

Elemental analysis of ten plant species at three phenological stages

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Abstract: Livestock rearing is a common practice in Tehsil Takht-e-Nasrati by the locals to earn their livelihood. Low productivity due to poor health of livestock is 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 plant species were analyzed for micro mineral quantification at three phenological stages. Mineral compositions of plants are used to diagnose probable deficiencies in food and forage and nutritional status of plants. Comparison among at vegetative stage of test species and micro nutrients showed that the amount of manganese was found high (64.4mg Kg⁻¹) in *Chrozophora obliqua*. Comparison among at reproductive and post reproductive stages of test species and micro nutrients pointed out that the amount of nickel was found high (67.24mg Kg⁻¹) and (80.4mg Kg⁻¹) respectively in *Vitex trifolia*. It is concluded that micro-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.

Keywords: Livestock health, micro-mineral contents, forage species, phenological stages, Tehsil Takht-e-Nasrati, Pakistan.

INTRODUCTION

Livestock are 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 in rangelands. Mineral evaluation of plant forages is considered indispensable for nutritional concerns. The uptake of mineral elements can provide significant information on plant forage quality (Yusuf *et al.*, 2003). Livestock grazing is one of the important components of land use of land management system (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 different physiological disorders, pitiable health and diseases in the livestock of Harboi rangelands to poor nutrient availability. Mineral deficiencies are the main cause 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 even growing on the same soil. The survival and physical condition of plants depend on the regular supply of mineral nutrients from the soil. Khan *et al.* (2004, 2005, 2006) reported that mineral composition of range plants is influenced by various environmental factors including geographic aspects,

climate, soil minerals and grazing stress, seasonal changes, phenological stages, available palatable species and ability of plant to uptake minerals from soil and digest in its body. The deficiencies of trace elements (Co, Cu, I, Mn, Se and Zn) 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). Khan *et al.*, (2014) report nutritional assessment of these plant species. Khan *et al.*, (2013) studied the Macro-mineral contents of such plant species in research area. The purpose of this study was to evaluate the variations in the concentrations of the micro-nutrients Cd, Cr, Cu, Ni, Pb, Zn and Mn 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 stage. This is because investigated area is an important mountainous rangeland that supports a considerable number of livestock but with poor health and productivity.

MATERIALS AND METHODS

Collection of plants

Plant leaves of ten plant species i.e. *Cymbopogon jwarancusa*, *Eragrostis poaoides*, *Boerhaavia diffusa*, *Chrozophora oblique*, *Datura metel*, *Rhazya stricta*, *Vitex trifolia*, *Withania somnifera*, *Albizia lebbek* and *Tamarix aphylla* were collected at three phenological stages (vegetative, reproductive and post reproductive) in 2011 from Tehsil Takht-e-Nasrati, District Karak. The

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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 sunlight then in 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

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

Atomic emission and absorption spectrophotometry

The standard working solutions of test elements were prepared to make the standard calibration curve. Micro mineral like cadmium (Cd), chromium (Cr), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn) and manganese (Mn) were measure 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

In present study, 10 plant species consisting of 2 grasses, 2 herbs, 4 shrubs and 2 trees at three phenological stages were analyzed for their mineral composition. This included 7 micro mineral like Zinc (Zn), copper (Cu), manganese (Mn), chromium (Cr), nickel (Ni), cadmium (Cd) and lead (Pb).

