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Wood waste compost as growing media components for cultivation of *Chrysanthemum morifolium* (Ramat.) Hemsl.

Kompost z odpadów drzewnych jako składnik podłoża do uprawy chryzantemy wielkokwiatowej *Chrysanthemum morifolium* (Ramat.) Hemsl.

Abstract. The chrysanthemum is a significant species grown in Europe in pots and as a cut flower. In the cultivation of this species, peat substrate is used as a medium. The aim of the research was to assess the possibility of using composts from post-consumer wood used for in controlled cultivation of chrysanthemum *Chrysanthemum morifolium* (Ramat.) Hemsl. Mount Listou cultivar. Compost obtained from post-consumer wood waste, were used as the medium, and marked as: PCW I and PCW II. These were old furniture. The third compost marked with the symbol FB was obtained from fiber boards. The substrates used with the addition of compost made on wood waste had an impact on the quality of chrysanthemum. As studies have shown, composts from post-consumer wood they can be a valuable component of horticultural substrates when used appropriately.

Keywords: post-consumer wood, compost, chrysanthemum

INTRODUCTION

The topic of using peat in horticulture raises a lot of concerns and controversy, especially in Europe. The exploitation and degradation of peatlands contributes to global greenhouse gas emissions. Its exploitation degrades the environment and increases CO_2 emissions into the atmosphere (1 billion tones CO_2 per year) [Bonn et al. 2014, Tubiello et al. 2016]. In various countries, there are regulations forcing the reduction of its consumption. In the many European country such as: Germany, Ireland, United Kingdom,

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Norway, the government has set specific goals to eliminate horticultural peat use by amateur (2025–2026) and by professionals (2030) [Hirschler et al. 2022, Hirschler and Thran 2023].

The introduced restrictions on the use of peat require the search for alternative substrates that will allow its elimination in horticultural production [Gioia et al. 2017]. Giving up peat substrates in favor of other substitutes is not easy because peat is characterized by, among other things, very good chemical, biological and physical properties [Gruda 2012, Diaspenza et al. 2016, Savvas and Gruda 2018, Gruda 2019, Zulfiqar et al. 2021].

Due to envirnomental concerns and political decision regarding the use of peat, substrates that can replace peat in production are being sought.

Wood is one of the most commonly used natural materials. Wood waste is an inherent result of the wood harvesting and processing process, as well as human activities. According to Kurowska [2016], there are three groups of wood waste: forest, industrial, and post-consumer waste. Post-consumer wood waste is the most diverse group among those mentioned. The elements of waste wood are most often old furniture, doors, windows, floors, construction materials, packaging, and other wooden products that have completed their life cycle [Komorowicz et al. 2021].

One of the oldest industrial activities in the world is furniture production, which is an inseparable part of everyday life. As much as 77% of furniture production takes place in 10 countries, with Poland being one of the most important producers. The assumptions of the European Green Deal stipulate that the products being introduced must be designed in such a way as to align with the concept of a circular economy and sustainable development through the rational management of products that have waste status [Nguyen et al. 2023]. Organic recycling of wood waste can be composting, that is, the transfer of biodegradable waste under controlled conditions using microorganisms (actinomycetes, bacteria and fungi) to produce organic matter. For example, *Lactobacillus plantarum* may accelerate the decomposition and fermentation in composting process. *Streptomyces albus* produce antibacterial matter for pathogenic bacteria and *Rhodobacter sphaeroides* involve in production of amino acids and amino nucleic. *Saccharomyces cerevisiae* and *Candida utilis* promote fermentation and produces bioactive substances. Likewise, fungal species *Aspergillus*, *Trichoderma*, *Sclerotinum* and white rot fungi, produce extracellular enzymes accountable for cellulose and lignin degradation during composting [Muttalib et al. 2016, Rastogi et al. 2020].

In recent years, composted organic waste has been increasingly used as growing media due to its high content of organic matter and nutrients, and because it enables the reuse of waste materials [Atzori et al. 2021].

