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Mineral contents of natural pasture crops in Central Anatolian region of Turkey

Kaplan M.
Department of Field Crops, Faculty of Agriculture, University of Erciyes, Kayseri, Turkey
Corresponding author's e-mail: mahmutk@erciyes.edu.tr
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Abstract
Objective of this study was to determine the mineral contents of common pasture forage legumes and cereals intensively grazed by livestock of Central Anatolian Region. A total of 10 forage cereals and 15 forage legumes collected at flowering periods during June 2011 from pastures of Kayseri and analyzed. Study revealed that forage legumes had sufficient Na and Cu levels in all plants, *Vicia narbonensis* and *Trifolium pratense* had desired levels of Zn and others had higher than desired levels of Zn. Other elements were found to be at higher levels than desired levels but not reaching to harmful levels. In forage cereals, while P, Ca, Na and Cu were found to be at desired ranges, Zn was within desired ranges in *Amaranthus edulis* and *Agropyron cristatum* and higher than desired levels in other plants. The other elements were found to be higher than desired ranges but lower than toxic or harmful levels. It was concluded that pasture crops of Central Anatolia were rich in trace elements and there was no need for supplemental trace element feeding.

Keywords: Forage cereals, Forage legumes, Mineral content, Pasture, Trace elements

Introduction

Steppe vegetation (including pastures, shrubs and trees) is among the most common type of vegetations in Turkey and commonly preserved by human activities, especially by livestock grazing. Total pasture lands of Turkey is about 14.617.000 ha (DIE, 2010), out of which 4.902.000 ha is located in Central Anatolia (DIE, 2001). Pastures are great source of forage for grazing livestock in semi-arid regions like Central Anatolia. They have a significant role in supporting livestock production activities producing sufficient quantity of quality forage (Karabak *et al*., 2009).

Yield and health of grazing animals depend on availability and sufficiency of essential minerals in pasture crops (Khan *et al.,* 2007). Mineral contents of fodder, forage and pasture crops vary significantly (McDowell, 1997; Underwood and Suttle, 1999) based on soil texture, crop types (Khan *et al.,* 2007), climate, topography, ripening period/stage of maturity and grazing management practices (McDowell *et al.,* 1993; Khan *et al.,* 2007; Khan *et al.,* 2009). Objective of this study was to determine mineral contents of pasture crops which have significant role in ruminant livestock feeding.

Materials and Methods

Plant samples from a total of 10 forage cereals and 15 forage legumes were collected from pastures of Kayseri Province and analyzed. Surface area of Kayseri is 16.917 km^2 with an altitude of 1050 meters with cold terrestrial climate. Summers are hot and dry and winters are cold and snowy. The province has an annual precipitation of 366 mm with the highest precipitation in March, April and May and the lowest in June, July and August. Extreme temperatures were recorded as between ï 32.5°C and +40.7°C.

Plant samples were taken in June 2011 during the flowering periods of the plants. Samples were dried at 70ºC for 48 hours and processed in a grinder machine with 1 mm sieve for chemical analysis. Plant samples were passed through wet-ashing process with hydrogen peroxide (2:3) in 3 different steps (1st step: at 145ºC 75% microwave power for 5 minutes, 2nd step: at 80ºC 90% microwave power for 10 minutes and 3rd step: at 100ºC 40% microwave power for 10 minutes) in a wet-ashing unit (speed wave MWS-2 Berghof products + Instruments Harresstr.1. 72800 Enien Germany) resistant to 40 bar pressure (Mertens, 2005a). Then P, K, Ca, Mg, Na, Fe, Mn, Zn and Cu, B, Si contents were determined by using ICP OES spectrometer (Inductively Couple Plasma spectrophotometer) (Perkin-Elmer, Optima 2100 DV, ICP/OES, Shelton, CT 06484-4794, USA) (Mertens, 2005b).

SAS (SAS, 1999) was used to perform variance analysis on experimental data and Duncan test was used to test the significance of differences among the means.

Results and Discussion

Mineral contents of forage legumes

While there were no significant differences among forage legumes with regard to K, Cd and Pb contents, highly significant differences were observed with regard to other elements (Table 1).

