|  |
| --- |
| Augsnes ielabošanas līdzekļa prototipu efektivitātes pārbaude ekoloģiski plastisku kārklu klonu produktivitātes uzlabošanā marginālos apstākļos  (ar samazinātu agrotehnisko pasākumu veikšanu)”  **Testing the effectiveness of soil amendment prototypes in improving the productivity of ecologically plastic willow clones under marginal conditions**  **(with reduced agrotechnical measures)** |
|  |
| **4.3. Rūpnieciskā apjomā izgatavotā augsnes ielabošanas līdzekļa prototipu sērijas efektivitātes pārbaude ekoloģiski plastisku augu klonu produktivitātes uzlabošanā marginālos apstākļos ar samazinātu agrotehnisko pasākumu veikšanu**  ***4***.3. Assessment of the industrial scale soil amendment mixture prototypes with a variety of resilient plants clones under marginal conditions and low- input agriculture |
| Salaspils 2023 |



**Materiāls sagatavots analizējot LVMI Silava 2021-2023.gadā ierīkotā izmēģinājumu objektā Jaunkalsnavā, “Margās” iegūtos datus īstenojot pētījumu: Inovatīvu Baltā vītola-daudzgadīgo zālaugu agromežsaimniecības sistēmu ierīkošana ar koksnes pelnu un  
mazāk pieprasīto kūdras frakciju maisījumiem ielabotās marginālās minerālaugsnēs**

Programma "Izaugsme un nodarbinātība" specifiskais atbalsta mērķis 1.1.1. "Palielināt Latvijas zinātnisko institūciju pētniecisko un inovatīvo kapacitāti un spēju piesaistīt ārējo finansējumu, ieguldot cilvēkresursos un infrastruktūrā"  
pasākums 1.1.1.1. "Praktiskas ievirzes pētījumi", 3. kārta Nr. 1.1.1.1/19/A/112

Authors:

Viktorija Vendiņa - measurements, installation text

Sindija Žigure – surveys, data analysis

Kārlis Dūmiņš – surveys-data collection,

Kristaps Makovskis – installation of plantations, work management

Dagnija Lazdiņa – visualization

,

Kristaps Makovskis - uzmērījumi-darbu vadība,

Dagnija Lazdiņa – teksts.

Summary

In 2021-2023, a willow and poplar plantation was established and expanded at the forest region of Forest Research Station in Kalsnava. The plantations are used for research and demonstration purposes, specifically focusing on:

1. Different soil ameliorants:

* Wood ash,
* Wood ash (4.3 t ha-1) + peat (2 t ha-1) (P4+K2),
* Wood ash (4.3 t ha-1) + peat (6 t ha-1) (P4+K6),
* Wood ash (4.3 t ha-1) + peat (12 t ha-1) (P4+K12),
* Peat pellets,
* wood charcoal.

The goal is to study the impact of these ameliorants on the height of Salix alba (white willow) cuttings (Task 4.3).

2. The influence of soil ameliorants on soil physical properties (Task 4.4):

* Water permeability,
* Density.

Hypotheses have been formulated as follows:

Higher content of organic matter in soil ameliorants promotes the growth of willow cuttings (4.3).

The organic matter content in soil ameliorants improves soil physical properties (4.4).

Design of experiment and establishment of trial

***Soil preparation, planting and grass sowing in Kalsnava field***

**In the autumn of 2020** suitable land for agroforestry plantation was searched and founded in Jaunkalsnava district (56.691253, 25.931245). The land was measured in 2020 and plantation design created. In three consecutive years of 2021, 2022 and 2023, a white willow (*Salix alba*) agroforestry plantation was established by planting cuttings that are 0,2 and 1,5 m long. The planting material selected for this project was sourced from “Silava”, and the chosen variety is the male white willow 'Platonis'.

**In the spring of 2021**, the plantation was established with long cuttings (1.5m) by planting them in prepared planting sites arranged in 'plots' – ensuring that successful plantation establishment required only the mineralization of the planting site, provided that competing vegetation consists of grassy plants up to 60 cm high (Figure 1).

Since it forms an agroforestry plantation and the white willow grows into a tall tree, the spacing between the cuttings is 2 m (figure 1). The distance between rows is 3 m to allow for mechanized mowing of grass.



