SCREENING OF FIVE PLANT SPECIES FOR MACRO/MICRO NUTRIENTS AND HEAVY METALS AT VARIOUS PHENOLOGICAL STAGES

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Abstract

This study presents the results of chemical analysis of five plant species. A total of 15 minerals were analyzed in these species at pre-reproductive and post-reproductive stages. These included 5 macronutrients i.e. P, K, Mg, Ca and S; 7 micronutrients i.e. Fe, Co, Ni, Cu, Zn, Mo, Mn and 3 trace elements i.e. Na, Si and Ba. Highest values were recorded for Ca while Co and Mo were below detection range in all samples. Based on mean values of all minerals the trend for all minerals in descending order for Aristida cyanaantha was Ca > K > S > Mg > P > Fe > Si > Na > Zn > Cu; Ba > Mn, for Andrachne cordifolia Ca > K > Mg > P > S > Fe > Na > Mn > Zn > Ba > Cu > Si > Ni, for Quercus baloot it was found to be Ca > K > Mg > S > P > Fe > Mn > Ba > Si > Na > Zn > Cu > Ni, for Indigofera heterantha var. heterantha it stood as Ca > K > Mg > S > P > Fe > Si > Na > Ba > Mn > Zn > Cu > Ni and for Cotoneaster nummularia it was recorded as Ca > K > Mg > S > P > Fe > Si > Ba > Na > Mn > Zn > Cu > Ni. Factorial analysis confirmed that these minerals varied significantly in both phenological stages.

Key words: Macronutrients, Micronutrients, Trace elements, Chemical screening, Phenological stages.

Introduction

This study was designed to analyze 15 elements in five selected plant species at two phenological stages i.e., pre-reproductive and post-reproductive stages. During growth and development of plant species they not only undergo morpho-anatomical changes but they also show variations in secondary metabolites as well as differences in elemental composition (Gull et al., 2015; Dastagir et al., 2014). These changes in mineral composition determine the palatability preferences of grazing and browsing animals in a habitat. A total of 15 elements were analyzed which included 5 macro-nutrients, 7 micro-nutrients and 3 trace elements. These plant species were collected from Hindukush range of Swat, Pakistan, between 72° 32' 1” to 72° 43' 3” longitude and 35° 3’ 40” to 35° 11’ 40” latitude.

Aristida cyanaantha Nees ex Steud. belongs to family Poaceae and is a common grass in the locality. It is a highly palatable species in post-reproductive stage (Hussain et al., 2007). It is usually fed to cattle in dry condition. Andrachne cordifolia (Wall. ex Dcne.) Muell. Arg. belongs to family Euphorbiaceae and is a common shrub along the Northern slopes in Chail, Bishigram, Shinku and Dabargai area. It is a poisonous species and is not palatable, but is often used by locals as verminfuge for cattle (Khan et al., 2012; Sher et al., 2012). Quercus baloot Griffith belongs to family Fagaceae and is a common tree species in the locality. Its leaves are used as fodder and is less palatable in post-reproductive stage but palatable in pre-reproductive stage. Its wood is used as fuel while its fruit is reported to have medicinal uses (Hassan et al., 2015). Indigofera heterantha Wall. ex Brandis var. heterantha belongs to family Papilionaceae. It is a common shrub on Northern and Southern slopes in Chail, Dabargai and Shinku area. It is a palatable species and its leaves are used to cure scabies. In addition to this it is also used to treat digestive disorders (Akhtar et al., 2013). Cotoneaster nummularia Fisch. & Mey. belongs to family Rosaceae, shrubby in nature and a palatable species. Its fruit is used as astringent and expectorant. Decoction of its fruits is an effective therapy for treating cough (Youssef, 2013; Ahmad et al., 2011).

Materials and Methods

Sampling: Plant specimens were collected at pre-reproductive and post reproductive stage from Chail valley of Hindukush ranges. Each collected sample weighed 2.5 kg. Contaminants were removed and each sample was labeled and taken in perforated polythene bags. Samples were dried in laboratory and later grounded to 0.5-1mm particle size.

