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EFFECT OF VERMICOMPOST-BASED PREPARATIONS ON YIELD FORMATION, PRODUCTION AND QUALITY OF SUNFLOWER

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Abstract

The research was carried out on fields of farm AGRO SAP s.r.o. located in Nenince near the town Veľký Krtíš in 2020–2022. The design of experiment was based on randomized split plot method in three repetitions, with a plot size 3 m × 20 m. The aim of experiment was found out effect of two vermicompost-based preparations T1 and T2 on two sunflower hybrids H1 and H2. Evaluated parameters were yield-forming elements (number of plants, diameter of heads, weight of head, thousand seed weight), seed yield and oil content. Use of vermicompost-based preparation T2 had significant impact on increase of yield-forming elements (diameter of head 17.29 ± 1.41 cm; weight of head 180.22 ± 18.90 g) and seed yield 3.68 ± 0.70 g, compared to untreated variant. The highest value of thousand seed weight (65.33 ± 2.40 g) and oil content (39.49 ± 1.91%) in three experimental years was achieved on treated variants by vermicompost-based preparation T1. Two used sunflower hybrids influenced all monitored experimental parameters, and significantly higher values were recorded in hybrid H1, except oil content (39.63 ± 1.86%). The evaluation of correlation analysis demonstrated the high positive relation between weight of head and diameter of head, seed yield and thousand seed weight. As a result, the use of vermicompost-based liquid fertilizers has positive effect on increase values of yield-forming elements, production and quality of sunflower.

Keywords: vermicompost, sunflower, fertilizers

INTRODUCTION

The development of agricultural production cannot do without the use of various methods and preparations that are chemical and synthetic in nature. The primary intensification factor is the application of macroelements, such as nitrogen and phosphorus, which significantly support the formation of production parameters of the crop and final quality of sunflower, therefore their adequate income plays a key role in cultivation technology (Škarpa and Lošák, 2008). However, the cyclical application of fertilizers burdens the environment, pollutes the soil and groundwater through the accumulation of undesirable substances that can endanger the human health and other living organisms (Schuman and Simpson, 1997). Therefore, alternative ways are being sought to intensify agricultural production in a biological way and at the same time supply the soil with the necessary organic matter (İlay *et al.*, 2013; Mondal *et al.*, 2017).

The vermicompost formation process, as one of the options for recycling biodegradable waste, is based on the intensive activity of earthworms (Adhikary, 2012; Neupauer *et al.*, 2023). It is important to note that vermicomposting at least increases the number of important macronutrients (nitrogen, phosphorus, potassium) in the final product (Mago *et al.*, 2022; Ahmed and Deka, 2022). From various studies implies (Zuhair *et al.*, 2022; Celikcan *et al.*, 2021; Zuo *et al.*, 2018) that, the positive effects of vermicomposting products have been confirmed not only in terms of direct effect on the plant (increases stem and root length, number and length of leaves, dry weight of plants, increases total strawberry yield and average fruit weight), but also on quality parameters such as increase in essential oil content, soluble sugars, vitamin C content, improvement of enzyme activity (Zuo *et al.*, 2018; Sharafabad *et al.*, 2022).

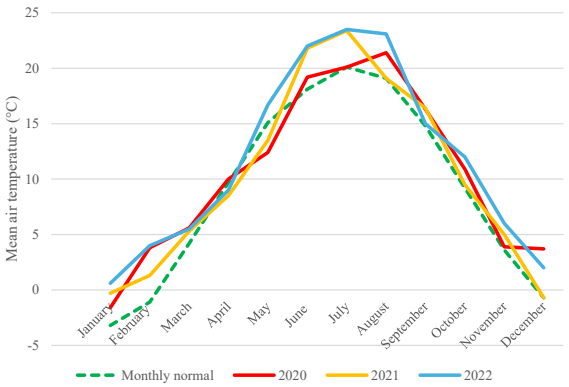
Vermicompost also has a positive effect on soil physical properties such as soil aeration and porosity, the degree of soil aggregation, and reduces soil bulk density (Arancon *et al.*, 2008; Manivannan *et al.*, 2009). In the scope of soil agrochemical properties, it increases the content of macro- and micronutrients (N, P, K, C, Ca, Mg, Zn), cation sorption capacity and oxidation potential of soil (Rajkhowa *et al.*, 2016; Azarmi *et al.*, 2008; Manivannan *et al.*, 2009).

