Comparative studies on mineral contents in soil and wild trees samples of *Boswellia sacra* collected from different locations of Dhofar

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Frankincense, the indicator of Dhofar region flourishes in all geographical location of Dhofar. The cultivars of frankincense grown in different location are known by different name such as Shaebi, Sahli, Houjri, Najdi etc. Mineral nutrition has direct effect on both primary and secondary metabolism of plants. Mineral element as nitrogen, phosphorus and potassium plays a major role in primary metabolism. Elements as Na, K, Fe, Mn, Ca, Mg, Zn and Cu were analyzed in soil and samples of various parts (leaves, bark, outer bark, flower, seed, root stem and resin) of *Boswellia sacra* collected from three different locations of Dhofar. The significant results was found to be that sample ST-1 contain high amount of iron, potassium, zinc, magnesium whereas sample ST-2 contain more amount of iron, magnesium, sodium, and calcium. Sample ST-3 found to be contain significant amount of calcium whereas ST-4 high amount of manganese, iron, sodium, and calcium. Soil samples obtained from Mughsail hill recorded more amounts of manganese, potassium, copper, and magnesium whereas, soil samples from Saddah hills found to contain high amount of magnesium and sodium. Further soil samples collected from valleys contains rich amount of calcium and noticeably the highest value gave by the soil sample obtained by plains followed by soil sample of valleys. On the basis of comparative study of data (Table 1-8) obtained for elements, it can be concluded that plants grown in different location showed difference in accumulation of mineral elements.

Keywords: *Boswellia sacra*, mineral nutrient, Dhofar

1. Introduction

The Dhofar region is famous for its mountain range and seasonal rain. Some mountains are very higher with mean height of 1400 m near Yemen border (i.e. Jabal Sayk) while other mountains are lower with average height of 800-900 meters (Jabal Qara) (Raffaelli et al., 2003). The difference in climatic conditions exists between plain and hill region of Dhofar, even weather conditions of plain areas are different on the basis of distance from hills. These differences are also the cause of different soil conditions especially moisture content of the soil. The environmental and soil conditions directly affect the mineral element absorption capacity of plants (Kreuzwieser and Gessler, 2010).

The Dhofar region supports various type of vegetation due to rainwater received in Khareef season (Raffaelli et al., 2003). Frankincense is the indicator of the Dhofar region, a member of family Burseraceae (Miller and Morris, 1988). The gum resin of frankincense has 5-6% essential oil (Al-Harrasi and Al-Saidi, 2008). The essential oil extracted from gum resin of frankincense has very high economic value due to its medicinal property. Aroma-therapy and topical drugs are major areas that use high amount of frankincense oil (Hussain et al., 2013). The main feature of the plant of the genus Boswellia is to produce gum resin. Generally, 5-6% essential oil is obtained by good quality resin. The main ingredients of the resin oil are monoterpenes which are in the range of 94-96% of the total. The remaining portion is constituted by sesquiterpenes (Ayoola, 2008; Kumar, et. al., 2009). There are major differences in quality and quantity of both gum resin and essential oils of frankincense trees grown in different parts of the world (Van Vuurena et al., 2010).

Elements not instantaneously limiting growth are usually taken up in some excess by plants, compared to calculated or demonstrated demands. This principle has been widely elucidated in studies of cultivated plants (Bergmann, 1988) and luxury or excess uptake of several mineral nutrients, related to soil chemical properties, has also been demonstrated in wild-growing species (Tyler, 1976). Elements that are becoming markedly diluted in an expanding biomass constitute potential limitations to further growth. Mineral nutrition has direct effect on both primary and secondary metabolism of plants. Mineral element like nitrogen, phosphorus and potassium plays a major role in primary metabolism that involves in the synthesis of primary metabolites like protein, carbohydrate and lipids. Other minerals are known as micronutrient elements takes parts in the production of secondary metabolites such as essential oil, alkaloids, flavonoids etc (Subramanian et al., 2012). Broad variation in the physical and chemical properties of soil provides a large challenge to plant to develop. Some

wild plants show specific adaptations to certain soils, and many efforts have been directed towards identification of the mechanisms permitting growth in these environments (Baker, 1987). In the present study, elemental analysis of *Boswellia sacra* was evaluated to find out the effect of various locations on elemental status of the plants and its relation with quality of resin and essential oil accumulation.