Microwave digestion of plant samples: Grounded plant material was digested by taking 200 mg of each sample. Each sample was digested with H2O2 and HNO3. Both H2O2 and HNO3 were taken in a 2:1 ratio. Closed vessel microwave method of digestion was applied.

Mineral analyses: After digesting the material, each sample was diluted by deionized H2O. Macronutrients, micronutrients and trace elements were estimated by Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES). ICP-OES spectrometer iCAP 6500 (Thermo Fisher, UK) was used for analysis.

Results

1. Aristida cyanaantha Nees ex Steud.

Macronutrients: In Aristida cyanaantha, phosphorus was estimated as 262 μg/g at pre-reproductive stage while at post-reproductive stage it slightly decreased to 215μg/g. Considerable drop in potassium levels was observed with maturity of the plant species. Potassium content was 6151 μg/g in pre-reproductive stage which came down to 3591 μg/g in post-reproductive stage. There was no marked...
variation in magnesium levels, which remained 244 μg/g and 264 μg/g in pre-reproductive and post reproductive stages respectively. Calcium was low in pre-reproductive stage i.e. 1460 μg/g and it increased considerably in post reproductive stage (1789 μg/g). A decrease in sulphur content was observed with increasing maturity of the plant. Its levels were recorded as 440 μg/g at pre-reproductive stage and 379 μg/g at post-reproductive stage.

**Micronutrients:** Iron content increased with maturity, it was 94 μg/g in pre-reproductive stage while 109 μg/g in post-reproductive stage. Though cobalt and molybdenum were below detection range at both phenological stages, traces of nickel were recorded at post-reproductive stage i.e. 1 μg/g. Nickel was not detected in pre-reproductive stage. Only 16 μg/g of copper was found in pre-reproductive stage which further decreases to 3 μg/g at post-reproductive stage. Zinc levels remained almost the same at both phenological stages i.e., 14 μg/g and 13 μg/g. Similarly, manganese levels showed no considerable variation at both phenological stages i.e., 5 μg/g and 7 μg/g.

**Trace elements:** An increase in sodium content was recorded at post-reproductive stage (76 μg/g) while at pre-reproductive stage it was 21 μg/g. Similar trend was seen in case of silicon, at pre-reproductive stage it was found to be 66 μg/g which slightly increased to 75 μg/g at post-reproductive stage. Lowest values were recorded for barium at both phenological stages i.e. 2 μg/g and 17 μg/g at pre-reproductive and post-reproductive stage respectively (Table 1, Fig. 1).

**Andrachne cordifolia (Wall. ex Dcne.) Muell. Arg.**

**Macronutrients:** Except phosphorous, a decrease was observed in all macronutrients with increasing maturity. This may be one of the reasons that this species in non-palatable (Sher et al., 2012). Phosphorous was estimated as 381 μg/g in pre-reproductive stage which increased to 574 μg/g in post-reproductive stage. Potassium levels were just 6187 μg/g in post-reproductive stage while they were 12659 μg/g at pre-reproductive stage. Considerable decrease in magnesium content was recorded i.e. from 4146 μg/g to 1612 μg/g in pre-reproductive and post-reproductive stages respectively. Calcium clicked just 11914 μg/g in post-reproductive stage while it was 17723 μg/g in pre-reproductive stage. A decrease in sulphur content was recorded with increasing maturity of the plant, which was 822 μg/g in post-reproductive stage and 1198 μg/g in pre-reproductive stage.

**Micronutrients:** With maturity, the micronutrients decreased as well. Iron contents decreased from 349 μg/g to 284 μg/g in pre-reproductive and post-reproductive stage. Cobalt levels were below detection range in both stages while nickel remained 1 μg/g at both phenological stages. Marked decreased was noticed in copper content, its levels were 23 μg/g in pre-reproductive stage while just 4 μg/g in post-reproductive stage. Zinc was estimated as 32 μg/g and 20 μg/g in successive stages. Molybdenum was not detected in either stage. Manganese remained almost same in both phenological stages i.e., 30 μg/g and 31 μg/g.

