The effect of wood ash on the structure of plant communities and phytomass yield in a solonetz soil grassland

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ABSTRACT

As a potential nutrient source, we investigated the effects of wood ash doses (10-20-30 g/m^2) on a semi-natural grass community formed on saline clay soil. The impact of the wood ash doses was evident in the structural composition of the vegetation, particularly in the higher cover values of Alopecurus pratensis and Poa pratensis sp. angustifolia, which are capable of achieving greater phytomass. The green yields correspondingly followed these structural changes in the vegetation. Notably, the most favorable economically viable plant community and yield levels were measured at the 20 g/m^2 dosage, while values decreased at the 30 g/m^2 dosage. Our experiment raised several questions, highlighting the justification for broadening the research.

Keywords: *wood ash, turf, coenology, green yield*

INTRODUCTION

The use of wood ash for the nutrient supply of cultivated plants, including lawns, is a centuries-old practice that has been largely forgotten due to the widespread adoption of fertilizers on a large scale (Baskay Tóth, 1962). However, in small farms, wood ash is utilized for various purposes, including application to lawns, with generally accepted doses of 50-70 g/m² (Szélesi, 2023). As one of the most significant products of primary energy production, substantial amounts of wood ash are still generated internationally today. Demeyer et al. (2001) state in their review that, for example, in the USA, 80% of ash goes to landfills, although it could play a role in improving acidic forest and tropical soils. Mahmood and Kamal (2022) identify the varying quality of ash produced in different ways as one reason for this phenomenon. According to Mayer et al. (2022), the increasing amount of wood ash from energy production presents unavoidable challenges for operators in the EU, where discussing the regulation of ash use becomes essential, as its application could offset ecosystem acidification caused by atmospheric S and N deposition. da Costa et al. (2020) emphasize that wood ash contains high inorganic nutrients, making it a more environmentally friendly soil amendment for liming than hydrated lime and a better K supplement than potassium nitrate, despite its alkaline pH. The application dose is a critical issue. Reed et al. (2017) found no harmful effect on soil microbial community structure or organic matter mobilization at a hardwood ash dose of up to 571 kg/ha, produced at 870 °C. Qin et al. (2017) observed that wood ash applied at a dose of 17.4 t/ha did not harm soil mesofauna but did raise soil pH in a clayey sandy soil in Denmark. Ondrasek et al. (2021) reported a two-unit increase in pH for acidic hydromorphic soil with wood ash application, which also enhanced the content of deficient soil in P-K-Ca-Mg-Zn-Mn-Cu and immobilized Cd. Blonska et al. (2023) applied wood ash at doses of 3-4.5-6 t/ha with a pH value of 12 to acidic brown forest soil in southern Poland, resulting in a 1.5 unit increase in soil pH independent of the dose, with significant effects on fungal taxon composition.

Our research aim was to investigate the effect of wood ash on the composition and yields of a representative grassland community with saline soil conditions in the Tisza region.

MATERIAL AND METHOD

We conducted our experiment in 2024 on a grassland area with medium marsh soil conditions, on the land marked with plot number 01710/1 of MATE Agrárcsoport Ltd. Prior to setting up the experiment, an average soil sample analysis was carried out by the accredited laboratory of the Research Institute, with the following results: pH (KCl) 4.48, Gold's binding (KA) 44, total soluble salts 0.03 m/m%, carbonate content 0.05 m/m%, humus 3.98 m/m%, nitrogen content 2.33 mg/kg, phosphorus pentoxide content 84.50 mg/kg, potassium oxide content 309.25 mg/kg, sodium content 569.50 mg/kg, magnesium content 533.00 mg/kg, sulfate content 14.18 mg/kg, zinc content 3.75 mg/kg, copper content 10.50 mg/kg, manganese content 324.25 mg/kg.

The 30-year rainfall average is 539 mm. The meteorological data for the area related to the relevant experimental period is presented in *Table 1*, based on the data from OMSZ (National Meteorological Service, Hungary) in Karcag.

The area is an association transition between the *Achilleo-Festucetum pseudovinae* and *Alopecuretum pratensis* associations. Since 2015, the utilization method has been mowing, while prior to that it was managed as a meadow. Since 1997, the area has not received any chemicals or organic fertilizers, overseeding, lawn aeration, or irrigation. The experiment was set up in the fall of 2023 with three ash dosage levels (0-30-60-90 dkg/plot, that is, 10-20-30 g/square meter), with four repetitions, a net plot size of 30 m^2, and 0.5 m wide access paths (H0-H3).

Table 1.

The meteorological data of the experimental area

Year(1)	Month(2)	Temperature(3) (°C)	Precipitation(4) (mm)
2023	September	20,72	53,34
2023	October	14,50	47,24
2023	November	6,17	120,40
2023	December	2,44	36,32
2024	January	0,72	19,05
2024	February	8,06	10,67
2024	March	9,50	19,30
2024	April	14,11	44,96
2024	May	18,06	45,97

1. táblázat: A kísérleti terület meteorológiai adatai
Év(1), hónap(2), hőmérséklet(3), csapadék(4)

We conducted the phytosociological survey of the plant community using Balázs's quadrat method on May 9, 2024 (Balázs, 1960), where the area covered by a given plant species is indicated by Balázs's dominance value (DB). The classification of plant species names was based on Király (2009). After the botanical survey, we cut the phytomass and measured the green yield of the grassland.

The recording and summarization of the data collected during the experiments, as well as the processing and evaluation of the results obtained, were carried out using Microsoft® Office Excel. One-way analysis of variance (ANOVA) was used for data analysis. For the statistical evaluation, the p-value from the elements of the analysis of variance was utilized at a significance level of 5%.

