Global Veterinaria 18 (6): 399-405, 2017
ISSN 1992-6197

DOI: 10.5829/idosi.gv.2017.399.405

Evaluation of Macro-mineral Concentration in Soil and *Atriplex halimus* from South East of Algeria in Relation to Ruminants Requirements

[1]Hadda Arab, [1]Smail Mehennaoui and [2]Mohamed-Laid Haddi

[1]Environment, Health and Animal Production Laboratory Veterinary and Agronomy Institute, Veterinary Department. University Hadj Lakhdar. Batna 1, 05000, Algeria
[2]Department of Microbiology. Laboratory of Mycology, Biotechnology and Microbial Activities, Faculty of Natural and life Sciences. University Constantine 1, 25000, Algeria

Abstract: Major minerals was evaluated in soil and *Atriplex halimus* collected from South-East of Algeria during the year. The soil and plant samples were taken from ten random locations in studied area each season. Seasonal effect ($P<0.001$) was observed for all major minerals except for Sodium (Na) in soil and *Atriplex halimus*. Soil moisture decreased in summer and autumn. Soil type is silt-clay and calcareous and its pH was slightly alkaline pH (7.5- 8.5). *Atriplex halimus* was succulent during autumn and driest in spring. Soil Calcium (Ca) levels were higher ($P<0.05$) during summer than in other seasons. Na concentrations in whole plant were high in all seasons whereas Phosphorus (P) levels were low. Potential intake of Ca, Magnesium (Mg), Na and Potassium (K) by range ruminants consuming this shrub was sufficient to satisfy their requirements. However, consumption of P was low. Ruminants grazing this shrub must be supplemented with P throughout the year for better performance.

Key words: Arid Soil · *Atriplex halimus* · Major Mineral · Halophyte Shrubs

INTRODUCTION

In arid areas, rangelands constitute the main source of ruminants production. However, their irrational use caused a continuous degradation of these resources. Browse plants represent an important fodder reserve for livestock in harsh conditions that can be used by grazing ruminants. In these areas, a major constraint to livestock production is the scarcity and fluctuating quantity and quality of the year-round feed supply [1]. The low forage production has motivated the use of shrub and tree fodders as feed resources for ruminants [2] in order to satisfy all of their nutritional requirements. In arid areas of Algeria, the climate variation leads to drought that becomes a constraint for the plant biodiversity [3].

In South-East of Algeria, El-Haouch is considered as an extremely arid zone, small ruminants feeding are largely dependent on pasture grasses and cereal residues. Additionally, fodder trees and shrubs have also played an important role in feeding livestock throughout the year. Drought and salinity are the major limiting factors that adversely affect the growth and development of plants, agricultural productivity and caused disappearance of some plant species [4]. Halophytic plants are the endemic species grazed specially by small ruminants and camels in this region. These groups of plants tolerate a high level of salinity and display optimal growth in saline conditions [5]. Most of the farmers are traditional-small holder nomads doing transhumance each year. However, the information on the nutritive value of these plants is scarce especially their mineral content. The potential of any feed to support animal production depends on the quantity consumed by ruminants and the extent to which the feed meets energy, protein vitamin and mineral requirements [6]. The physio-gnomical map of this area vegetation reveals the predominance of *Atriplex halimus* with 0.7 tons /hectare [7]. It is a perennial shrub tolerates well harsh conditions: drought, salinity, water stress and cold. This species is very palatable and is the preferred fodder of livestock during dearth periods, endowed with a

Corresponding Author: Hadda Arab, Environment, Health and Animal Production Laboratory Veterinary and Agronomy Institute. Veterinary Department. University Hadj Lakhdar. Batna 1, 05000. Algeria.

complex root system and a considerable biomass [8]. This forage plants are relatively high in crude protein, organic matter and ash 13%, 78% and 15% DM basis respectively [7] and reveal their nutritive potential through their leaves.