**Trace elements:** Sodium contents decreased from 276 μg/g to 66 μg/g in post-reproductive stage. Silicon levels remained almost unchanged at both phenological stages (8 μg/g and 9 μg/g). A slight decrease in barium content was recorded with increasing maturity, in pre-reproductive stage it was 37 μg/g while just 12 μg/g in post-reproductive stage. The results of this study indicate that high levels of Cu, Fe, Na and Ca are responsible for non-palatability of A. cordifolia. Moreover, it has a very bitter taste for which grazing animals don’t touch it in the wild. Findings of this study are also backed by work of Gillani et al., (2010) who have reported toxic secondary metabolites in this species (Table 1, Fig. 2).

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Parameter</th>
<th>Symbol</th>
<th>Aristida cyanantha</th>
<th>Andrachne cordifolia</th>
<th>Quercus baloot</th>
<th>Indigogera heterantha var. heterantha</th>
<th>Cotoneaster nummularia</th>
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<tr>
<td></td>
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<td>I I I I II II I I</td>
<td>I I I I II II I I</td>
<td>I I I I II II I I</td>
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<td>7173 8393</td>
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<td>3.</td>
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<td>3756 2101</td>
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<td>4.</td>
<td>Calcium</td>
<td>Ca</td>
<td>1460 1789 17723 11914 10905 7205 29802 35269</td>
<td>18460 14127</td>
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<td>5.</td>
<td>Sulphur</td>
<td>S</td>
<td>440 379 1198 822 719 654 696 3970</td>
<td>659 916</td>
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</tbody>
</table>

| 6.    | Iron        | Fe     | 94 109 349 284 147 364 136 179 188 281 |
| 7.    | Cobalt      | Co     | ND ND ND ND ND ND ND | ND ND ND ND ND |
| 8.    | Nickel      | Ni     | ND 1 1 1 1 3 2 2 3 1 |
| 9.    | Copper      | Cu     | 16 3 23 4 8 6 5 8 13 5 |
| 10.   | Zinc        | Zn     | 14 13 32 20 14 18 13 20 29 18 |
| 11.   | Molybdenum  | Mo     | ND ND ND ND ND ND ND ND ND ND |
| 12.   | Manganese   | Mn     | 5 7 30 31 65 139 18 53 24 30 |

| 13.   | Sodium      | Na     | 21 76 276 66 4 33 146 60 95 41 |
| 14.   | Silicon     | Si     | 66 75 8 9 11 39 205 94 171 16 |
| 15.   | Barium      | Ba     | 2 17 37 12 37 17 47 32 52 32 |

I = Pre-Reproductive stage, II = Post-Reproductive stage; ND = value below detection range

*All values in μg/g
CHEMICAL SCREENING OF HEAVY METALS AT VARIOUS PHENOLOGICAL STAGES

Fig. 1. Macro- micronutrients and trace element analysis of *Aristida cyanantha*.

Fig. 2. Macro-micronutrients and trace element analysis *Andracne cordifolia*.

Fig. 3. Macro-micronutrients and trace element analysis *Quercus baloot*. 
Quercus baloot Griffith

Macronutrients: In Quercus baloot a significant increase in phosphorous levels was noticed with increasing age of the plant. Phosphorous content was 377 μg/g in pre-reproductive stage which increased to 965 μg/g in post-reproductive stage. Potassium was recorded as 5696 μg/g in pre-reproductive stage which decreased to 4664 μg/g in post-reproductive stage. Magnesium content showed an increase with maturity of the plant, it was 1597 μg/g in pre-reproductive stage and 1968 μg/g in post-reproductive stage. Calcium was found to be 10905 μg/g in pre-reproductive stage which decreased to 7205 μg/g in post-reproductive stage. Usually the livestock consume its foliage, especially the young leaves, or its inflorescence.

Micronutrients: With growing age of the plant, increase in micronutrients was observed. Iron content was recorded as 147 μg/g in pre-reproductive stage which increased to 364 μg/g in post-reproductive stage. Nickel levels showed no marked variation at both phenological stages i.e. 1 μg/g and 3 μg/g. Cobalt and molybdenum were not detected in either of the phenological stages. Copper content was low i.e. 8 μg/g and 6 μg/g in pre-reproductive and post-reproductive stages respectively. Zinc content was 14 μg/g and 18 μg/g in successive phenological stages. Significant increase in manganese levels was noticed which showed an increase from 65 μg/g in pre-reproductive stage to 139 μg/g in post-reproductive stage.

