CRAIOVA
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UNIVERSITY OF CRAIOVA
FACULTY OF AGRONOMY

in collaboration with
University of Belgrade, Faculty of Agriculture, Serbia
***Episkop*" Konstantin Preslavsky"Shumen University, Bulgaria**
Universidade de Trás-os-Montes e Alto Douro, Portugal
Ege University, Agricultural Faculty, Izmir, Turkey

"THE ENVIRONMENT - RESEARCH, CHARGE, ADMINISTRATION"

WORLD DAY TO COMBAT DESERTIFICATION AND DROUGHT

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CONCLUSIONS

In 2023 in the field with barley variety Tangra, in Shumen region, Bulgaria is detected the occurrence and distribution of four diseases: powdery mildew (DI=30%), Barley yellow dwarf virus (DI=1%), loose smut (DI=10%) and yellow rust (DI=10%).

Two fungicides were applied against powdery mildew when DI=30% with tebuconazole and against yellow rust with protioconazole+tebuconazole when DI=10%.

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PHYTOREMEDIATION ABILITIES OF SPECIES FROM THE *FESTUCA* GENUS

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Abstract

The term phytoremediation refers to the sowing of plants that have the ability to grow in devastated areas. The aim of growing these plants on such substrates is to remove or stabilize pollutants in the ecosystem. Phytoremediation is a method of removing various pollutants, both organic and inorganic in origin. It offers a significant advantage over other remediation methods due to its relatively low investment requirements. Festuca species, with their strong fibrous root system and rapid growth of aboveground biomass, are ideal candidates for phytoremediation. The aim of this paper is to review the available literature and summarize the results of our research on the uptake of heavy metals in the organs of plants of the genus Festuca. The study focused on 3 species of the genus Festuca: red fescue (Festuca rubra), tall fescue (Festuca arundinacea) and meadow fescue

(Festuca pratensis). Our studies, conducted in pots in 2021 and 2022, found that Festuca arundinacea had the highest initial growth and the best above-ground biomass yield on substrates such as flotation tailings compared to the other two species. It was also concluded from these studies that the addition of organic fertilizer to the substrate contributed to increased growth performance in all three species tested, while plants fertilized with mineral NPK fertilizer and a combination of mineral and organic fertilizers showed significantly lower biomass yields. Therefore, the addition of organic material is recommended to improve the physical properties of tailings. The largest part of the heavy metals taken up by the substrate plants accumulates in the roots, while a significantly smaller part is transported to the above-ground organs. Therefore, these plants can be classified as heavy metal excluders.

Key words: *Phytoremediation, excluders, pollutants, heavy metal, Festuca species*

INTRODUCTION

The increase in world population has led to an increase in individual wants and needs, resulting in increased industrialization and increased agricultural production. Many human activities have a negative impact on the quality of the environment. These include, above all, large industrial complexes such as mines or power plants, as well as traffic, the irrational use of chemical substances for fertilization and plant protection in agriculture, etc (He et al., 2015). Soils near mines and similar industrial complexes often have a completely altered physical and chemical composition because large amounts of waste material have been deposited on the surface. This waste material is rich in heavy metals, which remain after ore mining, and poor in essential plant nutrients. Heavy metals are not biodegradable, remain in the soil for a long time and have potentially toxic effects on humans and animals when plants growing on such substrates enter the food chain (Sarwar et al., 2010).

In view of all this, it is important to pay close attention to restoring physical and chemical properties of degraded land. Such measures are called soil remediation. One particular method of soil remediation, known as phytoremediation, involves the cultivation of plants capable of growing in such areas and reducing the levels of heavy metals in the substrate by their uptake and accumulation in below- and above-ground plant organs (Greipsson, 2011; Sarwar et al., 2017). Plants with well-developed root systems, rapid growth, and the ability to produce a large amount of aboveground biomass are used for phytoremediation, such as plants from the *Poaceae* family (Kumar-Patra et al., 2021). Species belonging to the genus *Festuca* are able to grow in degraded areas and, thanks to their highly developed fibrous root system, help stabilize of degraded areas and prevent the spread of fine particles over long distances. In addition, these plants help to reduce the content of heavy metals in the substrate through their uptake and accumulation (Hu et al., 2015; Galende et al., 2014; Prasad, 2005).

The aim of this study was to investigate the growth potential of *Festuca* species on soils with altered physical and chemical properties that are enriched with heavy metals.

MATERIALS AND METHODS

In 2021 and 2022, a greenhouse experiment was conducted at the Faculty of Agriculture, University of Belgrade, to study the phytoremediation abilities of Festuca species. The study focused on three species of the genus *Festuca*: tall fescue (*Festuca arundinacea* Schreb.), red

fescue (*Festuca rubra* L.) and meadow fescue (*Festuca pratensis*). The experiment was carried out in pots with three different types of fertilizers and two levels of irrigation. Seeds of the above species, obtained from the Institute of Forage Crops in Kruševac, were sown in pots with a diameter of 12 cm and a depth of 10 cm. Immediately before sowing, the pots were filled with a substrate taken from the flotation tailings dump of a lead, copper, and zinc mine (Table 1). Fertilizer was applied with organic NPK fertilizer obtained by pelleting chicken manure (NPK 4:4:4), with mineral NPK fertilizer (NPK 16:16:16) and a with combination of these two fertilizers. Two different irrigation rates were applied: 50%, of the field water capacity (FWC) and 75% of the FWC. The amount of water used was replenished every 2-3 days by measuring the pot mass and above-ground biomass was harvested when the plants had reached a height of about 20 cm. Plant height was measured once a week and the yield of fresh above-ground biomass was determined immediately after harvest.

