|---|---|---|---|
| ***C.alligonum polygonoides*** | Leaves | 22.42±7.04 f | 18.79±3.29 hi | 4.185±0.66 cd |
| | Root | 18.29±4.30 f | 24.05±4.56 fgh | 5.331±0.66 bc |
| | Stem | 16.75±4.17 f | 11.83±1.79 ij | 4.042±0.66 cd |
| ***Haloxylon salicornicum*** | Stem | 36.02±5.92 f | 13.45±0.88 ij | 5.045±0.66 bcd |
| | Leaves | 115.14±8.10 d | 27.86±4.45 cdefg | 5.188±1.14 bc |
| ***Salsola imbricata*** | Leaves | 269.99±15.52 a | 33.83±8.06 bcde | 5.905±0.66 ab |
| | Root | 36.6±9.0 f | 42.10±10.85 b | 5.905±0.66 ab |
| | Stem | 82.97±48.08 e | 26.63±2.27 defgh | 5.905±0.66 ab |
| ***Calotropis procera*** | Leaves | 36.20±6.49 f | 20.43±1.47 ghi | 5.045±0.66 bcd |
| | Stem | 39.53±9.35 f | 67.78±7.80 a | 5.619±0.86 abc |
| ***Leptadenia pyrotechnica*** | Stem | 206.33±9.02 b | 25.58±4.34 efgh | 5.475±1.08 abc |
| ***Pseuda fruticosa*** | Stem | 182.87±6.52 c | 35.40±4.46 bcd | 7.051±1.08 a |
| ***Aerva javanica*** | Flower | 24.35±4.46 f | 8.8±1.16 j | 5.905±0.66 ab |
| | Stem | 128.83±6.75 d | 12.69±0.75 ij | 3.612±0.66 d |
| ***Abutilon indicum*** | Leaves | 172.28±5.33 c | 35.90±4.57 bc | 6.478±0.86 ab |
| | Stem | 109.007±3.56 d | 32.54±2.80 cdef | 5.905±0.90 ab |

Values sharing the same letters in respective column differ non significantly; LSD= least significant difference

**Table 2. Quantitative Estimation for Concentrations of Sodium, Potassium and Phosphorus in Some Herbs of Cholistan Desert**

| Species | Parts | Sodium ($Na^+$) (mg/g) LSD=(12.09) | Potassium ($K^+$) (mg/g) LSD=(15.74) | Phosphorus (P) (mg/g) LSD=(1.70) |
|---|---|---|---|---|
| | Stem | 18.96 ± 8.01 i | 105.79 ± 5.84 cd | 7.48 ± 0.89 bc |
| ***Citrullus colocynthis*** | Leaves | 155.62 ± 11.90 de | 108.53 ± 14.40 cd | 7.77 ± 1.2 ab |
| | Root | 186.96 ± 6.42 b | 108.14 ± 10.02 cd | 9.34 ± 1.31 a |
| ***Cressa cretica*** | Shoot | 17.34 ± 2.11 i | 39.10 ± 3.44 fg | 6.334 ± 1.08 bcde |
| ***Polygonum aviculare*** | Shoot | 27.18 ± 4.38 i | 98.77 ± 10.53 d | 5.62 ± 0.86 cde |
| | Leaves | 182.87 ± 6.52 bc | 270.71 ± 15.60 a | 5.05 ± 0.66 de |
| ***Orobanche aegyptiaca*** | stem | 234.95 ± 6.90 a | 119.93 ± 11.27 bc | 5.76 ± 1.08 cde |
| | Shoot | 172.28 ± 5.33 c | 134.61 ± 12.64 b | 5.91 ± 1.08 bcde |
| ***Euphorbia granulata*** | Root | 109.01 ± 3.56 g | 75.43 ± 11.11 e | 4.47 ± 0.66 e |
| | Shoot | 128.83 ± 6.75 f | 54.15 ± 10.59 f | 6.48 ± 0.43 bcd |
| ***Alhagi maurorum*** | Root | 79.520 ± 3.03 h | 13.75 ± 2.11 h | 7.05 ± 1.08 bc |
| | Leaves | 159.38 ± 9.23 d | 73.66 ± 8.93 e | 5.91 ± 0.66 bcde |
| ***Solanum xanthocarpus*** | Root | 84.74 ± 5.16 h | 12.55 ± 1.32 h | 7.20 ± 1.08 bc |
| | Leaves | 146.29 ± 13.09 e | 47.42 ± 3.92 f | 6.48 ± 1.72 bcd |
| ***Solanum surattense*** | Root | 111.69 ± 7.00 g | 27.70 ± 2.24 gh | 4.90 ± 0.66 de |