RESULTS

In the H0 area, we measured an average green yield of 1106.67 kg/ha, in the H1 area 986.67 kg/ha, in the H2 area 2980.00 kg/ha, and in the H3 area 1453.33 kg/ha. Our results indicate that the largest aboveground raw phytomass yield was provided by the H2 treatment.

During the coenological survey, we recorded a total of 10 species. In the control, H1, and H2 treatments, there were 7 species present, while the H3 treatment had 3 species. No undisturbed areas were recorded. In the control area, *Plantago lanceolata* was the dominant species (28.125%), which we attribute to the phenological effects, while *Alopecurus pratensis* was dominant in the other treatments. Only in the H2 treatment were *Euphorbia cyparissias* and *Silene alba* present, while *Poa pratensis sp. angustifolia* was noted in the H3 treatment. The recorded plant species were classified into Borhidi's ecological indicator groups (water needs, nitrogen needs, light needs), as well as into Social Behavior Types: *Alopecurus pratensis* (WB6, NB7, LB7, C5), *Cardaria draba* (WB3, NB4, LB8, W1), *Cerastium vulgare* (WB5, NB5, LB7, DT2), *Euphorbia cyparissias* (WB3, NB3, LB8, DT2), *Festuca pseudovina* (WB3, NB3, LB9, C5), *Festuca rupicola* (WB3, NB2, LB9, C5), *Plantago lanceolata* (WB4, NB5, LB7, DT2), *Poa pratensis sp. angustifolia* (WB6, NB5, LB6, G4), *Podospermum canum* (WB4, NB2, LB8, G4), *Silene alba* (WB4, NB7, LB8, W1).

The cover of plants in the WB 3 category decreased by 18.75% in the H1 treatment, 46.88% in the H2 treatment, and 25.00% in the H3 treatment compared to the control. For the WB 4 category, plant cover decreased by 27.27% in the H1 treatment, 40.91% in the H2 treatment, while it increased by 9.09% in the H3 treatment compared to the control. In the WB 5 category, plant cover remained unchanged in the H1 treatment, and decreased by 100.00% in both the H2 and H3 treatments compared to the control. In the WB 6 category, plant cover increased by 150.00% in the H1 treatment, 325.00% in the H2 treatment, and doubled in the H3 treatment compared to the control.

The coverage of plants in the NB 2 category decreased by 40.00% in the H1 treatment, by 70.00% in the H2 treatment, and by 20.00% in the H3 treatment compared to the control. The coverage of plants in the NB 3 category increased by 8.33% in the H1 treatment, by 41.67% in the H2 treatment, and by 16.67% in the H3 treatment compared to the control. The coverage of plants in the NB 4 category was 1.56% in the H2 treatment. The coverage of plants in the NB 5 category decreased by 30.00% in the H1 treatment compared to the control, by 40.00% in the H2 treatment, and increased by 10.00% in the H3 treatment. The coverage of plants in the NB 7 category decreased by 120.00% in the H1 treatment, by 240.00% in the H2 treatment, and increased by 40.00% in the H3 treatment compared to the control.

The coverage of plants in the LB 6 category was 3.13% in treatment H3 compared to the control. For the LB 7 category, the plant coverage increased by 21.43% in treatment H1, by 64.29% in treatment H2, and by 21.43% in treatment H3 compared to the control. The coverage of plants in the LB 8 category did not change in any treatment compared to the control. In the LB 9 category, plant coverage decreased by 18.75% in treatment H1, by 56.25% in treatment H2, and by 25.00% in treatment H3 compared to the control.

The cover of plants in category W 1 did not change compared to the control in the H1 treatment, decreased by 50.00% in the H2 treatment, and decreased by 100.00% in the H3 treatment. The cover of plants in category DT 2 decreased by 30.00% in the H1 and H2 treatments compared to the control, while it remained unchanged in the H3 treatment. The cover of plants in category G 4 did not change compared to the control in the H1 treatment, decreased by 50.00% in the H2 treatment, and doubled in the H3 treatment. The cover of plants in category C 5 increased by 15.00% in the H1 treatment and by 20.00% in the H2 treatment compared to the control, while it decreased by 5.00% in the H3 treatment.

The ANOVA did not show significant differences during the comparison of the treatments.

DISCUSSION

Our experiment's most notable result is that the ecological indicator of water demand (WB6) for grasses with potentially higher phytomass (*Alopecurus pratensis*, *Poa pratensis sp. angustifolia*) showed that the combined coverage value exceeded the average of the control plots by 150% for the 10 g/m^2 wood ash treatment, by 325% for the 20 g/m^2 treatment, and by 200% for the 30 g/m^2 treatment.

In our experiment, we investigated lower levels than the currently generally recommended wood ash doses of 50-70 g/m^2 (Szélesi, 2023). Even at the highest dose of wood ash we applied (30 g/m^2), we observed a decrease in green yield and a decline in the coverage value of economically valuable grass species compared to the treatment that received 20 g/m^2. Although the studied grassland habitat had a pH of 4.48 (KCl), which was acidic, the shallow A-horizon of the solonetz soil (10-15 cm) may have influenced the results.

CONCLUSION

Wood ash is a byproduct that generates significant amounts and causes waste disposal issues. Its use in agriculture as a soil nutrient supplement and improvement material could hold considerable potential. Due to the rising costs of currently used fertilizers, it is clearly justified to refine the agro-technical utilization of wood ash. Investigating the possibilities of reducing its strongly alkaline pH and studying dose levels adapted to specific sites are necessary steps.

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