Figure 1. The plantation from spring 2021 in the spring of 2022.

**In the spring of 2022** soil preparations was done with heavy mulcher what was powered by tractor, where soil was prepared in planting strips. Single strip width was approximately 60 cm and distance between stripes 2 meters. Soil ameliorations before incorporation were mixed by hands in the appropriate proportions by weight. Ameliorants were spread by hands and later mechanically incorporated using small hand mulcher. Mulching depth was 20 cm and width 50 cm. Soil amelioration was performed in strips, with vegetation of grassy plants preserved between rows (Figure 2).

|  |  |  |
| --- | --- | --- |
|  |  |  |

Figure 2. Establishment of the plantation in the spring of 2022.

The plantation was arranged so that each row includes every soil ameliorant. Variants were shuffled across the field to ensure the diverse application of soil ameliorants in different locations. The sequence of sample plots was determined using a randomized number generator calculator, where sample plots were generated in columns (rows) (Random Sequence Generator: <https://www.random.org/sequences>). This follows a Randomized Block design (<https://www.slideshare.net/DevendraKumar375/experimental-design-in-plant-breeding>). After soil preparation and ameliorant incorporation 20 cm willow cutting were planted in the strips.

Part of the site, where the vegetation height exceeded 60 cm and was characterized by typical weeds such as thistle and burdock were left fallow during the summer, autumn and winter. Leaving land fallow before tree plantation establishment allows to the soil to recover and replenish nutrients and can result in healthier and more fertile soils, which is essential for tree growth. Fallow can also help to control weed growth and reduce competition for water, nutrients and light between trees and weeds in the next years.

**In the spring of 2023** the fallow area was prepared before planting by continuous plowing. Willow cuttings were planted in rows (total 8 rows) where in every row different amelioration mixture were applied. Wood ash and peat ameliorations were mixed in proportions by weight and spread on field manually. Soil ameliorations before incorporation were mixed by hands in the appropriate proportions by weight. Ameliorants were mechanically incorporated in to the soils by small scale hand mulcher. Mulching depth was 20 cm and width 50 cm. After ameliorant incorporation 0,2 m white willow cuttings were planted, where distance between trees was 0,5 m and distance between rows 3m. (figure 3).

|  |  |
| --- | --- |
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Figure 3. Left fallow area mowed and cultivated into a plantation in the spring of 2023.

After planting between the strips, a meadow flower mixture was sown. In the site several different flower mixtures were used (“Airy meadow”, “One summer”, “Flower meadow”, “Wild meadow”), to ensure greater diversity of flowering plants and to diversify flowering times. Sowing flower seeds between tree lines have many advantages. By interspersing flowers among the rows of trees, the variety of plant species in the region is enhanced. This creates a conducive environment and food sources for a range of pollinators, including bees and butterflies, which play a pivotal role in pollinating willow trees. The nectar and pollen from the flowers planted can lure these beneficial insects to the plantation, thereby boosting the overall pollination of the willow trees and enhanced pollination can result in increased fruit or seed production around plantation. Also soil’s health can be improved by flowering plants as they foster microbial diversity and nutrient cycling. Some flowers possess deep root systems that can alleviate compacted soil and enhance drainage. This can subsequently benefit the root systems of the willow trees and their overall growth. Flowers can serve as ground cover and aid in mitigating soil erosion between tree rows. Their roots help consolidates the soil, preventing it from being washed away during heavy rainfall. Added benefit is the plantation’s visual appeal where it is enhanced by flowering plants. They can create a more pleasing and attractive landscape, which might be significant for certain types of willow tree plantations, such as those established for ornamental or landscaping purposes. Flower seeding could improve plantation management, where growth of weeds can be naturally suppressed by planting flowers between tree rows. Flowering plants can compete with weeds for resources like sunlight, water, and nutrients, reducing the necessity for herbicides or manual weed control. Different flower mixtures were used in the field to ensure, that the flowering is starting in spring and will continue till the autumn (figure 4).

Figure 4. Flower mixtures that were sowed between rows in 2023.

The schematic layout of the plantation is provided in the image below. The area is enclosed, and there are plans to develop it by creating elements of agroforestry practices such as tree groups and buffer zones for demonstration landscapes (figure 5).