Values sharing the same letters in respective column differ non significantly; LSD= least significant difference

**Table 3. Quantitative Estimation for Concentrations of Sodium, Potassium and Phosphorus of Some Trees of Cholistan Desert**

| Species | Parts | Sodium ($Na^+$) (mg/g) LSD = (23.89) | Potassium ($K^+$) (mg/g) LSD = (14.10) | Phosphorus (P) (mg/g) LSD = (1.32) |
|---|---|---|---|---|
| | Root | 159.4 ± 25.17 c | 35.83 ± 3.84 d | 5.475 ± 0.66 ab |
| ***Capparis decidua*** | Stem | 15.40 ± 3.66 e | 132.6 ± 12.85 a | 3.182 ± 0.90 c |
| | Stem | 275.13 ± 10.91 b | 76.11 ± 5.24 c | 4.472 ± 0.66 bc |
| ***Tamarix aphylla*** | Leaves | 305.40 ± 5.91 a | 109.18 ± 8.90 b | 1.75 ± 0.43 d |
| ***Accacia nilotica*** | Stem | 87.67 ± 7.82 d | 19.32 ± 3.68 e | 5.90 ± 0.89 a |

Values sharing the same letters in respective column differ non significantly; LSD= least significant difference

Significant differences were observed in potassium concentration of herbs and were shown in Table 2. Maximum (270.71 mg/g) concentration of sodium was observed in leaves of *O. aegyptiaca* while minimum (17.34 mg/g ) was in root of *Solanum xanthocarpus* (5.91 mg/g). Root of *Euphorbia granulata* (75.43 mg/g) and leaves of *S. xanthocarpus* (73.66 mg/g) did not reveal significant difference. Significant differences were observed among shoot of *C. cretica* (39.10 mg/g), shoot of *P. aviculare* (98.77 mg/g), leaves of *O. aegyptiaca* (270.71 mg/g), stem of *O. aegyptiaca* (119.93 mg/g), shoot of *E. granulata* (134.61 mg/g) and root of *S. surattense* (27.70 mg/g).

Significant differences were observed in phosphorus concentration of herbs and it was represented in Table 2. Maximum (7.77 mg/g) concentration of phosphorus was noted in root of *C. colocynthis* (9.34 mg/g) while of that minimum concentration was observed in root of *E. granulata* (4.47 mg/g). Shoot of *A. marorum* (6.48 mg/g) and leaves of *S. surattense* (6.48 mg/g) did not show significant difference. Significant difference has also not been shown by leaves of *O. aegyptiaca* (5.05 mg/g) and root of *S. surattense* (4.90 mg/g).

**Concentration of ions in trees.** Sodium concentrations in trees showed significant differences and are revealed in Table 3. Maximum (305.40 mg/g) concentration of

sodium was recorded in leaves of *T. aphylla* while minimum (15.40 mg/g) was found in stem of *C. decidua*. A clear cut difference was observed in leaves of *T. aphylla* and stem of *C. decidua*. Sodium concentration In root of *C. decidua* (159.4 mg/g); stem of *T. aphylla* (275.13 mg/g) and stem of *A. nilotica* (87.67 mg/g) was revealed. Significant difference was observed among all of the tree species.

Significant differences were observed in potassium concentration of trees which are revealed in Table 3. The highest amount (132.6 mg/g) of potassium was found in stem of *C. decidua* and the lowest one (19.32 mg/g) in stem of *A. nilotica*. A considerable difference was shown among stem of *C. decidua* and stem of *A. nilotica*. Root of *C. decidua* showed (35.83 mg/g); stem of *T. aphylla* (76.11 mg/g) and leaves of *T. aphylla* (109.18 mg/g) potassium.

Significant differences were examined in phosphorus of trees and are shown in Table 3. Stem of *A. nilotica* showed the maximum concentration of phosphorus (5.90 mg/g) and minimum (1.75 mg/g) concentration was noted in leaves of *T. aphylla*. A concentration of (5.475 mg/g) phosphorus was observed in root of *C. decidua*; 4.472 mg/g in stem of *T. aphylla* and 3.182 mg/g in stem of *C. decidua*. The above mentioned results revealed that the concentration of sodium potassium and phosphorus were different not only in catagories of herbs, shrubs and trees but also in different organs of same plants (Tables 1-3). These results coincide with the findings of Arshad *et al.* [24] who reported the differences among nutrients concentrations of desert plants. Such variations in nutrients might be due to differences in nutrients abosrption, reabsorption and their utilization rates [25, 26]. Another cause might be that perennial plant shift nutrients from senescing organs to healthy living tissues before senescence [27–30]. This decreases the dependency of plant on soil nutrients and enables plant adaptability to infertile habitats [27, 31].