Majors and trace minerals are essential for ruminants for getting optimum production, deficiency and excess of these elements cause poor performance [9]. Indeed deficiency of macro and micro-minerals in the ration of dairy cows adversely affects growth, milk production and reproduction efficiency [10]. The concentration of minerals in plants is dependent upon interactions among a number of factors including soil type, plant species, stage of maturity, dry matter yield, grazing management and climate [11]. The knowledge of the level of minerals concentration present in this shrub may suggest minerals supplementation strategies to get better growth and reproductive efficiency of the ruminants. The purpose of this study was to evaluate the major mineral concentration of soil and *Atriplex halimus* seasonally during the year. This knowledge will lead to a better understanding on mineral status in soil and plant, as indicators of mineral contribution, deficiencies or excess during each season for enhanced nutrition of grazing small ruminants in this area.

MATERIALS AND METHODS

Site Description: The study was conducted in El-Haouch near Biskra in the South-East Algeria (5° 52’ E longitude, 34° 39’ N latitude). The climate of this grazing zone is arid with an average annual rainfall of 147 mm year mainly during the end of autumn to the beginning of spring. The average minimum winter and maximum summer temperature are 7°C in January and 41°C in July [3]. According to Bazri and Ouahrani [12] in the same locality, the natural vegetation is presented mainly by halophytes plants include *Atriplex halimus* (11.68%), *Astractylis aristata* (10.66%), *Salsola vermiculata* (8.63%), *Suaeda vermiculata* (8.12), *Centaura pungens* (6.60%) and *Anabasis articulat*a (5.58%). Our focus has been on *Atriplex halimus* following its predominance in harsh environmental conditions and constitutes a solution to feed shortage that occurs during drought and dormant seasons for small-ruminants.

Sample Collection and Preparation for Analysis: Soil and plant samples were collected during four seasons from ten random locations during 2014-2015. Distance between different sampling positions varied from 10 to 15 m. Plant samples were clipped with stainless steel scissors and placed in plastic bags, then dried in oven at 55°C for 72 h [13]. Ground samples were collected using a 1 mm stainless steel sieve. The ground samples were stored in closed bottles awaiting chemical analysis. Calcium (Ca), magnesium (Mg), sodium (Na) and potassium (K) were determined after wet digestion in nitric acid and perchloric acid [13]. The photometric method using molybdovanadate was used to measure phosphorus (P) concentration [7]. Soil samples were taken near the clipped forage plant at 20 cm depth, using a soil auger. Samples were collected in paper bags, dried at 65°C for 72 h and passed through a 2 mm sieve. Soil moisture was measured by weighing each sample, oven dried at 136°C for 24 h and reweighed to determine the water loss [5]. The soil pH and the grain size distributions were determined according to the technique recommended by ISRIC [14]. To prepare samples for Ca, Mg, Na and K determinations, one gram of ground sample of soil was boiled in 10 ml of aqua regia (A mixture of HNO_3 and HCL : 1/3 ratio) for 2 h at 100°C [3]. The extract was cooled and filtered using Whatman filter paper (N° 540) and diluted to 50 ml with distilled water. Major minerals in soil and *Atriplex halimus* were measured using flame Atomic Absorption Spectrophotometry (Shimadzu model AA 6800).

Statistical Analysis: The data were analyzed by the Statistical Analysis System software [15]. One way analysis of variance was used to discriminate between the seasons. The Student Newman Keuls was used for mean classification and significance level was set at $P<0.05$. Correlation coefficients of soil-plant mineral concentrations were determined after pooling the data for mineral levels of soil and *Atriplex halimus*.

RESULTS AND DISCUSSION

Soil and *Atriplex Halimus* Analysis: Soil texture in study area is silt-clay. The means level of soil moisture varied from 1.76±1.35 to 3.70±1.7%. The low level was recorded in summer (Figure 1). A significant ($P<0.05$) decrease in soil moisture was observed during summer and autumn. These values were lower than those reported by Nedjimi [5] in Djelfa (Algeria), with a mean annual precipitation of 250 mm year. The low percentage of moisture in the soil results in reduced mobility and dissolution of the mineral substances [16] and even its transport to the root zone.

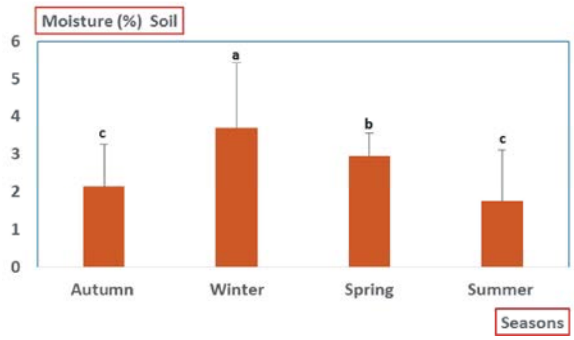

Fig. 1: Seasonal variation of moisture in soil from El-Haouch area. Values represent means±SD (n =10) Different letters above bars indicate significant difference at the 5% level.

