Arsenic accumulation in English Ryegrass (*Lolium perenne*)

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ABSTRACT

Arsenic contamination globally occurs in groundwater especially in deeper layers. Soil type, structure, water availability and land use both effect its concentration which varies between 10-170 µg/l. As more deep wells have been erected to access underground aquifers, arsenic accumulation became regular risk. Plants are in direct contact with groundwater therefore potential accumulators for heavy metals or metalloids. Through the food chain, both animals and humans are able to build up certain amount of metals and metal like salts. These elements accumulate in living tissues and may interrupt crucial physiological cycles (transcription, CO_2-release). We focused on English ryegrass (Lolium perenne) because its known genome sequence and wide cultivar availability. This species is often used as optimal roughage for ruminants and horses. Also used as lab-plant because its fast germination rate.

***Keywords**: metalloid; hyperaccumulator; irrigation; sheep-bath; ectoparasites*

ÖSSZEFOGLALÁS

Az arzénszennyezés világszerte előfordul a talajvízben, különösen a mélyebb rétegekben. A talaj típusa, szerkezete, a víz elérhetősége és a földhasználat egyaránt befolyásolja a koncentrációt, amely 10-170 µg/l között változik. Mivel egyre több mély kutat létesítettek a földalatti víztartó rétegekhez való hozzáférés érdekében, az arzénszennyezés mindennapos problémát jelent. A növények közvetlenül érintkeznek a talajvízzel, ezért potenciális nehézfém- vagy félfém-akkumulátorok. A táplálékláncon keresztül az állatok és az emberek is képesek bizonyos mennyiségű fémet és fémszerű sókat felhalmozni. Ezek az elemek felhalmozódnak a szövetekben, és gátolhatják a létfontosságú élettani ciklusokat (transzkripció, CO_2-kibocsátás). Az angol perjére (Lolium perenne) összpontosítottunk, mivel ismert a genomja és széles körben elérhetőek a fajtái. Ezt a fajt gyakran alkalmazzák kérődzők és lovak szálastakarmányaként. Gyors csírázása miatt laboratóriumi növényként is használják.

***Kulcsszavak**: félfém; hiperakkumulátor; öntözés; birkafürösztés; ektoparaziták*

INTRODUCTION

Arsenic contamination globally occurs in groundwater especially in deeper layers. Soil type, structure, water availability and land use both effect its concentration which varies between 10-170 µg/l (Egerer and Namesánszky, 1985; Galambos, 2006; Pető et al., 2012). As more deep wells have been erected to access underground aquifers, arsenic accumulation became regular risk. Plants are in direct contact with groundwater therefore potential accumulators (Dradrach and Szopka, 2020) for heavy metals or metalloids (Meharg and Hartley-Whitaker, 2002). Through the food chain, both animals and humans are able to build up certain amount of metals and metal like salts. These elements accumulate in living tissues and may interrupt crucial physiological cycles (transcription, CO_2-release).

MATERIALS AND METHODS

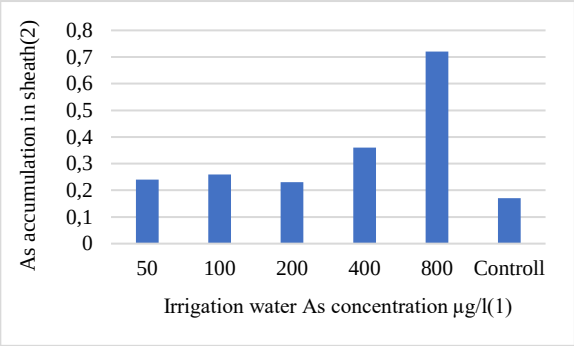
The experiment took place at the Hungarian University of Agriculture and Life Sciences in Gödöllő, Hungary. Natural mixed soil was used from the local botanical garden. English ryegrass (*Lolium perenne*) was the test plant as it is known genome sequence and wide cultivar availability. This species is often used as optimal roughage for ruminants and horses. Also used as lab-plant because its fast germination rate. Each trial pot was marked with different arsenic concentrations (50-800 µg/l). Daily monitoring was conducted at the Plant Physiology Lab under supervision. The treatments have started at the leafy phenophase (5-6 cm in height) at the age of 30 days. This phase was crucial because of the root system. The fully grown permanent hair roots are the primer uptakers of water-soluble elements. The treated water was dispensed by sprinkler irrigation. All plant parts (leaf, stem, root) contacted with water. 2 litres were used for each pot which is equivalent with 2 mm/day irrigation. After 60 days we collected the green mass and the root system separately. Roots were rinsed and cleaned from soil particles. Followed by 48 hours drying, samples have been delivered to the University of Veterinary Medicine, Department of Animal Hygiene, Herd Health and Mobile Clinic. Analytics processed with ICP-OES and ICP-MS spectrometer.

RESULTS

According to test results English ryegrass (*Lolium perenne*) accumulates soil-arsenic. Different concentrates build up in specific organs. Arsenic level was relatively high in the plant samples. The soluble concentration exceeded the risk level in drinking water, however live weight uptake stayed under threshold limit (2 mg/kg).

There is no significant accumulation in the root system. Concentration levels varied between 4-6,43 mg kg^{-1}. The natural soil-arsenic slightly altered the results. The sheath samples showed linear correlation with growing arsenic administration (*Figure 1*). Rapid accumulation was observed at concentration level of 800 µg. Possible explanation is that low soil-phosphorus content allows more intensive arsenic uptake.

Figure 1: **Arsenic accumulation in sheath (*Lolium perenne*)**



1. ábra: Arzén felhalmozódás a levélhüvelyben

Öntözővíz As koncentrációja (µg/l)(1), Arzén felhalmozódás a levélhüvelyben (mg/kg)(2)

CONCLUSION

As a summary, there was no visible sign of toxic arsenic level. Flower production was missing due to phosphorus-arsenate effect as a generative inhibitor. According to the Hungarian Forage Codex (44/2003. IV.26. FVM regulation) toxicity threshold limit is 2 mg kg^{-1}. The highest accumulated level, at 800 µg administered arsenic water, was 0.72 mg kg^{-1}. There is no considerable risk to use irrigation water high in arsenic.

DISCUSSION

Molecular analysis in *crown* (totipotent section in lower stem) is strongly recommended. This part of the plant is responsible for regrowth therefore emergence and growth intensity can reveal hidden arsenic effects. Soil-arsenic also has the potential to introduce any connections with nitrogen, phosphorus and potassium.

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