Salinity limits water absorption ad induces osmotic and ionic stress by potentially toxic salts within plant cells [32]. Differences among nutrients ions might be owed to many other reasons. Drought and salinity interaction in desert influences plant physiological activities including water potential, osmolytes concentrations, ions and water use efficiencies etc in stress tolerant species [33, 34]. $K^+/Na^+$ ratio is considered as a salt tolerance index [35]. Under low soil moisture, more $K^+$ is accumulated while more $Na^+$ is accumulated under more saline environment [36]. High soil $Na^+$ concentration reduce the availability of other ions [37], or $Na^+$ displaces membrane-bound $Ca^{+2}$ [38]. Salinity and water stress in desert soils tend to constrain nutrient resorption process by leaf [39]. Salinity and drought conditions may induce elevation in abscisic acid (ABA) concentration and weaken plant metabolic activities triggering earlier leaf senescence and nutrient retranslation [25, 39]. Drought conditions of desert also slow down the decomposition process in soil due to which desert plants had less chances of recuperate the lost nutrients from soil litter [40, 41]. Salt stress and drought condition of desert may contribute to variations in nutrients reabsorption and recycling in various groups of plants [42, 43]. Drought condition determines the efficiency of plant growth and other physiological functions [44]. Salinity stress directly or indirectly induces closing of stomata leading to a reduction in the nutrients and water transport [26, 45, 46]. Phosphorus availability more closely relates to moisture contents of soil so desert soils usually suffer phosphorus limitation more than that of nitrogen [46]. Ion accumulation in plants depends on its concentration in the soil.

Unilization of mineral nutrients in various metabolic activities might be another cause for their concentration differences. These play role in cell metabolism in addition to acting as structural moiety of plant tissues. These also are involved in water relations and acid-base balance [47]. Sodium is one of the major cations components in fluid of extra cellular nature. The high amount of sodium in plants is used in controlling acid-base balance in plant body. The low concentration of sodium might be owed to soil composition, climatic conditions or plant nutritional attributes [48]. The variations in potassium contents among the studied plants and their parts might be attributed to soil mineral composition differences, mineral absorption and storage, difference in botanical organ of plant or water and fertilizer availability [49]. The concentration of phosphate difference might be due to its involvement in metabolism to store energy and its transfer to formation of high energy bonds with adenosine triphosphate or diphosphate by ester linkage [50].

## Conclusion

The concentrations of various ions responsible for determination of ethnobotanical importance of plants differed in term of species, groups and various parts of the same plants. The Nutrional values and ethnobotanical uses of plants accordingly vary with respect to their groups, species and parts.

## Acknowledgment

The authors acknowledge the contribution of lab staff.

## References

[1] Fitzgerald, M., Heinrich, M., Booker, A. 2020. Medicinal Plant Analysis: A Historical and Regional Discussion of Emergent Complex Techniques. Front. Pharmacol. 10: 1480, https://doi.org/10.3389/fphar.2019.01480.

[2] Erdinc, C., Ekincialp, A., Turan, S., Kocak, M., Baloch, F.S., Şensoy, S. 2021. The first report about genetic diversity analysis among endemic wild rhubarb (*Rheum ribes* L.) populations through iPBS markers. Turk. J. Agric. Forest. 45(6): 784–796, https://doi.org/10.3906/tar-2102-12.

[3] Tamer, C.E., Temel, Ş.G., Suna, S., Karabacak, A.Ö, Özcan, T., Ersan, L.Y., Kaya, B.T., *et al*. 2021. Evaluation of bioaccessibility and functional properties of kombucha beverages fortified with different medicinal plant extracts. Turk. J. Agric. Forest. 45(1): 13–32, https://doi.org/10.3906/tar-2003-75.

[4] Akhtar, R., Arshad, M. 2006. Arid rangelands in the Cholistan desert (Pakistan). Sécheresse, 17(1): 210–217.

[5] Rasul, G., Mahmood, A., Sadiq, A., Khan, S.I. 2012. Vulnerability of the Indus Delta to Climate Change in Pakistan. Pak. J. Meteorol. 8(16): 89–107.