Zinc

It was observed that Zinc contents decreased with advancing phenological stages in *Cymbopogon jwarancusa*, *Eragrostis poaoides*, *Boerhaavia diffusa*, *Chrozophora obliqua* and *Datura metel* while increased in *Rhazya stricta*, *Withania somnifera*, *Vitex trifolia*, *Albizia lebbeck* and *Tamarix aphylla*. Overall average indicated that post reproductive stage had the maximum (22.34mg Kg⁻¹) and vegetative then minimum (19.11mg Kg⁻¹) Zinc

contents. Among the plants the maximum Zinc content were recorded for *Rhazya stricta* (52.37mg Kg⁻¹) followed by *Chrozophora obliqua* (30.77mg Kg⁻¹) and *Vitex trifolia* (19.11mg Kg⁻¹). The least sodium content was found in *Tamarix aphylla* (9.19mg Kg⁻¹). ANOVA showed that among the growth stages Zn was significantly high at post reproductive stage ($F=19.0524$). While among the plant species it was high in *Rhazya stricta* ($F=290.2262$) and between the groups it was highly significant in *Rhazya stricta* at post reproductive stage ($F=57.3217$). The significant differences within groups i.e. stages, plant species and between the groups are found with LSD 1.40, 2.081 and 3.605 respectively (tables 1, 2; fig. 1).

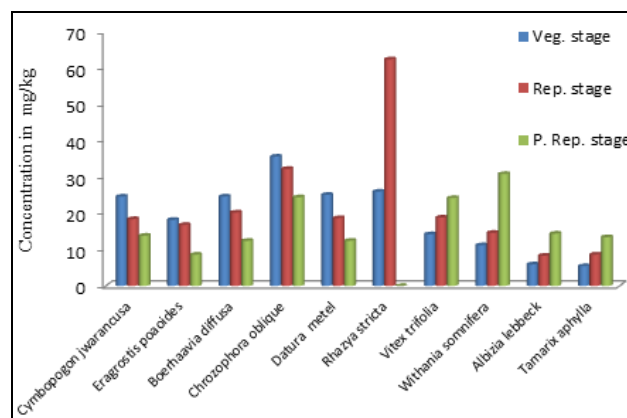


Fig. 1: Zinc contents (mg Kg⁻¹) of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

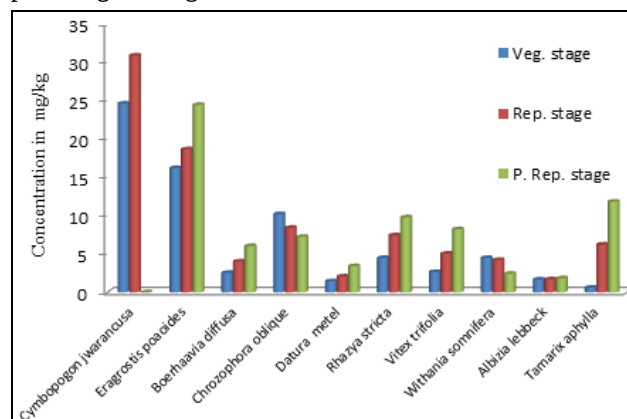


Fig. 2: Copper contents (mg Kg⁻¹) of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

Copper

It was observed that copper contents decreased with advancing phenological stages in *Chrozophora obliqua* and *Withania somnifera* while increased in *Cymbopogon jwarancusa*, *Eragrostis poaoides*, *Boerhaavia diffusa*, *Datura metel*, *Rhazya stricta*, *Vitex trifolia*, *Albizia lebbeck* and *Tamarix aphylla*. Overall average indicated that post reproductive stage had the maximum (11.01mg Kg⁻¹) and vegetative then minimum (6.9mg Kg⁻¹) copper

contents. Among the plants the maximum copper content were recorded for *Cymbopogon jwarancusa* (30.13mg Kg⁻¹) followed by *Eragrostis poaoides* (19.8mg Kg⁻¹) and *Chrozophora obliqua* (8.63mg Kg⁻¹). The least sodium content was found in *Albizia lebbeck* (1.73mg Kg⁻¹) followed by *Datura metel* (2.31mg Kg⁻¹). ANOVA showed that in stages and among plant species the presence of copper was significantly high at post reproductive stage (F=109.2303) and in *Cymbopogon jwarancusa* (F=634.6047). The comparison between the stages and plant species, copper was found significantly high in *Cymbopogon jwarancusa* at post reproductive stage (F=16.1486). Among the stages and plant species, significant differences were present at LSD 0.5564 and 1.016 respectively. The significant differences between the groups were at LSD 1.76 (tables 1, 2; fig. 2).

