# Contributions to the characterization of *Vavilovia formosa* (syn. *Pisum formosum)*. III. Contents of macro- and microelements

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Vavilovia *(Vavilovia formosa* (Stev.) Fed., syn. *Pisum formosum* (Stev.) Alef.) is a close botanical relative to vetchling *(Lathyrus* L.), lentil *(Lens* Mill.), pea *(Pisum* L.) and vetch *(Vicia* L.) which collectively form the tribe *Fabeae* (1). Its exact taxonomic position within the tribe has been examined for almost two centuries with molecular tools introduced rather recently and with already clarifying outcomes (2).

*V. formosa* has limited geographical distribution, ranging from the West Taurus Mountains in Turkey to southwest Iran and from Lebanon to north Caucasus. It is a perennial and a typical high-mountain plant (3) that is found at altitudes from 1500 to 3200 masl. *V. formosa* prefers shale or rocky ground, especially loose limestone screes and; therefore, has a well-developed root system (4). The goal of this preliminary research was to assess the chemical composition of the vegetative and generative organs of *V. formosa.*

## Materials and Methods

Two expeditions were carried out in 2009 to Mount Ughtasar in southern Armenia which is one of the three main habitats of *V. formosa* in the country (6). The first expedition, on July 17, resulted in collection of herbarium material of roots (Fig. la), stems (Fig. lb), leaves (Fig. lc) and flowers (Fig. Id) from one of the *V. formosa* populations, located at an altitude of between 3305 and 3315 masl, and a detailed soil chemical analysis was performed (Table l). The second expedition to the same place, on August 27, provided pods (Fig. le) with mostly immature and not fully developed seeds.

***Figure l. V. formosa material collected from the Mount Ughtasar in July and August2009: (a) roots; (b) stems; (c) leaves; (d) (e) pods with seeds.***

*Table. 1 Physical and chemical composition of aqueous extract of the soil under a population of V. formosa on the Ughtasar Mountain (6).*

| pH | Saline % | (% / mg-eq, in 100 g of soil) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | $CO_3$ | Total $CO_3^-$ | $Cl^-$ | $SO_4^{2-}$ | $Ca^{2+}$ | $Mg^{2+}$ | $Na^+ + K^+$ |
| 7.7 | 0.118 | - | 0.039 - 0.64 | 0.0034 - 0.96 | 0.008 - 0.17 | 0.010 - 0.24 | 0.003 - 0.24 | 0.024 - 1.03 |
| Carbonate content | | | | $CaCO_3$ - 1.3 %; $MgCO_3$ - 1.3 % | | | | |
| Exchange of ions in the clay-humus complex (mg-eq/100 g) | | | | Ca - 16.5; Mg - 4.5 l; Na - 0.4; K - 0.4 | | | | |
| Absorption capacity | | | | 21.8 mg-eq/100g | | | | |
| Mechanical composition | | | | light loamy soil | | | | |
| Nutrient supply (mg/100g) | | | | N - 2.7 (poor); $P_2O_5$ - 3.8 (average); $K_2O$ - 35.3 (high); humus (%) 4.4 | | | | |
| Heavy metal mobile forms (mg/kg of humus) | | | | Cu - 5 mg/kg; Ni - 15 mg/kg; Cr - 7 mg/kg; Pb - 6.1 mg/kg; Co - 4.1 mg/kg | | | | |

Prior to analysis all plant organs were air dried to a constant moisture content (10%). Total concentration of carbon (C), nitrogen (N) and sulfur (S) in the plant organs were determined by dry combustion using an automatic CNS analyzer (Vario EL III, Elementar). The total concentration of calcium (Ca), potassium (K), magnesium (Mg), sodium (Na), iron (Fe), manganese (Mn), zinc (Zn), copper (Cu), molybdenum (Mo), cobalt (Co) and boron (B) in the root, stem, leaf and flower samples were determined by an ICP-OES (Varian, Vista-Pro) after digestion in a mixture of 10 ml of $HNO_3$ (65%) and 2 ml of $H_2O_2$ (30%) using the microwave technique. The concentrations of these elements were not measured in the pods and seeds due to a lack of material.

