Research Paper

The Influence of Foliar Application of Selenium (VI) on the Concentration of Fe, Mn, Cd, Cu, Zn, S, and Mo in Common Buckwheat

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DOI: https://doi.org/10.3986/fag0049

Received: June 11, 2025; accepted June 27, 2025
Keywords: common buckwheat, Tartary buckwheat, selenium, trace elements

ABSTRACT

Selenium in the form of selenate (Se VI) was foliarly applied to buckwheat plants to evaluate its influence on the uptake and accumulation of other selected elements, including copper (Cu), zinc (Zn), sulfur (S), molybdenum (Mo), iron (Fe), manganese (Mn), and cadmium (Cd). Among these, Cu, Zn, Mo, Fe, and Mn are essential elements while cadmium, on the other hand, is a toxic pollutant absorbed by plants from contaminated soils. Foliar selenium (VI) application resulted in modest changes in the concentrations of Cd, Mo, Fe, Mn, and S in the leaves; Cu in the husks; and Mo and Mn in inflorescences. However, selenium had no significant effect on Zn accumulation. These results suggest that foliar application of selenium (VI) may both enhance and inhibit the uptake of specific elements, with effects varying by plant tissue.

INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* Moench) is a traditional crop that has nearly fallen out of widespread cultivation, despite its high nutritional value and various health benefits. It is a rich source of minerals such as zinc, copper, and magnesium, and contains significant levels of B-group vitamins (B1, B2, niacin, and B6) (Bonafaccia et al., 2003). Furthermore, buckwheat harbors a variety of bioactive compounds with antioxidant properties, including phytosterols, phenolic acids, squalene, fagopyritols, and, notably, high concentrations of polyphenols, particularly flavonoids such as rutin and quercetin (Fabjan et al., 2003).

Selenium is an essential trace element for humans and animals but is often deficient in the diet. Enriching plants with selenium may increase its dietary intake and simultaneously improve the nutritional quality of the crop. Selenium content in plants depends largely on the selenium concentration in the soil, which in many regions is insufficient to meet the daily human requirement (55 µg Se/day) (National Research Council, 2000). Various methods can be used to increase selenium levels in plants, including soil supplementation (Kitaguchi et al., 2008), seed soaking in selenium solutions, hydroponic or aeroponic cultivation using selenium-enriched nutrient solutions, and foliar application (Hawkesford et al., 2007). In addition to the total selenium concentration, the chemical form (species) of selenium within the plant is also critical, as it affects bioavailability and toxicity.

To further enhance the functional value of buckwheat, we applied foliar application of selenium (VI) in our studies. Previously (Vogrinčič et al, 2009), we studied selenium species in foliar Se enriched buckwheat plants. Over 63% of water-soluble selenium species accumulated in seeds, around 14% in stems, leaves, and inflorescences, and less than 1% in husks. The predominant selenium species in seeds was selenomethionine (SeMet, ~60% of total Se). In stems, leaves, and inflorescences, only selenate [Se(VI)] was detected (up to 10% of total Se), while no water-soluble selenium species were confirmed in husks. Notably, selenite [Se(IV)] showed instability in seed extracts, likely due to interactions with matrix components.

The aim of this study was to simultaneously investigate if foliar selenium (VI) supplementation would influence concentrations and distribution of selected elements (Fe, Mn, Cd, Cu, Zn, S, Mo) in different plant organs of buckwheat.

MATERIALS AND METHODS

Study was conducted on common buckwheat (*Fagopyrum esculentum* Moench), cv. Darja. The experiment was performed at the experimental fields of the Biotechnical Faculty of the University of Ljubljana in Kleče, Slovenia. At the onset of flowering, experimental plants were sprayed with a selenium solution containing 10 mg Se(VI)/L. Sampling was performed at two time points: 65- and 79-days post-sowing. Multiple random plant samples were collected, air-dried, and ground.

Total selenium concentration in plant tissues was measured using hydride generation atomic fluorescence spectrometry. The concentrations of other elements were determined using inductively coupled plasma mass spectrometry (ICP-MS). Detailed methodology is described by Vogrinčič et al. (2009) and Cuderman and Stibilj (2010).