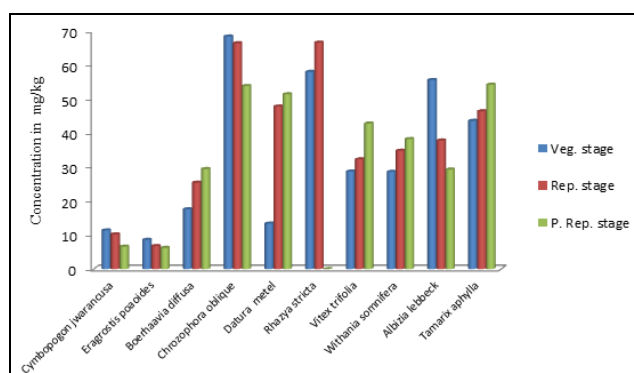


Fig. 3: Manganese contents (mg Kg⁻¹) of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

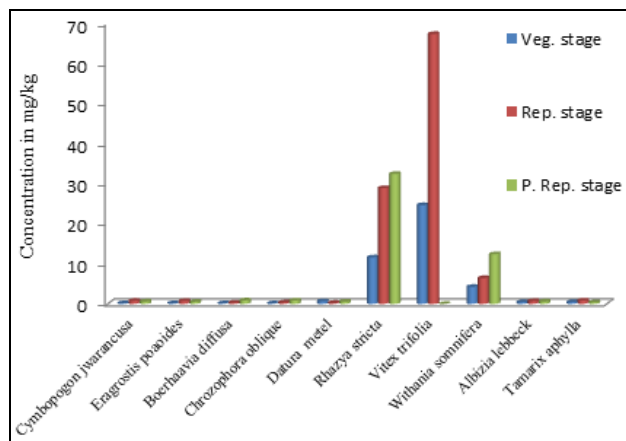


Fig. 4: Nickel contents (mg Kg⁻¹) of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

Manganese

It was observed that manganese contents increased with advancing phenological stages in *Boerhaavia diffusa*, *Rhazya stricta*, *Withania somnifera*, *Datura metel*, *Vitex trifolia* and *Tamarix aphylla* while decreased in *Cymbopogon jwarancusa*, *Eragrostis poaoides*, *Chrozophora obliqua* and *Albizia lebbeck*. Overall

average indicated that post reproductive stage had the maximum (38.45mg Kg⁻¹) and vegetative then minimum (33.4mg Kg⁻¹) manganese contents. Among the plants the maximum manganese content were recorded for *Rhazya stricta* (65.68mg Kg⁻¹) followed by *Chrozophora obliqua* (62.9mg Kg⁻¹) and *Tamarix aphylla* (48.1mg Kg⁻¹). The least manganese content was found in *Eragrostis poaoides* (7.21mg Kg⁻¹). ANOVA showed that with in groups the presence of manganese was significantly high at post reproductive stage (F=96.3419) and in *Rhazya stricta* (F=1554.2594) while comparison between the groups it was significantly high in *Rhazya stricta* at post reproductive stage (F=122.1608). The significant differences of manganese was present at phenological stages (LSD=0.7708), test species (LSD=1.407) and between the groups (LSD=2.43) (tables 1, 2 fig. 3).