P content varied between 2644.5-3198.5 mg/kg, the lowest value was obtained from *Medicago sativa* and the highest value in *Lotus corniculatus*. The lowest Mg value (2102.5 mg/kg) was obtained from *Vicia sativa* and the highest (2483.0 mg/kg) from *Medicago lupinae*. The lowest Ca content (8157 mg/kg) was found in *Vicia sativa* and the highest (9012 mg/kg) in *Melilotus officinalis*. Lowest (1134.5 mg/kg) Na content was observed in *Lathyrus sativus,* and highest value (1433.0 mg/kg) from *Medicago sativa*. Mn contents ranged between 65.110-76.975 mg/kg. The lowest and the highest values were obtained respectively from *Trifolium repens* and *Medicago polymorpha*. The lowest value for Zn (30.435 mg/kg) was observed in *Vicia narbonensis* and the highest (40.445 mg/kg) in *Lathyrus sativus*. Fe contents varied between 254.0-281.5 mg/kg and Cu contents between 7.130-9.260 mg/kg. The lowest Fe and Cu values were obtained from *Trigonella kotschyi* and *Medicago falcata,* respectively and the highest values from *Lotus corniculatus* and *Trifolium repens,* respectively. While the lowest (0.2265 mg/kg) Ni content was recorded in *Onobrychis sativa*, the highest value (0.2885 mg/kg) was observed in *Medicago polymorpha*. With regard to B contents, the lowest (9.875 mg/kg) and the highest (9.875 mg/kg) values were recorded in *Vicia sativa* and *Astragallus sp.* respectively.

Above findings were compared to values specified by NRC (1985) for mineral contents to meet the nutrient requirements of livestock. Comparisons revealed that Na and Cu were at normal levels in all forage legumes. While Zn was found to be at normal levels in *Vicia narbonensis* and *Trifolium repens*, higher but not harmful levels were observed in other plants. All the other elements were found to be higher than desired levels but not exceeding the maximum levels (Table 1).

Mineral contents of forage cereals

Highly significant differences were observed in mineral contents of forage cereals (Table 2). While both the lowest P (2412 mg/kg) and Mg (1876.5 mg/kg) contents were obtained from *Festuca ovina*, the highest P content (2912 mg/kg) was observed in *Agropyron cristatum* and the highest Mg value (2454.5 mg/kg) in *Phleum pratense*. The lowest Ca and N contents were obtained from *Avena elatior*, the highest Ca content (7897.5 mg/kg) was observed in *Poa pratensis* and the highest K value (11767.5 mg/kg) in *Bromus inermis*. While the lowest Na value (131.0 mg/kg) was obtained from *Festuca arundinacea*, the highest value (1454.5 mg/kg) was seen in *Avena elatior*. With regard to Mn contents, the lowest (62.110 mg/kg) and the highest (86.510 mg/kg) values were observed in *Bromus inermis* and *Avena elatior*, respectively. The lowest Zn content (30.540 mg/kg) was found in *Agropyron cristatum* and the highest (42.140 mg/kg) in *Festuca ovina*. Both the lowest Fe (219 mg/kg) and Cu (6.080 mg/kg) contents were seen in *Phleum pratense*, the highest Fe value (292 mg/kg) was obtained from *Avena elatior* and the highest Cu (8.625 mg/kg) from *Elymus sp.* While the lowest Ni and Cd contents were observed in *Dactylis glomerata* (0.230 mg/kg Ni, 0.1575 mg/kg Cd), the highest Ni content (0.3755 mg/kg) was observed in *Avena elatior* and the highest Cd value (0.2440 mg/kg) in *Elymus sp.* The lowest Pb and B contents (0.3105 and 8.045 mg/kg, respectively) were obtained from *Festuca arundinacea* and the highest values (0.4340 and 12.650 mg/kg) were observed in *Avena elatior*.

Mineral contents of forage cereals were compared to the values specified by NRC (1985) and comparisons revealed that P, Ca, Na and Cu values were at desired ranges. While Zn was found to be at normal levels in *Amaranthus edulis* and *Agropyron cristatum*, higher but not harmful levels were observed in other plants. All the other elements were found to be higher than desired levels but none of them exceeded the maximum levels.