Trace elements: An increase in sodium levels was noticed, it was recorded as 4 μg/g in pre-reproductive stage and 33 μg/g in post-reproductive stage. Silicon levels were also raised in post-reproductive stage (39 μg/g) which were only 11 μg/g in pre-reproductive stage. Barium showed a contrasting trend, it was found to be 37 μg/g in pre-reproductive stage and decreased to 17 μg/g in post-reproductive stage (Table 1 Fig. 3).

Indigofera heterantha Wall. ex Brandis var. heterantha

Macronutrients: An increase in all macronutrients was recorded with maturity of the plant. Phosphorous in pre-reproductive stage (344 μg/g) increased to 1019 μg/g in post-reproductive stage. There was a marked increase in potassium content in post-reproductive stage i.e. 8274 μg/g while in pre-reproductive stage it was just 3654 μg/g. In pre-reproductive stage magnesium levels were 3729 μg/g which became 4344 μg/g in post-reproductive stage. Calcium levels were 29802 μg/g in pre-reproductive stage and 35269 μg/g in post-reproductive stage. Considerable increase in sulphur content was recorded, it was found to be 69 μg/g in pre-reproductive stage and 3970 μg/g in post-reproductive stage.

Micronutrients: There was no substantial change in iron levels, which ranged between 136 μg/g and 179 μg/g during both the stages. Nickel content was low while molybdenum and cobalt were not detected in both phenological stages. Copper content was also low during both stages (5μg/g and 8μg/g). Zinc levels were estimated as 13 μg/g and 20 μg/g in pre-reproductive and post-reproductive stages respectively. Manganese content showed an increase with maturity and it was estimated as 53 μg/g in post-reproductive stage while it was 18 μg/g in pre-reproductive stage.

Trace elements: Trace elements showed a decrease with maturity. Sodium levels decreased in post-reproductive stage (60 μg/g) which were 146 μg/g in pre-reproductive stage. Similar trend was recorded for silicon, it was 205 μg/g in pre-reproductive stage and just 94 μg/g in post-reproductive stage. Barium content also decreased from 47 μg/g to 32 μg/g (Table 1, Fig. 4).

Cotoneaster nummularia Fisch. & Mey.

Macronutrients: Phosphorous levels showed a decrease with age of the plant, they were estimated as 632 μg/g and 551 μg/g in pre-reproductive and post-reproductive stages respectively. On the contrary, potassium content was 7173 μg/g in pre-reproductive stage which increased to 8390 μg/g in post-reproductive stage. Magnesium levels decreased from 3756 μg/g in pre-reproductive stage to 2101 μg/g in post-reproductive stage. Significant variation in calcium levels was recorded in both phenological stage, in pre-reproductive stage they were found to be 18460 μg/g which were reduced to 14127 μg/g in post-reproductive stage. Slight increase in sulphur content was recorded, in pre-reproductive stage they were 659 μg/g while 916 μg/g in post-reproductive stage.

Micronutrients: Iron levels showed an increase with maturity, 188 μg/g in pre-reproductive stage and 281 μg/g in post-reproductive stage. Copper and zinc showed a decrease in post-reproductive stage, while molybdenum and cobalt were below the detection range in either of the phenological stages. Manganese levels increased from 24 μg/g in pre-reproductive stage to 30 μg/g in post-reproductive stage.

Trace elements: Sodium levels were 95 μg/g in pre-reproductive stage which dropped to 41 μg/g in post-reproductive stage. Marked decrease was recorded for silicon levels, they were estimated as 171 μg/g in pre-reproductive stage which decreased to just 16 μg/g in post-reproductive stage. No drastic change was seen in case of barium, they stayed at 52 μg/g and 32 μg/g in successive stages (Table 1, Fig. 5).