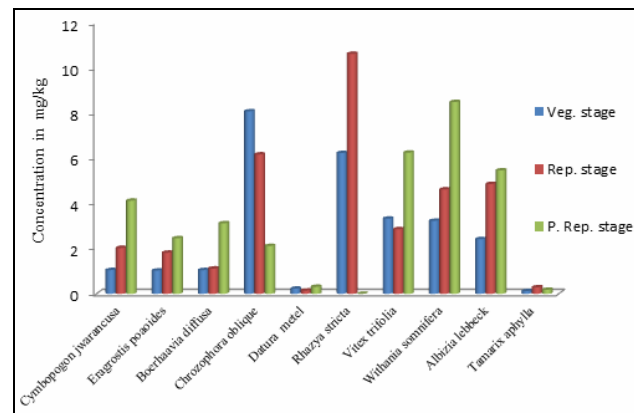


Fig. 5: Chromium contents (mg Kg⁻¹) of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

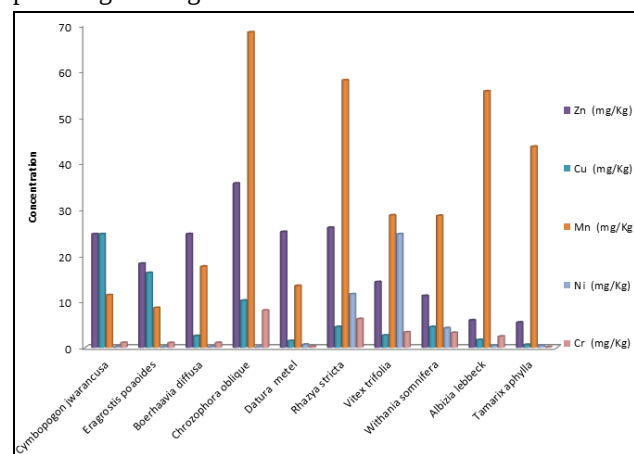


Fig. 6: Comparison of vegetative stages of different micro nutrients of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

Nickel

It was observed that nickel contents decreased with advancing phenological stages in *Datura metel* and *Tamarix aphylla* while increased in *Cymbopogon jwarancusa*, *Eragrostis poaoides*, *Boerhaavia diffusa*,

Chrozophora obliqua, *Rhazya stricta*, *Withania somnifera*, *Vitex trifolia* and *Albizia lebbeck*. Overall average indicated that post reproductive stage had the maximum (12.97 mg Kg^{-1}) and vegetative then minimum (4.28 mg Kg^{-1}) nickel contents. Among the plants the maximum nickel content were recorded for *Vitex trifolia* (57.4 mg Kg^{-1}) followed by *Rhazya stricta* (24.3 mg Kg^{-1}) and *Withania somnifera* (7.7 mg Kg^{-1}). The least nickel content was found in *Chrozophora obliqua* (0.45 mg Kg^{-1}) followed by *Boerhaavia diffusa* (0.46 mg Kg^{-1}). ANOVA showed the significant differences of Ni within the groups i.e. growth stages and plant species at LSD 0.4757 and 0.8684 respectively while between the groups at LSD (1.504). Within the groups, Ni was found significantly high at post reproductive stage ($F=717.0494$) and in *Vitex trifolia* ($F=3640.0361$) while between the groups it was found high ($F=310.0047$) at post reproductive stage in *Vitex trifolia* (tables 1, 2; fig.4).

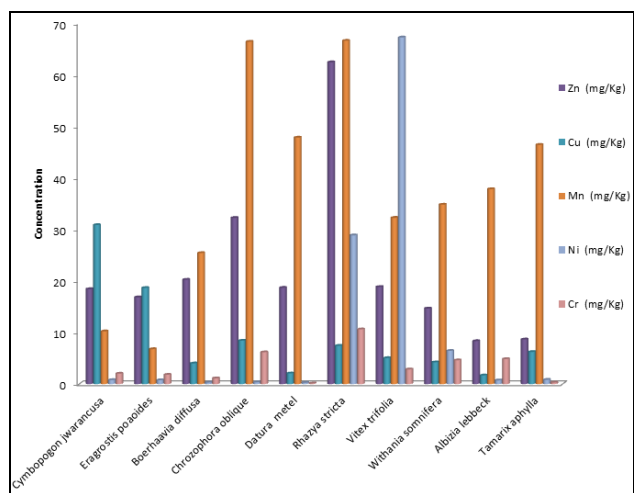


Fig. 7: Comparison of reproductive stage of different micro nutrients of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

