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Full Length Research Paper

Macro-mineral contents in ten species at three phenological stages in Tehsil Takht-e-Nasrati, District Karak, Pakistan

Musharaf Khan[1]*, Farrukh Hussain[1], Shahana Musharaf[2]

[1]Department of Botany, University of Peshawar, Pakistan.

[2]Department of Chemistry, Government Girls Degree College, Sheikh Malton, Mardan, Pakistan.

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Livestock rearing is a common practice by the locals in Tehsil Takht-e-Nasrati, and source of livelihood. Low productivity due to poor health of livestock is a major consideration in the study area. In order to know whether this low productivity and poor health might be due to poor quality of forage, ten forage species were analyzed for macro-mineral quantification at three phenological stages. The palatability of these species was recorded from the shepherds, after following the animals while grazing in the rangeland during this study. Mineral compositions of plants are used in the diagnoses of probable deficiencies in food, forage and nutritional status of plants. Comparison among the species at vegetative stage and macro nutrients showed that the highest amount of potassium (74.08 g kg^{-1}) was found in *Datura metel.* Comparisons at reproductive and post-reproductive stages among species and macro nutrients pointed out that the highest amount of potassium was found in *Rhazya stricta* (72.07 g kg^{-1} and 75.46 g kg^{-1}, respectively). It is concluded that macro-minerals concentrations available in these forage plants to the grazing livestock were very low, hence this may be one of the causes responsible for the pitiable health and productivity of the grazing animals in investigated area.

Key words: Macro-mineral contents, forage species, phenological stages, livestock health, Takht-e-Nasrati.

INTRODUCTION

Livestock farming is a potential source of food, which play a key role in Pakistan's annual export income (Finance Division, 2006). The growth and health of livestock are considerably governed by the concentration of trace minerals in feed/forage on rangelands. Mineral evaluation of plant forages is considered indispensable for nutritional concerns. Livestock grazing is one of the important components of land use of land management systems (Jones and Martin, 1994). The main sources of these minerals are water and soil upon which the forages grow (McDowell, 2003). Hussain and Durrani (2008) relate the different physiological disorders, pitiable health and diseases in the livestock of Harboi rangelands to poor nutrient availability. Mineral deficiencies are the main causes of growth and many reproductive problems in livestock even under satisfactory feed supply (Tiffany et al., 2000). Toxicity of heavy metal is another concern for livestock health (Tokalioglu et al., 2000). Underwood (1981) reported considerable variations in mineral levels of different plant species grown on the same soil. The survival and physical condition of plants depend on the regular supply of mineral nutrients from the soil. Ganskopp and Bohnert (2003) and Khan et al. (2004, 2005, 2006) and Hussain et al. (2009) reported that mineral composition of range- plants is influenced by various environmental factors including the geography,

*Corresponding author. E-mail: k.musharaf@gmail.com.

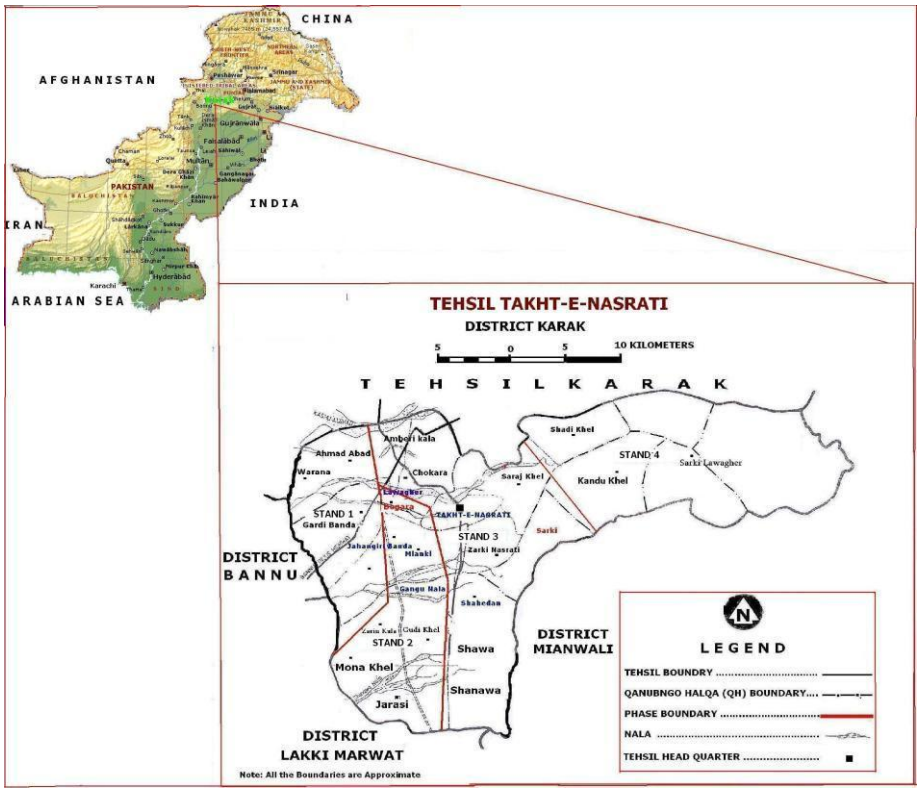

Figure 1. Map of Tehsil Takht-e-Nasrati showing research spots (Map of research area).