Figure 6 shows the mean values for all the minerals enumerated. The highest mean value for P was recorded in Indigofera heterentha (68.51 μg/g), followed by Quercus baloot (671 μg/g), Cotoneaster nummularia (591.5 μg/g) and Andrachne cordifolia (477.5 μg/g) while the lowest P levels were estimated in Aristida cyanantha (238.5 μg/g). Similarly, highest K levels were recorded in A. cordifolia (9423 μg/g) followed by C. nummularia (7783 μg/g), I. heteretha (5964 μg/g), and Q. baloot (5180 μg/g) whereas A. cyanantha (4871 μg/g) showed lowest concentration. Mg levels were highest in I. heterentha (4036.5 μg/g), followed by C. nummularia (2928.5 μg/g), A. cordifolia (2879 μg/g) and Q. baloot (1782 μg/g) and lowest in and A. cyanantha (254 μg/g).
Ca was abundant in *I. heterantha* (32535 μg/g), *C. nummularia* (16293.6 μg/g), and *Q. baloot* (9055 μg/g) while lowest in *A. cyanantha* (1624.5 μg/g). *I. heterantha* (2333 μg/g) had highest mean value for S, followed by *A. cordifolia* (1010 μg/g), *C. nummularia* (787.5 μg/g) and *Q. baloot* (686.5 μg/g) while the least S was recorded in *A. cyanantha* (409.5 μg/g). Fe levels were low in all selected plants with highest mean value observed in *A. cordifolia* (316.5 μg/g) and lowest in *A. cyanantha* (101.5 μg/g). Ni was not detected in *A. cyanantha* while *Q. baloot*, *I. heterantha* and *C. nummularia* had 2 μg/g mean value each while *A. cordifolia* had a mean value of 1 μg/g. Cu content was high in *A. cordifolia* (13.5 μg/g) and low in *I. heterantha* (6.5 μg/g). However highest mean value for Zn was observed in *A. cordifolia* (26 μg/g) followed by *C. nummularia* (23.5 μg/g), *I. heterantha* (16.5 μg/g) and *Q. baloot* (16 μg/g) and lowest in *A. cyanantha* (13.5 μg/g). Highest mean value for Mn was recorded in *Q. baloot* (102 μg/g), *I. heterantha* (35.5 μg/g) followed by *A. cordifolia* (30.5 μg/g) and *C. nummularia* (27 μg/g) and lowest in *A. cyanantha* (6 μg/g). Na exhibited highest value in *A. cordifolia* (171 μg/g) followed by *I. heterantha* (103 μg/g), *C. nummularia* (68 μg/g) and *A. cyanantha* (48.5 μg/g) while lowest in *Q. baloot* (18.5 μg/g). Similarly, Si levels were high in *I. heterantha* (149.5 μg/g) and low in *A. cordifolia* (8.5 μg/g). Ba exhibited high concentration among the plant viz. *C. nummularia* (84 μg/g) followed by *I. heterantha* (39.5 μg/g), *Q. baloot* (27 μg/g) and *A. cordifolia* (24.5 μg/g). Based on mean values the trend for *A. cyanantha* remained as Ca > K > S > Mg > P > Fe > Si > Na > Zn > Cu: Ba > Mn. For *A. cordifolia* it was Ca > K > Mg > P > S > Fe > Na > Mn > Zn > Ba > Cu > Si > Ni, for *Q. baloot* it stood as Ca > K > Mg > S > P > Fe > Mn > Ba > Si > Na > Zn > Cu > Ni, for *I. heterantha* var. *heterantha* it remained as Ca > K > Mg > S > P > Fe > Si > Na > Mn > Zn > Cu > Ni and for *C. nummularia* it was Ca > K > Mg > S > P > Fe > Si > Ba > Na > Mn > Zn > Cu > Ni.
Discussion