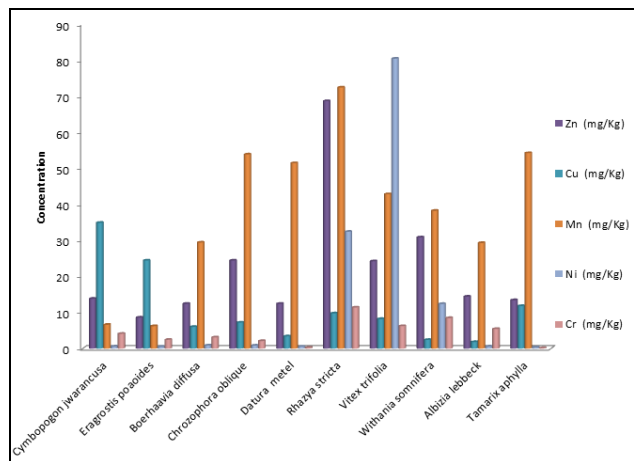


Fig. 8: Comparison of post reproductive stages of different micro nutrients of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

Chromium

It was observed that chromium contents increased with advancing phenological stages in *Cymbopogon jwarancusa*, *Eragrostis poaeoides*, *Boerhaavia diffusa*, *Rhazya stricta*, *Withania somnifera*, *Datura metel*, *Vitex trifolia*, *Albizia lebbeck* and *Tamarix aphylla* while decreased only in *Chrozophora obliqua*. Overall average indicated that post reproductive stage had the maximum (4.39 mg Kg^{-1}) and vegetative then minimum (2.68 mg Kg^{-1}) chromium contents. Among the plants the maximum chromium content were recorded for *Rhazya stricta* (9.42 mg Kg^{-1}) followed by *Chrozophora obliqua* (5.46 mg Kg^{-1}) and *Withania somnifera* (5.45 mg Kg^{-1}). The least chromium content was found in *Tamarix aphylla* (0.2 mg Kg^{-1}) followed *Datura metel* (0.23 mg Kg^{-1}). ANOVA showed that among the growth stages at post reproductive stage the chromium was significantly high ($F=4.6537$) while among plant species it was significantly high in *Rhazya stricta* ($F=950.8827$). Between the groups, chromium was significantly high ($F=120.0930$) in *Rhazya stricta* at post reproductive stage. The significant differences between the groups were found by LSD (0.4506) however within the groups i.e. growth stages and plant species were present on LSD 0.1425 and 0.2606 respectively (tables 1, 2; fig. 5).

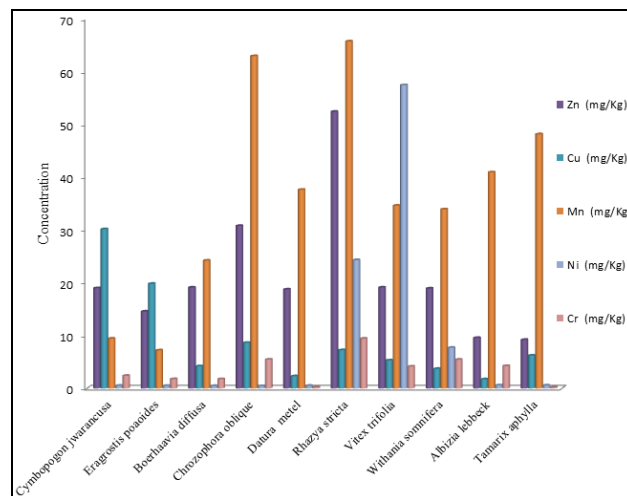


Fig. 9: Comparison of mean value of different micro nutrients of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

Cadmium and lead

Cadmium (Cd) and lead (Pb) were absent in all the test species. No industrial unit is present in the investigated area. Naser *et al.*, (2009) stated that lead and cadmium content were higher in those plant species which are present in polluted area and low or absent in those plant species which present in non-polluted area.