Mineral contents may vary based on crop type and species, time of harvest, soil and climate conditions and stress factors (Gralak *et al.,* 2006). Soils of Central Anatolia Plateau are rich in soluble salts and lime. Beside this, boric acid may be accumulated within sedimentary deposits of volcanic sites (Sonmez and Beyazgul, 2012). In present study, Na, Ca and B levels were found to be at desired levels to meet the requirements for animal feeding. Na level should be around 0.15% for a high yielding livestock (Netherlands Committee on Mineral Nutrition 1973). Similar findings were observed by Volarire *et al.,* (1998) with regard to Na contents. Ca contents were mostly affected by pasture soils and the values were higher than the findings of Khan *et al.,* (2007) and Tiffany *et al.,* (2000; 2001). There is no serious risk for livestock when the Ca:P ratio is not exceeding 10:1 (Khan *et al.,* 2007). Findings of current study were within these limits. Turkish soils are mostly sufficient or rich in K (Yýldýz and Bilgin, 2008). Fe requirement of domestic animals was reported as 30 ppm,

Mg as 0.12% and zinc as 50 ppm (Agricultural Research Council, 1965). Considering these reports, Fe and Mg values of current study exceedingly meets the needs of livestock and Zn values were thought to be sufficient based on NRC (1985). Mg values of the present study were above the values recommended by NRC (1985) for ruminants but were below the critical values. Considering the increasing effect of Potassium on Magnesium transport through flume (Yýldýz and Bilgin, 2008), high K contents of current plants may have also increased the Mg contents of plants.

The soils of Turkey, over which intensive agricultural practices are performed, are rich in potassium (Turhan and Piokin, 2012). Therefore, lack of potassium is scarce in Turkish soils. Plants of current study had also high levels of K. Potassium deficiency usually occur during the late growth season of the plants grown on potassium deficient soils (McDowell and Valle, 2000). Findings of current study with regard to potassium content were higher than the findings of Khan *et al.,* (2007) in Pakistan, Prabowo *et al.,* (1990) in Indonesia and Ogebe *et al.,* (1995) in Nigeria and were similar with the findings of Khan *et al.,* (2005) and Volarire *et al.,* (1998). Mn content should be around 40 mg/kg for ruminants (Anonymous, 1996). The values in present study were higher than the requirements, but below the maximum tolerance levels (Anonymous, 1996).

Table 1. Mineral contents of forage legumes (mg/kg/DM)

Plants	P	Mg	Ca	K	Na	Mn
Vicia narbonensis	2915.5 ab	2196.5 i	8412.5 g	10231	1221 f	67.435 m
Trifolium incarnatum	2894.0 ab	2144.5 l	832.03 i	10875	1290 de	68.545 k
Trifolium repens	2976.5 ab	2364.5 b	8220.5 k	11981	1386 bc	65.110 o
Medicago sativa	2644.5 b	2314.5 d	8276.0 j	11301	1433 a	71.405 h
Astrogallus sp.	3071.0 ab	2170.0 k	8330.5 h	10613	1298 de	74.555 c
Lathyrus sativus	3083.5 ab	2240.5 h	8613.0 e	11321	1135 g	69.405 j
Onobrychis sativa	3100.0 a	2314.0 d	8439.5 f	11208	1423 ab	72.100 g
Trifolium pratense	3002.0 ab	2260.5 g	8664.5 c	10537	1258 ef	69.475 i
Vicia sativa	2831.5 ab	2102.5 m	8157.0 n	10657	1264 e	67.175 n
Medicago lupinae	3125.5 a	2483.0 a	8631.0 d	10999	1263 e	68.390 l
Trigonella kotschyi	3113.5 a	2291.0 e	8193.0 l	6186	1419 ab	72.345 e
Lotus corniculatus	3198.5 a	219.0 j	8413.5 g	10718	1312 d	75.305 b
Medicago polymorpha	3145.5 a	2286.5 f	8784.5 b	11546	1158 g	76.975 a
Medicago falcata	3007.5 ab	2245.5 h	8187.5 m	10874	1379 c	73.145 d
Melilotus officinalis	3124.5 a	2350.5 c	9012.0 a	10959	1308 d	72.255 f
Significance Level	*N.S.*	***	***	*N.S.*	***	***