The sunflower (*Helianthus annuus* L.) is a popular crop among farmers for the wide use of high-oil seeds and is admired for its beautiful habit. Sunflower seeds and the oil obtained from them are used for a variety of food and non-food purposes. The oil itself is nutritionally valuable for high content of unsaturated fatty acids, such as linolenic and linoleic acids, which help to reduce cholesterol and prevent the clotting of fats in the arteries. In addition, it contains important vitamins A, D, E and K (Puttha *et al.*, 2023). Sunflower is a crop with high nutrient requirements, and therefore the use of vermicompost-based preparations presents a supplement to the nutrition and fertilization that sunflower requires for proper growth, development and maturation. However, vermicompost-based products represent one of the environmentally sustainable options to increase the yield and quality of sunflower seeds. Therefore, the research was focused to identify the effect of vermicompost-based products on the production process of sunflower.

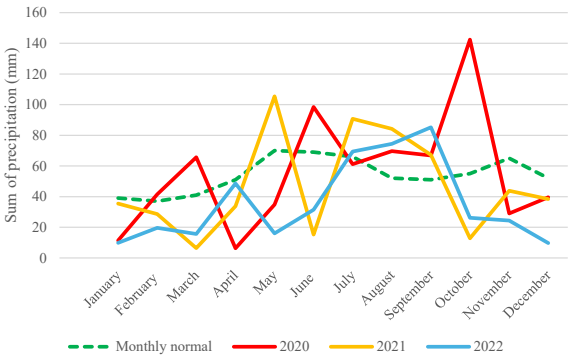
MATERIALS AND METHODS

Experimental Area

The research was established on the fields of AGRO SAP s.r.o. farm in Nenince, approximately 18 km from the town of Veľký Krtíš, Slovak Republic, during the years 2020, 2021, and 2022. The geographical coordinates of the locality are 48°8'34.17" N and 19°16'7.20" E. Experimental area belons to warm, slightly dry climatic area with mild to cold winters. The average of annual precipitations is 631 mm. The average precipitation for months IV–IX (important for sunflower cultivation) is 358 mm. The weather conditions during the experimental period are shown in Fig. 1, and Fig. 2. The experiment was established on Cutanic Luvisol, Haplic Fluvisol, and Mollic Fluvisol (VÚPOP, 2014).



1: *Temperature difference during experimental seasons in comparison to monthly normal*



2: *Precipitation difference during experimental seasons in comparison to monthly normal*

Experimental Material

Vermicompost-based preparations used in experiment were:

Preparation 1 (P1) is commercially produced live organic-mineral foliar fertilizer with a stimulating effect, enriched by macroelements N, K, S and Mg and microelements in chelated water-soluble form Mn, Zn, Cu and B, the contents of which are listed below. The application of P1 was in BBCH 15 (8 leaves) in dose 10 L/ha.

pH	7.0 – 9.5
Dry matter (% min.)	25.0
Total N (% min.)	9.5
Total S (g/L min.)	6.5
Mg (g/L min.)	3.9
Zn (g/L min.)	3.9
B (g/L min.)	7.7
Cu (g/L min.)	3.2

Preparation 2 (P2) is commercially produced active natural vermicompost leachate. It contains humic substances (humic and fulvic acids), phytohormones, enzymes, amino acids and substances of protein nature, the contents are listed below. The application of P2 was in BBCH 15 (8 leaves) in dose 5 L/ha.

pH	6.5–8.5
Humic acids (% min.)	0.5
Amino acids (mg/L min.)	200.0
Histidine (mg/L)	33.0
Leucine (mg/L)	22.0
Isoleucine (mg/L)	17.0
Lysine (mg/L)	27.0
Methionine (mg/L)	38.0
Phenylalanine (mg/L)	24.0
Threonine (mg/L)	10.0
Valine (mg/L)	20.0
Arginin (mg/L)	25.0

Sunflower hybrids used in experiments were:
Hybrid 1 (H1) is a medium-tall hybrid grown by Clearfield technology and characterized by high plasticity, resistance to pathogens such as Sclerotinia sclerotiorum, Plasmopara halstedii, Diaporthe helianthi, Verticillium dahliae, and Phoma helianthi.