DISCUSSION

Minerals are essential for the normal growth and development of plants that ultimately effect the growth,

Table 1: Concentration gradient of micro elements i.e. Zn, Cu, Mn, Ni and Cr of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

Species	Zn				Cu				Mn				Ni				Cr			
	Vegetative	Reproductive	Post Reproductive	Mean	Vegetative	Reproductive	Post Reproductive	Mean	Vegetative	Reproductive	Post Reproductive	Mean	Vegetative	Reproductive	Post Reproductive	Mean	Vegetative	Reproductive	Post Reproductive	Mean
<i>Cymbopogon jwarancusa</i> (Jones) Schult.	24.62	18.43	13.85	18.97	24.6	30.86	34.90 ⁺	30.13 [*]	11.4	10.23	6.62	9.42	0.18	0.78	0.61	0.52	1.05	2.03	4.12	2.4
<i>Eragrostis poaeoides</i> Beauv.	18.23	16.83	8.62	14.56	16.2	18.66	24.43	19.8	8.63	6.787	6.227	7.21	0.17	0.76	0.54	0.49	1.03	1.82	2.46	1.77
<i>Boerhaavia diffusa</i> L.	24.63	20.24	12.43	19.1	2.54	4.02	6.04	4.2	17.6	25.42	29.42	24.2	0.18	0.3	0.89	0.46	1.05	1.12	3.12	1.76
<i>Chrozophora obliqua</i> (Vahl) A. Juss.	35.62	32.24	24.44	30.77	10.2	8.42	7.22	8.63	68.4	66.42	53.85	62.9	0.15	0.35	0.85	0.45	8.08	6.17	2.12	5.46
<i>Datura metel</i> L.	25.11	18.68	12.45	18.74	1.45	2.07	3.42	2.31	13.4	47.82	51.42	37.6	0.67	0.25	0.57	0.5	0.23	0.143	0.31	0.23
<i>Rhazya stricta</i> Decne.	26.03	62.44	68.63 ⁺	52.37 [*]	4.5	7.43	9.79	7.24	58	66.61	72.41 ⁺	65.68 [*]	11.6	28.85	32.4	24.3	6.23	10.62	11.4 [*]	9.42 [*]
<i>Vitex trifolia</i> L.	14.24	18.85	24.23	19.11	2.65	5.05	8.22	5.31	28.7	32.26	42.82	34.6	24.6	67.24	80.4 ⁺	57.4 [*]	3.33	2.86	6.25	4.15
<i>Withania somnifera</i> (L.) Dunal.	11.24	14.66	30.85	18.92	4.48	4.22	2.42	3.71	28.6	34.81	38.23	33.9	4.25	6.45	12.4	7.7	3.23	4.62	8.49	5.45
<i>Albizia lebbeck</i> (L.) Benth.	5.94	8.34	14.43	9.57	1.67	1.69	1.83	1.73	55.6	37.82	29.29	40.9	0.44	0.72	0.62	0.59	2.42	4.86	5.46	4.25
<i>Tamarix aphylla</i> (L.) Karst.	5.47	8.66	13.44	9.19	0.62	6.23	11.82	6.22	43.6	46.42	54.23	48.1	0.45	0.84	0.38	0.56	0.12	0.29	0.18	0.2
Means	19.11	21.94	22.34	21.13	6.89	8.87	11.01	8.93	33.39	37.46	38.45	36.450	4.27	10.65	12.97	9.29	2.68	3.45	4.39	3.51

Table 2: Analysis of variance of Zn, Cu, Mn, Ni and Cr contents of some forage plant species of Takht-e-Nasrati, district Karak at different phenological stages.