Plants	Zn	Fe	Cu	Ni	Cd	Pb	B
Vicia narbonensis	30.435 o	264 f	8.625 g	0.2335 j	0.1765	0.3335	9.345 e
Trifolium incarnatum	37.135 e	273 c	8.960 b	0.2660 c	0.1670	0.3460	8.785 j
Trifolium repens	35.975 g	266 ef	9.260 a	0.2580 e	0.1925	0.4120	9.265 f
Medicago sativa	39.375 b	255 g	7.630 i	0.2485 g	0.1885	0.3620	9.135 g
Astrogallus sp.	35.140 i	279 b	7.290 l	0.2405 i	0.1655	0.3760	9.875 a
Lathyrus sativus	40.445 a	269 de	7.925 h	0.2835 b	0.1955	0.6895	9.650 b
Onobrychis sativa	34.670 j	264 f	7.355 k	0.2265 k	0.2115	0.3855	9.250 f
Trifolium pratense	31.345 n	271 cd	8.885 d	0.2405 i	0.1820	0.3440	9.610 c
Vicia sativa	34.120 k	266 f	8.775 e	0.2620 d	0.1645	0.3405	8.615 l
Medicago lupinae	37.790 d	281 ab	8.945 c	0.2545 f	0.1765	0.3755	8.745 k
Trigonella kotschyi	39.975 c	254 g	7.555 j	0.2450 h	0.1855	0.3580	9.040 h
Lotus corniculatus	35.465 h	282 a	7.360 k	0.2875 a	0.1945	0.3805	9.250 f
Medicago polymorpha	36.770 f	271 cd	8.670 f	0.2885 a	0.5845	0.3655	9.425 d
Medicago falcata	33.610 l	256 g	7.130 m	0.2660 c	0.1950	0.3745	8.985 i
Melilotus officinalis	32.615 m	281 ab	7.355 k	0.2505 g	0.1880	0.3910	8.805 j
Significance Level	***	***	***	***	*N.S.*	*N.S.*	***

P<0.05; ** P<0.01; *** P<0.001;* ***N.S:* *Non-Significant*

Table 2. Mineral contents of forage cereals (mg/kg/DM)

Plants	P	Mg	Ca	K	Na	Mn	Zn
Dactylis glomerata	2701.0 f	2240.5 g	7701 f	10801 g	1351 c	62.455 i	34.405 f
Poa pratensis	2668.0 g	2314.5 f	7898 a	11211 d	1288 f	65.110 f	36.490 e
Amaranthus edulis	2756.0 d	2413.0 b	7612.5 g	10976 e	1378 b	63.680 h	32.115 g
Bromus inermis	2815.0 c	2336.0 c	7755 e	11768 a	1245 g	62.110 j	36.445 e
Festuca arundinacea	2723.5 e	2330.5 d	7813 c	10941 f	1131 j	66.405 d	38.650 d
Phleum pratense	2888.0 b	2455.0 a	7860 b	11221 c	1199 i	64.270 g	34.105 f
Agropyron cristatum	2912.0 a	2322.0 e	7763 d	11321 b	1234 h	65.785 e	30.540 h
Festuca ovina	2412.0 j	1876.5 j	6912 h	9871 i	1342 d	78.890 c	42.140 a
Elymus sp.	2554.0 h	1887.0 i	6881 i	9908 h	1321 e	79.115 b	40.430 b
Avena elatior	2444.5 i	1964.0 h	6712.5 j	9785 j	1455 a	86.510 a	39.415 c
Significance Level	***	***	***	***	***	***	***

Plants	Fe	Cu	Ni	Cd	Pb	B
Dactylis glomerata	251.0 d	7.765 d	0.2300 g	0.1575 j	0.3325 e	8.545 f
Poa pratensis	244.0 e	7.225 f	0.2450 f	0.1655 i	0.3230 f	8.125 g
Amaranthus edulis	266.5 c	7.895 c	0.2300 g	0.1775 f	0.3160 g	8.655 e
Bromus inermis	233.0 f	7.020 g	0.2350 g	0.1705 h	0.3325 e	8.625 e
Festuca arundinacea	265.5 c	7.710 e	0.2440 f	0.1855 e	0.3105 h	8.045 h
Phleum pratense	219.0 g	6.080 i	0.2660 e	0.1745 g	0.3445 d	9.255 d
Agropyron cristatum	244.5 e	6.430 h	0.2740 d	0.1890 d	0.3530 c	8.560 f
Festuca ovina	265.5 c	7.765 d	0.3335 c	0.2355 b	0.4110 b	11.100 b
Elymus sp.	271.0 b	8.625 a	0.3425 b	0.2440 a	0.4090 b	10.855 c
Avena elatior	292.0 a	8.110 b	0.3755 a	0.2325 c	0.4340 a	12.650 a
Significance Level	***	***	***	***	***	***