The data obtained were processed using ANOVA in Statistica 10 software. The results are displayed cumulatively as the sum of the plant heights and biomass achieved.

RESULTS AND DISCUSSION

Based on our investigations, we can conclude that all three *Festuca* species tested are able to grow on substrates with unfavourable physicochemical properties, such as flotation tailings. Flotation tailings are characterized by a very poor nutrient capacity, with a very low content of essential plant nutrients. The concentration of heavy metal residues in the tailings is very high and exceeds the maximum permissible concentrations for agricultural soils.

Table 1. Chemical properties of tailings that was used as substrate in the experiment and the maximum permissible amounts of heavy metals for arable land (Official Gazette of RS, No 30/2018)

Parameter	Concentration	MPA (mg kg^{-1})
pH (in H_2O)	6.85	/
pH (in KCl)	6.59	/
N (%)	0.005 ± 0.001	/
P_2O_5 (mg/100 g soil)	1.08 ± 0.006	/
K_2O (mg/100 g soil)	8.49 ± 0.04	/
Organic C (%)	3.71 ± 0.25	/
Pb (mg kg^{-1})	655.3 ± 0.86	85
Zn (mg kg^{-1})	1217 ± 49.3	140
Ni (mg kg^{-1})	217.2 ± 8.47	35
Cu (mg kg^{-1})	443.4 ± 2.30	36
Cd (mg kg^{-1})	7.33 ± 0.63	0.8
Mn (mg kg^{-1})	884.6 ± 50.9	2000

The high concentration of organic carbon in the tailings is not due to the presence of organic material, but to the addition of the organic compound xanthate, which promotes ore decomposition (Table 1).

Table 2. The influence of fertilization and irrigation on the yield of festuca species grown on flotation tailings

Fertilizer (A)	Tall fescue		Red fescue		Meadow fescue	
	Plant height (cm)	Biomass (g)	Plant height (cm)	Biomass (g)	Plant height (cm)	Biomass (g)
O.	56.3	6.1	24.7	1.9	42.2	4.7
M.	16.3	1.0	11.7	1.2	18.7	0.9
O.+M.	18.8	0.5	11.3	0.8	35.5	3.4

Irrigation (B)						
50% FWC	29.1	2.6	16.3	1.2	31.7	2.8
75% FWC	31.9	2.5	17.2	1.5	32.5	3.1
ANOVA						
A	**	**	**	**	**	**
B	NS	NS	*	NS	NS	NS
A×B	NS	NS	*	NS	*	*

NS - non significant; * significant influence; ** very significant; O - organic fertilizer; M - mineral fertilizer; O+M mixture of organic and mineral fertilizers; FWC - field water capacity

Fertilization had a statistically significant effect on plant growth and aboveground biomass yield. Based on the data in Table 2, it can be seen that the addition of organic fertilizer significantly improved the growth of above-ground biomass in all three plant species tested.

The highest plant height of 56 cm was found in tall fescue plants treated with organic fertilizer, followed by meadow fescue with the same fertilizer treatment (42 cm), while red fescue reached a height of about 25 cm.

Meadow fescue plants treated with a combination of the two fertilizers reached a slightly lower height than a the treatment with pure organic fertilizer (35 cm), while the other two species showed significantly lower heights, about 19 cm for tall fescue and 11 cm for red fescue.

The weakest results were obtained in the treatment with pure mineral fertilizer. Similar results were obtained for the yield of fresh above-ground biomass, with tall fescue treated with organic fertilizer giving the highest yield, followed by meadow fescue with the same treatment, while red fescue gave lower results (Table 2).

These results are consistent with studies by numerous authors reporting that plant growth on such substrates is limited by a lack of nutrients and organic matter (Fontaine et al., 2003; Wei et al., 2011). The addition of organic fertilizers improves the microbiological activity of the substrate, promotes plant growth and thus enhances the effect of phytoremediation (Pillai et al., 2013).

Statistically significant differences between the applied irrigation levels were only observed for red fescue height, while in other cases different irrigation levels had no significant effect on plant height and yield.

CONCLUSION

Many human activities, especially those related to mining and coal burning, have a significant impact on the environment. The dumping of a large amount of waste materials on the adjacent land leads to changes in the physicochemical properties of the soil.

These waste materials are rich in heavy metals, which can have toxic effects if they enter the food chain. It is therefore crucial to pay attention to the remediation of such soils.

One possible method is phytoremediation, which involves growing plants capable of growing on substrates with unfavourable characteristics.

Species from the genus *Festuca* are suitable candidates for this purpose due to

their rapid growth and the formation of a large amount of above-ground biomass.

The addition of organic fertilizer promotes plant growth on substrates such as flotation residues and thus improves the effectiveness of phytoremediation.

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