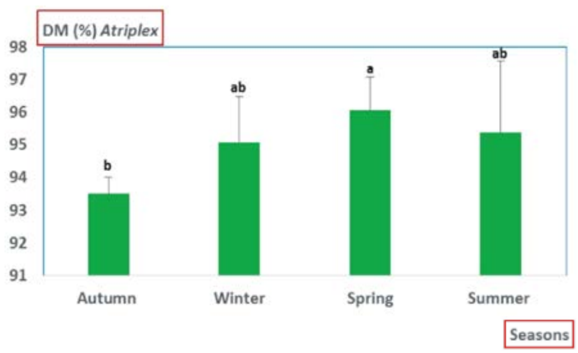

Fig. 2: Seasonal variation in dry matter (DM) of *Atriplex halimus.* Values represent means±SD (n =10) Different letters above bars indicate significant difference at the 5% level.

The average dry matters (DM) in *Atriplex halimus* are low in autumn and high in spring (Figure 2). A similar values (P>0.05) were revealed in winter and summer, 95.1±1.40 versus 95.4±2.21% respectively. The high dry matter content in *Atriplex halimus* results in an increased needs of water for the animals consuming this shrub. In addition, high levels of DM are known as limiting factors for the digestibility of the fodder concerned.

Mineral elements exist in the cells and tissues of the animal body. Livestock usually derive most of their dietary nutrients from the feed they eat; however, significant quantities of minerals may be obtained from water, soil consumption and feed contamination [11]. The concentrations of essential elements must usually be maintained within quite narrow limits if the functional and structural integrity of the tissues is to be safeguarded and the growth, health and productivity of the animal are to remain unimpaired [17]. Soil is a major source of minerals for plants, animals and human being. Mineral plant nutrition consists in optimizing the various variables in order to maximize the productivity, the quality and the profitability of the plants. Mineral uptake by plants and hence their mineral composition are greatly influenced by soil pH. The pH of the soil determines the availability of major and minor mineral elements. In this study pH mean levels varied from 7.97±0.15 in spring to 8.30±0.34 in summer (Table 1). Similar values (P>0.05) were observed in all seasons except for summer season (P<0.05). This range is in agreement with that reported by Nedjimi [5]. Macronutrients (N, K, Ca, Mg and S) are more readily available at a pH from 6.5 to 8. However, phosphorus is widely available at a pH from 6 to 7 [16].

Major mineral concentration in soil and *Atriplex halimus* are presented respectively in Table 1 and 2. Mean soil calcium concentration varied significantly (P<0.001) from one season to another (Table 1). The high level was observed in summer, whereas the levels during winter and spring seasons were similar (P>0.05). Mean calcium levels in all seasons are higher than the critical level of 72 mg/kg in soil suggested by Rhue and Kidder [18] for optimal plant growth. Calcium constitute an essential part of the plant cell wall, provides support, rigidity and strength. High Ca level in study area may be a result of high level of calcium carbonate ($CaCO_3$) and other Ca salt in soil. Soil Ca concentrations in the present study disagreed with those recorded in in Pakistan [6] and in Djelfa of Algeria [5] due to the difference in climate and the texture of the soil.

Table 1: Mean concentration (±SD) of major minerals in soil and pH during the different seasons

Season	Ca (g/kg DM)	Mg (g/kg DM)	Na (g/kg DM)	K (g/kg DM)	pH
Autumn	$173^{b}\pm49$	$33^{a}\pm3.2$	4.03±2.6	$6^{b}\pm2.6$	$8.0^{b}1\pm0.20$
Winter	$133^{c}\pm15.04$	$31.42^{a}\pm3$	3.65±1.44	$4.50^{c}\pm0.95$	$8.08^{b}\pm0.19$
Spring	$126.5^{c}\pm37$	$31^{a}\pm4$	3.77±3.43	$6.86^{a}\pm1.54$	$7.97^{b}\pm0.15$
Summer	$205^{a}\pm59.3$	$10^{c}\pm3.4$	1.60±1.53	$3.60^{c}\pm1.37$	$8.30^{a}\pm0.34$
Season effect	P<0.001	P<0.001	ns	P<0.001	P<0.05
Critical values$^{(*)}$ (mg/ kg)	< 72	30	< 62	80 $^{(**)}$	-

Means with different letters in the same column are significantly different.

