Journal of Ecology and Toxicology

Mini Review Open Access

The Impact of Different Agrotechnical Treatments on Miscanthus Hybrid Growth in Trace Metal-Contaminated Soil

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Abstract

Miscanthus plant establishment in the field may suffer as a result of natural pollution and climate change. This is especially important because biomass can be produced on uncultivated land without harming food crops. The chosen hybrid, the cultivation method, the climatic conditions, and the concentration of pollutants in the soil all have an impact on establishment success. During the first growing season and after the first winter, there are a number of ways to increase the chances that the plants will survive. Utilizing biochar and photodegradable plastic mulch, both of which have the potential to be a solution for polluted soils containing trace elements (TMEs), is one of them. For two Miscanthus hybrids planted by rhizome (TV1) and seedling plugs (GNT43) on soils contaminated with trace metal elements (Pb, Cd, and Zn), the purpose of this study was to investigate the application of plastic mulch and biochar separately and in combination at the planting stage. TV1 is not suitable for TME-contaminated field cultivation, as the survival rate was below 60% in the majority of the treatments studied. The survival rate did not rise with the chosen treatments. This parameter was significantly reduced when biochar and plastic mulch were combined, regardless of the hybrid under investigation. Pb and Cd in GNT43 were significantly higher in all treatments, but applied agrotechnology had no effect on TME accumulation in TV1's aboveground plant parts. During establishment on TME-contaminated soil or after the first growing season, neither biochar nor plastic mulch applied separately nor in combination increased survival or decreased the accumulation of toxic TMEs.

Keywords: Plantation Establishment ; Biochar; Plastic Mulch; Cadmium

Introduction

Climate change has an impact on miscanthus varieties, making it one of the greatest threats to the establishment of perennial plants. is an excellent option for growing on uncultivated land where food production is either impossible or unprofitable due to other issues like polluted soil, poor soil quality, and waterlogging, even in the face of climate change. is thought to be a crop for energy. It has been reported that this plant's TMEs may be used for phytoremediation in addition to phytoextraction. Field tests on such contaminated soils have demonstrated that crops should be used for the phytostabilization process rather than phytoextraction in mature plantations due to the low concentration of TMEs in the aboveground biomass. Inappropriate establishment alongside susceptible varieties can result in significant financial losses when the plantation grows again in subsequent years. CO2 sequestration and storage in below-ground organs are the responsibility of this perennial grass that is native to Asia [**1**]. This risk is especially high in relation to a number of Miscanthus hybrids that investigated the advantages and disadvantages of various methods of Miscanthus propagation, such as directly sowing seeds, micropropagation, stem-derived plants, and rhizome planting. Because rhizome-derived plants have the highest survival success (>85%) and overwintering rate, the rhizome-derived plant technique and direct seeding were the most important propagation methods being studied at the time. However, the multiplication factor of seed propagation is the highest and the least expensive of the examined methods. The first method has many issues, including a slow rate of multiplication, sensitivity to water scarcity, spring frosts, and low germination rates in the field. proposed an alternative to direct sowing and micropropagation in which the seed is grown first in a greenhouse before being transferred to the field, where it is more likely that the seedlings will successfully adapt to the conditions of the field [**2-5**].

Regardless of the species, variety, annual or perennial type, the most common abiotic stressors for plant establishment are temperature and water availability. For energy crops grown on marginal soils, pollutants like polycyclic aromatic hydrocarbons (PAHs), trace metal elements (TMEs), and deficiencies in nutrients are additional stressors that may result in a cross-reaction in the plants.

The application of transparent polymer photodegradable mulch films has been found to shorten the time it takes for newly seeded rhizome-based Miscanthus plants to reach mature biomass yields as well as their establishment and growth rates. This is one approach to circumventing the difficulties with endurance that Miscanthus plants initially encounter due to a lack of water or spring ice. Further. reported that despite no increase in germination, direct seeding of Miscanthus reduced overwintering plant failure [**6**].

Properties of Plants and Soil [7]

Soil samples were taken from each plot prior to planting. Soil samples were collected from various plot segments for the purpose of analysis and utilized as the foundation for the creation of additional spatial maps. The middle of each plot served as the analysis's sampling points. The soil's physicochemical parameters were measured on the material that went through a 2 mm sieve. The pH of the soil at 20 °C in H2O (ratio 1:2.5 m/v) and KCl was measured with a pH meter (CPC-551, Elmetron, Gliwice, Poland) and a combined glass/calomel electrode (OSH 10-10, METRON, Gliwice, Poland). The electrical

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Received: 07-Jan-2023, Manuscript No: jety-23-86064, **Editor assigned:** 10-Jan-2023, PreQC No: jety-23-86064 (PQ), **Reviewed:** 24-Jan-2023, QC No: jety-23-86064, **Revised:** 27-Jan-2023, Manuscript No: jety-23-86064 (R), **Published:** 31-Jan-2023, DOI: 10.4172/jety.1000145

Citation: Sohaib K (2023) The Impact of Different Agrotechnical Treatments on Miscanthus Hybrid Growth in Trace Metal-Contaminated Soil. J Ecol Toxicol, 7: 145.

conductivity (EC) was measured using an ESP 2ZM electrode (EUROSENSOR, Gliwice, Poland) in accordance with the Polish standard. The hydrometric method was utilized to evaluate the soil's texture in accordance with the Polish standard **[8-10]**.