RESULTS AND DISCUSSION

Selenium concentrations in untreated plants were low, while foliar-treated plants exhibited selenium concentrations 50- to 500-fold higher, depending on plant organ

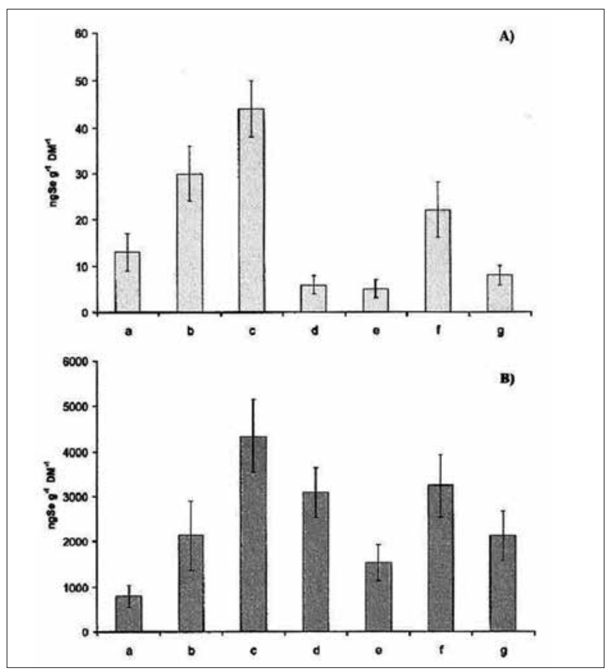

Figure 1. *Distribution of Se in plant parts in control (A) and Se-enriched (B) group of buckwheat plants. a – stems; b – leaves; c – inflorescences; d – dehusked ripe seeds; e – husks of ripe seeds; f – dehusked unripe seeds; g – husks of unripe seeds (Vogrinčič et al., 2009)*

(ranging from 708 to 4231 ng Se/g dry weight). A similar distribution pattern of selenium across plant tissues was observed in both treated and untreated groups, with the most significant differences found in mature seeds.

Distribution of selenium among plant parts in the treated group followed the order: inflorescences > seeds > leaves > husks > stems. Selenium concentrations did not significantly vary between sampling times, indicating limited temporal effects during the growth period.

Figures 2–4 illustrate the concentrations of Cu, Zn, S, Mo, Fe, Mn, and Cd in different plant parts from both control and selenium-treated groups.

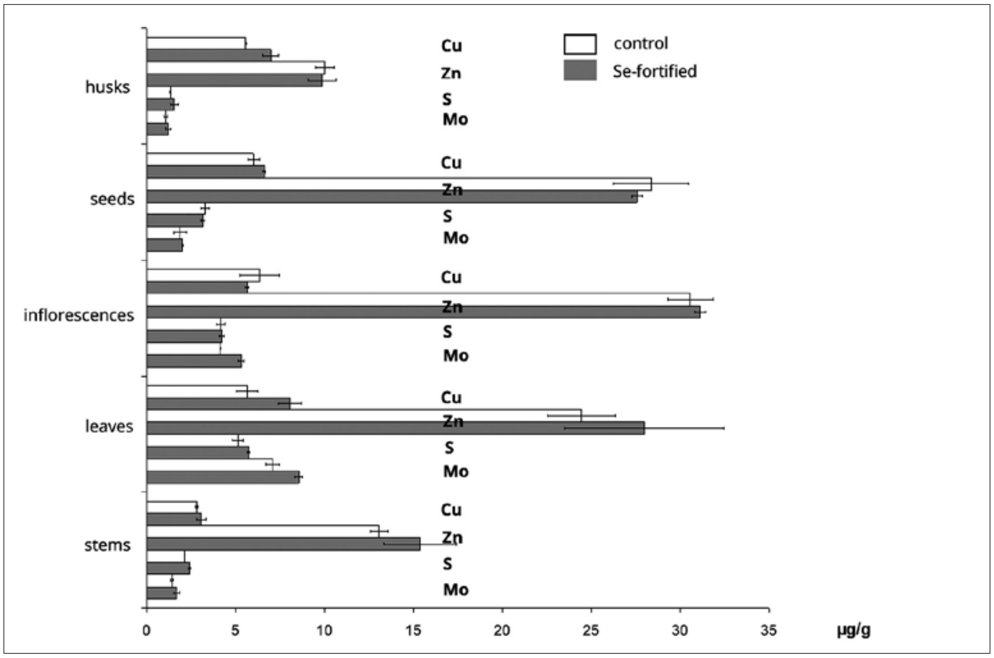

Figure 2. Content of Cu, Zn, S, and Mo (µg/g dry matter) in various buckwheat plant parts.