(*): According to Rhue and Kidder [18]

(**): As reported by Khan *et al*. [29]

Table 2: Mean concentration (±SD) of major minerals in *Atriplex halimus* during the different seasons

Season		Ca (g/kg DM)	P (g/kg DM)	Mg (g/kg DM)	Na (g/kg DM)	K (g/kg DM)
Autumn		$3.78^{d}\pm1.64$	$0.99^{c}\pm0.22$	$9.43^{b}\pm2.64$	49.1±6.35	$9.54^{b}\pm3.70$
Winter		$10.85^{a}\pm1.12$	$1.26^{b}\pm0.29$	$19.42^{a}\pm3.24$	50.3±5.53	$7.74^{c}\pm2.30$
Spring		$5.54^{c}\pm0.99$	$3.13^{a}\pm1.80$	$18.38^{a}\pm1.71$	46.33±4.17	$15.44^{a}\pm3.33$
Summer		$6.47^{b}\pm6.02$	$1.02^{c}\pm0.29$	$6.74^{c}\pm1.37$	49.37±16	$14.5^{a}\pm4.50$
Season effect		P<0.001	P<0.001	P<0.001	ns	P<0.001
Normal requirement range (g/ kg DM) *	Minimum	1.9	1.2	-	0.6	5
	Maximum	8.2	4.8	-	1.8	10
Goat requirements (g/kg DM) **	2.6	2.7	1.7	0.7	2.2	

Means with different letters in the same column are significantly different.

ns: non-significant.

*: Recommended range of mineral elements as suggested by NRC [19] in Ghazanfar *et al*. [9]

**: Recommended requirement by Kessler [20] in Ramirez-Orduna *et al*. [2]

The mean Ca concentration in *A. halimus* ranged from 3.78±1.64 to 10.85±1.12 g/ kg DM. A significant season effect (P<0.001) was observed (Table 2). A high level was observed in winter 10.85±1.12 g/kg DM compared to summer (6.47±6.02 g/kg DM). High Ca levels in both seasons may be explained by the lowest rainfall and by a characteristic process of adaptation in the response of the plant to hydric stress. Forage Ca requirements of grazing ruminants is a subject of considerable debate as the requirement is influenced by animal type and level of production, age and weight. Calcium is the most abundant mineral in the the skeleton (99%) of the body [17]. Calcium is essential for the activity of a number of enzyme systems, including those necessary for the transmission of nerve impulses and for the contractile properties of muscle. It is also concerned in the coagulation of blood. Maintenance, growing and lactating sheep requirement for Ca was recommended to be 1.2 – 2.6/kg [11].

As reported by Mirzaei [11], NRC [19] and Kessler [20], the results of the current study considered that Ca values found in *Atriplex halimus* were adequate for optimum performance of ruminants (Table 2). Calcium deficiency produces osteomalacia in adulte and rickets in young growing animals [21]. High calcium is not generally regarded as a toxic element, because homeostatic mechanisms ensure that excess dietary calcium is extensively excreted in feces [17]. This study reported no relationship between Ca levels in soil and Ca contents in *Atriplex halimus* (r = 0.030; P>0.05).