climate, soil minerals and grazing stress, seasonal changes, phenological stages, available palatable species and ability of plant uptake of minerals from soil. The deficiencies of macro elements (Na, Mg and p) are likely to affect production of grazing livestock at pasture in most of the regions of the world (Judson et al., 1987; Judson and McFarlane, 1998). The purpose of this study was to evaluate the variations in the concentrations of the macro-nutrients Na, P and Mg at three phenological stages in ten forage plant species from Tehsil Takht-e-Nasrati. This information will lead to a better understanding of the likely micro-nutrient needs of grazing ruminants during particular phenological stages. This is because the investigated area is an important mountainous rangeland that supports a considerable number of livestock but with poor health and productivity.

MATERIALS AND METHODS

Study area

The Tehsil Takhti Nasratti district is situated at 32.47° to 33.28° North and 70.30° to 71.30° East. The Tehsil is bounded by Tehsil Banda Dawood Shah on the North West, Tehsil Karak on the North East, District Mianwali and District Lakki Marwat on the South East, and Tribal area Adjoining District Bannu on the South West (Figure 1). The total area of Tehsil is about 613.66 km^2. The majority of the area consists of rigged dry hills and rough field areas, that is, 323.97 km^2 and agricultural land is about 289.7 km^2. The major income source of the people is Agriculture, which is rain dependent. The area is situated at 340 m above the sea level. In the year 2001 - 2010, 121.6 mm of rainfall per 10 year recorded. The area is very hot in summer and very cold in winter. June and July are the hottest months, while December and January are the coldest months. In the year 2001 - 2010 the mean maximum temperature was 39.5° C, in the month of June, whereas the mean minimum temperature was as low as 4.26°C, in the month of January (Table 1).

Collection of plants

In the present study, 10 forage species consisting of 2 grasses, 2 herbs, 4 shrubs and 2 trees at three phenological stages were analyzed for their mineral composition. This includes 3 macro mineral such as sodium (Na), potassium (K) and calcium (Ca). Plant leaves of ten forage species that is, *Cymbopogon jwarancusa*, *E. poaoides, Boerhaavia diffusa, Chrozophora oblique, Datura metel, Rhazya stricta*, *Vitex trifolia*, *Withania somnifera*, *Albizia lebbeck* and *Tamarix aphylla* were collected at three phenological stages (vegetative, reproductive and post reproductive) in 2011 from Tehsil Takht-e-Nasrati, District Karak. The identification and nomenclature of these forage plants was based on the flora of Pakistan (Nasir and Ali, 1978). The voucher specimens were deposited in the Herbarium, Department of Botany, University of Peshawar, Pakistan.

Drying and grinding of plants

Leaves of each plant were washed thoroughly with deionized water, air dried, spread on an aluminium foil then heat dried, first under

Table 1. Meteorological data of Tehsil Takht -e -Nasrati for the year 2001-2010.

Months	Temperature (°C)		Humidity (%)		Rainfall (mm)	Soil temperature (°C) average	Wind speed (Km/h)
	Max	Min	Max	Min			
January	19.18	4.26	75.80	35.24	27.43	7.03	2.9
February	21.69	7.29	77.39	42.23	37.72	9.14	3.2
March	28.20	12.06	75.38	35.23	37.17	13.89	3.5
April	34.74	17.94	66.12	29.42	36.54	19.02	5.2
May	38.32	22.33	59.66	30.73	31.6	21.87	5.4
June	39.50	25.9	59.96	32.89	74.24	25.78	5.5
July	38.44	25.76	73.33	38.76	121.6	26.77	5.2
August	36.66	25.29	75.68	42.61	108.3	26.37	4.1
September	35.47	21.95	77.21	39.29	61.58	23.49	3.7
October	32.33	16.79	71.55	35.51	15.13	20.09	3.5
November	26.71	10.01	71.56	36.66	5.80	14.10	3.2
December	21.93	5.67	75.20	35.90	15.38	8.96	3.1
Mean	31.1	16.27	71.57	36.21	47.71	18.04	4.04

Source: Agricultural Research Farm Ahmad Wala Karak.

sunlight then in an oven at 60°C. The dried leaves were grinded well into a fine powder (60 mesh sieve size) with pastel mortar. The powdered plant material was then stored in glass bottles at 4°C.

