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ORIGINAL RESEARCH PAPER

Effect of natural fertilization on the yield, biological value, and qualitative and quantitative composition of essential oil in common basil (*Ocimum basilicum* L.)

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Abstract

Basil (*Ocimum basilicum* L.) is one of the most popular herbal plants used globally in the food and pharmaceutical industries and as an ornamental plant. It is highly valued for the rich content of active substances, whose amount depends on environmental and anthropogenic factors. The type of fertilizer used is an important determinant of the yield and quality of the herb and the soil environment. The aim of the study was to assess the effect of natural fertilizers (granulated cattle manure and granulated chicken manure) applied at different doses (50, 100, 150, 200 g m^{-2}) on the quantity and quality of the yield of common basil (*Ocimum basilicum* L.) cultivated in the temperate climate of Lublin Upland. The applied doses of manure had a significant effect on the fresh weight of *O. basilicum* L. A significant effect of the type and dose of manure on the content of L-ascorbic acid was found. Additionally, the fertilizer dose had a significant effect on the extract content in the analyzed plants. Significantly higher basil yields were achieved in the fertilization variant with 50 g m^{-2} and 100 g m^{-2} of the manure. The concentration of essential oil in the plants did not change under the influence of the applied manure dose. The experimental factors did not exert an effect on the content of essential oil with its main component (linalool), total nitrogen, and protein in basil plants. The highest content of linalool (78.22%) in the *O. basilicum* L. herb was determined in the variant with chicken manure fertilization at the dose of 150 g m^2.

Keywords
essential oil; manure; ascorbic acid; herb

1. Introduction

The genus *Ocimum* comprises several species and subspecies native to Mediterranean, tropical, and subtropical regions (Oziegbe et al., 2016; Putievsky & Galambosi, 1999). Darrah (1980) distinguished seven groups of common basil: sweet basil with tall and slender plants, Italian basil with large lettuce-resembling leaves, dwarf forms with small leaves and a bushy habit, Thai basil with a compact habit, lemon basil (citriodorum type), and two other groups characterized by purple leaves and stems: the purpurascens type with the typical basil aroma and purple basil with convex leaves and the aroma of cloves. As shown by Varga et al. (2017), basil varieties can be identified with the use of the standardized list compiled by the International Union for the Protection of New Varieties of Plants (UPOV), which is based on the morphological traits of these plants. The list divides the common basil into six morphotypes: lettuce leaf, small-leaf, true basil, purple basil A, purple basil B, and purple basil C (Carović-Stanko et al., 2011; Varga et al., 2017). The common basil *Ocimum basilicum* L. is most often cultivated in the temperate climate (Biesiada & Kuś, 2010; Dzida, 2011; Jadczak et al., 2006; Majkowska-Gadomska et al., 2015, 2017; Scharafzadeh et al., 2011; Zawiślak et al., 2022). This herbal plant is grown for seasoning and medicinal purposes (Gavrić et al., 2021; Labra et al., 2004; Saha et al., 2016). One of the basic determinants of the quality and quantity of herbal raw material is the method used for plant cultivation and nutrition. Fertilization is one of the basic elements of plant agrotechnics. Natural fertilizers have an impact on the physicochemical and biological properties of soil, contributing to its richness, fertility, and performance. Numerous studies have proved that the use of natural fertilizers, especially manure, is the best fertilization method (Jaskulska & Jaskulski, 2003). Systematic organic fertilization is the basic determinant of the accumulation of organic carbon as well as macro- and microelements in soil. It has a positive effect on the content of organic matter both directly by providing a source of carbon and indirectly by increasing plant productivity (Łabętowicz et al., 1996). Fertilization is one of the factors responsible for soil physical properties. Multiyear fertilization has been reported to induce changes in soil structure and stability, water resistance of aggregates, soil bulk density, porosity, water–air relations, soil compactness, and moisture (Domżał & Pranagal, 1994; Jaskulski & Kotwica, 1999; Mezeyová et al., 2020; Suwara, 1999). As reported by Lenart (1999), manure fertilization increases the organic C content in soil microaggregates and the amount of polysaccharides, thereby contributing to the formation of a stable, waterproof lumpy structure. Manure also increases the number of water-retaining pores, especially capillary ones (Suwara, 1999). Environmental factors, e.g., high air temperature and large amounts of precipitation, support the process of mineralization of organic fertilizers in soil, which facilitates the uptake of macro- and micronutrients by plants (Kucharski & Mordalski, 2009). The conditions of plant growth and development determine the chemical composition of plant material, i.e. the content of essential oil, phenolic compounds, flavonoids, anthocyanins, vitamins, and minerals.