The phosphorus status of forages varied widely and is influenced by the phosphorus status of the soil, the stage of maturity of the plant and the climate [17]. Phosphorus level in *Atriplex halimus* varied significantly (P<0.001) from 0.99±0.22 to 3.13±1.80 g/kg DM (Table 2). The highest level was recorded in spring and the lowest was observed in autumn. Similar findings were reported by Ramirez-Orduna *et al*. [2] in Mexico and by Ghazanfar *et al*. [9] in Pakistan. Variable content of P in different seasons could be due to variability in the available soil P and soil pH. Generally, contents of minerals in forages including P decrease with plant maturity. At a neutral or alkaline pH, phosphorus forms insoluble complexes with iron and aluminum or with calcium and magnesium [22]. The low P concentration in *A. halimus* is most probably due to its low availability in the soil. Those concentrations are marginally below the critical levels for ruminant requirements except during spring (Table 2). A severe P deficiency (< 1g / kg DM) leads to locomotors disorders followed by paralysis of the rear end and spontaneous fractures are observed in cattle and small ruminants [23]. The loss of appetite caused by phosphorus deprivation is often paralleled by a craving for and a consumption of abnormal materials, such as soil, wood, flesh and bones [17]. Ramirez-Orduna *et al*. [2] reported that the P daily requirements by range goat consuming shrubs evaluated in California might not meet goat requirements. This situation became more severe during the reproductive performance of goats, affecting the frequency of multiple fetuses.

Ca: P ratio in *Atriplex halimus* varied from 2 to 1. Low P and high Ca concentration resulted in an unusually wide Ca: P ratios. However, it seems that ruminants can sustain high Ca: P ratio, until 16, without affecting P metabolism [23].

Statistical analysis showed that soil Mg concentration was affected significantly (P<0.001) by season (table 1). Mean soil magnesium ranged from 10±3.4 in summer to 33±3.2 g/kg DM in autumn. Similar values were observed in autumn, winter and during spring (P>0.05). Those values were higher than those reported in Sargodha of Pakistan [24]. Mg levels of soil samples whatever the seasons were above the critical level of 30 mg/kg [6, 18] for Mg concentration (Table 1).

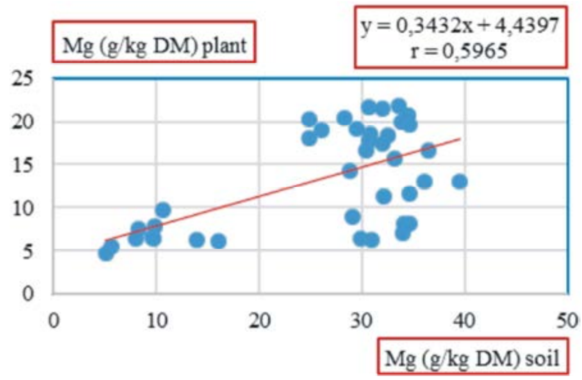

Fig. 3: Correlation between magnesium levels in soil and in *Atriplex halimus*

Mg concentration in *Atriplex halimus* showed a significant effect (P<0.001) in different seasons (Table 2). Similar values were observed in winter and spring (P>0.05). Mean Mg levels ranged from 6.74±1.37 in summer to 19.42±3.24 g/kg DM in winter (Table 2). This range is in agreement with that reported by Van Niekerk *et al.* [25] in the same shrub from South Africa. However, Mg levels in the same shrubs growing in Nigeria [26], California and Mexico [2] had lower Mg than those studied in the current research. The magnesium content of herbage plants vary with the species and with the soil and climatic conditions in which the plants are grown [17]. According to the theoretical requirement of Mg recommended for goats (1.7 g/kg M) [2] and those recommended for beef cattle and for lactating cows ranged from 1.2 to 2.1 g/kg DM [11]. The Mg content of *Atriplex halimus* is high enough to fulfill the requirements for small and large ruminants. However, the dietary Mg availability to stock is markedly affected by other dietary components, especially K; high dietary levels of K and N will inhibit Mg absorption from the rumen [11]. A simple deficiency of magnesium in the diet leads to decreased appetite and fibers digestibility of plant fibers in ruminants. A sharp deficiency of Mg is manifested by a hypomagnesaemic tetany and nervous signs [23]. A positive significant correlation was observed between the levels of soil Mg and plant Mg (r = 0.5965; P<0.05), which indicate that Mg concentrations in plant are depending on Mg concentrations in soil (Figure 3).

Mean soil sodium levels did not differ significantly (P>0.05) between seasons (Table 1). Conversely, Nedjimi [5] and Khan *et al.* [6] reported a seasonal variation in Na content. Means Na values ranged from 1.60±1.53 to 4.03±2.6 g/ kg DM in summer and autumn (Table 1).