Sample preparation

0.25 g powder sample of each plant was dissolved in 5 ml of nitric acid and temperature was maintained at 80°C for 15 m. 2 ml of perchloric acid was added to the above solution and resultant mixture was left for digestion for about 2 h until white dense fumes appeared. The clear solution was diluted up to 50 ml with deionized water and filtered with Whatman No. 01 filter paper.

Atomic emission and absorption spectrophotometery

The standard working solutions of test elements were prepared to make the standard calibration curve. 3 macro mineral such as calcium contents were measured at 422.7 nm, potassium at 766.5 nm, and sodium at 589.0 nm using computerized atomic adsorption spectrophotometer following standard procedures (PARC, 1982; NRC, 1985; Galyean, 1985).

Statistical analysis

The data obtained was subjected to two way analysis of variance, randomized complete block design (RCBD) and the mean values were separated at $P < 0.05$ applying least significant difference test (LSD).

RESULTS AND DISCUSSION

Sodium

It was observed that sodium contents increased with advancing phenological stages in all tested species. Overall average indicated post reproductive stage had the maximum (2.1 g Kg^{-1}) and vegetative; then minimum (1.22 g Kg^{-1}) sodium contents. Among the plants the mean maximum sodium content were recorded for *T. aphylla* (3.17 g Kg^{-1}) followed by *R. stricta* (2.78 g Kg^{-1}) and *W. somnifera* (2.46 g Kg^{-1}). The least sodium content was found in *A. lebbeck* (0.54 g Kg^{-1}). Statistical analysis of ANOVA showed that within groups, that is, among the growth stages, plants species and between groups the significant differences of sodium were found at LSD 0.03269, 0.05968 and 0.1039, respectively. The Na was significantly high at post reproductive stage ($F = 1421.7805$) and in *T. aphylla* ($F = 1778.0359$) while between the groups it was significantly high in *T. aphylla* at post reproductive stage ($F = 82.8847$) (Tables 2, 3; Figures 2, 5, 6, 7, 8).

The present result showed that Na content was found low in all test species. The maximum content was present in *T. aphylla.* It controls acid-base balance in the body fluid. Its ingestion is correlated with hypertension in humans. James et al. (2010) found out the highest level of Na in *Saba florida*. Hussain et al. (2010) determined the highest level of Na in *Dalbergia sisso*. In *Bupleurum falcatum* the low level of Na was determined by Adnan et al. (2010) and also pointed out that Na content was high in *Otostegia lambata*. Ahmad et al. (2008) stated that Na contents in pods were higher than those found in the leaves and leaflets. According to Hanif et al. (2006) maximum amount of Na present, was reddish while low content in bottle gourd. The current study showed that low content of Na was due to the soil physiochemical properties and climate conditions. Cheema et al. (2011) stated that the Na contents were high in *Ziziphus jujube*. In our result the Na contents were also high in tree species that is, *T. aphylla* than all other test species. Our result also agrees with Hussain et al. (2011) which stated that Na contents were low in *Datura alba* as compared to other test species.

Table 2. Concentration gradient of macro elements, that is, Na, K and Ca of some forage plant species of Takht-e-Nasrati, district Karak at different

Species	Na				K				
	Vegetative	Reproductive	Post Reproductive	Mean	Vegetative	Reproductive	Post Reproductive	Mean	Vegetative
Cymbopogon jwarancusa (Jones) Schult	1.23	1.89	1.92	1.68	28.02	36.08	48.06	37.39	20.69
Eragrostis poaoides Beauv.	1.18	1.48	1.85	1.5	2.22	24.11	34.05	20.13	12.69
Boerhaavia diffusa L..	1.17	1.39	1.91	1.49	42.06	52.07	64.74	52.96	10.71
Chrozophora obliqua (Vahl) A. Juss	1.19	1.66	2.07	1.64	56.04	44.08	40.13	46.75	24.71
Datura metel L.	0.49	0.93	1.32	0.91	74.08	44.13	38.16	52.13	20.75
Rhazya stricta Decne.	2.01	2.88	3.46	2.78	44.06	72.07	75.46+	63.86*	1.85
Vitex trifolia L.	0.57	0.58	0.5	0.55	18.06	28.12	31.72	25.96	12.73
Withania somnifera (L) Dunal.	1.16	2.83	3.4	2.46	42.72	56.1	70.16	56.32	10.37
Albizia lebbeck (L.) Benth.	0.27	0.47	0.86	0.54	20.05	26.14	40.03	28.74	22.75
Tamarix aphylla (L.) Karst	2.91	2.91	3.69+	3.17*	10.05	12.08	16.08	12.74	23.35
Mean	1.22	1.7	2.1*	1.67	33.736	39.498	45.86*	39.69	16.06