The aim of the study was to assess the effect of natural fertilizers applied at different doses on the yield and quality of basil (*Ocimum basilicum* L.) cultivated in the temperate climate of Lublin Upland.

2. Material and methods

2.1. Location of the plantation

The field experiments were carried out in 2019–2020 on the Experimental Farm of the University of Life Sciences in Lublin (51°25′ N 22°56′ E), south-eastern Poland. The experiment was established on loess soil formed of loose sands and clayey silt formations (Figure 1A).

2.2. Plant material

Basil (*Ocimum basilicum* L.) plants from the Lamiaceae family were the research material.

Basil seedlings were produced in a greenhouse. The seeds were sown in the second half of April in seed boxes filled with a peat substrate and covered with a 2–3 mm layer of fine sand. The first seedlings emerged after two weeks. They were transferred into conical multi-pots in early May. The basil plants grown in the conical multi-pots produced a very well-developed and compact root system, which facilitated planting the seedlings in the field. *O. basilicum* was planted in the field at the end of May at 40 × 40 cm spacing in four replications. One plot had an area of 1 m^2. The experiment was established in a two-factor design with the fertilizer type (granulated cattle manure - CM and granulated chicken manure - CHM) and the fertilizer dose (50, 100, 150, 200 g m^{-2}) as the experimental factors. The cultivation plots were prepared in accordance with agrotechnical recommendations. Before the experiment, the soil contained (mg dm^{-3}) 11 of $N\text{-}NO_3$, 17 of $P\text{-}PO_4$, 46 of K, 380 of Ca, and 39 of Mg; pH = 5.8. The fertilizers tested in the experiment were applied to the soil one

Figure 1 *Ocimum basilicum* L. (**A**) before harvest; (**B**) dried herb.

week before planting the seedlings into the permanent site. They had the following composition: cattle manure: 3% of total nitrogen, 2% of P_2O_5, 2% of K_2O, and 0.8% of MgO; chicken manure: 2% of total nitrogen, including 1.7% of organic nitrogen, 4% of P_2O_5, 3% of K_2O, 0.8% of MgO, 2% of CaO, and microelements: Fe, Mn, Zn, Cu, B and Mo.

Basil plants were harvested at the beginning of flowering. The plants were cut with the use of pruning shears at a height of 5–10 cm above the soil surface and dried in a dryer at 35 °C (Figure 1B). The herb was dried for approximately 5 days.

The content of L-ascorbic acid was determined in the fresh basil herb, whereas the dry herb was used for the determination of the essential oil content. After drying and grinding the basil plant material, the total N content was determined with the Kjeldahl method in the laboratory of the Chemical-Agricultural Station in Lublin. The qualitative and quantitative composition of the essential oil was determined in the Central Research Laboratory of the University of Life Sciences in Lublin.

The results were statistically processed using the variance analysis function. The significance of the differences was determined with Tukey's test at the significance level of $\alpha = 0.05$.

2.3. Determination of the content of L-ascorbic acid, nitrates, total N, and protein

The content of L-ascorbic acid and $N\text{-}NO_3$ in the fresh material was determined with the reflectometry method using the RQflex apparatus, the content of the extract was measured with the refractometer, and the content of protein was calculated by multiplying the total nitrogen content by a factor of 6.25.

2.4. Essential oil extraction

The analysis was performed in the Clevenger apparatus. For the determination, a 20 g dry herb sample was placed in a round-bottomed flask and distilled water (400 ml) was added. The mixture was brought to a boil and then the distillation rate was regulated. The distillations were carried out for 3 hours. Next, the heating was turned off, and the volume of oil collected in the calibration tube was read after 10 minutes (Farmakopea Polska IX, 2011).

2.5. Analysis of the qualitative and quantitative composition of essential oil

The quantitative and qualitative composition of the basil essential oil was determined with the gas chromatography and mass spectrometry (GC/MS) technique. An ITS-40

Table 1 Effect of organic fertilization on yield and essential oil content in basil herb (*Ocimum basilicum* L.) (average from 2019–2020).