2. Materials and Methods:

2.1. Sample collection

Soil and samples of various parts (leaves, bark, outer bark, flower, seed, root stem and resin) of *Boswellia sacra* were collected from three different locations of Dhofar as followings, during March to May 2016.

1. Collected from Velleys (Sample Type-1 = **ST-1)**
2. Collected from Salalah plains (Sample Type-2 = **ST-2**)
3. Collected from Mughsail hills (Sample Type-3 = **ST-3**)
4. Collected from Saddah hills (Sample Type-4 = **ST-4**)

The codes **ST-1, ST-2, ST-3 and ST-4** are used in whole article to express samples types as mentioned above. Age of *B. sacra* tree collected from Dokha valley is 13 years and *B. sacra* tree collected from Saddah could be more than 50 years. Frankincense tree is a small evergreen tree and it is about 4.5-5 meter height in Dokha valley, whereas, of Sadah is about 6.75 – 8.0 meter height. Dokka is Natural Park of famous Omani frankincense *B. scara* and is about 40 kilo meter north of Salalah. Sadah is a coastal village 135 kilometer north of Salalah. Distance between the trees in Dokha is about 5-7 meters, whereas in Sadah the distance is varied and could reach 10-15 meters between each tree. The mature leaves were collected with a size of 4 to 5 X 1.5 cm. The sample was collected from the field and transported to the lab immediately in polythene bags and dried at room temperature. The soil characteristics in sadah is sandy-clay loam with particle size ranging from 0.002 mm to 2 mm whereas, the soil characteristics of Dokha is almost textured sandy loam with up to 20% clay with particle sizes ranging from 0.002 mm – 0.05 mm. We collected three soil samples per site and performed the experiments triplicate of each sampling. Depth of sampling is 20-35 cm. The resin used in is commercial grade is known as “Najdi” which can be classified as second grade resin having a pale yellow color. Sampling of resin is done by local people and we usually obtain the resin from them.

2.2. Elemental analysis

Elements as Na, K, Co, Fe, Mn, Ca, Mg, Zn and Cu were analyzed using AAS (Model: PerkinElmer PinAAcle 500). 1.0 g of each sample was dried in the furnace. Each sample was transferred in Kjeldhal tube and digested with 10.0 ml nitric acid. The digested samples were further diluted with distilled water up to 25 ml.

2.3. Extraction of oil

Extraction of essential oil was carried out by Clevenger's apparatus to get the different fraction of oil. 250 g of each sample and 2.5 l water were transferred in 5.0 l round bottom flask and fixed it with Clevenger. The sample was heated with help of heating mantle at 100 ˚C. The first, second and third fraction of essential oil were collected after 2 h.

2.4. Statistical analysis

The data presented as mean ± SD of triplicates. The data were evaluated by Duncan's multiple range tests. P value <0.01 was considered significant.

3. Results:

The data obtained from this study are in tabulated (Tables 1-8) and discussed here briefly. The data showed clearly differences in concentrations belong to different part of plant.

3.1. Determination of Manganese (Mn) in soil and frankincense parts

Among tested sample, bark, outer bark, seeds of ST-1 showed the highest value for manganese while leaves of ST-4 gave maximum value for same parameters (Table 1). Regarding root samples, no significant difference was observed. The lowest value of the manganese was recorded in bark sample of ST-4 (Tables 1). Frankincense crystal gave more value for manganese than that of crystal powder (Table 5). Among soil samples, sample obtained from Mughsail hill recorded the highest value for manganese (Table 7).

3.2. Determination of Iron (Fe) in soil and frankincense parts

The bark and outer bark of ST-1 and ST-2 respectively gave the highest value for iron. Leaves and seeds of ST-4 recorded the maximum value for iron. Root of ST-2 gave more value than that of root of ST-3. There was no significant difference between samples of outer bark of ST-2 and ST-3 for iron content (Table-1). Frankincense crystal gave more value for iron than that of crystal powder (Table 5). The highest value gave by the soil sample obtained by plains followed by soil sample of

valleys. However, values for both soil samples (plains and valleys) are not significantly different but gradually (Table 7).

3.3. Determination of Potassium (K) in soil and frankincense parts

Bark, outer bark, leaves and seeds of ST-1 showed maximum value for potassium than these of other sample types. Root of ST-2 gave more value than that of root of ST-3. Root of ST-3 recorded the lowest value for potassium among various sample types (Table 2). Frankincense crystal gave more value for potassium than that of crystal powder (Table 5). Among soil samples, sample obtained from Mughsail hill recorded the highest value for potassium (Table 7).