One possibility of using wood waste for the disposal of materials of wood origin may be composting this waste. Disposal of post-consumer wood waste has recently become increasingly popular in the European Union. Composted materials obtained from wood waste after consumption can be used as a source of humus and organic substances [Komorowicz et al. 2021]. Wood waste comprises almost 90% of the organic matter including carbohydrates (65–75%) and lignin (18–35%) [Rowell et al. 2012].

The potted chrysanthemum is a very popular because it has many varieties of different colors, size and type of flowers [Singh et al. 2023, Lu et al. 2024]. Thanks to controlled cultivation, flowering plants are available all year round.

The aim of the research was to assess the possibility of using composts from post-consumer wood as a component of the substrate for growing chrysanthemums and to obtain good quality plants.

MATERIAL AND METHODS

The research was carried out in controlled cultivation on chrysanthemum (*Chrysanthemum morifolium*) Mount Listou as a model plant from horticultural farm A.A. Kłak (Szczepankowo, Poland). Rooted cuttings were pinched off above the fifth leaf and planted five pieces each into pots of 14 cm diameter and a volume of 1 dm^3. In order to obtain a compact habit, the growth retardant – daminozide (2550 mg dm^{-3}), contained in the Dazide Enchance 85 SG preparation was used twice.

Beginning from the second week of cultivation, fertigation was applied using Superba Brown (10% $N\text{-}NO_3$ and 4.1% $N\text{-}NH_4$, 9.2% P_2O_5, 25.4% K_2O, 2.8% MgO, 6% SO_3, 0.16% Fe, 0.1% Mn, 0.02% Zn, 0.007% Cu, 0.03% B, 0.002% Mo) in the concentration of 0.1%.

From the moment the plant was planted, it was grown under short day conditions, shortening the day with the help of shading curtains (figure 1).

Fig. 1. Controlled chrysanthemum cultivation in plastic tunnel

Compost obtained from post-consumer wood waste were used as the medium, and marked as: PCW I and PCW II. These compost consisted of old kitchen furniture. The third compost marked with the symbol FB was obtained from fiber boards. Selected waste was preliminarily crushed.

The composting process was conducted in three 160 dm^3 volume chambers of the bioreactor of each for a period of three months.

The chambers of the bioreactor contained:

I. PCW I – post-consumer wood (70%), powdery waste from processing MDF boards (6%), mature compost made from fiber board waste (19%), high peat (4%), $CO(NH_2)_2$ (20 kg), Activit Las,
II. PCW II – post-consumer wood (70%), powdery waste from processing MDF boards (6%), mature compost made from fiber board waste (19%), high peat (4%), NH_4NO_3 (1.5 kg), $MgSO_4$ (0.4 kg), K_3PO_4 (0.8 kg), $Ca_3(PO_4)_2$ (0.9 kg), Activit Las,
III. FB – fiber boards waste (65%), pine shavings (28%), high peat (7%), $CO(NH_2)_2$ (20 kg), Activit Las.

A biological inoculum Activit Las containing bacteria, actinomycetes, and fungi *Trichoderma* sp., *Penicillium* sp. The composted wood waste is shown in figure 2.

Fig. 2. The composted wood waste

The plants were cultivated in mediums consisting of peat substrate with addition PCW I, PCW II or FB composts in different proportions (25%, 50%, 75%). The control plants were grown in peat substrate TS1 Klasmann-Deilmann (GmbH Geeste, Germany). The parameters of composts before mixing with peat and the chemical composition of the medium before and after cultivation are presented in tables 1–3.

Table 1. The content of dry mass, ash, density in the peat substrate and composts before mixed

Medium	Dry mass	Ash	Density	Organic carbon	Total nitrogen	C:N ratio
	%		$g\ dm^{-3}$	$g\ kg^{-1}$		
Peat substrate	31.9	15.8	330	52.9	0.9	56.2:1
PCW I	32.3	11.6	324	403.6	36.1	11.2:1
PCW II	32.6	12.1	319	401.0	25.1	16.0:1
FB	31.7	11.2	322	417.3	15.1	28.0:1

Table 2. The chemical composition before plant cultivation (C – compost, PS – peat substrate)