P<0.05; ** P<0.01; *** P<0.001; **N.S: Non-Significant **DM**: Dry Matter*

About 50 mg/kg Fe is sufficient for ruminants (McDowell, 1985). The values observed in current study were above this requirement but below the harmful threshold. With regard to Cu, an amount of 8-14 mg/kg is usually sufficient for ruminants (Khan *et al.,* 2006). While the forage cereals, except *Elymus sp.* and *Avena elatior*, had lower values than the above specified value, almost half of the forage legumes had lower values than the requirement. Cu uptake decreases with both plant ripening and increasing Fe contents (Phillippo *et al.,* 1987). However, current findings are in compliance with daily copper needs of ruminants specified in NRC (1985). Similar to findings of present study, Khan *et al*., (2009) also observed high Fe contents. Zn values were generally above the desired ranges. Cu and Zn usually exhibit a positive correlation (Underwood, 1962).

Positive and significant correlation between Fe-P, Fe-Ca and Cd-Mn contents and a negative and significant correlation between Cu-Mn contents of forage legumes ($p<0.05$) were observed (Table 3). On the other hand, highly different correlations were observed in forage cereals. A total of 34 correlations were found to be negative and significant, 24 were positive and significant (Table 4).

Figure 1 is a biplot with a polygon view for nutrient content of forage legumes. The PC1 and PC2 explained 43.92 % of the total variability attributed to Genotype +GT. The vertex plants for nutrient *Medicago polimorpha (Mp)*, *Lotus corniculatus* (*Lc*), *Trigonella kotschyi* (*Tc*), *Medicago sativa* (*Ms*), *Vicia sativa* (*Vs*), *Trifolium repens* (Tr), *Medicago lupinae* (Ml) fell into the six sectors. Therefore, it seems that *Medicago polimorpha* and *Lotus corniculatus* had the highest values of P, Ni and Mn, while they had the lower values of Na and Mg (Figure 1 and Table 3). *Medicago sativa* and *Trigonella kotschyi* had the highest values of Na; *Trifolium repens* and *Medicago lupinae* had the highest values of Mg and Cu.

Figure 2 is a biplot with a polygon view for nutrient content of forage cereals. The PC1 and PC2 explained 86.98 % of the total variability attributed to Genotype +GT. The vertex plants for nutrient *Avena elatior (Ave), Amaranthus edulis (Ae), Festuca ovina (Fo), Phleum pratense (Php)*, *Bromus inermis(Bi)* fell into the three sectors. *Avena elatior* and *Festuca ovina* had the highest values of most of nutrients (Mn, Fe, Ni, Pb, Zn and B). *Bromus inermis* and *Phleum pratense* had the highest values of nutrients P, K and Mg (Figure 2, Table 4).

Table 3. Correlations among mineral contents of forage legumes

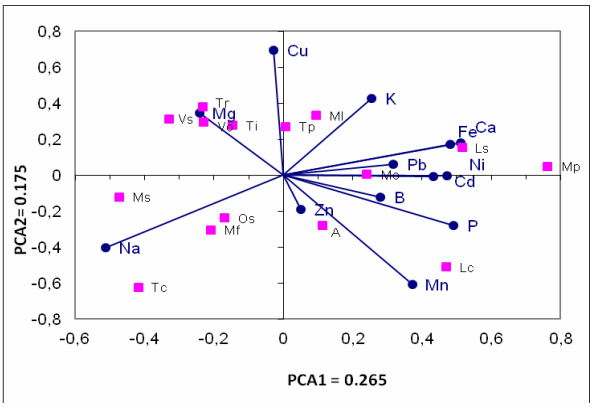
	P	Mg	Ca	K	Na	Mn	Zn	Fe	Cu	Ni	Cd	Pb	B
P	1												
Mg	0.261	1											
Ca	0.477	0.403	1										
K	-0.159	0.098	0.278	1									
Na	-0.244	0.225	**-0.518**	-0.270	1								
Mn	0.466	-0.068	0.256	-0.121	0.020	1							
Zn	-0.024	0.233	-0.157	-0.111	0.059	0.095	1						
Fe	**0.515**	0.072	**0.590**	0.353	-0.463	0.136	-0.149	1					
Cu	-0.242	0.077	0.030	0.239	-0.402	**-0.667**	-0.061	0.136	1				
Ni	0.242	-0.166	0.129	0.267	-0.472	0.274	0.410	0.243	0.090	1			
Cd	0.283	0.117	0.392	0.201	-0.390	**0.529**	0.126	0.038	0.143	0.461	1		
Pb	0.229	0.074	0.217	0.216	-0.400	-0.082	0.491	0.056	-0.133	0.402	-0.030	1	
B	0.220	-0.137	0.126	0.110	-0.275	0.294	-0.023	0.068	-0.156	-0.048	0.201	0.359	1