[6] Khan, A.A., Ruby, T., Naz, N., Rafay, M. 2017. Desert Ecosystem Management: A Sustainable and Wise Use. In Sandhu, H. (eds.), Ecosystem Functions and Management. Springer. Switzerland. pp. 85–99.

[7] Malik, S. Ahmad, S., Sadiq, A., Alam, K., Wariss, H.M., Ahmad, I., Hayat, M.Q., Anjum, S., *et al*. 2015. A comparative ethno-botanical study of Cholistan (an arid area) and Pothwar (a semi-arid area) of Pakistan for traditional medicines. J. Ethnobiol. Ethnomed. 11: 31, https://doi.org/10.1186/s13002-015-0018-2.

[8] Ahmad, Z., S.M. Khan, E.F. Abd_Allah, A.A. Alqarawi and A. Hashem. 2016. Weed species composition and distribution pattern in the maize crop under the influence of edaphic factors and farming practices: A case study from Mardan, Pakistan. Saudi J. Biol. Sci. 23(6): 741–748, https://doi.org/10.1016/j.sjbs.2016.07.001.

[9] ur Rahman, A., Khan, S.M., Ahmad, Z., Alamri, S., Hashem, M., Ilyas, M., Aksoy, A., *et al*. 2021. - Impactof multiple environmental factors on species abundance in various forest layers using an integrative modeling approach. Glob. Ecol. Cons. 29: e01712, https://doi.org/10.1016/j.gecco.2021.e01712.

[10] Arshad, M. and Akbar, G. 2002. Benchmark of plant communities of Cholistan desert. Pak. J. Biol. Sci. 5(10): 1110–1113, https://doi.org/10.3923/pjbs.2002.1110.1113.

[11] Shamim, T., Asif, H.M., Shaheen, G., Sumreen, L., Ayaz, S., Qureshi, T., Ghauri, A.O., *et al*. 2022. Anti-diabetic Potential of Indigenous Medicinal Plants of Cholistan Desert, Pakistan: A Review. Rev. Diabetic Stud. 18(2): 93–99, https://doi.org/10.1900/RDS.2022.18.93.

[12] Sati, V.P., Vangchhia, L. 2016. A Sustainable Livelihood Approach to Poverty Reduction: An Empirical Analysis of Mizoram, the Eastern Extension of the Himalaya, 1st ed. Springer. Switzerland.

[13] Sharma S. 2021. Neurotoxic Medicinal Plants of Indian Himalayan Regions: An Overview. In Agrawal, D.C., Dhanasekaran, M. (eds.), Medicinal Herbs and Fungi. Springer. Singapore. pp. 469–493.

[14] Faruque M.O. 2018. Quantitative Ethnobotany of Medicinal Plants Used by Indigenous Communities in the Bandarban District of Bangladesh. Front Pharmacol. 9: 40, https://doi.org/10.3389/fphar.2018.00040.

[15] Azhar,M.F., Aziz, A, Ali,E. 2022. Assessment of medicinal folklores and chemical composition of *Aerva javanica* (Burm. f.) Juss. Ex Schult.) in Cholistan desert of Pakistan. Ethnobot. Res. Applicat. 24: 1–10, http://dx.doi.org/10.32859/era.24.32.1-10.

[16] Ganie, S.H., Upadhyay, P., Das, S., Sharma, M.P. 2015. Authentication of medicinal plants by DNA markers. Plant Gene. 4: 83–99, https://doi.org/10.1016/j.plgene.2015.10.002.

[17] El-Tayeh, N.A., Galal, H.K., Soliman, M.I., Zaki, H. 2020. Association of Morphological, Ecological, and Genetic Diversity of *Aerva javanica* Populations Growing in the Eastern Desert of Egypt. Agronomy. 10(3): 402, https://doi.org/10.3390/agronomy10030402.

[18] Zaynab, M., Fatima, M., Abbas, S., Sharif, Y., Umair, M., Zafar, M.H., Bahadar, K. 2018. Role of secondary metabolites in plant defense against pathogens. Microb. Pathog. 124: 198–202, https://doi.org/10.1016/j.micpath.2018.08.034.

[19] Phumthum, M., Balslev, H. 2019. Use of Medicinal Plants Among Thai Ethnic Groups: A Comparison. Econom. Bot. 73: 64–75, https://doi.org/10.1007/s12231-018-9428-0.