Hybrid 2 (H2) is medium-early hybrid designed for Clearfiled technology with rapid initial growth development. It has tolerance to stem and limb Sclerotinia sclerotiorum, diseases like Puccinia helianthi, and Plasmopara halstedii.

Experimetal Methods

The experimental plot had an area of 60 m^2 (3 m × 20 m). The design of experiment was based on randomized split plot method in three repetitions according to Ehrenbergerová (1995). The sunflower cultivation was included after winter wheat (*Triticum aestivum* L.). Preparation of soil in accordance with conventional cultivation technology of sunflower consisted in stubble plowing, followed by deep plowing (Lal, 1991). For thorough fertilization of sunflower, soil samples were taken for agrochemical analysis in autumn and spring. The results are shown in Tab. I. The doses of mineral fertilizers, 100 kg NPK (10-24-24) and 300 kg urea (46% N), were calculated by method of balanced fertilization for expected seed yield 3 tons per hectare according to Ernst *et al.* (2022). Sunflower sowing was carried out by a 4-row seeder with 0.70 m length between rows and 0.22 m was the distance in a row. The treatments used in experiment were T0 (control/untreated variant), T1 (treatment by preparation 1 in dose 10 L/ha in BBCH 15), T2 (treatment by preparation 2 in dose 5 L/ha in BBCH 15).

Statistical Analysis

Achieved results of experiments were evaluated by statistical software TIBCO Statistica®, Version 14.0 (TIBCO Software Inc., Palo Alto, California, USA). A multifactor ANOVA was used for the individual treatment comparison at $P = 0.05$, with separation of the means by the HSD multi-range test. For correlation analysis simple correlation coefficient according to Pearson was used and simple regression was chosen to predict some factors.

RESULTS

The evaluation of experimental results shown statistically insignificant effect between, thousand seed weight in grams and experimental year ($P = 0.125$). In interaction relations were found statistically high significant ($P = 0.000$) effects between year x hybrid and thousand seed weight, year x hybrid and seed yield, year x treatment and seed yield, hybrid x treatment and oil content, year x hybrid x treatment and oil content (Tab. II).

Statistically significantly higher values were recorded in experimental parameters number per plants (59 372.78 ± 676.53 pcs/ha), diameter of head (18.16 ± 0.86 cm), weight of head (191.56 ± 10.37 g) in 2020 compared to other years (Tab. III).

I: *Agrochemical soil analysis in autumn and spring*

Autumn			
Nutrient and determination method	2019	2020	2021
Phosphorus (mg/kg) - colorimetrically by Mehlich III	18.80	72.00	58.00
Potassium (mg/kg) - flame photometry by Mehlich III	235.00	213.4	225.00
Calcium (mg/kg) - AAS by Mehlich III	263.00	251.00	259.00
Magnesium (mg/kg) - AAS by Mehlich III	706.10	477.00	531.00
pH - by KCl (0.2 mol/dm KCl) (pH units)	6.69	6.60	6.65
Spring			
Nutrient and determination method	2020	2021	2022
Inorganic Nitrogen (mg/kg) - sum of ammonium and nitrate nitrogen	12.55	6.60	8.65
NO_3^- - N (mg/kg) - colorimetrically by phenol 2.4-disulfonic acid	5.80	2.50	3.86
NH_4^+ - N (mg/kg) - colorimetrically by Nessler's reagent	6.75	4.10	4.80