Table 3. Analysis of variance of Na, K and Ca contents of some forage plant species of Tehsil Takht-e-Nasrati, district Karak at different ph

Element	K Value	Source	Degrees of freedom	Sum of squares	Mean square	F Va
Sodium	1	Replication	2	0.045	0.022	5.44
	2	Factor A	2	11.679	5.839	1421.
	4	Factor B	9	65.722	7.302	1778.
	6	AB	18	6.127	0.34	82.8
	-7	Error	58	0.238	0.004	
		Total	89	83.811		
Potassium	1	Replication	2	10.407	5.204	1.3
	2	Factor A	2	2206.42	1103.21	287.9
	4	Factor B	9	23978.715	2664.302	695.3
	6	AB	18	7302.291	405.683	105.
	-7	Error	58	222.244	3.832	
		Total	89	33720.077		
Calcium	1	Replication	2	6.518	3.259	2.14
	2	Factor A	2	1431.28	715.64	469.9
	4	Factor B	9	5785.526	642.836	422.1
	6	AB	18	1549.316	86.073	56.5
	-7	Error	58	88.314	1.523	
		Total	89	8860.953		

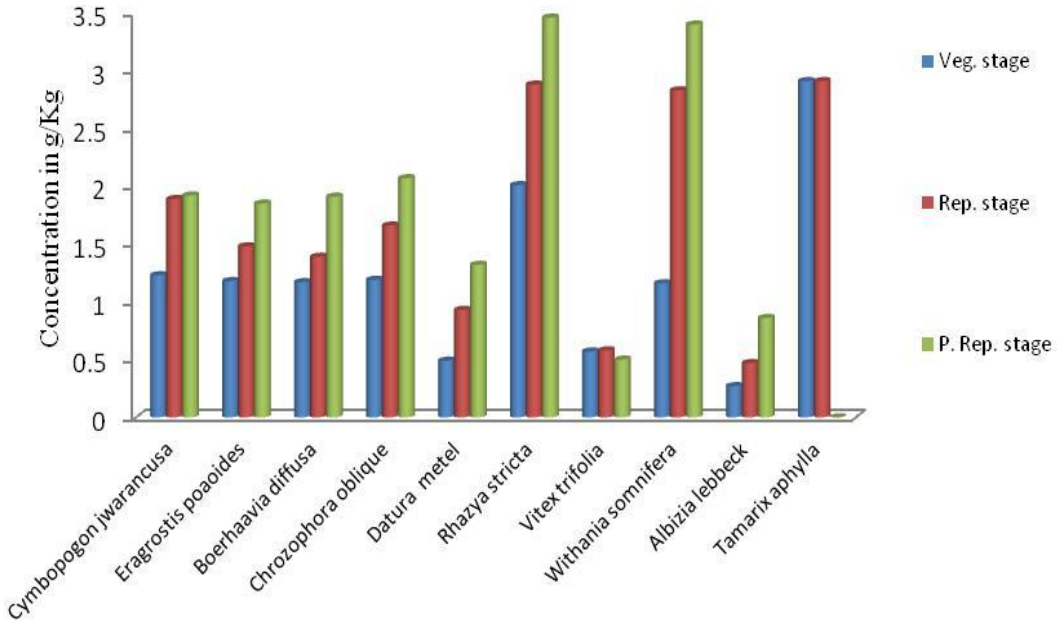

Figure 2. Sodium contents (g Kg^{-1}) of some forage plant species of Takht-e-Nasrati Disctrict Karak, at different phenological stages.