The lowest soil sodium in summer was probably due to the accumulation of dissolved salts such as NaCl on the surface forming a salty crust. Those distinct accumulations are represented by calcium carbonate, gypsum and very soluble salts at the surface [27]. Sodium is necessary for the optimal growth of plants at low concentrations. The mean soil Na concentration was higher than the critical level of 62 mg/kg as stated by Rhue and Kidder [18]. In halophyte plants such as *Atriplex halimus,* sodium can replace certain minerals like potassium and is accumulated in high levels in its aerial parts. Na level in *Atriplex halimus* did not differ significantly (P>0.05) among seasons (Table 2). Mean Na in *Atriplex halimus* ranged from 46.33±4.17 to 50.3±5.33 g/kg DM (Table 2). This range is in disagreement with other reports [2, 6, 9, 26]**.** Na concentrations in studied plant in different seasons were higher than the critical levels for ruminants as suggested by NRC (Table 2). The high Na level in *Atriplex halimus* might refer to the possibility of this plant tolerates not only high level of salinity but displays optimal growth in saline conditions [5]. High quantities of salt are sequestrated in vacuoles for osmotic adjustment and the surplus is excreted through specialized cells termed trichomes covering the leaf surface [28].

When the soil becomes driest, salt concentrations increase, osmotic potential become more negative; desert plants accumulate Na in order to improve water and saline stress. Most of the sodium of the animal body is present in the soft tissues and body fluids. Sodium is concerned with the acid–base balance and osmotic regulation of the body fluids [21]. It is reported that an adequate range from 1 to 4 g/kg of Na has been recommended for ruminants [1]. The high levels of Na in *Atriplex halimus* may depress digestibility and lead to energy losses, associated with low digestibility. Na toxicity is indicated clinically by anorexia and water retention and physiologically by intracellular dehydration, due to hypertonicity of the extracellular fluid (ECF), with sodium and chloride both contributing to disturbances [17]. There was a negative low relationship between Na levels in soil and Na levels in *Atriplex halimus* (r = - 0.1833; P>0.05).

Mean K levels in soil ranged from 3.60±1.37 in summer to 6.86±1.54 g/kg in spring (Table 1). There was a significant difference between seasons (P<0.001). K is a regulator of plant growth functions; it is required for photosynthesis and synthesis of carbohydrates and proteins. Soil K concentrations were higher than the critical level of 80 mg/kg as reported by Khan *et al*. [29] for optimal plant growth. The values of K in soil in

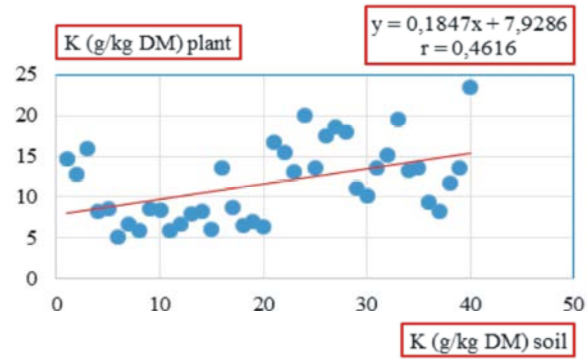

Fig. 4: Correlation between potassium levels in soil and in *Atriplex halimus*

the present study were higher than those reported by Shisia *et al*. [30] in Kenya and by Khan *et al*. [29] in central Punjab, Pakistan. Mean K concentrations determined in *Atriplex halimus* varied significantly ($P<0.001$) from 7.74±2.30 in winter to 15.44±3.33 g/kg in spring (Table 1). This range is in agreement with previous records [2, 11, 31]. Similar values were noted during spring and summer ($P>0.05$). Potassium is the major intracellular ion in animal tissues. This element plays a very important part, along with sodium, chlorine and bicarbonate ions, in osmotic regulation of the body fluids and in the acid–base balance in the animal [21]. K concentrations whatever the seasons were sufficient for the requirements ruminants as suggested by NRC (Table 2). It is reported that seasonal variation in K concentration might be related to water availability, because K absorption by the root is linked to soil moisture [2].

