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Natural Soil Amendment Application in Agriculture

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***Abstract*—The aim of research was to evaluate the impact of low rates of application of environmentally friendly organo-mineral soil amendments on yields components (number of productive tillers m^2, 1000 grain weight, grain number per ear), grain yield and yield quality of spring and winter wheat under organic farming conditions. Soil amendments were obtained based of forest logging residues - lignocellulosic biomass, after isolation of polyphenols by water extraction and enrichment with silicon (Si), included the content of polyphenolic compounds. The soil amendments were used for seed material treatment. Field experiments were carried out in the certified organic farming field. The control variant and organo-mineral soil amendments, containing inorganic oligomer in various mass ratios (three variants) were tested. The varieties (spring wheat 'Robijs', winter wheat 'Edvins'), certified for growing under organic farming conditions, were used in trial. It was shown that the treatment of seed material with organo-mineral soil amendments increased the number of productive tillers as well as have a beneficial effect on the yield (the increase till 21.6% compared to the control) but decreased the number of grains per ear of spring wheat, depending on concentration of inorganic oligomers). In variant with the highest tested concentration of inorganic oligomer, a trend towards yield growth for winter wheat can be observed. The obtained results show that the treatment of seed material with promotes plant growth and development, researches should be continued.**

Keywords*— *organo-mineral soil amendments, organic farming, wheat, quality, polyphenols

I. INTRODUCTION

Wheat is the most widely cultivated cereal grain worldwide and plays a vital role in agriculture. Internationally, wheat provides approximately 55% of carbohydrates and 21% of the dietary calories consumed worldwide. Wheat also contains other beneficial components such as minerals (Cu, Mg, Zn, Fe, and P), protein, vitamins (riboflavin, thiamine, niacin, and alpha-tocopherol), also provides significant amounts of biologically active components that are essential or beneficial to human health. These include not only protein, vitamins, and dietary fiber, but also phytochemicals, such as polyphenols, which are primarily composed of flavonoids, phenolic acid, proanthocyanidins, and other compounds with powerful antioxidant, bacteriostatic, anti-infective, and preventive properties against numerous health problems [1-4]. In the previous study, the authors indicated that soil amendments increase yield and improve cereals' target composition [5]. Therefore, it is necessary to evaluate the effects of the resulting soil amendments on wheat yield and grain chemical composition, focusing on polyphenols, which could be done using the analytical pyrolysis method.

II. MATERIALS AND METHODS

A. Field experiments

Field experiments were carried out in 2023/2024 growing season (winter wheat) and in 2024 (spring wheat)

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at the certified organic farming field (N 56º 69.275´, E 25º 14.173´). The soil at the site was sod-podsolic sandy loam. The soil is characterized by the following: pH_{KCl} 5.6, organic matter content 27 g kg^{-1}, P_2O_5 content 105 mg kg^{-1} and K_2O content 201 mg kg^{-1} of the soil. The cultivars 'Edvins' and 'Robijs', characterised by good productivity and winterhardiness (for winter wheat) under organic farming conditions, were used in the field trials. For winter wheat plot size was 0.9 m^2 (2 m x 0.45 m (3 rows)), four replicates, seed rate – 500 seed per m^2. For spring wheat plot size 13.5 m^2 (1.5 m x 9 m), sown with seeding machine Hege 80, four replications, seed rate – 550 seed per m^2.

The control variant and three variants of organo-mineral soil amendments, containing inorganic oligomer in various mass ratio, were tested: S1 – without soil additive; S2 – soil additive with 5% of Si; S3 – soil additive with 10% of Si and S4 – soil additive with 15% of Si.

Soil amendments were obtained based of forest logging residues-lignocellulosic biomass, after isolation of polyphenols by water extraction and enrichment with silicon (Si), included the content of polyphenolic compounds. The soil amendments were used for seed material treatment.

Organic or some other type of fertilizer have not been used in the previous 5 years, except for plant residues after harvest.

The grain yield of winter wheat obtained by indirect method – using a plant samples, in turn the grain yield of spring wheat obtained by harvester "Wintersteiger". After harvesting, grain was weighed, grain purity and moisture content detected and yield data were recalculated to standard moisture (14%) and 100% purity.