It is the chemical profile of a plant species which determines its palatability status and its relative preference by grazing and browsing animals (Sultan et al., 2009 & 2007). Chemical changes during growth and development of plant species either attract or repel grazing animals. Some plants become more palatable after maturity while some become less or even non-palatable with growing age. Potential intake of a plant by grazing animals and their relative preference is largely dependent on its chemical constituents (Khan & Hussain, 2012; Hussain & Durrani, 2009). Kothmann (1980) reported that some plants become less palatable as they age, mainly due to raised mineral content. Results reported here are supported by previous works of similar nature which reported an increase in K, P, Ca, Mg, Co and Cu levels in post-reproductive stage (Sher et al., 2012; Bano et al., 2009; Sultan et al., 2009 and Rahim et al., 2008). Phosphorous is an important mineral required by plants for vegetative growth and its deficiency leads to shorter internodes in plants. Phosphorous levels were not low at both phenological stages in all five plants, though seasonal variation was recorded in its values. These findings are backed by reports of Gull et al., (2015) and Dastagir et al., (2014). Potassium affects plant growth as it is an important activator of several plant enzymes (Sultan et al., 2008; Hussain & Durrani, 2007; Khan et al., 2007). Previous studies suggest that potassium content is higher in pre-reproductive stages in free grazing lands (Sultan et al., 2008), this was found true for A. cyanantha, A. cordifolia and Q. baloot. But in I. heterantha var. heterantha and C. nummularia, potassium content increased with maturity. Similarly, Minson (1990) reported low levels of potassium in grasses and forbs while present study contradicts his findings as in A. cyanantha potassium content was high in both phenological stages (6151 μg/g and 3591 μg/g). Magnesium is an important component of chlorophyll molecule and it is a must for ribosomal sub-unit association. Though magnesium levels were slightly low in A. cyanantha in both phenological stages, in rest of the plant species analyzed, higher values were recorded which suggest them to be good for lactating livestock. Findings presented here are strongly supported by Rahim et al., (2008); Khan et al., (2006); Islam et al., (2003); Skerman & Riveros (1990) and Georgievskii (1982). Calcium levels were considerably high in all plant species tested. Variable calcium levels in different plant species are reported by Hameed & Hussain (2015); Zafar et al., (2010); Bano et al., (2009); Hani et al., (2006); White & Broadly (2003), but our results contradict their findings. Role of sulphur is well established as a macronutrient which governs the proper growth of plants and enables them to tolerate stress (Matraszek et al., 2016). Sulphur levels varied with age in all plant samples. Highest levels of iron were found in post-reproductive stage of Q. baloot i.e., 364 μg/g followed by 349 μg/g in pre-reproductive stage of A. cordifolia. Iron is an important component required for chlorophyll synthesis hence having an impact on overall photosynthetic yield. Our results are favored by work of Hameed & Hussain (2015); Adnan et al., (2010) and Khan et al., (2006) who reported high levels of iron in plant of moist regions and from grazing pastures. Nickel content was low in all plant species analyzed and below detection range in pre-reproductive stage of A. cyanantha. This is in line with the work of Musharaf et al., (2017). In pre-reproductive stages of A. cyanantha, A. cordifolia and C. nummularia copper levels were 16 μg/g, 23 μg/g and 13 μg/g respectively which are above the permissible limit (10 μg/g) reported by Khuda et al., (2012); Demirezen & Aksoy (2006). Our findings are backed by reports of Hameed et al., (2008); Hussain & Durrani (2008); Garg et al., (2007) and Said et al., (1996) who have reported raised levels of copper in various plant species. Zinc is required by 200 different enzymes for their activity hence it is present in all living organisms in varying concentrations. It is also required for nucleic acid metabolism. Khuda et al., (2012) reported the permissible limit of 50 μg/g in medicinal plants. In our findings, the values for Zinc were found well below this limit and these results are supported by work of Demirezen & Aksoy (2006). Manganese is an important micronutrient but if its levels are raised it can prove to be injurious (Hameed &

