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Taifun Soy Info

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Specialist information for soy producers and processors

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Heavy metals in soybeans

The absorption of heavy metals in plants is similar to the absorption of micro- or macronutrients. The absorbed heavy metals often compete with the nutrients for the binding sites and displace them without fulfilling their function. Often plants are resistant to the accumulation of heavy metals, so that effects only become apparent higher up the food chain. Critical concentrations for heavy metals in the soil have been defined (Table 1), which, for example, serve as a rough guide when applying sewage sludge or compost. For absorption, however, the heavy metals must be present in an available form in the soil. Hence, the total concentration is less meaningful than the actual proportion available for plant uptake. In soils with acidic pH, heavy metals are more readily available. Consequently, liming can reduce plant uptake. Also the micronutrients Cu and Zn can be found in high concentrations with toxic effects on the plant. The origin of heavy metals in the soil can be both natural (geogenic) and anthropogenic. Through natural weathering, heavy metals are washed out of rocks and ores and distributed by wind or rivers. The rapid economic growth in recent decades has increased the anthropogenic input through industry, mining, fertilisation, pesticides, waste, growing traffic, etc. worldwide.

Several experiments (Rodriguez et al., 2014; Lavado et al., 2001; Hao et al., 2011) have shown that soybeans are more sensitive to heavy metals in the soil than other crops and can absorb them better.

Table 1: Critical concentrations of certain heavy metals in soil [mg(kg)] (Schubert, 2011)

Pb	Cd	Cr	Cu	Ni	Hg	Zn
100	3	100	100	50	2	300

In the following, we give an overview of some different heavy metals in soy:

Lead (Pb)

In principle, lead is not readily available in soil, as it is strongly bound to soil colloids, especially to soil organic matter. In addition, it is strongly fixed in cell walls of roots and mycorrhizal fungi and, in particular in dicotyledons (to which soy belongs) (Pourrut et al., 2013) hardly ever translocated to above-ground plant parts (Schubert, 2011; Pourrut et al., 2013; Wierzbicka, 2007). If lead is translocated, it usually accumulates in the leaves, as here the highest evaporation of water takes place, with which metal ions are transported in the plant (Tung and Temple, 1996).

Cadmium (Cd)

Cadmium is also a non-essential metal and the most dangerous heavy metal for humans. It is, among other sources, introduced into soils via phosphorus fertilisers (de Borne et al., 1998) and is highly mobile in soil and plants. At the same time Cd has a particularly low phytotoxicity as plants produce so-called phytochelatins. These are small molecules similar to metallothioneine with high cysteine levels that bind cadmium (Schubert, 2011; Zitka et al., 2013), thus rendering them harmless to plants. However, cadmium is released during digestion (Schubert, 2011). In soybean plants Cd accumulates more in the root than in the shoot and more in the shoot than in the beans (MacLean, 1976; Reddy and Dunn, 1983).

Among the soybean varieties, there are varieties that accumulate cadmium less than others. For example, Merlin, Primus or Lissabon are highly accumulative and ES Mentor is less accumulative (Vollmann et al., 2015).

As with other heavy metals, soil Cd availability is influenced by organic matter, pH (high values usually reduce availability) and clay content (high clay content usually reduces availability). Liming can increase the pH value, which leads to an increased absorption of calcium ions instead of Cd ions, but at the same time to a higher Cd availability, which is why liming is not always advised.

For cadmium, the EU Contaminants Regulation (EC) No 1881/2006 sets a maximum level of 0.2 mg/kg fresh weight in soybeans.

Figure 1: Soybean plants of different cultivars, which accumulate Cd to different extents from the Cd-saturated soil (Arao et al., 2003).

Zinc (Zn)

Zinc is an essential metal and, in small quantities, has a growth-promoting effect on soybean plants (Gupta et al., 2016). Absorption of excessive amounts of Zn inhibits the absorption of iron and leads to iron deficiency in the plant.

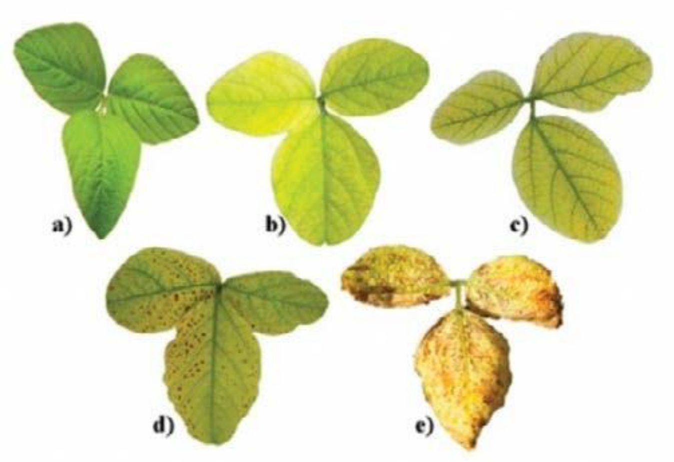

Figure 2: Increasing symptoms on the leaves of soybean plants by excess zinc uptake (Silvia et al., 2014).

Nickel (Ni)

Recently, research on soy drinks (https://www.test.de/Sojadrinks-im-Test-1567644-0) has focused attention on nickel, which can also be accumulated by soybean plants. Nickel is mobile in the plant and is accumulated both in leaves and seeds. Since it is a bivalent cation, it competes with Cu2+ and Zn2+ and is translocated in the same way (Cataldo et al., 1987).

According to the GU nutritional value-calorie table (Elmadfa et al., 2007, p. 102), soybeans contain the highest nickel content among cereals and pulses, with 4.8 mg Ni/kg. Peeled soybeans show significantly lower values of only 0.8 mg/kg (http://www.nickelfrei.de/wissenswertes/le-bensmittelallergie/singleview/article/nickel-in-food- was-steckt-drin.html). A large proportion of the nickel is hence found in the seed shell of soybeans.

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