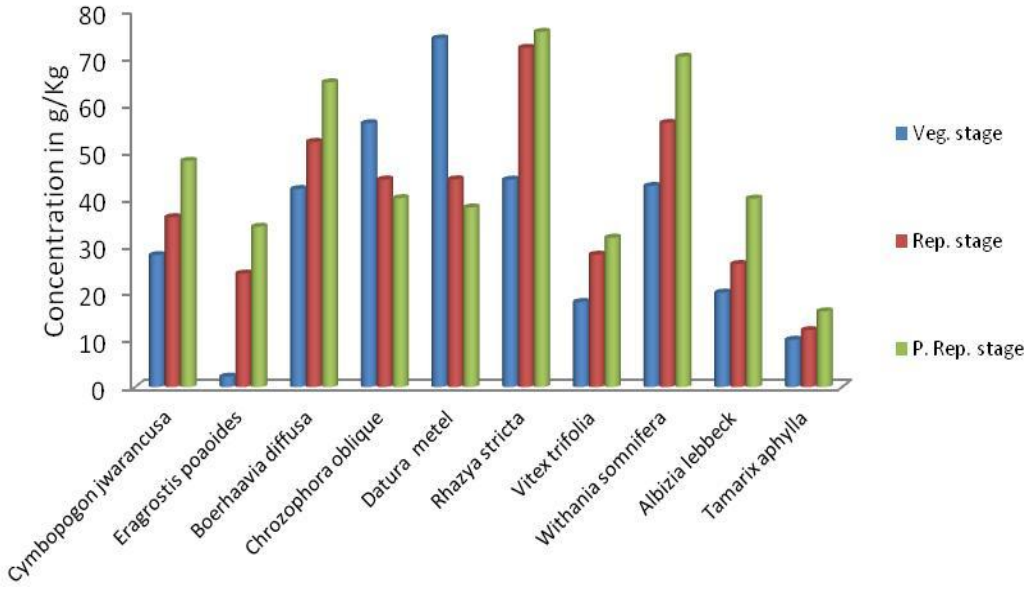

Figure 3. Potassium contents (g Kg^{-1}) of some forage plant species of Takht-e-Nasrati Disctrict Karak, at different phenological stages.

Potassium

It was observed that potassium contents decreased with advancing phenological stages in *Chrozophora obliqua* and *D. metel* while it increased in *C. jwarancusa, E. poaoides, B. diffusa, R. stricta, W. somnifera, V. trifolia, A. lebbeck* and *T. aphylla.* Overall average indicated that post reproductive stages had the maximum (45.86 g Kg^{-1}) and vegetative then minimum (33.74 g Kg^{-1}) potassium contents. Among the plants the mean maximum potassium content was recorded for *R. stricta* (63.86 g Kg^{-1}) followed by *W. somnifera* (56.32 g Kg^{-1}) and *B. diffusa* (52.96 g Kg^{-1}). The least content was found in *T. aphylla* (12.74 g Kg^{-1}). ANOVA showed that within the

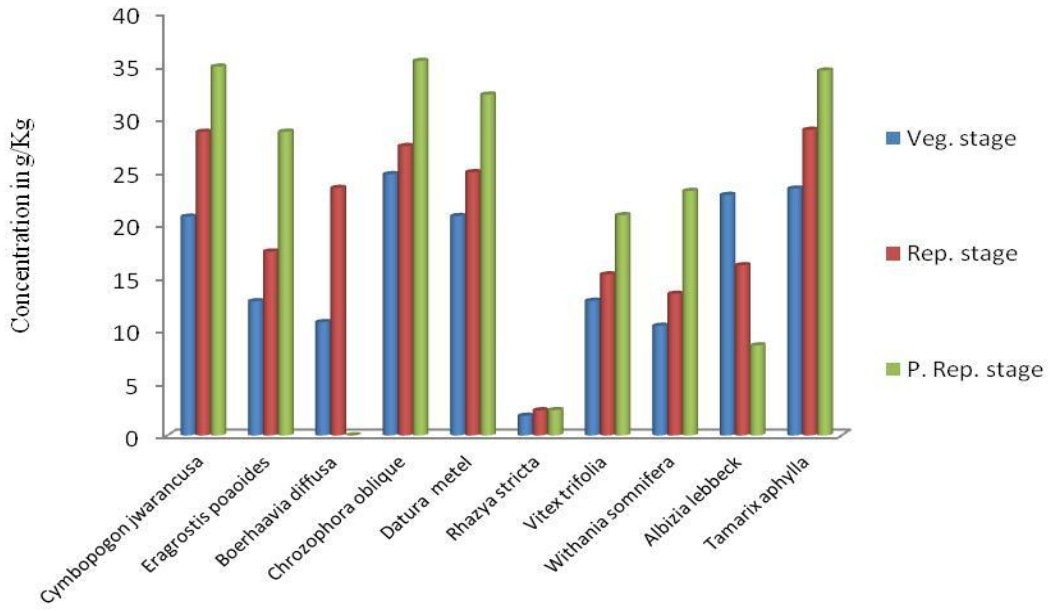

Figure 4. Calcium contents (g Kg^{-1}) of some forage plant species of Takht-e-Nasrati Disctrict Karak, at different phenological stages.