Fertilizer dose (B) (g m^{-2})	Plant fresh weight (kg m^{-2})			Essential oil (ml 100 g^{-1})		
	Type of fertilizer (A)					
	CM	CHM	Mean for dose	CM	CHM	Mean for dose
50	1.58	1.23	1.40	0.67	0.73	0.70
100	1.14	1.59	1.36	0.57	0.77	0.67
150	0.66	1.19	0.93	0.63	0.60	0.62
200	0.86	0.62	0.74	0.73	0.65	0.69
Mean for fertilizer	1.06	1.15		0.65	0.69	
$LSD_{\alpha = 0.05}$						
A			n.s.			n.s.
B			0.254			n.s.
A × B			0.431			n.s.

CM - cattle manure, CHM - chicken manure; n.s. - not significant.

device (GC/ITMS system from Finnigan MAT, USA) with a DB-5 column (J&W, USA) with a length of 30 m, a diameter of 0.25 mm, and a 0.25 mm stationary phase film thickness was used in the analyses. The temperature of the dispenser was 280 °C. A temperature gradient of 35 °C was used for 2 minutes followed by 4 °C increments to 280 °C. The qualitative analysis was based on MS spectra, which were compared with spectra from the NIST library (2008). The identity of the compounds was confirmed using retention indices provided in the literature (Adams, 2004).

2.6. Atmospheric conditions

The weather conditions prevailing during the experiment (air temperature and precipitation sums) were recorded at the Meteorological Station of the University of Life Sciences in Lublin located on the Felin Experimental Farm. The average air temperature in May 2019 was similar to the mean multiyear value. A lower temperature in May was recorded in 2020. In turn, the temperatures in June and July in 2019 and 2020 were higher than the average multiyear values.

The distribution of precipitation was very irregular and deviated from the average multiyear precipitation sums. The precipitation in May 2019 was higher than the average multiyear sum. In turn, a very small amount of precipitation was recorded in May 2020 (11.7 mm) in comparison with 2019 and with the average multiyear sum. Nevertheless, the basil seedlings were growing very well in 2020, as the water shortage in the soil was compensated for in June when the amount of rainfall reached 168.1 mm. The low level of precipitation in July 2020 compared to 2019 and to the average multiyear sum did not disturb the basil yielding.

3. Results

The organic fertilizer dose was a significant factor modifying the basil herb yield. The highest herb yield was obtained using chicken manure at a dose of 100 g m^{-2} (1.59 kg m^{-2}) and cattle manure at a dose of 50 g m^{-2} (1.58 kg m^{-2}). The analysis of the data contained in Table 1 revealed no significant effect of the organic fertilizer type on the basil yield. The yield of basil herb ranged from 1.06 kg m^{-2} (cattle manure) to 1.15 kg m^{-2} (chicken manure). The test results did not show a significant relationship between the dose of the applied fertilizer and the content of essential oil in the dry basil herb. The essential oil content ranged from 0.57 to 0.77 ml 100 g^{-1}. Similarly, the type of manure introduced did not significantly affect the accumulation of essential oil in the basil herb. The average content of essential oil in the herb obtained from plants treated with cattle manure was 0.65 ml 100 g^{-1}, but was slightly higher (0.69 ml 100 g^{-1}) in basil grown on chicken manure.

Table 2 Effect of organic fertilization on L-ascorbic acid content and extract content in basil herb (*Ocimum basilicum* L.) (average from 2019–2020).

Fertilizer dose (B) ($g\ m^{-2}$)	L-ascorbic acid ($mg\ 100\ g^{-1}$)			Extract (%)		
	Type of fertilizer (A)					
	CM	CHM	Mean for dose	CM	CHM	Mean for dose
50	50.33	45.00	47.67	4.57	5.13	4.85
100	62.00	41.00	51.50	5.93	5.43	5.68
150	51.67	59.00	55.33	5.07	5.37	5.22
200	70.67	52.33	61.50	5.30	5.07	5.18
Mean for fertilizer	58.67	49.33		5.22	5.25	
$LSD_{\alpha = 0.05}$						
A			2.761			n.s.
B			5.271			0.135
A × B			9.020			0.231

CM - cattle manure, CHM - chicken manure; n.s. - not significant.