3.4. Determination of Zinc (Zn) in soil and frankincense parts

Bark, outer bark, and leaves of ST-1 showed maximum value for zinc than these of other sample types. Seed of ST-2 recorded highest value in comparison to other sample type. There was no significant difference between samples of roots of ST-2 and ST-3 for iron content (Table-2). Frankincense crystal gave more value for zinc than that of crystal powder (Table 5). Among soil samples, sample obtained from Mughsail hill recorded the highest value for zinc (Table 7).

3.5. Determination of Copper (Cu) in soil and frankincense parts

The maximum value for copper obtained from samples of bark, outer bark of ST-4 and from leaves, seeds and root of ST-2. The lowest value for copper was registered from bark of ST-2 (Table 3). Copper was not detected in both sample of frankincense crystal and powder (Table 5). The maximum value for copper gave by soil sample of Mughsail. Both soil samples obtained from Saddah hills and valleys registered similar values for copper content (Table 7).

3.6. Determination of Magnesium (Mg) in soil and frankincense parts

Bark, outer bark and leaves of ST-1 and seeds of ST-2 showed maximum values for magnesium than those of others sample types. The minimum value for magnesium was recorded in bark sample of ST-4 (Table 4). Frankincense crystal gave more value for magnesium than that of crystal powder (Table 6). Both soil samples obtained from Mughsail hills and Saddah hills registered similar values for magnesium content (Table 8).

3.7. Determination of Sodium (Na) in soil and frankincense parts

Outer bark leaves and seeds of ST-2 and bark of ST-4 gave maximum values than those of others samples types for sodium content. Root of ST-2 registered more value for sodium than that of

ST-3 (Table 4). Frankincense crystal gave more value for sodium than that of crystal powder (Table 6). Soil sample of Saddah hills gave maximum value for sodium content (Table 8).

3.8. Determination of Calcium (Ca) in soil and frankincense parts

Bark of ST-3, outer bark of ST-4, leaves, seeds and root of ST-2 registered maximum values for calcium than those of other sample types. Seeds of ST-4 gave minimum value for calcium (Table-4). Contrary to other elements, frankincense powder gave more value for sodium than that of frankincense crystal (Table 6). The highest value of calcium was reported in soil sample of valleys (Table 8).

4. **Discussion**

4.1. Determination of quality of tree by mineral content

The quality of medicinal plants is due by the geochemical features of the soil, the capacity of plants to accumulate nutrients, environmental pollution and fertilization (Queralt et al., 2005). Climate and soil conditions in Dhofar region of Oman favored the development of a diverse wealth and impressive variability. Regarding the number and the importance of species with pharmaceutical interest, frankincense appears as one of the most important, providing an immense field for study and research. The therapeutic value of medicinal plants is based on the relationship between chemical structure of the active substances, called active ingredients and their pharmaco-dynamic action exercised on reactive elements of the body. The fact that most medicinal plants have complex chemical composition from 2-3 to 30-40 chemical compounds identified in some plants explains multiple pharmaco-dynamic properties of one and the same plant. The main content of frankincense is oil and other terpenes (Mustafa and Kiczorowska, 2016). Forests are usually developed on nutrient-poor and rocky soils, while nutrient-rich soils have been dedicated to agriculture for cultivation of economically important plants. In this context, nutrient access by the plants from the soil depends on nutrient content in particular minerals (Colin et al. 2017). It has been reported that the age and quality of the tree is depending the mineral (Ca, K, Mg, Fe, Zn, Cu, and Mn) contents and it reflects on fruit quality of trees (Kumar and Ram, 2018). By understanding this fact here in we report for the first time mineral contents of soil and different part of frankincense collected from dhofar regions. Further we intended to study the correlation between mineral content and quality of frankincense.