B. Yield-forming components

Yield-forming components were determined at growth stage (GS) 87-89 of wheat according to BBCH scale (the phenological growth stages of cereals according to the 'Biologisce Bundesanstalt, Bundessortenamt und Chemische Industrie' (BBCH) scale). The plant samples collected in each plot at two locations from 0.5 m^2: number of productive tillers per 1 m^2, grain number per ear calculated as the total number of grains in the plant samples divided by the number of productive tillers. Weight of 1000 grains determined according to standard EN ISO 520:2011 "Cereals and Pulses", using a "Pfeuffer CONTADOR" seed counter and an electronic balance.

C. Grain quality analyses

The quality indicators: protein content (%), gluten (%), Zeleny index, volume weight for the crops studied using near-infrared spectroscopy (NIRS) with analyzers Infratec TM NOVA. Falling number (s) for winter wheat was determined by the Hagberg-Perten method (ISO 3093: 2009).

D. Meteorological conditions

Meteorological conditions were characterised by measurements of air temperature (Fig.1) and precipitation (Fig. 2.), compared with long-term values. Data were obtained from the Skriveri Observation Station of the Latvian Environment, Geology, and Meteorology Centre (www.meteo.lv).

During the sowing of winter wheat (27.09.2024.), soil conditions for seed germination were favourable. October were very rainy, with warm air temperature. Vegetation ended on November 17, 2024, but renewed on March 15, 2025. The winter was warmer than long-term observations. The vegetation period of 2024 was characterized as dry and hot, and were not favourable for the growth and development of both winter and spring wheat. For several years now, the average daily air temperature had exceeded the long-term average air temperature, and this year it was also significantly higher.

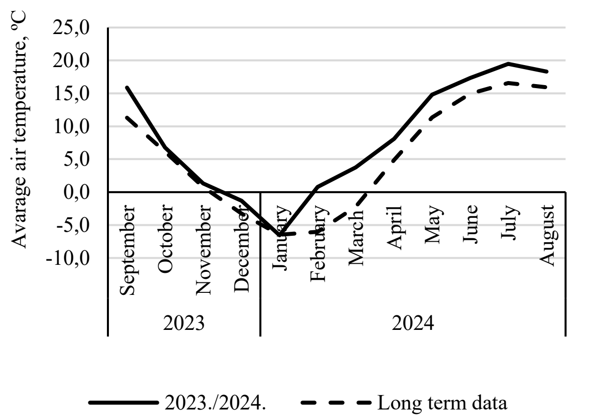

Fig. 1. Average air temperature in 2023/2024 growing season (Skriveri Observation station), ºC.

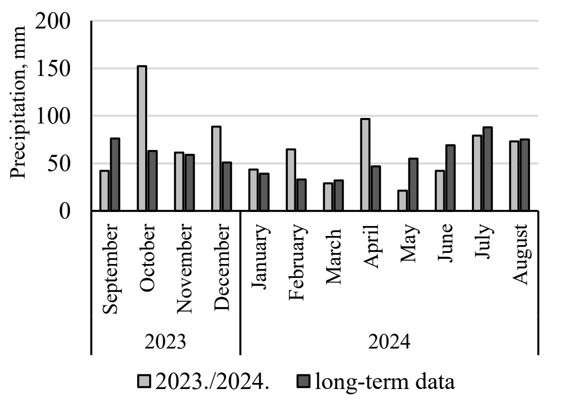

Fig. 2. Amount of precipitations in 2023/2024 growing season (Skriveri Observation station), mm.

During the sowing of spring wheat (02.05.2025.), soil conditions for seed germination were good, but a drought period began in May, which lasted until mid-august. Only in the first decade of June the amount of precipitation reached a norm (96% of the norm). Dry and hot weather promoted the ripening of wheat, winter wheat was harvested already on July 25, but spring wheat – on August 5, 2025. Drought stress is also evidenced by the short height of wheat (spring wheat only 50-55 cm).