II: *ANOVA of sunflower production and qualitative factors in 2020–2022*

	Number of plants (pcs/ha)	Diameter of head (cm)	Weight of head (g)	Thousand seed weight (g)	Seed yield (t/ha)	Oil content (%)
			P values			
Year	0.001**	0.000**	0.000**	0.125	0.000**	0.000**
Hybrid	0.000**	0.000**	0.000**	0.000**	0.000**	0.000**
Treatment	0.208	0.000**	0.000**	0.000**	0.000**	0.000**
Year*Hybrid	0.318	0.017*	0.070	0.000**	0.000**	0.117
Year*Treatment	0.607	0.983	0.765	0.040*	0.000**	0.319
Hybrid*Treatment	0.603	0.235	0.300	0.011*	0.315	0.000**
Year*Hybrid*Treatment	0.722	0.050	0.394	0.143	0.299	0.000**

* Statistically significant effect by 0.95 confidence intervals
** Statistically significant effect by 0.99 confidence intervals

III: *Mean values and significant differences inside experimental factors (95% level Tukey test)*

	Number of plants (pcs/ha)	Diameter of head (cm)	Weight of head (g)	Thousand seed weight (g)	Seed yield (t/ha)	Oil content (%)
2020	59 372.78 ± 676.53^{b}	18.16 ± 0.86^{c}	191.56 ± 10.37^{c}	64.39 ± 2.93^{a}	3.33 ± 0.97^{a}	36.74 ± 0.61^{a}
2021	58 708.33 ± 597.12^{a}	17.86 ± 0.55^{b}	179.89 ± 12.95^{b}	64.28 ± 1.93^{a}	3.93 ± 0.10^{c}	40.62 ± 0.50^{b}
2022	58 814.44 ± 553.15^{a}	15.17 ± 0.44^{a}	155.17 ± 6.20^{a}	65.06 ± 2.31^{a}	3.49 ± 0.21^{b}	40.53 ± 0.53^{b}
H1	59 281.48 ± 554.05^{a}	17.40 ± 1.62^{b}	180.74 ± 20.35^{b}	65.81 ± 2.08^{b}	3.85 ± 0.39^{b}	38.97 ± 1.92^{a}
H2	58 648.89 ± 627.86^{b}	16.72 ± 1.30^{a}	170.33 ± 14.59^{a}	63.33 ± 2.08^{a}	3.31 ± 0.70^{a}	39.63 ± 1.86^{b}
T0	58 830.00 ± 682.72^{a}	16.63 ± 1.52^{a}	168.22 ± 16.97^{a}	63.11 ± 2.17^{a}	3.42 ± 0.62^{a}	38.94 ± 1.83^{a}
T1	59 144.44 ± 643.70^{a}	17.26 ± 1.54^{b}	178.17 ± 16.67^{b}	65.33 ± 2.40^{b}	3.65 ± 0.64^{b}	39.49 ± 1.91^{b}
T2	58 921.11 ± 674.00^{a}	17.29 ± 1.41^{b}	180.22 ± 18.90^{b}	65.28 ± 2.05^{b}	3.68 ± 0.70^{b}	39.46 ± 2.02^{b}

H1, H2 – used sunflower hybrids
T0, T1, T2 – treatments

IV: *Correlation analysis of monitored parameters of sunflower hybrids treated by two preparations in three growing seasons*

	Number of plants (pcs/ha)	Diameter of head (cm)	Weight of head (g)	Thousand seed weight (g)	Seed yield (t/ha)
Number of plants (pcs/ha)	1.000				
Diameter of head (cm)	0.382^{++}	1.000			
Weight of head (g)	0.409^{++}	0.929^{+++}	1.000		
Thousand seed weight (g)	0.356^{++}	0.136^{+}	0.186^{+}	1.000	
Seed yield (t/ha)	0.231^{+}	0.294^{+}	0.205^{+}	0.618^{+++}	1.000

\+ Values between 0 and 0.3 (0 and -0.3) indicate a weak positive (negative) linear relationship through a shaky linear rule
++ Values between 0.3 and 0.7 (0.3 and -0.7) indicate a moderate positive (negative) linear relationship through a fuzzy-firm linear rule
+++ Values between 0.7 and 1.0 (-0.7 and -1.0) indicate a strong positive (negative) linear relationship through a firm linear rule

Statistically higher seed yield (3.93 ± 0.10 t/ha), and oil content (40.62 ± 0.50%) were achieved in 2021 compared to other years. For parameter thousand seed weight was most favourable year 2022 (65.06 ± 2.31 g) compared to years 2020 and 2021.