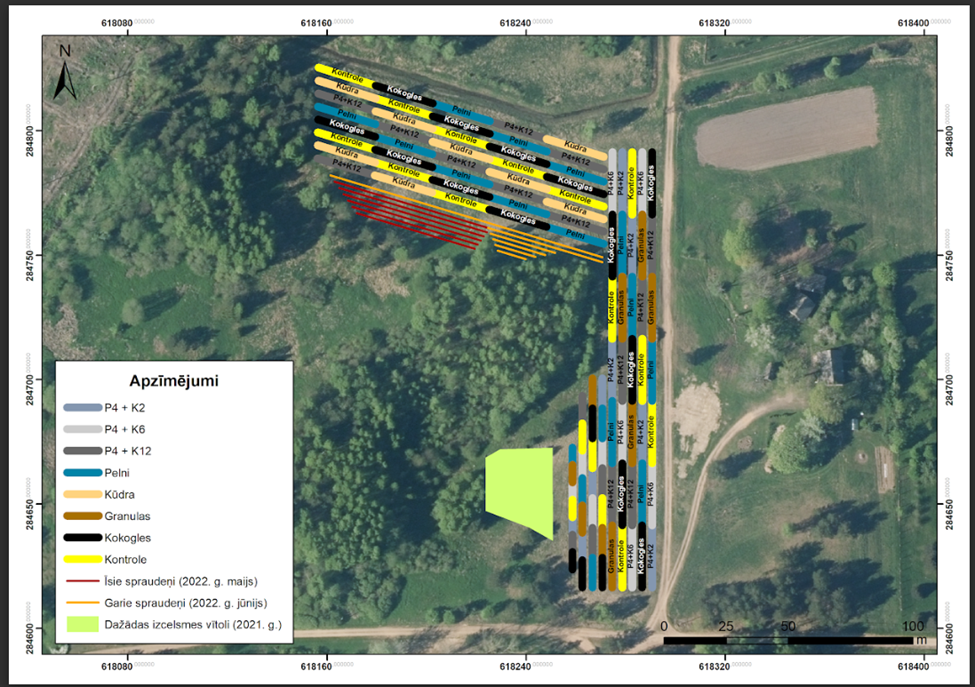


Figure 5. The schematic layout of the plantation established in strips and fallow areas.

*Plantation management and maintenance*

Surrounded area has high deer, muse and rabbit populations what makes difficult to grow trees in plantation, especially broadleaved trees. To protect trees from browsing in 2022 study site was fenced with metal fence. Every year grass between tree rows was mowed. Mowing methods were different and included heavy machinery mower, small lawn mower and brush cutters. Mowing was done 1-2 times per year depending on overgrown in different plantation parts. The spaces between rows were mowed high in 2023 to allow the growth of meadow plants while the spaces with no flowers were mowed as usually (Figure 6).

Figure 6. Plantation maintenance and agrotechnical care

*Willows in Forest research station nursery*

In the spring of 2022, a plantation of white willow was established in the nursery of the Forest Research Station, specifically in a monoculture area, for the cultivation and testing of planting material under marginal conditions in a section of the nursery where not even weeds grow. The plantation has been successful, but the trees exhibit low growth and a shrub-like form. In 2023, the adjacent area of the plantation was amended with peat and wood ash (figure 7).

Figure 7. Willows in nursery and peat and wood ash spreading.

MEASUREMENTS, METHODOLOGY

In 2021, the survival of planted trees was recorded.

During the summer of 2022, the biomass and species composition of one-year and perennial plants that had grown in the rows were assessed.

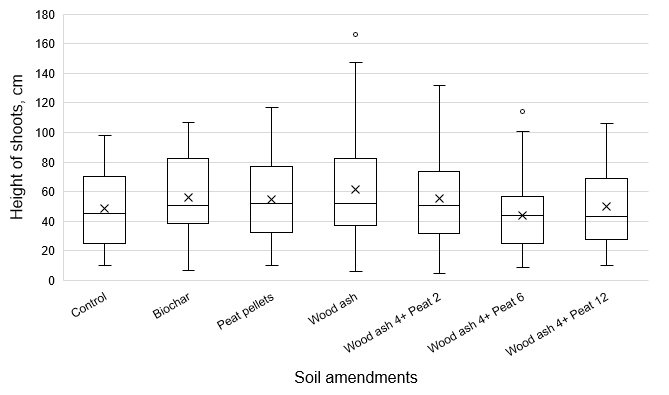
In October 2022, the height and survival (live shoots without signs of browsing, no signs of damage to the shoots) of the saplings in the agroforestry plantation of white willow in Jaunkalsnava were evaluated.