Discussion

Human activities, particularly the century-long smelting of Pb and Zn, are to blame for the widespread soil contamination with TMEs like Pb, Cd, and Zn. The addition of regular physical processes in the soil, such as runoff or leaching, may further exacerbate the uneven distribution of these elements. Therefore, field trials must be properly randomized, particularly when cultivating crops on soils contaminated with trace metals. Plant TME accumulation is directly influenced by the bio-available fraction or ion exchange of soil metals. The assimilable fractions of phosphorus and potassium are identical. On spatial distribution maps, the bioavailable Cd and Zn fractions associated with the aforementioned processes are clearly arranged in a gradient. The absence of such observations for the bio-available fraction of the metal appears to be related to Pb's low mobility in soil and generally low concentration ranges. The treatment-based soil analysis revealed that, with the exception of Fe and K, the majority of the elements and physicochemical parameters measured in the soil did not significantly differ between plots with different treatments. However, for the assimilable forms of K (K2O), which have the potential to influence plant growth and development, there were no significant differences between plot treatments.

Survival was heavily dependent on hybrids after planting at the end of the first growing season and after the second growing season. TV1 had a lower overall survival rate despite treatment. Clifton-Brown discovered that, for a number of Miscanthus species (M. giganteus, M. sinensis, and M. sachariflorus), winter losses were highest in Scandinavia (percent), where M. giganteus lost nearly its entire population. Everyone was surprised to learn that only one hybrid, Sin-H6, had a satisfactory success rate in these nations. discovered that of the studied propagation methods, the rhizome-based method had the highest survival rate; The exact opposite was accomplished in this work. This could be caused by either one of two things. The first concern is the absence of research on a mixed method for pre-cultivating cuttings with seeds in the greenhouse prior to planting them in the field. It's possible that the second factor is connected to the hybrid response, which appears to be more pertinent in light of the morphological data. Contrary to expectations, plastic mulch treatments were the agrotechnical treatments that significantly reduced survival. These results are inconsistent with previous reports on plastic mulch films. This one-of-a-kind perception may be related to late planting, which may cause heat pressure and high temperatures beneath the film. However, the film's application may cause undesirable crossing effects with the soil's TMEs.

Biochar applied without plastic mulch did not significantly reduce survival when compared to the control, despite TV1's downward trend. The treatment with the lowest survival rates combined biochar and plastic mulch. The fact that this treatment had a lower survival rate after the first winter is intriguing because it suggests that the seedlings were in poor condition during the first growing season. Biochar reduces TME mobility in the soil, which improves growth parameters and reduces TME accumulation above ground, according to the majority of studies that report crop cultivation on TME-contaminated soils. The number of TV1 stems or plant height did not significantly differ between these treatments and the control during the first and second growing seasons. The GNT43 plants, on the other hand, had varying heights, indicating that the biochar treatment or the combination treatment had a negative impact on plant height. At this point, accumulation of TME in aboveground plants is crucial. Aboveground TME concentrations and concentrations of macro- and micronutrients did not differ significantly for TV1, but they did differ significantly for GNT43.

Conclusions

The studied Miscanthus hybrids' highly hybrid-dependent survival rates were significantly influenced by the specific planting method. In comparison to the seed-based GNT43, which had a survival rate of over 90% in the most effective treatment, which was the control for both hybrids, the TV1 planted with rhizomes had a lower survival rate (about 60%) and was characterized by weaker growth (height and number of stems). The agrotechniques used to speed up establishment were the opposite in this experiment. Regardless of hybrid, the treatment with biochar and plastic mulch resulted in the greatest number of plant losses. TV1 and GNT43 had identical element concentrations after the first growing season, but GNT43 had significantly higher concentrations of Pb and Cd than the control. Biochar and plastic mulch applied separately or in combination did not decrease the accumulation of toxic TMEs during establishment on contaminated soils or increase the survival rate, contrary to published research on uncontaminated soils. However, Miscanthus, particularly GNT43, grows extremely well with low offtakes once established. Because there are no other options, these slightly contaminated areas should be expanded with Miscanthus hybrids. To determine how Miscanthus hybrids establish in the first year after planting on difficult soils contaminated with TMEs, additional research employing a variety of methods is required. It is necessary to commercially develop agronomic innovations for various nations' slightly contaminated soils.

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