The vermicompost-based preparations statistically significantly affected the important parameters mainly seed yield and oil content. Evaluation of weight of head confirmed statistically significant higher value (180.22 ± 18.90 g) in variant T2 compared to T0. Thousand seed weight was affected statistically significantly higher in variant T1 (65.33 ± 2.40 g) compared to control variant. Evaluation of seed yield, as a one of most important parameters, confirmed statistically significantly higher value (3.68 ± 0.70 t/ha) in variant T2 compared

to variant T0. Statistically significantly higher oil content was found in variant T1 (39.49 ± 1.91%) compared to variant T0 (Tab. II).

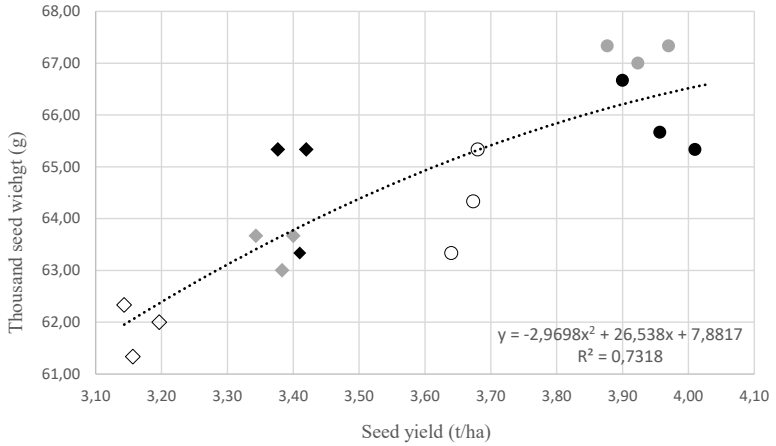
Sunflower hybrids affected all monitored parameters statistically high significantly (Tab. II). Within the comparison of used hybrids, the higher values were observed for hybrid H1, except for oil content, where higher oil content was achieved in hybrid H2 (39.63 ± 1.86%) (Tab. III).

The evaluation of correlation analysis demonstrated the high positive relation between weight of head and diameter of head, seed yield and thousand seed weight (Tab. IV). Enlarge of head diameter increased weight of head (Fig. 4), and higher value of thousand seed weight also increased seed yield (Fig. 3). Other relations between parameters have less correlation dependence.