The research factors used differentiated the content of L-ascorbic acid and the amount of extract in the fresh mass of basil (Table 2). The plants were characterized by high content of L-ascorbic acid. The concentration of L-ascorbic acid ranged from 41.0 to 70.67 mg 100 g^{-1} FW. The chemical analyses showed a significant effect of the type and dose of the organic fertilizer on the content of L-ascorbic acid in the plants. The highest content of the analyzed parameter was found (70.67 mg 100 g^{-1} FW) after the application of 200 g CM m^{-2}. As shown by the analysis of the effect of the fertilizer type on the concentration of L-ascorbic acid in the raw material, significantly higher content of this nutrient was found after applying CM compared to the applied CHM. The content of the extract in the basil changed significantly with the applied dose of the organic fertilizer. The highest amount of the extract was recorded after applying a 100% higher dose than the initial dose for fertilizing plants. On the other hand, the further increase in the dose of manure reduced the concentration of the extract in the plants. The concentration of the extract in the plants after the application of higher doses of both cattle and chicken manure (150, 200 g m^{-2}) decreased. The fertilizer type did not differentiate the extract content in the plant, which was 5.2% in both objects.

The content of total N, protein, and N-NO_3 in the basil herb is shown in Table 3. Both the type of the fertilizer and the dose of the natural fertilizer had a small effect on the concentration of total N and protein in the plant. There was a slight increase in the amount of total N and protein in basil after the application of 150 and 200 g m^{-2} of both chicken and cattle manure. In terms of the content of nitrates V in the fresh basil herb, a very significant relationship was observed after the application of cattle manure. The concentration of the examined parameter decreased significantly in the raw materials after the application of the increasing doses of this fertilizer. The content of N-NO_3 in the plants was 197.33 mg kg^{-1} FW in the 50 g of CM m^{-2} variant and 78.0 mg kg^{-1} FW in the fertilization variant of 200 g of CM m^2. The fertilizer type also significantly differentiated the content of N-NO_3 in the raw material. Plants fed with CM contained an average of 142.67 mg N-NO_3 kg^{-1} FW, and those fertilized with CHM exhibited a level of 207.17 mg N-NO_3 kg^{-1} FW.

The analysis of the influence of the studied factors on the qualitative and quantitative composition of basil essential oil revealed the presence of 45 compounds (Table 4). The main component of basil essential oil was linalool, with its content ranging from 66.48 to 68.59% in objects fertilized with cattle manure. In turn, the raw material collected from plants fed with chicken manure contained greater amounts of this compound ranging from 67.96 to 78.22%. The second identified main component of basil oil was cineole(1,8-), whose average content was 8.28% in the raw material obtained from plants fertilized with CHM and 8.84% in the raw material fed with CM. In addition, the following compounds accounted for above 1%: cadinol (epi-alpha-) (3.73–6.14%),

Table 3 Effect of organic fertilization on the content of N-total, protein, and N-NO_3 in basil herb (*Ocimum basilicum* L.) (average from 2019–2020).

Fertilizer dose (B) ($g\ m^{-2}$)	N-total (% d.m.)			Protein (%)			N-NO_3 (mg kg f.m.)		
	Type of fertilizer (A)								
	CM	CHM	Mean for dose	CM	CHM	Mean for dose	CM	CHM	Mean for dose
50	2.60	2.53	2.56	16.25	15.81	16.00	197.33	226.00	211.67
100	2.58	2.51	2.55	16.13	15.69	15.94	187.67	222.00	204.83
150	2.65	2.54	2.60	16.56	15.88	16.25	107.67	179.67	143.67
200	2.66	2.67	2.66	16.63	16.69	16.63	78.00	201.00	139.50
Mean for fertilizer	2.62	2.56		16.34	16.00		142.67	207.17	
$LSD_{\alpha = 0.05}$									
A			n.s.			n.s.			12.525
B			n.s.			n.s.			23.913
A × B			n.s.			n.s.			40.915

d.m. - dry matter, f.m. - fresh matter, CM - cattle manure, CHM - chicken manure; n.s. - not significant.

bergamotene(alpha-trans-) (2.72–5.82%), and cadinene(gamma-) (1.27–2.22%). Five compounds were not identified in the analyses.

4. Discussion

Natural fertilizers are most often recommended for the cultivation of medicinal plants (Sodré et al., 2011).