	K Value	Source	Degrees of Freedom	Sum of Squares	Mean Square	F Value	Prob
Zinc	1	Replication	2	0.231	0.115	0.0237	
	2	Factor A	2	185.324	92.662	19.0524	0
	4	Factor B	9	12703.745	1411.527	290.2262	0
	6	AB	18	5018.153	278.786	57.3217	0
	-7	Error	58	282.085	4.864		
		Total	89	18189.538			
Copper	1	Replication	2	1.404	0.702	0.6053	
	2	Factor A	2	253.258	126.629	109.2303	0
	4	Factor B	9	6621.176	735.686	634.6047	0
	6	AB	18	336.974	18.721	16.1486	0
	-7	Error	58	67.238	1.159		
		Total	89	7280.05			
Manganese	1	Replication	2	3.721	1.861	0.8366	
	2	Factor A	2	428.548	214.274	96.3419	0
	4	Factor B	9	31111.441	3456.827	1554.2594	0
	6	AB	18	4890.561	271.698	122.1608	0
	-7	Error	58	128.998	2.224		
		Total	89	36563.269			
Nickel	1	Replication	2	0.374	0.187	0.221	
	2	Factor A	2	1214.882	607.441	717.0494	0
	4	Factor B	9	27752.569	3083.619	3640.0361	0
	6	AB	18	4727.11	262.617	310.0047	0
	-7	Error	58	49.134	0.847		
		Total	89	33744.069			
Chromium	1	Replication	2	0.71	0.355	4.6537	0.0134
	2	Factor A	2	44.361	22.18	290.8428	0
	4	Factor B	9	652.647	72.516	950.8827	0
	6	AB	18	164.854	9.159	120.093	0
	-7	Error	58	4.423	0.076		
		Total	89	866.994			

maintenance and productivity of range animals at secondary level. 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. Comparison among at vegetative stage of test species and micro nutrients showed that the highest amount of manganese was found (64.4mg Kg^{-1}) in *Chrozophora obliqua*. The least amount (0.12mg Kg^{-1}) of chromium among micro nutrients was found in *Tamarix aphylla* (fig. 6). Comparison among at reproductive stage of test species and micro nutrients pointed out that the highest amount of nickel was found high (67.24mg Kg^{-1}) in *Vitex trifolia* while the chromium was low (0.29mg Kg^{-1}) in *Tamarix aphylla* (fig. 7). Comparison among at post reproductive stage of test species and micro nutrients showed that the highest amount (80.4mg Kg^{-1}) was found in *Vitex trifolia* of nickel while the chromium was low (0.18mg Kg^{-1}) in *Tamarix aphylla* (fig. 8). Comparison among the means

value of micro nutrients of test species showed that the highest amount of manganese was also high (65.68mg Kg^{-1}) in *Rhazya stricta* while the chromium was low (0.2mg Kg^{-1}) in *Tamarix aphylla* (fig. 9). The producers require minute amount of micro elements for their growth although their importance could not be judged the minimum amount in the growth and development of livestock. Some of the micro minerals upset affects of macro elements in different condition. The main sources of these elements were water, soil temperature, moisture and soil types leading 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 the Sobukola *et al.*, (2010) that the heavy metals should be in safe and sound limits in food. Domestic animals nurture was a common practice in the research area because the people solve their economical problem.

Minerals are required for soil fertility. In plants, as herbs and grasses fully developed, some minerals were transferred to the fruit. Also, the minerals content of the plant was inclined clearly by the accessibility of mineral in the soil. As a result of this, low-quality fields without legumes and range plants lean 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 an 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 micro-minerals concentrations available in these plant species to the grazing livestock were very low, hence this may be, one of the causes responsible for the deplorable health and productivity of the grazing animals in Tehsil Takht-e-Nasrati, District Karak. It is suggested that further investigation like proximate composition and digestibility of these plants species is needed because micro-minerals deficiency in forage plant species may not be the only cause of the said problem.

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