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USE OF CHARKOR AND KAMETHUR FOR IMPROVING GROWTH AND PHYTOREMEDIATION PROCESSES OF MISCANTHUS X GIGANTEUS ON SOILS CONTAMINATED WITH TRACE ELEMENTS

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Abstract. *The effect of polycomponent biostimulant Charkor and synthetic plant growth regulator Kamethur on the growth of Miscanthus× giganteus on the contaminated with trace elements (TEs) soils was studied. When cultivating M×g in the more contaminated Vseborice soil, Kamethur contributed to higher leaf and stem biomass (57.1 and 126%, respectively), while Charkor only increased leaf biomass (49.5%) in the contaminated soil. In the Chomutov soil, Charkor increased the accumulation of elements essential for plant development (EEs) and potentially toxic (PTEs) elements in leaves by 12.4 and 21.2%, respectively; Kamethur resulted in a much greater accumulation of both groups' elements in the leaves by 93.1 and 69.5%, respectively. Accumulation in stems had a different tendency: Charkor reduced the accumulation of EEs and PTEs elements in the stem, by 33.3 and 11.4%, respectively; Kamethur reduced the accumulation of EEs by 11.4% and increased the accumulation of PTEs by 23.3% in the stem. The obtained results confirmed the prospects of using Kamethur and Charkor to improve the growth and phytoremediation processes of Miscanthus× giganteus on soils contaminated with trace elements (TEs).*

Keywords: *Miscanthus giganteus, trace elements, soil, Kamethur, Charkor.*

Miscanthus× giganteus (*M×g*) is a popular C4 energy crop showing a high biomass yield and immense lignocellulose content; its cultivation requires less input compared to other energy crops and promotes carbon sequestration potential [1]. Furthermore, having a good tolerance to nutrient deficiency, a wide temperature range, and a good ability to cultivate in marginal and contaminated soils, *M×g* has become effective in phytoremediation processes [2]. The crop has been successfully utilised as a phytoagent in soil contaminated with trace elements (TEs), oil products, pesticides, and a mixture of chemicals [2, 3]. Growing *M×g* as a non-food crop in contaminated soils is not in conflict with food security and limits contaminant entry into the food chain [1, 2, 3]. Miscanthus biomass can be converted to bio-solid, bio-liquid, and bio-gaseous fuels using thermo-chemical or biological

methods. It can be processed for use in construction materials, geotextiles, pulp, and paper via mechanical or chemical-mechanical pulping [1, 2, 3].

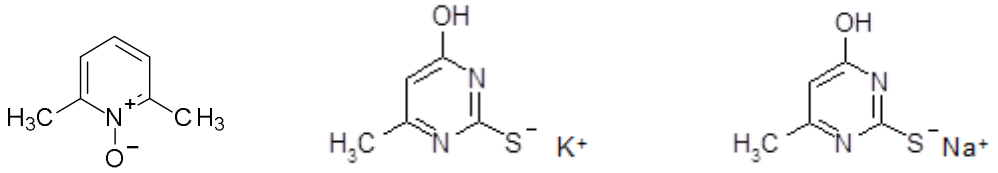
Soil contamination with trace elements (TEs) is a pressing problem limiting the cultivation of agricultural crops; however, the non-food energy crop (*M*×*g*) showing a high biomass yield and immense lignocellulose content can be grown on such soil. The effect of polycomponent biostimulant Charkor and synthetic plant growth regulator Kamethur was studied when *M*×*g* was cultivated in TE-contaminated soils from Vseborice (former mining) and Chomutov (former military), in the Northern Czech Republic [3].

Polycomponent biostimulant Charkor is a complex composition which consists of synthetic plant growth regulator Ivin (2,6-Dimethylpyridine-N-oxide), natural plant growth regulator Emistim C and synthetic auxin NAA (1-naphthylacetic acid) [4]. Emistim C is unique biostimulator of plant growth with a broad spectrum of action - a product of biotechnological cultivation of epiphytic fungi from the root system of ginseng and sea buckthorn, transparent colorless water-alcohol solution [4].The active substance of Emistim C: complex of biologically active compounds - metabolism products of fungi-micromycetes (saturated and unsaturated fatty acids (C14-C28), polysaccharides, 15 amino acids, analogues of phytohormones of cytokinin and auxin nature). Emistim C is recommended for use for pre-sowing seed treatment by soaking or inlaying and spraying vegetative plants at all stages of ontogenesis, increasing yield and quality of such crops: wheat, barley, peas, rapeseed, rice, soybeans, buckwheat, watermelons, melons, sugar beets, alfalfa, clover, corn, sunflower, vegetables, potatoes, vineyards, strawberries, mushrooms [4].

The synthetic plant growth regulator Kamethur (6-methyl-2-mercapto-4-hydroxypyrimidine) potassium salt is low molecular weight heterocyclic compound, derivative of plant growth regulator Methyur (6-methyl-2-mercapto-4-hydroxypyrimidine sodium salt. Field and laboratory studies of Kametur and Methyur showed [5] their stimulating effect on the growth and development of major agricultural crops (corn, wheat, barley, sunflower, sorghum, peas, chickpeas, beans, soybeans, rapeseed and flax). Moreover, the use of these compounds has increased yields and improved adaptation to stressors of abiotic origin.