In bold. significant values (except diagonal) at the level of significance alpha=0.050 (two-tailed test)

Table 4. Correlations among minerals contents of forage cereals

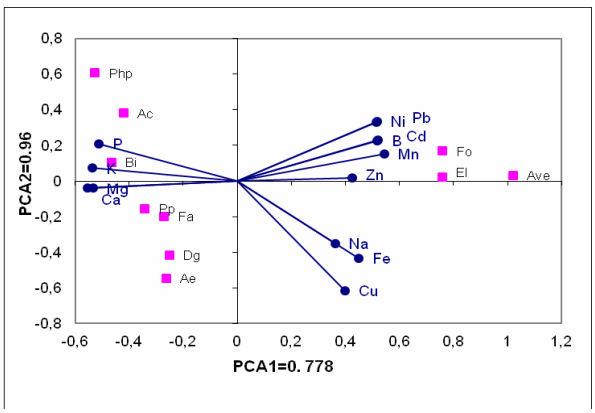
	P	Mg	Ca	K	Na	Mn	Zn	Fe	Cu	Ni	Cd	Pb	B
P	1												
Mg	**0.890**	1											
Ca	**0.858**	**0.931**	1										
K	**0.894**	**0.902**	**0.926**	1									
Na	**-0.640**	-0.546	**-0.677**	-0.613	1								
Mn	**-0.845**	**-0.893**	**-0.953**	**-0.911**	0.563	1							
Zn	**-0.842**	**-0.792**	**-0.692**	**-0.705**	0.188	**0.717**	1						
Fe	**-0.768**	**-0.678**	**-0.765**	**-0.797**	0.618	**0.758**	0.509	1					
Cu	**-0.759**	**-0.680**	**-0.679**	**-0.726**	0.574	0.576	0.600	**0.848**	1				
Ni	**-0.741**	**-0.866**	**-0.926**	**-0.861**	0.505	**0.976**	**0.636**	0.627	0.432	1			
Cd	**-0.747**	**-0.894**	**-0.930**	**-0.867**	0.403	**0.933**	**0.702**	**0.680**	0.558	**0.936**	1		
Pb	**-0.741**	**-0.893**	**-0.938**	**-0.843**	0.577	**0.942**	0.614	0.566	0.417	**0.978**	**0.904**	1	
B	**-0.773**	**-0.831**	**-0.948**	**-0.858**	**0.653**	**0.950**	0.621	**0.636**	0.470	**0.955**	**0.867**	**0.964**	1

In bold. significant values (except diagonal) at the level of significance alpha=0.050 (two-tailed test)



Vo: *Vicia narbonensis,* ***Ti:*** *Trifolium incarnatum,* ***Tr:*** *Trifolium repens,* ***Ms:*** *Medicago sativa,* ***A:*** *Astragallus sp.,* ***Ls:*** *Lathyrus sativus,* ***Os:*** *Onobrychis sativa,* ***Tp:*** *Trifolium pratense,* ***Vs:*** *Vicia sativa ,* ***Ml:*** *Medicago lupinae,* ***Tc:*** *Trigonella kotschyi,* ***Lc:*** *Lotus corniculatus,* ***Mp:*** *Medicago polymorpha,* ***Mf:*** *Medicago falcata,* ***Mo:*** *Melilotus officinalis*

Fig. 1: Biplot polygon for mineral contents of forage legumes



Dg: *Dactylis glomerata,* ***Pp:*** *Poa pratensis,* ***Ae:*** *Amaranthus edulis,* ***Bi:*** *Bromus inermis,* ***Fa:*** *Festuca arundinacea,* ***Php:*** *Phleum pratense,* ***Ac:*** *Agropyron cristatum,* ***Fo:*** *Festuca ovina,* ***El:*** *Elymus sp.,* ***Ave:*** *Avena elatior*

Fig 2: Biplot polygon for mineral contents of forage cereals

Conclusion

It was concluded herein that mineral contents of 15 legumes and 10 grass species grazed over the investigated pastures were found to be sufficient to meet the nutrient needs of ruminants and there were no need for additional minerals.

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