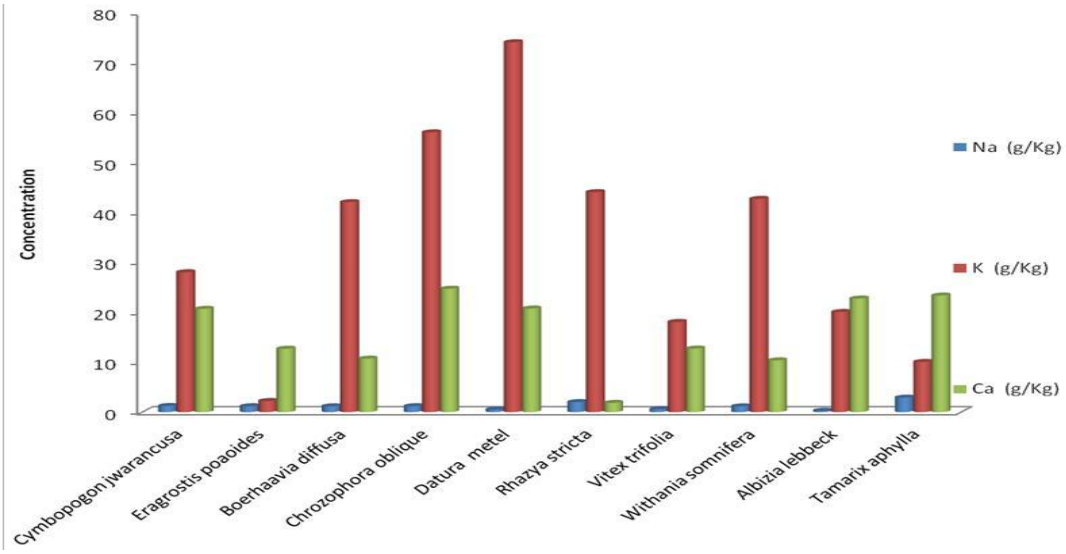

Figure 5. Comparison of vegetative stages of different macro nutrients of some forage plant species of Takht-e-Nasrati Disctrict Karak, at different phenological stages.

group, the potassium quantity were significantly high at the post reproductive stage and in *R. stricta* with F = 287.9101 and F = 695.3157, respectively; while between the groups it was found high in *R. stricta* at post reproductive stage (F = 105.8730). The significant difference of K was found in plant species at LSD 1.012 and 1.847, respectively, while between the groups with LSD 3.199 (Tables 2, 3; Figures 3, 5, 6, 7, 8). The result showed that potassium content were low in *T. aphylla* at two phenological stages that is, reproductive and post reproductive; while at vegetative stage, it was low in *E. poaoides.* The highest content was found in *R. stricta* at two phenological stages. According to Hameed et al. (2008) the potassium content was not present in the *Rumex hastatus*'s flowers. They also stated that in the members of Polygonaceae family, potassium varied from 1.04 – 6.57 ppm. Their work supports our judgment.

Our result also supported by Saidu and Jideobi (2009)

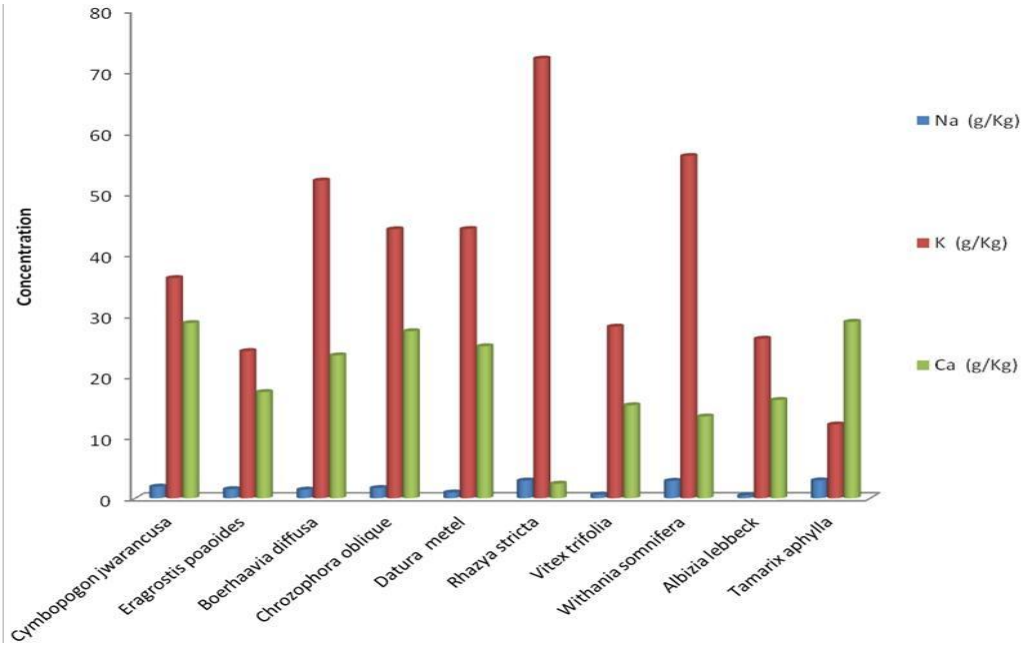

Figure 6. Comparison of vreproductive stages of different macro nutrients of some forage plant species of Takht-e-Nasrati Disctrict Karak, at different phenological stages.