In the spring of 2023, an inventory was conducted to account for the trees that had survived the winter of 2022/23.

results

**Willow growth**

In October of 2022 the growth of willow saplings (figure 8) was evaluated, considering those shoots that had grown without any damage.

Figure 8. The heights of white willow saplings in various soil ameliorants (horizontal axis from left – control, biochar, peat pellets, wood ash, wood ash (4,3 t/ha) + peat (2 t/ha), wood ash (4,3 t/ha) + peat (6 t/ha), wood ash (4,3 t/ha) + peat (12 t/ha)).

Dataset - the height of willow saplings does not conform to a normal distribution (p-value < 0.05). Therefore, for data comparison, the Shapiro-Wilk normality test was employed, resulting in a p-value > 0.05. This implies that among the soil ameliorants, there is no significant impact on the height of white willow saplings. However, when applying the soil ameliorant - wood ash, the largest variation in sapling height was observed. On the other hand, when applying the soil ameliorant - peat pellets and wood ash, the white willow plantation exhibited the highest sapling survival rate (figure 9).

Figure 9. The survival rate of white willow cuttings in various soil ameliorants (horizontal axis from left – control, biochar, peat pellets, wood ash, wood ash (4,3 t/ha) + peat (2 t/ha), wood ash (4,3 t/ha) + peat (6 t/ha), wood ash (4,3 t/ha) + peat (12 t/ha)). Orange – live cuttings, blue – dead cuttings.

Vegetation

Soil amelioration works were carried out in approximately one-meter-wide strips, and the ameliorants were incorporated to a depth of 20 cm (figure 2). Six types of fertilizers were used: wood ash, biochar, peat pellets, P4+K6, P4+K2, P4+K12, along with control strips without any fertilizer. Natural grass vegetation was preserved between the strips.

In August 2022, at the end of the vegetation season, all vegetation from approximately one-square-meter sample plots (in width and one meter in length) was collected by cutting the gathered plants at the level of the topsoil. Sample plots were established in the middle of strips representing one type of fertilizer each, to minimize the potential impact of other fertilizer types on the results. Samples were collected in three replicates for each treatment. The total fresh weight of the samples was recorded, and plants were sorted by species (dicotyledons) and collectively into a group of monocotyledons. Plants that could not be precisely identified to the species level were categorized by family. The fresh mass of the dominant species in each sample plot and the combined mass of the remaining plants were determined. The samples were then dried to obtain dry masses.

Conducting a dispersion analysis of vegetation data yielded the conclusion that the type of fertilizer does not have a statistically significant impact on the fresh and dry vegetation mass (obtained p-values are 0.716 and 0.466, respectively) (figure 10). Visually inspecting the boxplot graphs reveals that, overall, larger dry and fresh vegetation masses were obtained with pellets, P4+K6, and wood ash fertilizers.

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| Attēls, kurā ir teksts, diagramma, ekrānuzņēmums, krāsainība  Apraksts ģenerēts automātiski Attēls, kurā ir diagramma, krāsainība, ekrānuzņēmums, teksts  Apraksts ģenerēts automātiski |
|  |

Figure 10. Fresh and dry masses of collected vegetation samples in each sample plot (horizontal axis from left – biochar, control, peat pellets, wood ash, wood ash (4,3 t/ha) + peat (12 t/ha), wood ash (4,3 t/ha) + peat (2 t/ha), wood ash (4,3 t/ha) + peat (6 t/ha)).

The number of identified plants per sample varied from seven to 24, depending on the sample plot (table 1). It should be noted that the actual number of species is higher, as monocots were only categorized without species determination, and some plants were identified only up to the family level, which could include multiple species. Dispersion analysis did not reveal a significant impact of fertilizer on the number of species (p-value 0.507). Based on the boxplot graph, it is observed that the greatest variation in the number of species is seen with pellets, while the least variation is observed in the control and biochar variants (figure 11).