Additionally, salt ions such as Na^+, Cl^-, Mg^+ and SO_4^- can induce nutrients deficiencies by limiting uptake of essential nutrients such as K^+, Ca^{2+}, HPO_4, NH_4^+ and NO_3^- [2]. The decrease of K contents in *Atriplex halimus* leaves can be explained by a K competition with Na for the same binding sites or it might be due to a down regulation of the genes engaged in K transport [28]. Therefore, in this study high Na concentration and water stress during winter might be the cause for the low K concentration in *Atriplex halimus*. A dietary excess of potassium is normally excreted rapidly from the body, mainly in the urine. The high intake of the element may interfere with the absorption and metabolism of magnesium in the animal, which may be an important factor in the etiology of hypomagnesaemic tetany [21].

As for Mg, a positive correlation was observed between soil and plant studied K ($r = 0.4616$; $P<0.05$), which indicates that the K contents vary in a linear way and in the same direction for the soil and for *Atriplex halimus* (Figure 4).

CONCLUSION

Our results indicated that major mineral Ca, Mg, Na and K in soil were above recommended levels for growth plants. Mineral concentration in *Atriplex halimus* were affected by climatic conditions and soil type. This shrub was found to be high salt tolerant. The Ca, Mg, Na and K concentration in whole plant were at sufficient level to meet the requirement of ruminants. The P concentrations in shrub were minimal in terms of requirements and Ca: P ratios may present a problem in terms of P utilization. This deficiency may be a limiting factor for the local production of ruminants that graze this forage alone. The low P level most probably due to the calcareous and alkaline soil. Supplementation of P should be considered with this plant as the only forage. It is necessary to take into consideration the results obtained in order to formulate an adequate mineral supplement to the ruminants which consume this forage shrub.

REFERENCES

1. Ammar, H., S. Lopez and J.S. Gonzalez, 2005. Assessment of the digestibility of some Mediterranean shrubs by in vitro techniques. Animal Feed Science and Technology, 119: 323-331.
2. Ramirez-Orduna, R., R.G. Ramirez, H. Gonzalez-Rodriguez and G.F.W. Haenlein, 2005. Mineral content of browse species from Baja California Sur, Mexico. Small Ruminant Research, 57: 1-10.
3. Arab, H., M.L. Haddi, A. Boudaoud and S. Mehennaoui, 2016. Seasonal variation of Cu, Zn, Mn and Fe levels in soil and Atriplex halimus in arid zones of South East Algeria. Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7(6): 1727-1733.
4. Belkhodja, B. and A. Benaldj, 2007. The eco physiological interest of halophytic plants in the rehabilitation of arid and semi-arid areas in Algeria. In African Crop Science Society, 8: 1699-1702.
5. Nedjimi, B., 2012. Seasonal variation in productivity, water relations and ion contents of Atriplex halimus spp. schweifurthii grown in Chott Zehrez wetland, Algeria. Journal of the Saudi Society of Agricultural Sciences, 11: 43-49.