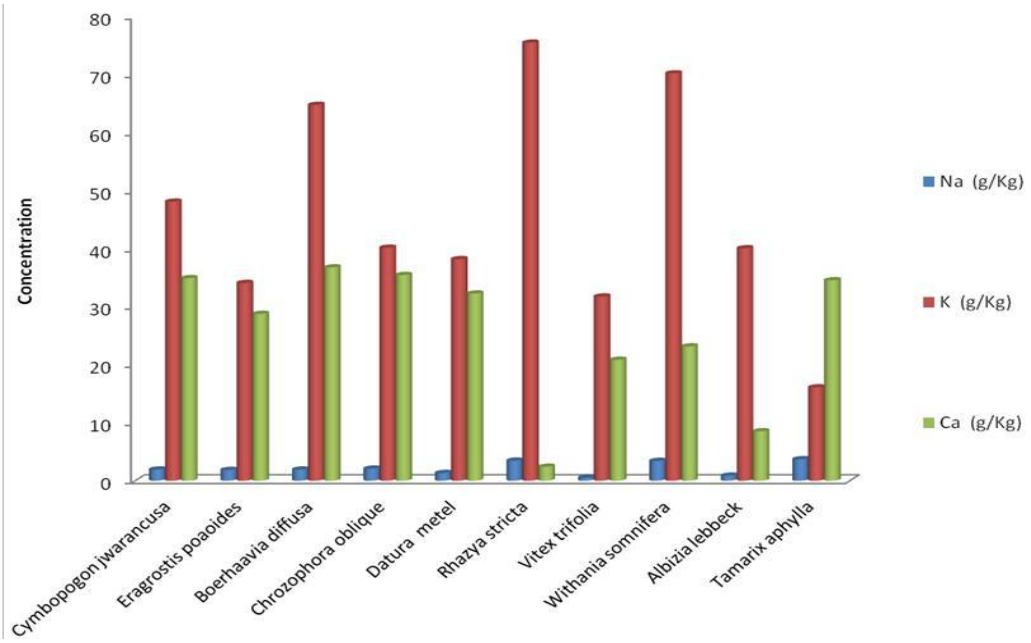

Figure 7. Comparison of post reproductive stages of different macro nutrients of some forage plant species of Takht-e-Nasrati Disctrict Karak, at different phenological stages.

and Zafar et al. (2010).

According to Sultan et al. (2008) the potassium content was higher in free grazing lands at premature stage than at ripeness. But they stated that potassium increases with maturity which agrees with our results. Our result agrees with Minson (1990) who stated that in herbs potassium content is higher than grasses. According to Hussain and Durrani (2008), Khan et al. (2007), Sultan et al. (2007) and Sultan et al. (2008) potassium affects the development of plant, their growth and structure because it is essential to activate growth enzymes. Khan et al. (2009) stated that potassium was high in summer than winter.