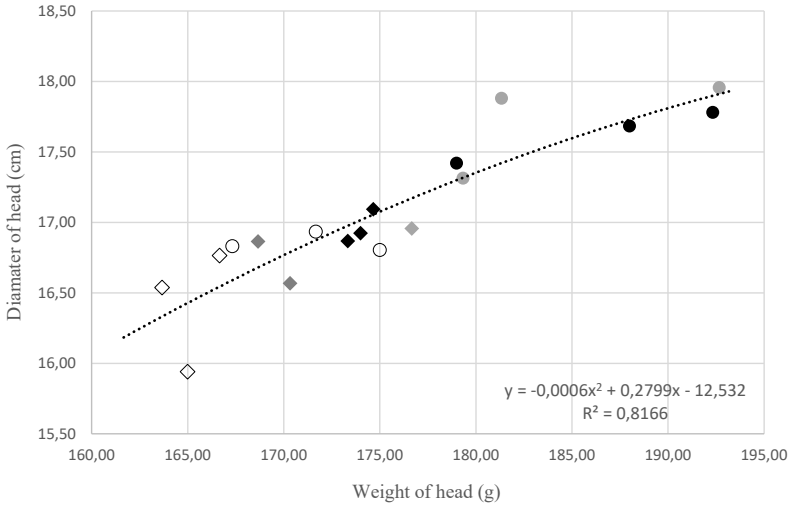
DISCUSSION

Climatic change is related to weather variables, resulting in increased incidence of floods, droughts, desertification not only agricultural soil, diseases and pest occurrence. The literature disposes by little information on the potential use of vermicompost to mitigate the adverse effects of weather conditions on agriculture production. Existing knowledges evidence strongly suggests that vermicompost and its derivatives contain valuable substances such as humic acids, nutrients, earthworm excretions, rich microbial populations, growth hormones and enzymes, which help crops withstand a wide range of abiotic and biotic stresses (Vambe *et al.*, 2023).

Vermicompost is a very high quality organic and biocontrol fertilizer, which makes it a better organic fertilizer option compared to mineral



3: *Relations of three growing seasons and application of vermicompost-based preparations. Symbols: hybrid H1 – circle; hybrid H2 – diamond; untreated variant T0 – white, variant T1 – grey, variant T2 – black. Dash line shows polynomial quadratic regression*



4: *Relations of three growing seasons and application of vermicompost-based preparations. Symbols: hybrid H1 – circle; hybrid H2 – diamond; untreated variant T0 – white, treated variant T1 – grey, treated variant T2 – black. Dash line shows polynomial quadratic regression*

fertilizers. Many scientific works of authors such as Karmakar *et al.* (2012), Yan *et al.* (2013), Açıkbaş and Bellitürk (2016) have confirmed that vermicompost in solid and liquid form increases the yield as well as the quality of the harvest obtained used not only in agriculture but also in vegetable, fruit and landscape plant cultivation, what confirmed our achieved results.

In the scope of study organic and mineral fertilizers were found increases of crop yields and qualitative parameters. A particularly interesting finding was that a combination of 50% chemical fertilizers and 50% organic fertilizers can effectively increase the yield and quality of cultivated plants. These results have important implications for guiding plant fertilizer management and the development of sustainable agriculture (Hou *et al*., 2024). Our findings confirmed a positive increase in yield and oil content not only for the organo-mineral preparation but also for the organic leachate.

Vermicompost itself is ideal for better growth and higher yields of many plants. The positive effects of vermicompost are in increasing of seed germination, stem elongation, increase of number of leaves, leaf area, dry leaf weight, root length, number of roots, total yield, chlorophyll content, micro- and macro-nutrient content, carbohydrate and protein content and improves the nutritional quality of fruits and seeds (Joshi *et al*., 2014). From the results of the effect of vermicompost fertilizers on sunflower yield-forming elements, authors found that with increasing vermicompost dose, stem diameter, diameter of head and plant height of sunflower increased (Ramasamy and Umavathi, 2011). Our results confirmed the increase diameter of head and weight of thousands grains of sunflower after one application rate of vermicompost-containing preparations. In study, based on using of fertilizers with vermicompost addition, were confirmed significant impact on the bean plant's development, growth, and productivity (Al-Tawarah *et al*., 2024). According to researchers Shehata and EL-Khawas (2003) and Tamer *et al.* (2016) have been proven positive effects of vermicompost on seed yield and oil content in sunflower seeds, which is consistent with our results.

CONCLUSION

The use of vermicompost-based preparations is one of the keyways in agriculture to enrich the soil with valuable organic matter and nutrients. Positive effects of vermicompost in plant cultivation was confirmed, therefore the impact of vermicompost liquid derivations were evaluated on sunflower hybrids in three growing seasons. It is possible conclude that use of vermicompost-based preparation T2 had significant impact on increase of diameter of head, weight of head, and the yield and T1 on weight of thousand seeds, and oil content. Two used sunflower hybrids influenced all monitored experimental parameters, and significantly higher values were recorded by hybrid H1 except oil content. In the scope of further research, it is necessary to find out the effect of the application of vermicompost-based formulations not only on other important agricultural crops, but also on the physical and agrochemical properties of the soil.

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