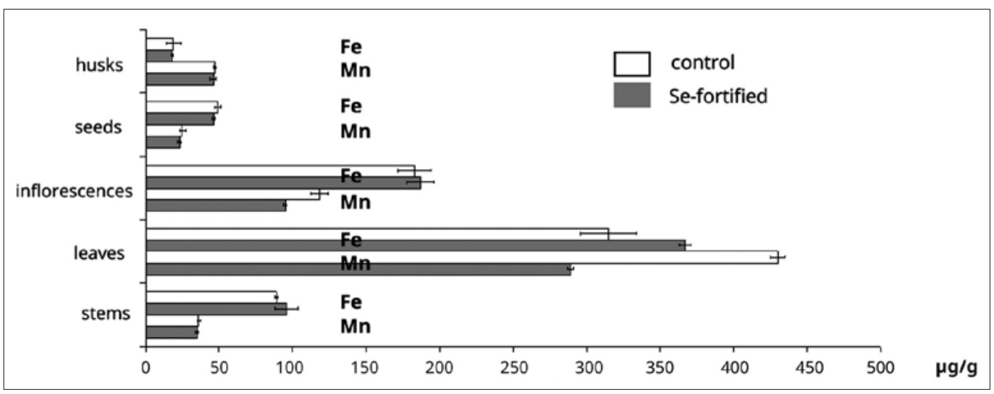

Figure 3. Concentrations of Fe and Mn (mg/g dry matter) in different plant parts.

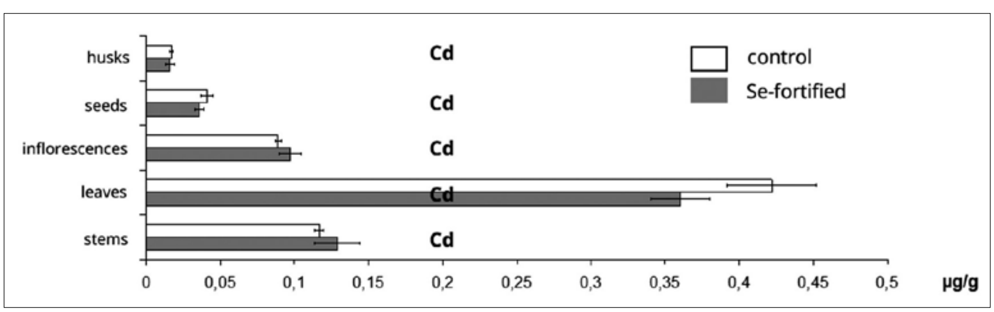

Figure 4. Cadmium levels in distinct buckwheat plant parts (µg/g dry matter).

Foliar selenium treatment induced minor changes in Cd, Mo, Fe, Mn, and S levels in leaves; Cu levels in husks; and Mo and Mn concentrations in inflorescences. However, Zn content remained unaffected by selenium application. These findings suggest that selenium can influence the uptake and accumulation of certain elements, depending on their chemical interactions and specific plant organ.

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IZVLEČEK

Vpliv foliarnega dodajanja selenata na koncentracijo Fe, Mn, Cd, Cu, Zn, S in Mo pri navadni ajdi

Rastlinam ajde smo v začetku cvetenja foliarno dodajali selen (VI), da bi ugotovili njegov vpliv na privzem in vsebnost izbranih elementov, kot so baker (Cu), cink (Zn), žveplo (S), molibden (Mo), železo (Fe), mangan (Mn) in kadmij (Cd). Cu, Zn, Mo, Fe, S in Mn so esencialni elementi, ki jih rastline potrebujejo za rast, nalaganje Cd v rastlinah pa je posledica onesnaženja in je lahko v velikih koncentracijah toksičen za rastline. Foliarno dodajanje selena in posledično povečanje koncentracije tega elementa v rastlini je vplivalo na manjše spremembe v koncentracijah Cd, Mo, Fe, Mn in S v listih, Cu v luščinah ter Mo in Mn v pediclih. Dodajanje selena pa ni imelo vpliva na koncentracijo Zn. Rezultati analize kažejo, da lahko dodajanje selena vpliva tako na povečan kot zmanjšan privzem nekaterih elementov, to pa je odvisno tudi od posameznega dela rastline, ki ga opisujemo.