[20] Arshad, M., Rao, A. 1994. Flora of the Cholistan desert: systematic list of trees, shrubs and herbs. J. Econ. Taxon. Bot. 18: 615–625

[21] Yasin, G., Anwer, I., Altaf, A. and Saima, S. 2021. Floristic Indices and Nutritional Ions of Some Medicinal Plants along Sand Dunes Altitude in Cholistan desert of Pakistan. Sindh Univ. Res. J. (Sci. Ser.). 53: 12–20.

[22] Zhang, M. X., Dong, Z., Li, H. L., Wang, Q., Liang, Y., and Han, X. F. 2018. Improvement Effects of Different *Ulmus pumila* strains on coastal saline alkali soil and distribution and absorption of salt ions. J. Soil Water Cons. 32: 340–345, https://doi.org/10.13870/j.cnki.stbcxb.2018.06.049.

[23] Khalid, Z., Yasin, G., Altaf, A., Batool, S.A., Kanwal, A., Sohai, S. 2021. Phytopharmacological Assessment of Some Medicinal Plants of Thal Desert of Pakistan. J. Pharm. Res. Int. 33(31A): 217–226, https://doi.org/10.9734/jpri/2021/v33i31A31687.

[24] Arshad, M., Anwar,H., Ashraf, M.Y., Noureen, S., Moazzam, M. 2008. Edaphic factors and distribution

of vegetation in the Cholistan desert, Pakistan. Pak. J. Bot. 40(5): 1923–1931.

[25] Drenovsky, R.E., Richards, J.H. 2006. Low leaf N and P resorption contributes to nutrient limitation in two desert shrubs. Plant Ecol. 183: 305–314, https://doi.org/10.1007/s11258-005-9041-z.

[26] Yang, Y., Liu, B.R., An, S.S. 2018. Ecological stoichiometry in leaves, roots, litters and soil among different plant communities in a desertified region of Northern China. Catena. 166: 328–338, https://doi.org/10.1016/j.catena.2018.04.018.

[27] Aerts, R. 1996. Nutrient resorption from senescing leaves of perennials: Are there general patterns. J. Ecol. 8494): 597–608.

[28] Brant, A.N., Chen, H.Y.H. 2015. Patterns and Mechanisms of Nutrient Resorption in Plants. Crit. Rev. Plant Sci. 34(5): 471–486, https://doi.org/10.1080/07352689.2015.1078611.

[29] Han, W.X., Tang, L.Y., Chen, Y.H., Fang, J.Y. 2013. Relationship between the relative limitation and resorption efficiency of nitrogen vs phosphorus in woody plants. PLoS One. 8(12): e83366, https://doi.org/10.1371/journal.pone.0083366.

[30] Killingbeck, K.T., Whitford, W.G. 2001. Nutrient Resorption in Shrubs Growing by Design, and by Default in Chihuahuan Desert Arroyos. Oecologia. 128(3): 351–359.

[31] Drenovsky, R.E., James, J.J., Richards, J.H. 2010. Variation in nutrient resorption by desert shrubs. J. Arid Environ. 74(11): 1564–1568, https://doi.org/10.1016/j.jaridenv.2010.05.030.

[32] Youssef, A.M., Al-Fredan, M.A. 2008. Community Composition of Major Vegetations in the Coastal Area of Al-Uqair, Saudi Arabia in Response to Ecological Variations. J. Biol. Sci. 8(4): 713–721, https://doi.org/10.3923/jbs.2008.713.721.

[33] Nunes, C., de Sousa Araújo, S., da Silva, J.M., Fevereiro, M.P.S., da Silva, A.B. 2008. Physiological responses of the legume model *Medicago truncatula* cv. Jemalong to water deficit. Environ. Exp. Bot. 63(1–3): 289–296, https://doi.org/10.1016/j.envexpbot.2007.11.004.

[34] Aziz, I., Gul, B., Gulzar, S., Khan, M.A. 2011. Seasonal variations in plant water status of four desert halophytes from semi-arid region of Karachi. Pak. J. Bot. 43(1): 587–594.

[35] Morant-Manceau, A., Pradier, E., Tremblin, G. 2004. Osmotic adjustment, gas Exchanges and chlorophyll fluorescence of a hexaploid triticale and its parental species under salt stress. J. Plant Physiol. 161(1): 25–33, https://doi.org/10.1078/0176-1617-00963.