4.2. Analysis of major mineral content in soil and frankincense tree

Manganese (Mn) is a very essential trace heavy metal for plants and animal's growth. The present study indicated that concentrations of manganese were reported within range 4-45 ppm that supports the fact that among plants parts, Mn content varied between the range 3.1 -84.73 ppm (Afzal et al., 2013). However, the accumulation of Mn in plant organs did not follow any consistent pattern (Stefanowicz et al., 2016) but in present study highest accumulation of manganese was occurred in leaves in comparison to other plants parts (Table 1). This might be due to the source to sink relationship between leaves and soil. According to Kabata-Pendias (2011), similar or even higher amounts of Mn are found in some non-metalliferous (calcareous) soils. Iron is one of 16 essential elements for plant growth and reproduction. Iron is a micronutrient and is required by plants in small amounts. Iron is necessary for many enzyme functions and as a catalyst for the synthesis of chlorophyll. It is essential for the young growing parts of plants. The outer bark accumulates more iron content in comparison to other plant parts (Table 1). However, we have no exactly justification for iron accumulation but again it might be related with high amount of iron presence in calcareous soil. Iron (Fe) is one of the most abundant elements on the planet (Kim and Guerinot, 2007). Copper is another important micronutrient that is very useful in chlorophyll formation and proper enzyme activity (Yruela, 2005). The concentration of copper generally decreases in old leaves, thus demonstrating a remobilization process between leaves. Cu deficiency also triggered an increase in Cu in old roots and leaves (Billard et al., 2014). Sodium has no major role in plant metabolism; however, it is needed in C4 plants to regenerate phosphoenolpyruvate and synthesis of chlorophyll. In our study, the concentrations of sodium were in normal range that is not harmful to plants. The data obtained for sodium is in accordance to Ştef et al. who reported concentration macro element of some medicinal plants (Ştef et al., 2010). The concentrations of calcium noted in different studied samples were in agreement with findings obtained by Chowdhary and Rasool (2010) as they reported calcium levels in medicinal plants of three families. Calcium and Magnesium are important components in cell walls, nucleic acids, plant metabolism and photosynthesis (Anjorin et al., 2010). Various role of magnesium in plant metabolism are already discussed in detail (Sium et al., 2016). Further, in some plants, the tissue concentration of magnesium is comparable to that of phosphorus, a primary nutrient. The most important role of magnesium is as the central atom in the chlorophyll molecule. Chlorophyll is the pigment that gives plants their green color and carries out the process of photosynthesis. It also aids in

the activation of many plant enzymes needed for growth and contributes to protein synthesis. A magnesium concentration of 2000 mg/kg in plants is commonly regarded as the minimum ‘‘safe’’ dietary concentration for adequate animal health (Imelouane et al., 2011). The various elements present in frankincense crystal (before and after distillation) is due to the presence of impurities. The concentrations of elements present in oil samples are very low that can be consider as negligible. Overall our data reveals that there is a variation in frankincense tree parts collected from different dhofar region. The mineral content is varied from one cultivar to another and it is remain elusive. High accumulation minerals could be responsible for resin quality and this hypothesis would be attributed further. Our preliminary data forms the rationale for future physiological studies on frankincense such as mineral content variation across different genotype and cultivars.

Conclusion:

In conclusion **o**n the basis of comparative study of data (Table 1-8) obtained for elements, it can be concluded that plants grown in different location showed difference in accumulation of mineral elements. The reason behind these differences might be related to soil and environmental conditions as these are able to affect physiology of the plants (Gomez and Gomez, 1984). Furthermore, varietal differences among the accessions are greater than the differences between related species or genera (Millikan, 1961). Elemental uptake, distribution and storage processes involve multiple molecular components including transporters, channels, chelators and the genes that encode and regulate them. Processes that alter the physiological properties such as root architecture and transpiration can also affect elemental accumulation (Baxter et al., 2009). However, the physiological and molecular drivers of the elemental response and the rules governing relationships between many other elements are far from clear.

Table 1. Elements manganese and iron present in various parts of plants collected from different location.

	Mn (manganese)					Fe (Iron)				
Sample type	Bark	Outer bark	Leaves	Seeds	Root	Bark	Outer bark	Leaves	Seeds	Roots
ST-1	4 ± 0.19[a]	22.8 ±1.5[b]	33.47 ±2.8[b]	11.93 ±0.95[a]	nt	58.73 ± 8.98[a]	95.67 ± 19.95[a]	32.67 ± 3.05[c]	15 ± 3.21[c]	nt
ST-2	2.93 ± 0.19[b]	7.46 ± 1.8[c]	23.47 ± 1.8[c]	6.13 ± 0.95[c]	2.93 ±0.53[a]	22.4 ± 2.91[c]	105.9 ± 7.6[a]	79 ± 1.6[b]	77 ± 8.0[b]	25.6 ± 6.69[a]
ST-3	2.99 ± 0.2[b]	6.34 ± 1.4[c]	19.48 ± 1.49[d]	5.5 ± 1.15[c]	2.80 ± 0.73[a]	19.8 ± 1.85[d]	105 ± 1.65[a]	78.5 ± 1.56[b]	17.7 ± 1.5[c]	10.6 ± 1.55[b]
ST-4	2.5 ± 0.14[c]	28.2 ± 1.8[a]	42.48 ± 1.5[a]	10.84 ± 0.82[b]	nt	48.52 ± 8.24[b]	80.67 ± 8.0[b]	89.5 ± 2.15[a]	95 ± 2.25[a]	nt

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Table 2. Elements potassium and zinc present in various parts of plants collected from different location.