The main advantage of using Kamethur and Methyur is the broad specificity of their action on the growth of different plant species and varieties during ontogenesis in low concentrations from 10^{-5}M to 10^{-9}M, which do not have toxic effects for humans, animals and the environment.

The chemical structures of the synthetic plant growth regulators Ivin, Kamethur and Methyur are shown in Fig. 1.



Ivin (MW=125.17) Kamethur (MW=181.28) Methyur (MW=165.17)

Figure 1. The chemical structures of the synthetic plant growth regulators Ivin (2,6-Dimethylpyridine-N-oxide), Kamethur (6-methyl-2-mercapto-4-hydroxypyrimidine potassium salt) and Methyur (6-methyl-2-mercapto-4-hydroxypyrimidine sodium salt)

The obtained results showed that the soil contamination did not influence *M*×*g* yield, whereas the cumulative effect of soil contamination and PGR was statistically significant. The leaves and stems dry weight (DW) was dependent on soil contamination; lower stem DW was observed for the plant in Vseborice soil. Charkor increased the leaf DW in Vseborice soil, while Kamethur increased the

stem's DW in both soils. Charkor increased leaf DW in the Vseborice soil, while Kamethur increased leaf DW in both soils and stem DW in the more contaminated Vseborice soil.

It was found that Kamethur contributed to an increase in the biomass of leaves and stems (by 57.1% and 125%, respectively), while Charkor only increased the biomass of leaves (by 49.5%) when *M*×*g* was cultivated in the more contaminated Vseborice soil.

Analysis of the comprehensive bio-concentration index (a predictable indicator to access the ability of phytoagent to accumulate multiple TEs) it was revealed that when cultivating *M*×*g* in the Chomutov soil, the control plant accumulated EEs and PTEs mainly in the stems. Charkor increased the accumulation of EEs and PTEs in leaves by 12.4 and 21.2%, respectively; Kamethur resulted in a much greater accumulation of both groups' elements in the leaves by 93.1 and 69.5%, respectively. Accumulation in stems had a different tendency: Charkor decreased EEs' accumulation in stems by 33.3 and 11.4%, respectively; Kamethur decreased the accumulation of EEs by 11.4% and increased the accumulation of PTEs by 23.3%.

In the more contaminated Vseborice soil, the control plant accumulated EEs mainly in leaves, while the PTEs mainly accumulated in the stems. Charkor reduced the accumulation of EEs and PTEs' in leaves by 31.4 and 4.1%, respectively; and in stems by 17.6 and 43.4%, respectively. Kamethur showed a different effect: it increased EEs' accumulation in stems by 12.0% and reduced it in leaves by 29%. Kamethur also decreased PTEs' accumulation in stems by 21.7% and increased their accumulation in leaves by 40.6%.

Statistical evaluation of the current results illustrated the ability of Charkor to reduce the uptake of PTEs, which is critical for converting clean biomass to bioproducts. It can be recommended for the reduction of PTEs uptake to biomass when the crop is cultivated in varied contaminated soils. Kamethur can be recommended to increase the biomass of leaves and stems when cultivating *M*×*g* on various polluted soils. Further research should confirm the influence of Kamethur and Charkor on the growth and phytoremediation processes of *M*×*g* at the field plantation level.

The use of Charkor and Kamethur for Miscanthus cultivation is an important component of sustainable crop production under climate change and will help of crop adaptation in response to global warming and pollution.

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ВИКОРИСТАННЯ ЧАРКОРУ ТА КАМЕТУРУ ДЛЯ ПОКРАЩЕННЯ ПРОЦЕСІВ РОСТУ ТА ФІТОРЕМЕДІАЦІЇ МІСКАНТУСУ ГІГАНТСЬКОГО НА ҐРУНТАХ, ЗАБРУДНЕНИХ МІКРОЕЛЕМЕНТАМИ

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Ключові слова: *мікроелементи, Міскантус гігантський, ґрунт, Каметур, Чаркор.*

Анотація
Досліджено вплив полікомпонентного біостимулятора Чаркор та синтетичного регулятора росту рослин Каметур на ріст міскантусу гігантського (Miscanthus× giganteus) на забруднених мікроелементами (МЕ) ґрунтах. При вирощуванні M×g на більш забрудненому ґрунті Всеборице Каметур сприяв збільшенню біомаси листя і стебла (57,1 і 126%, відповідно), тоді як Чаркор збільшував лише біомасу листя (49,5%) на забрудненому ґрунті. У ґрунті Хомутова Чаркор збільшував накопичення елементів, необхідних для розвитку рослин (ЕРР) та потенційно токсичних елементів (ПТЕ) у листках на 12,4 та 21,2% відповідно; Каметур призводив до значно більшого накопичення елементів обох груп у листках - на 93,1 та 69,5% відповідно. Накопичення в стеблах мало іншу тенденцію: Чаркор зменшував накопичення елементів ЕЕ і ПТЕ в стеблі на 33,3 і 11,4%, відповідно; Каметур зменшував накопичення ЕЕ на 11,4% і збільшував накопичення ПТЕ на 23,3% в стеблі. Отримані результати підтвердили перспективність використання Каметуру та Чаркору для покращення процесів росту та фіторемедіації Miscanthus× giganteus на ґрунтах, забруднених мікроелементами (МЕ).