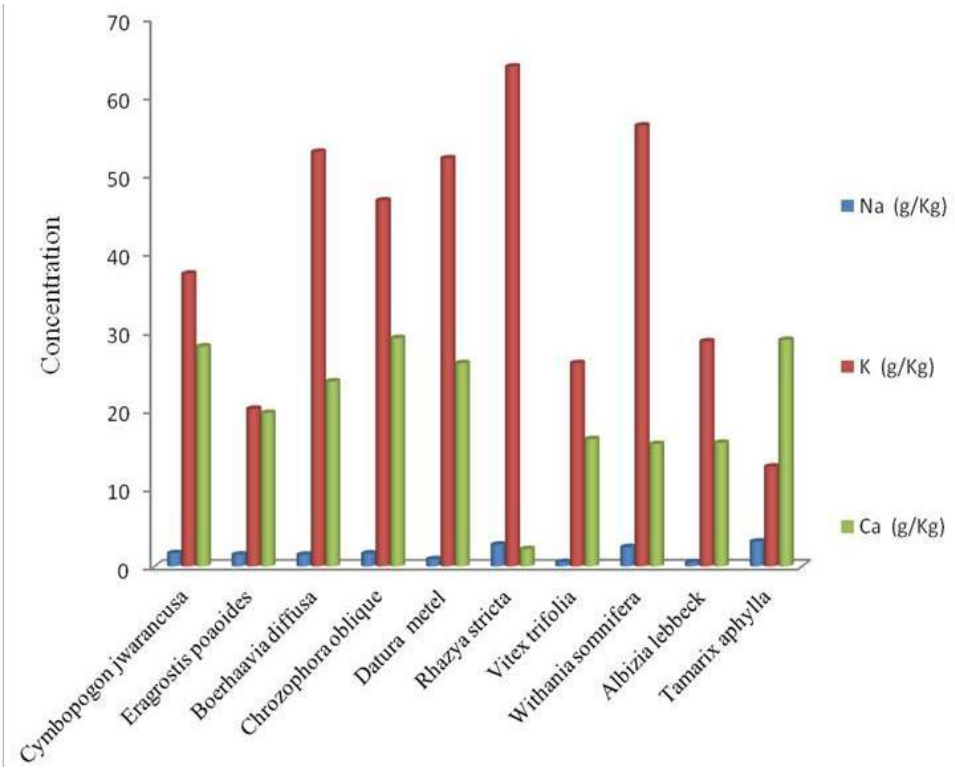

Figure 8. Comparison of mean value of different macro nutrients of some forage plant species of Takht-e-Nasrati Disctrict Karak, at different phenological stages.

The result of this study also agrees with the above statement, wherein the potassium contents were increased with advancing phenological stages in test species.

Calcium

It was observed that calcium (Ca) contents decreased with advancing phenological stages in *A. lebbeck* while it increased in *C. jwarancusa, E. poaoides, B. diffusa, C. obliqua, D. metel, R. stricta, W. somnifera, V. trifolia* and *T. aphylla.* Overall average indicated that post reproductive stage had the maximum (25.74 g Kg^{-1}) and vegetative then minimum (16.06 g Kg^{-1}) calcium contents. Among the plants the mean maximum calcium content were recorded for *C. oblique* (29.17 g Kg^{-1}) followed by *T. aphylla* (28.93 g Kg^{-1}) and *C. jwarancusa* (28.09 g Kg^{-1}).

The least calcium content was found in *R. stricta* (2.204 g Kg^{-1}). ANOVA showed that calcium was significantly high at post reproductive stage (F = 469.9962) and in *C. obliqua* (F = 422.1825) while between the groups it was found high (F = 56.5285) in *B. diffusa* at post reproductive stage. The significant differences of calcium was found at all stages (LSD = 0.6378), among plant species (LSD = 1.165) and between the groups (LSD = 2.017) (Tables 2, 3; Figures 4, 5, 6, 7, 8).

It is noted that herbs had higher contents of calcium followed by trees and then grasses. The least calcium contents were present in the shrub *R. stricta.* WHO proposed a daily intake of calcium at 450-1200 mg. According to Zafar et al. (2008) the calcium concentration in plants was present persistently. Bano et al. (2009) described calcium in *C. jwarancusa*. James et al. (2010) stated that higher calcium contents were present in *S. florida*. In plants, seasonal effect on calcium was reported by Khan et al. (2009). According to Hussain et al. (2010) plants provide 25% of calcium in foodstuff. In the present study the calcium contents were high in herbs followed by trees. Cheema et al. (2011) reported that calcium concentration was high in trees like *Acacia nilotica.*

Minerals are essential for the normal growth and development of plants that ultimately affect the growth, maintenance and productivity of range animals at secondary levels. Various environmental factors including edaphic, climatic, geographic and biotic stresses influence the mineral composition of plants including forage species. Mineral compositions of plants are used to diagnose probable deficiencies in food and forage and nutritional status of plants.

Some of the micro minerals upset the effects of macro elements in different conditions. The main sources of these elements were water, soil temperature, moisture and soil types on which the plant species produce (McDowell, 2003). Elements deficiencies could reduce

herbage digestibility and ingestion and eventually decline animal's productivity (Khan et al., 2005). The elements glut also originated harsh physiological disorder. Heavy metals influenced the nutritional value of farming yield and also caused harmful effect on livestock.

According to Sobukola et al. (2008) heavy metals should be in safe and sound limits in food. Domestic animals nurture was a common practice in research because it aids in solving economical problems. Minerals are required for soil fertility. In plants, as herbs and grasses fully developed, some minerals are transferred to the fruits. Also, the mineral content of plants was inclined clearly by the accessibility of minerals in the soil. As a result of this, low-quality fields without legumes and range plants tend to be naturally low in minerals, as the forage full-fledged and the seeds fall; naturally, the range soil was also deficient in minerals. Some sufficient mineral availability stimulates premature development and speed up plant's maturity. Thus, it was essential that the time of sampling, stage of growth and character of growth prior to sampling be known and considered when taking a plant analysis result.

Conclusion

It is concluded that required levels of macro-minerals are available in these forage plants and the grazing herds in Tehsil Takht-e-Nasrati, District Karak, hence there is no need to supplement macro-minerals in feeds given to the ruminants of this area. Nonetheless, further study is needed to search out the causes of poor health and productivity of these animals because mineral availability is not the only reason responsible for the health and productivity of the grazers.

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