	K (ppm)					Zn (ppm)				
Sample type	Bark	Outer bark	Leaves	Seeds	Root	Bark	Outer bark	Leaves	Seeds	Roots
ST-1	446.33 ± 2.57^{a}	395 ± 41.24^{a}	790 ± 108.03^{a}	7950.33 ± 924.92^{a}	nt	16.4 ± 2.57^{a}	15.47 ± 2.37^{a}	13.73 ± 0.71^{a}	6.67 ± 0.74^{b}	nt
ST-2	85.2 ± 11.74^{b}	90.3 ± 3.96^{b}	196.2 ± 25.3^{b}	7726.2 ± 845.92^{b}	168.6 ± 21.5^{a}	2.13 ± 0.75^{b}	6.26 ± 0.78^{b}	6.37 ± 6.37^{b}	7.87 ± 0.64^{a}	5.07 ± 0.54^{a}
ST-3	25.8 ± 1.45^{d}	20.3 ± 0.48^{d}	19.5 ± 0.44^{d}	5224.6 ± 726.25^{c}	18.5 ± 2.5^{b}	1.63 ± 0.54^{b}	4.26 ± 0.48^{c}	5.37 ± 5.37^{c}	5.59 ± 0.54^{c}	5.37 ± 0.56^{a}
ST-4	52.30 ± 8.24^{c}	32.8 ± 8.0^{c}	55 ± 1.02^{c}	38.32 ± 18.18^{d}	nt	2.2 ± 0.85^{b}	6.85 ± 0.95^{b}	6.31 ± 6.31^{b}	5.25 ± 0.31^{c}	nt

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Table 3. Elements copper and magnesium present in various parts of plants collected from different location.

	Cu (ppm)					Mg (%)				
Sample type	Bark	Outer bark	Leaves	Seeds	Root	Bark	Outer bark	Leaves	Seeds	Roots
ST-1	3.73 ± 0.74^{b}	5.33 ± 0.08^{b}	7.53 ± 1.62^{a}	5.53 ± 0.27^{a}	nt	0.33 ± 0.018^{a}	0.21 ± 0.04^{a}	0.2 ± 0.02^{a}	0.19 ± 0.03^{b}	nt
ST-2	2.93 ± 0.24^{c}	4.4 ± 0.52^{c}	8.53 ± 1.02^{a}	6.0 ± 0.64^{a}	4.13 ± 0.38^{a}	0.26 ± 0.015^{c}	0.036 ± 0.008^{d}	0.13 ± 0.07^{b}	0.26 ± 0.05^{a}	0.16 ± 0.05^{a}
ST-3	3.05 ± 0.25^{c}	3.6 ± 0.45^{d}	7.26 ± 1.12^{ab}	4.56 ± 0.21^{b}	3.43 ± 0.19^{b}	0.21 ± 0.015^{d}	0.046 ± 0.006^{c}	0.15 ± 0.05^{b}	0.16 ± 0.03^{c}	0.14 ± 0.05^{b}
ST-4	5.00 ± 0.35^{a}	6.01 ± 0.25^{a}	5.41 ± 0.82^{c}	5.62 ± 0.20^{a}	nt	0.029 ± 0.003^{b}	0.104 ± 0.08^{b}	0.11 ± 0.09^{c}	0.015 ± 0.09^{d}	nt

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Table 4. Elements sodium and calcium present in various parts of plants collected from different location.