Medium		$N\text{-}NO_3$	P	K	Ca	Mg	Fe	Mn	Zn	Cu	Cl	Salnity g NaCl dm^{-3}	pH
		mg $\cdot dm^{-3}$											
Control – peat substrate		91	64	39	2491	127	47.4	4.2	5.6	1.12	39	1.23	6.0
PCW I	75% C + 25% PS	321	27	51	894	56	51.4	13.2	694	0.96	53	1.98	5.1
	50% C + 50% PS	276	29	45	987	61	49.1	11.3	327	0.75	42	1.85	5.5
	25% C + 75% PS	210	25	40	1250	60	37.2	9.8	205	0.47	49	1.72	6.0
PCW II	75% C + 25% PS	430	35	55	872	67	54.2	14.7	591	0.48	47	2.31	5.2
	50% C + 50% PS	378	34	51	1124	70	47.6	12.5	324	0.42	56	1.46	5.8
	25% C + 75% PS	223	34	47	1435	72	41.5	10.8	217	0.39	61	1.18	6.2
FB	75% C + 25% PS	147	42	38	483	20	79.0	53.1	12.3	2.7	27	2.04	5.5
	50% C + 50% PS	142	51	76	536	31	64.0	47.2	10.7	3.4	37	2.01	5.8
	25% C + 75% PS	117	50	70	587	28	69.0	45.1	9.8	4.2	40	1.96	5.4

Table 3. The chemical composition of the medium after plant cultivation (C – compost, PS – peat substrate)

Medium		$N\text{-}NO_3$	P	K	Ca	Mg	Fe	Mn	Zn	Cu	Cl	Salnity g NaCl dm^{-3}	pH
		mg dm^{-3}											
Control – peat substrate		391	112	110	2628	210	21.9	2.54	6.2	1.37	81	1.9	5.6
PCW I	75% C + 25% PS	246	37	62	1108	102	37.9	12.7	602	2.78	224	2.25	5.0
	50% C + 50% PS	321	26	49	1456	141	32.7	10.2	357	1.84	356	2.02	5.8
	25% C + 75% PS	237	32	38	1827	162	26.2	8.7	196	1.56	407	2.71	6.0
PCW II	75% C + 25% PS	296	26	50	927	98	46.3	9.1	478	1.12	169	1.8	5.5
	50% C + 50% PS	312	31	48	1532	106	32.9	5.2	322	1.41	174	2.4	5.6
	25% C + 75% PS	152	30	21	1967	124	34.1	2.1	207	1.03	182	2.3	6.1
FB	75% C + 25% PS	129	39	37	826	27	76.0	42.7	11.9	2.81	51.2	2.1	5.4
	50% C + 50% PS	120	40	56	921	33	61.0	45.1	10.2	3.62	60.7	1.96	5.7
	25% C + 75% PS	112	42	50	992	31	60.0	39.8	8.7	3.91	69.8	1.92	5.5

The collected substrate samples were subjected to chemical analysis using universal methods described in the methodology published by Schroeter-Zakrzewska et al. [2021].

When the one half off flowers was developed biometric measurements were taken such as the: height and diameter of plants, the number of leaves, flowers, flower buds and the diameter of flowers. The diameter of flowers was measured using electronic calliper. The height and diameter of the plants were measured using a ruler. On the last day of the experiment the chrysanthemum were cut and the aboveground parts was weighed. Then the fresh mass was marked using an electronic balance. Then, they were dried in a drier for 48 h at 60°C and weighed to mark the dry weight.

The green leaf index SPAD (Soil Plant Analysis Development) was measured using of Yara N-Tester apparatus. The mean sample consisted of 36 leaves per one combination (3 leaves for each pot). The size of leaf area was measured using of WinDIAS 3.2 (Delta-T Devices).

The experiment consisted of 10 combinations and 12 replications, were 1 replication was 1 pot. The experiment was established in 2 culture cycles. The results of measurement given as mean from 2 cycles.

The results were statistically analyzed using Statistica 13.0 software. The averages were grouped using Duncan's test at a significance level of $p = 0.05$.

RESULTS AND DISCUSSION

The results of chemical analysis of medium before cultivation indicate differences in the content of nutrients, pH and salinity (table 2). The high Zn content was determined in medium containing PCW I and PCW II compost, both at the beginning and after the end of cultivation. This is probably due to the presence of zinc white used in the production of paints used to cover post-consumer wood. FB compost had a low content of this element (tables 2–3).