D. Chemical characterization of grain

Analytical pyrolysis of wheat samples was performed using Frontier Lab Micro Double-shot Pyrolyser Py-

2020iD directly coupled with gas chromatography-mass spectrometer Shimadzu GC/MS/FID-QP ULTRA 2010 (Shimadzu, Kyoto, Japan). The individual compounds were identified based on GC/MS using Library MS NIST 11 and NIST 11s. The relative area of the peak of individual compounds was calculated using Shimadzu software based on GC/FID data. The variation coefficient of the measurement was ≤ 3%.

E. Statistical analyses of data

The analysis of variance by R-studio was used for statistical analysis of the experimental data (yield forming compounds, yields). Bonferroni test was used for the comparison of means at $p<0.05$. Significantly different values were labelled with different letters in superscript (^{a,b}). If effect of studied factor was not significant ($p>0.05$), used symbol "n".

III. RESULTS AND DISCUSSION

A. Yield components

Yield of any crop is mathematical function of separate yield components such as the number of plants per unit area and productivity of an individual plant. For cereals the number of productive tillers per 1 m^2, number of grain per ear, and 1.000 kernel weight is measured.

Yield components formed sequentially throughout the plant' development. The yield-forming elements of the crops affect the yield by interacting each other [6].

Analysing the yield-forming components for winter wheat, no significant ($p>0.05$) differences among the variants were found (Table 1).

TABLE 1 YIELD-FORMING COMPONENTS OF WINTER WHEAT

Variants	Number of productive tillers per 1 m^2, pieces	Number of grains per ear, pieces	Weight of 1000 grains, g
S1	308.8^n	28.8^n	33.5^n
S2	309.9^n	28.8^n	33.7^n
S3	317.0^n	29.3^n	33.4^n
S4	322.1^n	29.8^n	33.6^n

S1 – without soil additive; S2 – soil additive with 5% of Si, S3 – soil additive with 10% of Si; S4 - soil additive with 15% of Si; ^{n} - effect of studied factors was not significant ($p>0.05$).

The treatment of seed material with organo-mineral soil amendments increased the number of productive tillers of spring wheat. A significant increase ($p<0.001$) of productive tillers compared to the S1 (without soil additive) was obtained only in variant S4 with the largest concentration of Si (15%) (Table 2.).

However, in that variant (S4) were obtained significantly lower ($p<0.001$) grain number in ears. The weight of 1000 grains was similar in all tested variants, which can be explained by the dry period during the maturation of the grain.

TABLE 2. YIELD-FORMING COMPONENTS OF SPRING WHEAT

Variants	Number of productive tillers per 1 m^2, pieces	Number of grains per ear, pieces	Weight of 1000 grains, g
S1	338.9^b	26.8^{ab}	31.1^n
S2	367.8^{ab}	27.5^a	31.7^n
S3	396.1^{ab}	26.3^{ab}	31.2^n
S4	433.8^a	25.3^b	31.4^n

S1 – without soil additive; S2 – soil additive with 5% of Si, S3 – soil additive with 10% of Si; S4 - soil additive with 15% of Si; ^{n} - effect of studied factors was not significant ($p>0.05$),^{a,b} – effect of studied factors was significant ($p<0.05$)

B. Grain yield

The obtained yields correspond to the average yields in trials conducted under organic farming conditions in the Baltic region [7-9]. Treatment of seed material with organo-mineral soil amendments, containing inorganic oligomer, increased the grain yield both spring and winter wheat. However, a significant yield increase ($p<0.001$) compared to the S1 (without soil additive) was obtained only in variant S4 (soil additive with 15% of Si) for spring wheat (Fig. 3.).

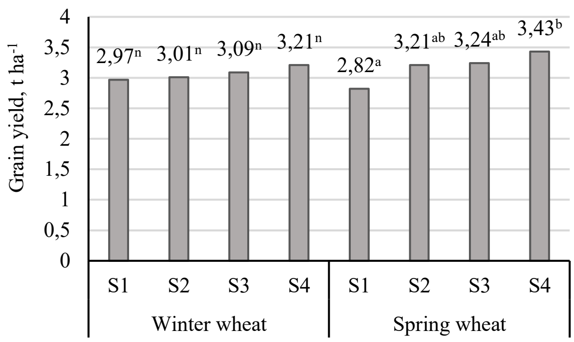

Fig. 3. The grain yield of wheat, t ha^{-1}.
S1 – without soil additive; S2 – soil additive with 5% of Si, S3 – soil additive with 10% of Si; S4 - soil additive with 15% of Si; ^{n} - effect of studied factors was not significant ($p>0.05$) for winter wheat, ^{a,b} - effect of studied factors was significant ($p<0.05$) for spring wheat.