Attēls, kurā ir diagramma, teksts, ekrānuzņēmums, krāsainība

Apraksts ģenerēts automātiski

Figure 11. The number of identified species in each sample plot (horizontal axis from left – biochar, control, peat pellets, wood ash, wood ash (4,3 t/ha) + peat (12 t/ha), wood ash (4,3 t/ha) + peat (2 t/ha), wood ash (4,3 t/ha) + peat (6 t/ha)).

Table 1. The compilation of collected vegetation's fresh and dry mass, along with the count of identified species, for each sample plot.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Nr. | Soil ameliorant | Fresh vegetation mass, g/m2 | Dry vegetation mass, g/m2 | The number of identified plants at the species level |
| 4.1. | Control | 628,75 | 206,51 | 12 |
| 7.1. | Control | 504,2857 | 171,13 | 12 |
| 9.1. | Control | 603,75 | 222,34 | 10 |
| 4.2. | Wood ash | 678,75 | 253,23 | 16 |
| 6.2. | Wood ash | 1332,857 | 386,21 | 21 |
| 8.2. | Wood ash | 678,75 | 247,77 | 11 |
| 4.3. | P4+K6 | 466,25 | 182,67 | 8 |
| 8.3. | P4+K6 | 903,75 | 287,19 | 15 |
| 6.3. | P4+K6 | 1070,667 | 480,2 | 11 |
| 4.4. | P4+K2 | 790 | 192,55 | 12 |
| 7.4. | P4+K2 | 1418,571 | 341,39 | 19 |
| 8.4. | P4+K2 | 478,75 | 152,18 | 12 |
| 4.5. | P4+K12 | 353,75 | 133,34 | 7 |
| 9.5. | P4+K12 | 1103,75 | 255,33 | 13 |
| 7.5. | P4+K12 | 444 | 155,91 | 12 |
| 4.7. | Peat pellets | 891,25 | 307,22 | 15 |
| 8.7. | Peat pellets | 1353,75 | 328,84 | 24 |
| 7.7. | Peat pellets | 553,75 | 186,51 | 9 |
| 4.6. | Biochar | 590,6667 | 182,48 | 15 |
| 9.6. | Biochar | 703,75 | 216,84 | 16 |
| 6.6. | Biochar | 524 | 294,5 | 13 |

In total, at least 55 plant species were identified across the sample plots, as presented in the table (table 2). To assess the relationship between the type of fertilizer and vegetation composition, Pearson's chi-square (χ2) test and Fisher's exact test were conducted. The results revealed no significant differences between fertilizer types and the overall composition of vegetation species (p-value 0.2776) or dominant species composition (p-value 0.3166).

Although there are no significant differences in the composition of plant species between groups, according to Fisher's exact test among all possible combinations of 210 pairs of sample plots with all plant species, 20 of them have a p-value lower than 0.05 significance level. Conducting the test with dominant plant species in the sample plots resulted in 40 pairs with significant differences.

Table 2. The compilation of observed plant species.