The quality of chrysanthemum depended on the type of medium (tables 4–5, figure 1). The plants cultivation in medium with 50% PCW I compost and 25% PCW II compost were slightly taller and wider than the other plants. The taller plants of *Leucanthemum maximum* but with smaller diameter were obtained by Kozik et al. [2010] growing the plants in media with fiber board compost and mineral soil.

The compost containing medium used, with the exception of the 25% PCW I and PCW II compost, significantly stimulated leaf formation. The plants cultivation in medium with 75% FB compost were characterized by the highest number (27 more compared to control plants).

Schroeter-Zakrzewska et al. [2021] also observed the stimulating effect of compost on leaf formation in the cultivation of zonal geraniums with the exception of plants grown in compost alone.

The leaf greenness index was significantly dependent on the medium used. The lower SPAD values were recorded in plants growing in media containing PCW I and PCW II compost. The reason could be the high Zn content, which can block the uptake of other microelements. According to Zawadzińska et al. [2021], geraniums grown in a medium containing 40% wood fibers formed brighter leaves, which was associated with lower leaf greenness index, compared to control plants. The low SPAD values under the influence of wood waste composts were observed by Wróblewska et al. [2013, 2014] and by Adamczewska-Sowińska et al. [2021].

The leaf area, as well as weight of the chrysanthemum grown in the compost supplemented medium was greater compared to the plants growth in the peat substrate. A positive effect of using compost that included wood fibers, pecan wood, willow wood and post-consumer wood was obtained by Brito et al. [2015], Picchioni et al. [2016], Schroeter-Zakrzewska et al. [2021], Bekier et al. [2022]. Also research by Kozik et al. [2010] show an increase in the fresh weight of *Leucanthemum maximum* after the application of compost obtained from waterproof plywood waste. In the case of *Geranium sanquineum*, the above mentioned authors showed no differences in plant weight after the application of compost. The study by Adamczewska-Sowińska et al. [2021] showed that cucumber grown on substrates with the addition of willow compost (75% or 50%) had a similar weight as cucumber grown on peat substrate. On the other hand, the negative effect of application of post-consumer wood compost at 100%, 75%, 50% on the fresh weight and leaf area of canna lily is reported by Wróblewska et al. [2014].

Table 4. Vegetative characteristics of the chrysanthemum depending on the medium (C – compost, PS – peat substrate)

Medium		Height of plants (cm)	Plant diameter (cm)	Number of leaves	Green leaves index (SPAD)	Leaf area (cm^2)	Fresh weight (g) per pot	Dry weight (g) per pot
Control – peat substrate		15.8 a*	18.6 b	132.6 a	56.9 bcd	12.2 a	68.5 a	5.8 a
PCW I	75% C + 25% PS	14.9 a	17.0 a	152.1 b	49.8 a	15.4 c	105.9 c	9.8 bc
	50% C + 50% PS	17.1 b	19.9 c	146.2 b	54.8 bc	15.7 c	100.0 c	9.4 bc
	25% C + 75% PS	14.8 a	19.3 bc	131.4 a	54.9 bc	14.1 b	102.8 c	10.1 c
PCW II	75% C + 25% PS	14.6 a	16.8 a	145.9 b	53.5 ab	15.1 c	94.7 b	7.8 b
	50% C + 50% PS	15.1 a	18.6 b	159.5 b	55.0 bc	15.6 c	91.3 b	8.3 b
	25% C + 75% PS	16.9 b	20.1 c	138.2 a	55.2 bc	14.5 b	123.2 d	12.4 d
FB	75% C + 25% PS	14.9 a	18.3 b	160.1 c	57.5 bcd	14.9 b	94.7 b	8.9 b
	50% C + 50% PS	15.6 a	18.5 b	153.8 b	58.1 cd	15.2 c	104.0 c	10.2 c
	25% C + 75% PS	15.8 a	19.1 b	147.6 b	60.2 d	14.7 b	112.0 cd	11.1 c

*means followed by different letters are significantly differ $p = 0.05$

The quality of chrysanthemums is primarily determined by the number of flowers. Only plants that flower abundantly attract buyers.