6. Khan, Z.I., M. Ashraf, E.E. Valeem, K. Ahmed and M. Danish, 2007. Pasture concentration of minerals in relation to the nutrient requirements of farm livestock. Pakistan Journal of Botany, 39(6): 2183-2191.
7. Haddi, M.L., H. Arab, F. Yaacoub, J.L. Hornick, F. Rollin and S. Mehennaoui, 2009. Seasonal changes in chemical composition and in vitro gas production of six plants from Eastern Algerian arid regions. Livestock Research of Rural Development, 21(4): 1-11.
8. Walker, D.J., S. Lutts, M. Sanchez-Garcia and E. Correal, 2014. Atriplex halimus L.: Its biology and uses. Journal of Arid Environments, 100 (10): 111-121.
9. Ghazanfar, S., A. Latif, I.H. Mirza and M.A. Nadeem, 2011. Macro-minerals concentrations of major fodder tree leaves and shrubs of District Chakwal, Pakistan. Pakistan Journal of Nutrition, 10(5): 480-484.
10. Bhanderi, B.M., A. Goswami, M.R. Garg and S. Samanta, 2016. Study on minerals status of dairy cows and their supplementation through area specific mineral mixture in the state of Jharkhand. Journal of Animal Science and Technology, 58: 42, DOI 10.1186/s4078-016-0124-2.
11. Mirzaei, F., 2012. Minerals profile of forages for grazing ruminants in Pakistan. Open Journal of Animal Sciences, 2(3): 133-141.
12. Bazri, K. and G. Ouahrani, 2015. Contribution à une analyse de la dynamique de la végétation des parcours steppiques dans la région de Biskra au Sud-Est Algérien. European Scientific Journal, 11(32): 1857-1881.
13. Arab, H., M.L. Haddi and S. Mehennaoui, 2009. Evaluation de la valeur nutritive par la composition chimique des principaux fourrages des zones arides et semi-arides en Algérie. Sciences et Technologie, 30: 50-58.
14. ISRIC, 1984. Procedures for soil analysis. 3rd ED, International soil reference and information center Wageningen, pp: 360.
15. SAS, 2003. Statistical analysis system: User's guide. Cary Ny USA.
16. Calvet, R., 2003. Le sol propriétés et fonctions: Phénomènes physiques et chimiques, applications agronomiques et environnementales. Editions France Agricole, pp: 511.
17. Underwood, E.J. and N.F. Suttle, 1999. The mineral nutrition of livestock. CABI Publishing, Wallingford, UK. 3rd edition, pp: 614.
18. Rhue, R.D. and G. Kidder, 1983. Analytical procedures used by the IFAS extension soil laboratory and the interpretation of results. Soil Department, University of Florida, Gaineville, FL.
19. NRC, 1984. Nutrient Requirements of Dairy Cattle. 3th Rev. Edn., National Academy Press, National Research Council, Washington DC., USA.
20. Kessler, J., 1991. Mineral nutrition of goats. In: Morand-Fehr, P. (ED), Goat Nutrition, Vol. 46. EAAP publication, pp: 104-119.
21. McDonald, P., R.A. Edwards, J.F.D. Greenhalgh, C.A. Morgan, L.A. Sinclair and R.G. Wilkinson, 2010. Animal nutrition. Seventh Edition, Prentice Hall is an imprint of PEARSON, pp: 103-137.
22. Lehner, A., 2014. La nutrition hydrique et minérale chez les plantes. Laboratoire de glycobiologie et matrice extracellulaire végétale. Université de Rouen, pp: 118.
23. Meschy, F., 2010. Nutrition minérale des ruminants. Editions Quae, pp: 208.
24. Ahmed, K., Z.I.Khan, M. Shaheen and A. Seidavi, 2012. Dynamics of magnesium, copper and zinc from soil to forage grown in semiarid area in Sargodha, Pakistan. Legume Research, 35(4): 294-302.
25. Van Niekerk, W. A., C.F. Sparks, N.F.G. Rethman and R.J Coertze, 2004. Mineral composition of certain Atriplex species and Cassia sturtii. South African Journal of Animal Sciences, 34(1): 105-107.
26. Kallah, M.S., J.O. Bale, U.S. Abdullahi, I.R. Muhammad and R. Lawal, 2000. Nutrient composition of native forbs of semi-arid and dry sub-humid savannas of Nigeria. Animal Feed Sciences and Technology, 84: 137-145.
27. Pouget, M., 1980. Les relations sol-végétations dans les steppes Sud-algéroises. O.R.S.T.O.M., Paris, pp: 569.
28. Bendaly, A., D. Messedi, A. Smaoui, R. Ksouri, A. Bouchereau and C. Abdelly, 2016. Physiological and leaf metabolome changes in the xerohalophyte species *Atriplex halimus* induced by salinity. Plant Physiology and Biochemistry, 103: 208-218.
29. Khan, Z.I., K. Ahmed, M. Ashraf, S.A.H. Naqvi, S. Kashaf, A. Ejaz and E.E. Valeem, 2010. Evaluation of potassium status of rams: the use of pasture and blood plasma as indicators under semi-arid environmental conditions in Punjab, Pakistan. Pakistan Journal of Botany, 42(6): 3933-3938.
30. Shisia, K.S., N. Veronica, N. Hudson, J. Isaac and O. Fredrick, 2014. Assessment of mineral deficiencies among grazing areas in Uasin Gishu County, Kenya. International Journal of Nutrition and Food Sciences, 3(2): 44-48.
31. Badshah, L., F. Hussain, S. Perveen and Z. Sher, 2012. Seasonal variation in the macromineral in some woody and herbaceous forage in rangeland District, Tank, Pakistan. Journal of Medicinal Plants Research, 6(25): 4167-4175.