**Results and Discussion**

*Macroelements.* The nitrogen content of *V. formosa* dry matter ranged from 1.37% in the pods to 5.73% in the seeds (Table 2). Crude protein content in leaf dry matter surpasses 200 g $kg^{-1}$ based of the nitrogen content and the multiplication coefficient of 6.25. Crude protein content of the seed was higher than 350 g $kg^{-1}$, although the analyzed seeds were not fully mature and thus might contain more crude protein in comparison to mature seeds. Both values may explain why *V. formosa* is severely endangered by grazing from domestic and wild animals and through seed loss caused by mice (5). The carbon content was relatively homogenous in all *V. formosa* organs, varying between 39.97% in its roots and 41.39% in its pods. The flowers and the seeds of *V. formosa* were richest in sulphur with 0.35% and 0.34%, while the stems were the poorest with 0.14%.

*V. formosa* flowers had the greatest content of Ca (11.40%) (Table 2). Leaves and flowers had roughly twice the content of K (1.44 % and 1.33%) and Mg (0.29 % and 0.27%) compared to roots and stems. The highest Na content was in the flowers (0.13%).

*Table 2. Content of macroelements (%) in V. formosa organs on a dry matter basis. Values are means ± SE (n = 3).*

| Organ | Macroelement content | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | C | S | Ca | K | Mg | Na |
| Roots | 1.92 ± 0.005 | 39.9 ± 0.009 | 0.161 ± 0.001 | 0.572 ± 0.002 | 0.582 ± 0.003 | 0.139 ± 0.003 | 0.071 ± 0.001 |
| Stems | 2.25 ± 0.007 | 40.4 ± 0.098 | 0.139 ± 0.002 | 0.826 ± 0.005 | 0.742 ± 0.004 | 0.156 ± 0.003 | 0.098 ± 0.001 |
| Leaves | 3.53 ± 0.008 | 40.2 ± 0.104 | 0.271 ± 0.002 | 2.764 ± 0.004 | 1.436 ± 0.005 | 0.285 ± 0.004 | 0.062 ± 0.002 |
| Flowers | 4.88 ± 0.003 | 40.6 ± 0.056 | 0.348 ± 0.004 | 11.40 ± 0.046 | 1.329 ± 0.003 | 0.274 ± 0.003 | 0.134 ± 0.002 |
| Pods | 1.37 ± 0.002 | 41.4 ± 0.047 | 0.203 ± 0.004 | / | / | / | / |
| Seeds | 5.72 ± 0.002 | 40.9 ± 0.059 | 0.338 ± 0.007 | / | / | / | / |

*Microelements.* The content of Cu, Co and Mo in all analysed plant organs were below detection limits. The highest content of Fe (1651 mg $kg^{-1}$) was in the roots. The roots also had the greatest content of Mn (61.76 mg $kg^{-1}$) while the leaves had the greatest content of Zn (72.11 mg $kg^{-1}$). It is noteworthy that boron was accumulated to the highest extent (262.60 mg $kg^{-1}$) in the flowers of *V. formosa* (Table 3.).

*Table 3. Contents of microelements (mg $kg^{-1}$) in the V. formosa organs dry matter. Values are means ± SE (n = 3).*

| Organ | Microelement content | | | |
|---|---|---|---|---|
| | Fe | Mn | Zn | B |
| Roots | 1651 ± 9.81 | 61.76 ± 0.45 | 36.77 ± 0.18 | 39.60 ± 0.11 |
| Stems | 598.6 ± 2.03 | 31.74 ± 0.24 | 69.35 ± 0.08 | 88.71 ± 0.22 |
| Leaves | 309.9 ± 0.64 | 41.84 ± 0.36 | 72.11 ± 0.13 | 94.72 ± 0.16 |
| Flowers | 157.4 ± 0.55 | 42.99 ± 0.20 | 52.86 ± 0.17 | 262.60 ± 3.15 |

**Conclusions**

The preliminary research on the macro- and microelement content in *V. formosa* provides a solid background for further testing of its tolerance to the lack and surplus of individual elements, as well as assessing its nutritional value and comparison to pea and other related species.

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