The present research showed that the composts used in the study had a significant effect of plant flowering (table 5). The highest number of flowers was observed in plants grown in media with 50%, 25% PCW I compost and 25% PCW II compost addition. Lu et al. [2024] observed significant differences in the growth of chrysanthemum Hanluqiushi cv. depending on the cultivation substrate. The plants grown in a substrate composed of coir, moss peat, perlite, and pine needle soil in a 2:4:2:2 ratio developed flowers with a larger diameter compared to the control group.

The lower number of flower head was characteristic for plants grown in a media with FB composts. A similar trend obtained by Kozik et al. [2010] in *Leucanthemum maximum* cultivation in fiber boards composts. Wróblewska et al. [2014] observed that use of wood waste composts at 25% and 50% has no effect on the flowering of petunia. According to the literature, plant flowering will be influenced by species, compost composition and percentage of compost in the medium [Wróblewska et al. 2014, Zawadzińska et al. 2021].

A higher proportion of compost (75%) in the substrate influenced a decrease in the number of inflorescence buds. Cultivation of plants in substrates with the addition of compost resulted in the formation of flowers with a larger diameter of flower heads, except for the use of substrates with a 25% share of compost. Smaller flowers of marigold and French marigold were obtained by Gariglio et al. [2004] after using a substrate with 75% willow sawdust.

Table 5. Generative characteristics of the chrysanthemum depending on the medium (C – compost, PS – peat substrate)

Medium		Number of flower head	Number of flower buds	Diameter of flower head (cm)
Control – peat substrate		37.5 b*	74.6 c	8.0 a
PCW I	75% C + 25% PS	36.8 b	43.5 a	8.3 b
	50% C + 50% PS	41.5 c	76.6 c	8.3 b
	25% C + 75% PS	43.6 c	80.5 d	8.0 a
PCW II	75% C + 25% PS	36.1 b	56.0 b	8.5 c
	50% C + 50% PS	35.3 b	60.5 b	8.5 c
	25% C + 75% PS	45.1 d	73.9 c	8.0 a
FB	75% C + 25% PS	33.1 a	58.6 b	8.3 b
	50% C + 50% PS	32.6 a	72.4 c	8.3 b
	25% C + 75% PS	31.6 a	76.6 c	8.0 a

* means followed by different letters are significantly differ $p = 0.05$

Fig. 3. The chrysanthemum cultivated in the substrates with 50% share of composts and in control (1 – PCW I, 2 – PCW II, 3 – FB, 4 – control-peat substrate)

CONCLUSIONS

The applied substrates with the addition of composts made from post-consumer wood had an effect on the quality of chrysanthemum. Taller and wider plants were formed after applying a medium with 50% addition of PCW I and PCW II compost. Adding compost to the substrate stimulated the formation of leaves, which were characterized by a larger leaf blade area. The fresh and dry plant matter was also higher compared to plants grown in peat substrate. The composts used (with the exception of FB compost) adversely affected the leaf greenness index, whose values were lower in relation to plants grown in peat substrate. The greatest number of flower heads was observed in plants cultivated in substrates containing 50% and 25% of PCW I compost as well as those with 25% addition of PCW II compost. A higher proportion of compost (75%) in the substrate influenced a decrease in the number of inflorescence buds.

Since ornamental plants are valued for their appearance, it is recommended to grow chrysanthemums in a substrate consisting of peat and compost in rations of 75:25% or 50:50% by volume. Better plant quality with a higher proportion of peat in the substrates is likely due to the improvement of air-water relations in the substrate.

This approach not only supports the production of high-quality plants but also significantly reduces peat usage, thereby aiding in the preservation of peatland ecosystems.

As studies have shown, composts from post-consumer wood can be a valuable component of horticultural substrates when used appropriately. The conducted research indicates that composts made from post-consumer wood waste meet the requirements for soil improvers or peat substitutes in horticultural substrates according to Regulation (EU) 2019/1009 of the European Parliament and of the Council of 5 June 2019 laying down rules on the making available on the market of EU fertilising products.

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