|  |  |  |
| --- | --- | --- |
| species/ family | | The number of observations |
| Viendīgļlapji | *Monocotyledoneae* | 21 |
| Birztalas veronika | *Veronica chamaedrys* | 20 |
| Vīķi | *Vicia sp.* | 20 |
| Parastais pelašķis | *Achillea millefolium* | 19 |
| Skābenes | *Rumex sp.* | 19 |
| Balandas | *Chenopodium sp.* | 18 |
| Madaras | *Galium sp.* | 16 |
| Podagras gārsa | *Aegopodium podagraria* | 9 |
| Tīruma pēterene | *Knautia arvensis* | 9 |
| Zāļlapu virza | *Stellaria graminea* | 9 |
| Vijolītes | *Viola sp.* | 9 |
| Gundegas | *Ranunculus sp.* | 8 |
| Kosas | *Equisetum sp.* | 7 |
| Parastā virza | *Stellaria media* | 7 |
| Cietpienes | *Crepis sp.* | 6 |
| Pļavas dedestiņa | *Lathyrus pratensis* | 6 |
| Ložņu āboliņš | *Trifolium repens* | 6 |
| Suņuburkšķi | *Anthriscus sp.* | 5 |
| Vītoli | *Salix sp.* | 5 |
| Parastais rasaskrēsliņš | *Alchemilla vulgaris* | 4 |
| Akļi | *Galeopsis sp.* | 4 |
| Ganu plikstiņš | *Capsella bursa-pastoris* | 3 |
| Savvaļas burkāns | *Daucus carota* | 3 |
| Pļavas bitene | *Geum rivale* | 3 |
| Divšķautņu asinszāle | *Hypericum perforatum,* | 3 |
| Parastā priede | *Pinus sylvestris* | 3 |
| Šaurlapu ceļteka | *Plantago lanceolata* | 3 |
| Virzas | *Stellaria sp.* | 3 |
| Tāla sīkplikstiņš | *Arabidopsis thaliana* | 2 |
| Mārsila smiltenīte | *Arenaria serpyllifolia* | 2 |
| Idra | *Camelina sp.* | 2 |
| Meža zemene | *Fragaria vesca* | 2 |
| Purva gandrene | *Geranium palustre* | 2 |
| Efeju sētložņa | *Glechoma hederacea* | 2 |
| Parastā vīrcele | *Linaria vulgaris* | 2 |
| Sudraba retējs | *Potentilla argentea* | 2 |
| Tīruma āboliņš | *Trifolium arvense* | 2 |
| Zirgu āboliņš | *Trifolium medium* | 2 |
| Parastā vībotne | *Artemisia vulgaris* | 1 |
| Tīruma usne | *Cirsium arvense* | 1 |
| Parastā vīgrieze | *Filipendula ulmaria* | 1 |
| Pļavas gandrene | *Geranium pratense* | 1 |
| Gandrenes | *Geranium sp.* | 1 |
| Pilsētas bitene | *Geum urbanum* | 1 |
| Mauragas | *Hieracium sp.* | 1 |
| Vītolu vējmietiņš | *Lythrum salicaria* | 1 |
| Meža ābele | *Malus sylvestris* | 1 |
| Lielā ceļteka | *Plantago major* | 1 |
| Vidējā ceļteka | *Plantago media* | 1 |
| Sūrenes | *Polygonum sp.* | 1 |
| Plaukšķenes | *Silene sp.* | 1 |
| Dzeltenā zeltgalvīte | *Solidago virgaurea* | 1 |
| Pļavas āboliņš | *Trifolium pratense* | 1 |
| Āboliņi | *Trifolium sp.* | 1 |
| Mārsila veronika | *Veronica serpyllifolia* | 1 |

For the exploration of relationships between identified plant species composition in sample plots, cluster analysis was employed. It was conducted both with the overall identified species composition and the dominant species. Considering the small sample size, the data were divided into three clusters (results in the table 3). In both cases, no clear separation was observed among fertilizer variants within the unified cluster groups.

Table 3. Results of Cluster Analysis.

|  |  |  |  |
| --- | --- | --- | --- |
| Nr. | Soil ameliorant | Clusters (dominant species) | Clusters (all species) |
| 4.1. | Control | 1 | 1 |
| 7.1. | Control | 1 | 2 |
| 9.1. | Control | 1 | 1 |
| 4.2. | Wood ash | 2 | 2 |
| 6.2. | Wood ash | 2 | 2 |
| 8.2. | Wood ash | 1 | 3 |
| 4.3. | P4+K6 | 1 | 1 |
| 8.3. | P4+K6 | 2 | 2 |
| 6.3. | P4+K6 | 3 | 1 |
| 4.4. | P4+K2 | 2 | 2 |
| 7.4. | P4+K2 | 2 | 2 |
| 8.4. | P4+K2 | 1 | 1 |
| 4.5. | P4+K12 | 3 | 3 |
| 9.5. | P4+K12 | 2 | 2 |
| 7.5. | P4+K12 | 1 | 1 |
| 4.7. | Peat pellets | 1 | 1 |
| 8.7. | Peat pellets | 2 | 2 |
| 7.7. | Peat pellets | 1 | 1 |
| 4.6. | Biochar | 1 | 3 |
| 9.6. | Biochar | 2 | 2 |
| 6.6. | Biochar | 1 | 1 |

Soil Chemistry and Vegetation

Before and after soil improvement, soil samples were collected for chemical analyses, including the determination of soil pH and total nitrogen content. After the ANOVA test, there are no significant differences in the influence of ameliorant on soil pH and nitrogen concentration, with respective p-values of 0.619 and 0.0951. There are also no significant differences in the changes in soil pH before and after soil amelioration (p-value 0.518). However, significant differences are observed in nitrogen concentration in the soil before and after soil amelioration, with a corresponding p-value of 0.00345.