	Na (ppm)					Ca (%)				
Sample type	Bark	Outer bark	Leaves	Seeds	Root	Bark	Outer bark	Leaves	Seeds	Roots
ST-1	0.136 ± 0.008^{b}	0.463 ± 0.04^{c}	0.16 ± 0.01^{c}	0.153 ± 0.006^{c}	nt	1.683 ± 0.04^{c}	0.99 ± 0.14^{c}	1.05 ± 0.06^{d}	0.27 ± 0.005^{d}	nt
ST-2	0.04 ± 0.002^{c}	1.38 ± 0.24^{a}	0.7 ± 0.03^{a}	1.32 ± 0.006^{a}	0.066 ± 0.004^{a}	10.56 ± 0.74^{a}	1.47 ± 0.54^{b}	14.4 ± 0.36^{a}	2.7 ± 0.5^{a}	12.06 ± 1.05^{a}
ST-3	0.035 ± 0.003^{d}	0.68 ± 0.16^{b}	0.4 ± 0.06^{b}	0.72 ± 0.12^{b}	0.056 ± 0.08^{b}	11.05 ± 0.54^{a}	0.95 ± 0.54^{c}	8.4 ± 0.82^{b}	1.8 ± 0.12^{b}	4.05 ± 0.85^{b}
ST-4	0.507 ± 0.05^{a}	0.5 ± 0.14^{b}	0.49 ± 0.13^{b}	0.09 ± 0.06^{d}	nt	8.34 ± 1.46^{b}	4.74 ± 0.13^{a}	5.78 ± 0.009^{c}	0.607 ± 0.009^{c}	nt

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Table 5. Elements (In ppm) present in sample gum resin and oil.

ST-5 Gum resin & oil sample			
Elements	Frankincense Crystal (Pre-distillation)	Frankincense Crystal powder (Post-distillation)	Oil
Mn (ppm)	45 ± 1.8^{a}	19± 0.86^{b}	nd
Fe (ppm)	139 ± 12.1^{a}	107 ± 8.5^{b}	nd
K (ppm)	300± 25^{a}	76 ± 2.4^{b}	1.27 ± 0.012^{c}
Zn (ppm)	11 ± 0.65^{a}	8.8 ± 0.45^{b}	2.5 ± 0.008^{c}
Cu (ppm)	nd	nd	nd

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Table 6. Elements (In %) present in sample gum resin and oil.

ST-5 Gum resin & oil sample			
Elements	Frankincense Crystal (Pre-distillation)	Frankincense Crystal powder (Post-distillation)	Oil
Na (%)	0.11 ± 0.065^{a}	0.014 ± 0.006^{b}	0.0008 ± 0.00002^{c}
Ca (%)	0.54 ± 0.082^{a}	1.37 ± 0.062^{b}	0.0004 ± 0.00001^{c}
Mg (%)	0.03 ± 0.002^{a}	0.008 ± 0.002^{b}	0.0003 ± 0.00001^{c}

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Table 7. Elements (In ppm) present in soil samples of different location.

ST-6 Soil samples of different locations				
Elements	Sample from Plains	Sample from Mughsail hills	Sample from Saddah hills	Sample from Valleys
Mn (ppm)	39 ± 2.31^{c}	80 ± 4.5^{a}	55 ± 4.8^{b}	45 ± 4.8^{c}
Fe (ppm)	655.33 ± 18.55^{a}	260 ± 125.8^{c}	545 ± 14.35^{b}	645 ± 12.41^{a}
K (ppm)	6.33 ± 0.51^{b}	346 ± 12.5^{a}	6.30 ± 0.65^{b}	4.250 ± 0.23^{c}
Zn (ppm)	6.93 ± 0.58^{b}	13.2 ± 0.28^{a}	5.85 ± 0.38^{c}	7.25 ± 0.41^{b}
Cu (ppm)	2.13 ± 0.24^{c}	8.0 ± 0.12^{a}	3.90 ± 0.50^{b}	3.90 ± 0.44^{b}

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Table 8. Elements (In %) present in sample gum resin and oil.

ST-6 Soil samples of different locations				
Elements	Sample from Plains	Sample from Mughsail hills	Sample from Saddah hills	Sample from Valleys
Na (%)	7.3 ± 0.23^b	0.041 ± 0.003^d	8.4 ± 0.043^a	6.8 ± 0.033^c
Ca (%)	21.1 ± 0.05^c	33.9 ± 5.6^b	34.9 ± 4.3^b	41.2 ± 3.6^a
Mg (%)	0.23 ± 0.02^c	4.1 ± 0.09^a	4.1 ± 0.08^a	3.6 ± 0.09^b

Data are means ± standard error of triplicate. Values with different superscript are significantly different at ($P \leq 0.05$) by Duncan's multiple range test.

Competing interests:

The authors have no conflicts of interest relevant to the ideas and/or contents of the manuscript.

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