Fig. 6. Mean values for minerals in all plants analyzed.
Hussain, 2015). Our results are in line with this, apart from post-reproductive stage of Q. baloot which exhibited 139 μg/g of manganese. This may be a reason that in post-reproductive stage plant leaves are seldom browsed by the livestock. Low sodium content was detected in all plant samples. Our results are in line with work of Adnan et al., (2010) but contradictory to the reports of James et al., (2010) and Hanif et al., (2006) who reported high levels of sodium in other plant species. In most of the elemental studies, silicon is usually neglected but recent studies suggest its important role in influencing the plant nutrition as well as nutrient cycling (Schaller et al., 2016). Lowest silicon levels were recorded in A. cordifolia i.e., 8 and 9 μg/g in both phenological stages respectively while highest values were found in I. heterantha var. heterantha in pre-reproductive stage (205 μg/g). Former is a non-palatable species while later is a palatable one hence it clearly indicates that silicon is an important factor in deciding the palatability status of a plant. Some of the problems related to animal growth and reproduction are linked to low mineral content in soils and forage plants in the locality (Tiffany et al., 2000). Variation in concentrations of macro and micronutrients are reported by Gull et al., (2015) and Dastagir et al., (2014). This supports findings of this study which reports a variation in concentration of macro and micronutrients in forage plants at different phenological stages. Studies of similar kind were conducted for Ba, Ca, Co, Cu, Fe, Mg, Mn, Mo, Ni, P, K, Si, Na, S and Zn (Gull et al., 2015; Abreu 2012; Sher et al., 2012; Cheema et al., 2011; Sultan et al., 2010, 2008; Bano et al., 2009; Ahmad et al., 2008 and Rahim et al., 2008).

Fig. 7. Comparison of all nutrients at two phonological stages.

Statistical analysis
Anova was applied to analyze the results of this study. Detail of statistical analysis are given below (Fig. 7).

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<th>ANOVA. Overall analysis of Macronutrients, Micronutrients and Trace elements at Pre-reproductive stage.</th>
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<tr>
<td>Within 5 plants</td>
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Micronutrients - (Phosphorous, Potassium, Magnesium, Calcium, Sulphur),
Micronutrients - (Iron, Cobalt, Nickel, Copper, Zinc, Molybdenum, Manganese) & Trace elements (The amount of Sodium, Silicon, Barium) are non-significant at stage – I

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<th>ANOVA. Macronutrients, micronutrients and trace elements at post-reproductive stage.</th>
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<td>Sum of squares</td>
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Micronutrients - (Phosphorous, Potassium, Magnesium, Calcium, Sulphur),
Micronutrients - (Iron, Cobalt, Nickel, Copper, Zinc, Molybdenum, Manganese) & Trace elements (The amount of Sodium, Silicon, Barium) are non-significant at stage – II.
Post – Hock test
The LSD value = 2456.10
Sample mean – 1 = 435.9333
Sample mean – 2 = 1435.733
Sample mean – 3 = 1071.667
Sample mean – 4 = 3554.933
Sample mean – 5 = 1767.467

Comparison of means | LSD | Remarks |
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<td>1 vs. 3</td>
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<td>Significant</td>
</tr>
<tr>
<td>1 vs. 5</td>
<td>&lt;</td>
<td>Non-significant</td>
</tr>
<tr>
<td>2 vs. 3</td>
<td>&lt;</td>
<td>Non-significant</td>
</tr>
<tr>
<td>2 vs. 4</td>
<td>&lt;</td>
<td>Non-significant</td>
</tr>
<tr>
<td>2 vs. 5</td>
<td>&lt;</td>
<td>Non-significant</td>
</tr>
<tr>
<td>3 vs. 4</td>
<td>&gt;</td>
<td>Significant</td>
</tr>
<tr>
<td>3 vs. 5</td>
<td>&lt;</td>
<td>Non-significant</td>
</tr>
<tr>
<td>4 vs. 5</td>
<td>&lt;</td>
<td>Non-significant</td>
</tr>
</tbody>
</table>

In further analysis sample means 1, sample mean 3 and sample mean 4 are significant.
From above ANOVA, the amount of Phosphorous, Potassium, Magnesium, Calcium, Sulphur are non-significant at stage –1.

From above ANOVA, we conclude that the amount of Phosphorous, Potassium, Magnesium, Calcium, Sulphur are significant at stage-2.

From above ANOVA, the amount of Iron, Cobalt, Nickel, Copper, Zinc, Molybdenum, Manganese are non-significant.

From above ANOVA, we conclude that the amount of Iron, Cobalt, Nickel, Copper, Zinc, Molybdenum, Manganese are non-significant.

The amount of Sodium, Silicon, Barium is significant at stage -1.

The amount of Sodium, Silicon, Barium is significant at stage -II.

References