[36] Glenn, E., Pfister, R., Brown, J.J., Thompson, T.L., O'leary, J.W. 1996. Na and K Accumulation and Salt Tolerance of *Atriplex Canescens* (Chenopodiaceae) Genotypes. Am. J. Bot. 83(8): 997–1005, https://doi.org/10.2307/2445988.

[37] Wang, S., Wan, C., Wang, Y., Chen, H., Zhou, Z., Fu, H., Sosebee, R.E. 2004. The characteristics of Na+, K+ and free proline distribution in several drought-resistant plants of the Alxa desert, China. J. Arid Environ. 56(3): 525–539, https://doi.org/10.1016/S0140-1963(03)00063-6.

[38] Khan, M.A., Ungar, I.A., Showalter, A.M. 2000. Effects of Salinity on Growth, Water Relations and Ion Accumulation of the Subtropical Perennial Halophyte, *Atriplex griffithii* var. stocksii. Ann. Bot. 85(2): 225–232.

[39] Zhang, M.X., Luo, Y., Yan, Z.B., Chen, J., Eziz, A., Li, K.H., Han, W.X. 2019. Resorpt of 10 mineral elements in leaves of desert shrubs and their contrasting responses to aridity. J. Plant Ecol. 12(2): 358–366, https://doi.org/10.1093/jpe/rty034.

[40] He, M.Z., Dijkstra, F.A. 2014. Drought effect on plant nitrogen and phosphorus: a meta-analysis. New Phytol. 204(4): 924–931, https://doi.org/10.1111/nph.12952.

[41] Huang, G., Su, Y.G., Mu, X.H., Li, Y. 2018. Foliar nutrient resorption responses of three life-form plants to water and nitrogen addition in a temperate desert. Plant Soil. 424: 479–489, https://doi.org/10.1007/s11104-017-3551-z.

[42] Wang, L.L., Wang, L., He, W.L., An, L.Z., Xu, S.J. 2017. Nutrient resorption or accumulation of desert plants with contrasting sodium regulation strategies. Sci. Rep. 7: 17035, https://doi.org/10.1038/s41598-017-17368-0.

[43] Pan, J., Peng, F., Tedeschi, A., Xue, X., Wang, T., Liao, J., Zhang, W., Huang, C. 2020. Do halophytes and glycophytes differ in their interactions with arbuscular mycorrhizal fungi under salt stress? A meta-analysis. Bot. Stud. 61: 13, https://doi.org/10.1186/s40529-020-00290-6.

[44] Horie, T., Karahara, I., Katsuhara, M. 2012. Salinity tolerance mechanisms in glycophytes: An overview with the central focus on rice plants. Rice. 5: 11, https://doi.org/10.1186/1939-8433-5-11.

[45] Ellouzii, H., Hamed, K.B., Hernández, I., Cela, J., Müller, M., Magné, C., Abdelly, C., Munné-Bosch, S. 2014. A comparative study of the early osmotic, ionic, redox and hormonal signaling response in leaves and roots of two halophytes and a glycophyte to salinity. Planta. 240(6): 1299–1317, https://doi.org/10.1007/s00425-014-2154-7.

[46] Delgado-Baquerizo, M., Maestre, F.T., Gallardo, A., Bowker, M.A., Wallenstein, M.D., Quero, J.L., Ochoa, V., *et al*. 2013. Decoupling of soil nutrient cycles as a function of aridity in global drylands. Nature. 502: 672–676.

[47] Humphry, C.M., Clegg, M.S., Keen, C.L., Grivetti, L.E. 1993. Food diversity and drought survival. The Hausa example. Int. J. Food Sci. Nutr. 44(1): 1–16, https://doi.org/10.3109/096374893090 17417.

[48] Hamurcu, M., Ozcan, M.M., Dursun, N., Gezgin, S. 2010. Mineral and heavy metal levels of some fruits

grown at the roadsides. Food Chem. Toxicol. 48(6): 1767–1770, https://doi.org/10.1016/j.fct.2010.03.0 31.

[49] Masson, P., Dalix, T., Bussière, S. 2010. Determination of Major and Trace Elements in Plant Samples by Inductively Coupled Plasma-Mass Spectrometry. Commun. Soil Sci. Plant Anal. 41(3): 231–243, https://doi.org/10.1080/00103620903460757.

[50] Tarmizi, S.A., Wattoo, M.H.S., Iqbal, J., Wattoo, F.H., Kanwal, S. 2005. Inorganic nutrients of *Saccharum bengalense*. J. Chem. Soc. Pak. 27: 186–189.