In sample plots where the P4+K12 fertilizer was used, a decrease in nitrogen content is observed, while in the other fertilizer variants, it increased (figure 12). This explains the significant differences observed in nitrogen concentration in the soil before and after soil amelioration (table 4). However, there is no observed impact of nitrogen content reduction on other examined features.

Attēls, kurā ir teksts, diagramma, ekrānuzņēmums, skice

Apraksts ģenerēts automātiski

Figure 12. The impact of the ameliorant on changes in nitrogen content (horizontal axis from left – biochar, control, peat pellets, wood ash, wood ash (4,3 t/ha) + peat (12 t/ha), wood ash (4,3 t/ha) + peat (2 t/ha), wood ash (4,3 t/ha) + peat (6 t/ha)).

Table 4. Results of ANOVA post hoc analysis on the impact of the ameliorant on changes in nitrogen content.

|  |  |
| --- | --- |
| Combinations | p-value |
| P4+K12 – peat pellets | 0,0056979 |
| P4+K12 – biochar | 0,0037873 |
| P4+K12 - control | 0,0192359 |
| P4+K2 – P4+K12 | 0,0076587 |
| P4+K6 – P4+K12 | 0,0407021 |

To assess the impact of nitrogen content and pH on species composition, the Spearman's rank correlation test was employed. Correlations were determined for a total of four species (table 5).

Table 5. Correlations between nitrogen content or pH and plant species.

|  |  |  |  |
| --- | --- | --- | --- |
| Species | Factor | Correlation coefficient | p-value |
| Divšķautņu asinszāle *Hypericum perforatum* | N | 0,5655 | 0,0076 |
| Parastā priede *Pinus sylvestris* | pH | -0,4946 | 0,0227 |
| Mārsila smiltenīte *Arenaria serpyllifolia* | pH | 0,4690 | 0,0319 |
| Zirgu āboliņš *Trifolium arvense* | pH | -0,4826 | 0,0268 |

Conclusions

In search of patterns among all the examined viewpoints, in fields with the highest variation in shoot growth (wood ash), vegetation mass and species count variation are moderately high compared to other fields. In fields with the highest shoot survival rates (wood ash and peat pellets), a moderate degree of vegetation was observed compared to other fields. It is often believed that dense vegetation suppresses shoot growth. In this case, there is no evidence to suggest that vegetation has a suppressive effect on shoot development. Looking at the overall nitrogen changes, wood ash fields showed a slight increase, while granule fields showed the second-highest increase. Therefore, there is no observed correlation between the increase in nitrogen concentration and shoot survival or growth.

The experiment was conducted in field conditions, and the utilized area has a characteristic slight relief. This can result in variations in soil properties, such as physical and chemical composition, within the sample plots. Additionally, the influence of slope can lead to different moisture levels in various field zones. The impact of these factors on the same plant species in different field zones affects mutual competition and survival opportunities of plant species.

The composition of vegetation is also influenced by natural seed dispersal pathways. Before the collection of vegetation samples, the soil was treated only with fertilizer, without seeding. All vegetation has developed from seeds naturally dispersed from the previous vegetation and other dispersal pathways. In addition, the process of soil cultivation may have influenced seed distribution in the area.

In field conditions, there are many factors that affect the results and their reproducibility. To draw conclusions about the individual impact of fertilizer on vegetation mass and species composition, it would be necessary to repeat the experiments on a flat area; determine the species composition of the previous season before plowing and fertilizing operations to assess its impact on the vegetation results of the experiment; ensure the uniformity of soil properties in the area.

Although statistical analysis did not reveal significant correlations between the type of fertilizer and obtained vegetation mass or species composition, there is a significant diversity of vegetation observed in the samples. Additionally, the characteristic stand of species in the sample plots, along with the plowing method forming microrelief in the furrows, contributes significantly to species diversity. The results suggest considering the use of this combination of plowing and fertilization methods to promote plant biodiversity in areas.