C. Grain quality

The grain quality indicators were analysed using near-infrared spectroscopy only for spring wheat. The dry and hot weather also significantly affected the grain quality of spring wheat. Unfortunately, the grain quality indicators do not meet the requirements of food wheat. The grain has a good protein content (12.4-13.5%) and gluten content (23.1-26.4%) as well as gluten quality (Table 3).

However, the grain obtained in the trial has a low volume weight (<730 g L^{-1}) (Table 3).

D. Chemical characterization of grain

The Py-GC/MS/FID data represent volatiles formed from cellulose, hemicellulose, lignin, and extractives. Carbohydrates-derived volatiles represented 98-99% of the total wheat biomass volatile organic products. When comparing wheat samples with and without soil additive, the relative content of phenyl- and benzyl derivatives in wheat samples grown on treated soil (S2-S4) was higher, thereby demonstrating the beneficial effect of soil additives on target compounds content (Fig. 4.).

TABLE 3. PROTEIN CONTENTS AND QUALITY FOR SPRING WHEAT

Variants	Protein content, %	Gluten, %	Zeleny index, ml
S1	13.5	25.7	51.86
S2	13.5	25.8	52.11
S3	13.0	24.7	47.38
S4	12.4	23.1	43.11

S1 – without soil additive; S2 – soil additive with 5% of Si, S3 – soil additive with 10% of Si; S4 - soil additive with 15% of Si

TABLE 4. VOLUME WEIGHT AND FALLING NUMBER FOR SPRING WHEAT

Variants	Volume weight, g L^{-1}	Falling number, sec
S1	726.6	300
S2	717.8	307
S3	724.7	289
S4	729.0	292

S1 – without soil additive; S2 – soil additive with 5% of Si, S3 – soil additive with 10% of Si; S4 - soil additive with 15% of Si

The target compound tended to grow with the content of Si in the soil additive. However, this increase was within the variation coefficient.

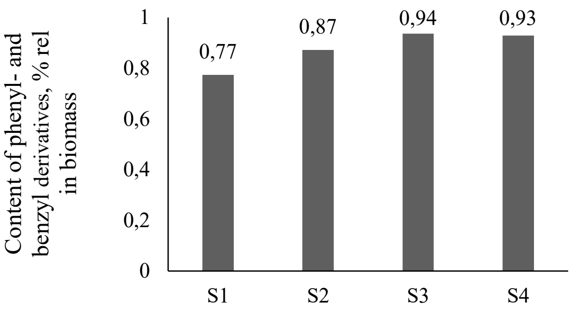

Fig. 4. Soil additive effect on the content of phenyl- and benzyl-derivatives in wheat based on analytical pyrolysis data of wheat samples: S1 – without soil additive; S2 – soil additive with 5% of Si, S3 – soil additive with 10% of Si; S4 - soil additive with 15% of Si.

The content of total phenyl and benzyl derivatives formed from extractives ranged from 0.77 to 0.93 rel% in biomass. Among the phenyl and benzyl-derived volatiles, the predominant one is phenyl, 3 and 4 methyl-derived volatiles as methoxy-substituted benzoquinone, which has been proven to have potential antitumor and immunostimulating activity (Fig.5).

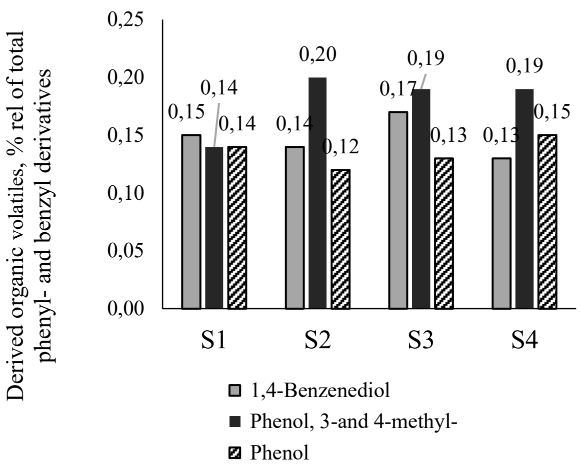

Fig. 5. Analytical pyrolysis data of phenyl and benzyl-derived volatiles of wheat samples: S1 – without soil additive; S2 – soil additive with 5% of Si, S3 – soil additive with 10% of Si; S4 - soil additive with 15% of Si

IV. CONCLUSIONS

In variant with the highest tested concentration of inorganic oligomer, a trend towards yield growth for wheat can be observed (increase of productive tillers).

The study's results showed a positive effect of the soil additive (S2-S4) on the content of biologically active compounds in wheat samples. The higher content of phenyl and benzyl derivatives in wheat grains may indicate an increased content of phenolic acid, flavonoids, benzoquinone compounds, etc., – compounds with documented antitumor and immunostimulating properties.

The obtained results show that the treatment of seed material with promotes plant growth and development, researches should be continued.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] W. Tian, Y. Zheng, W. Wang, D. Wang, M. Tilley, G. Zhang, A. He and Y. Li, "A comprehensive review of wheat phytochemicals: From farm to fork and beyond", Comprehensive Reviews in Food Science and Food Safety, vol. 21, Issue 3, pp. 2274–2308, May 2022 . https://doi.org/10.1111/1541-4337.12960 [Accessed March 2, 2025].

[2] Q. Li, X. Wang, J. Chen, C. Liu, T. Li, D.J. McClements, T. Dai and J. Liu, "Antioxidant activity of proanthocyanidins-rich fractions from Choerospondias axillaris peels using a combination of chemical-based methods and cellular-based assay", Food Chem., vol 208, pp. 309–317, October 2016. https://doi.org/10.1016/j.foodchem.2016.04.012

[3] S. Janceva, A. Andersone, L. Lauberte, N. Zaharova, V. and Nikolajeva, Fruit shrubs' twigs as a source of valuable oligomeric polyphenolic compounds with antibacterial and antifungal potential: 15th International Scientific and Practical Conference

"Environment. Technology. Resources", June 27– 28, 2024, Rezekne, Latvia. Rezekne: Rezekne Academy of Technologies, 2024.

[4] S. Janceva, L. Lauberte, T. Dizhbite, J. Krasilnikova, G. Telysheva and M. Dzenis, "Protective effects of proanthocyanidins extracts from the bark of deciduous trees in lipid systems", Holzforschung, vol. 71, pp. 675–680, March 2017. https://doi.org/10.1515/hf-2016-0185

[5] A. Andersone, S. Janceva, A. Svarta, N. Zaharova, G. Rieksts and G. Telysheva, Lignin and lignocellulose-based organomineral complex for organic agriculture: Multidisciplinary Scientific GeoConference SGEM 2023, July 3-9, 2023, Albena, Bulgaria. STEF92 Technology, 2023.

[6] Z. Gaile, A. Ruza, D. Kreita and L. Paura, "Yield components and quality parameters of winter wheat depending on tillering coefficient", Agronomy Research, vol. 15, no. 1, pp. 79– 93, Jan. 2017.

[7] B. Feledyn-Szewczyk, J. Kuś, K. Jończyk and J. Stalenga, "The suitability of different winter and spring varieties for cultivation in organic farming," in Organic Agriculture Towards Sustainability. Intechopen, 2014. http://dx.doi.org/10.5772/58351

[8] V. Strazdiņa, V. Fetere and L. Legzdiņa, Evoluation of spring wheat heterogeneous population and variety mixtures under organic farming system: Zinātniski praktiskā konference "Līdzsvarota lauksaimniecība", February 20, 2020, Jelgava, Latvija. Jelgava: Latvia University of Life Sciences and technologies, 2020.

[9] B. Tein, Effect of organic and conventional production system on the quality of spring wheat: 18th International Scientific conference Research for Rural Development 2012, May 16-18, 2012, Jelgava, Latvia. Jelgava: Latvia University of Life Sciences and technologies, 2012.