They contain all the macro and micronutrients indispensable for plants and exert a positive effect on the growth of soil microorganisms, soil structure, and soil water availability (Hirzel et al., 2018). A disadvantage of organic fertilizers is their slow decomposition rate, which results in slower release of nutrients into the rhizosphere (Nikolova et al., 2021; Scagel & Lee, 2012). The results presented in Table 1 indicate a significant effect of the applied dose of the manure, regardless of its type, on common basil yields. The increase in the manure dose resulted in a reduction in the fresh weight of the basil plants. The highest fresh matter yield, i.e. on average 1.4 kg m^{-2} and 1.36 kg m^{-2} fresh weight, was obtained in the treatment with the dose of 50 g m^{-2} and 100 g m^{-2}. It has been reported by many researchers that organic fertilizers have a positive effect on the fresh and dry weight of spice and medicinal plants, including basil, and on the content of essential oil (Ipsilandis et al., 2020; Lima et al., 2020). Gavrić et al. (2021) analyzed the impact of mineral, organic, and organic-mineral fertilizers and reported similar values of fresh and dry matter of basil plants upon application of organic and organic-mineral fertilizers. The highest yield was achieved by plants receiving mineral fertilizers, which are characterized by the fastest rate of nutrient release into the soil solution. Investigations conducted by Toaima et al. (2022) have proved the beneficial effect of composted manure on the yield of various basil varieties. The yield-enhancing effect of organic fertilization on basil field cultivation may be associated with the role of the fertilizer in alleviation of plant stress. The present experiment was carried out on loess soil, which exhibits specific properties. This soil promotes water stagnation during heavy rains and becomes crusted in hot weather. Therefore, the application of organic matter in such conditions has several advantages. It releases nutrients slowly, maintains soil structural stability, protects soil from erosion, and improves physical, chemical, and biological properties of soil to increase its overall fertility, consequently increasing plant weight and secondary metabolite content (Hasanuzzaman et al., 2018).

The analysis of the effect of the experimental factors on the content of essential oil in the *Ocimum basilicum* L. herb revealed fairly similar amounts of this secondary metabolite, regardless of the type and dose of the natural fertilizers applied (Table 1). Slightly higher oil content was found in plants fertilized with chicken manure at a dose of 100 g m^2, compared to the other doses. The beneficial effect of organic fertilization on sustainable productivity improving the amount and quality of basil yields was

Table 4 Effect of organic fertilization on the qualitative and quantitative composition of essential oil in basil herb (*Ocimum basilicum* L.) (average from 2019–2020).

Compounds	IR	Type of fertilizer							
		Chicken manure				Cattle manure			
		Fertilizer dose (g m^{-2})							
		50	100	150	200	50	100	150	200
Pinene(alpha-)	933	0.42	0.34	0.29	0.38	0.43	0.39	0.40	0.42
Camphene	949	0.06	Tr.	Tr.	0.06	0.07	0.06	0.06	0.08
Sabinene	972	0.33	0.29	0.24	0.32	0.39	0.33	0.33	0.36
Pinene(beta-)	978	0.76	0.65	0.59	0.71	0.86	0.78	0.77	0.78
Myrcene	989	0.37	0.51	0.44	0.39	0.46	0.46	0.41	0.47
Limonene	1030	0.19	0.18	0.13	0.18	0.20	0.19	0.19	0.20
Cineole(1,8-)	1033	9.07	8.44	6.97	8.63	9.43	8.67	8.68	8.57
Ocimene(E)-beta	1047	0.08	0.07	0.06	0.07	0.10	0.08	0.09	0.06
Terpinene(gamma-)	1059	0.05	Tr.	Tr.	Tr.	Tr.	Tr.	-	Tr.
Sabinene hydrate(cis)	1071	0.16	0.17	0.10	0.12	0.18	0.17	0.14	0.15
Terpinolene	1087	0.06	Tr.	-	Tr.	0.07	-	-	0.06
Linalool	1100	67.96	71.03	78.22	70.97	66.48	68.42	68.58	68.59
Camphor	1150	0.06	Tr.	0.11	Tr.	0.07	0.05	-	0.08
Terpineol(delta-)	1173	0.06	0.08	0.05	0.05	0.07	0.06	0.06	0.06
Borneol	1175	0.34	0.24	0.13	0.31	0.38	0.36	0.31	0.40
Terpinen-4-ol	1183	0.17	0.26	0.05	0.06	-	0.09	-	0.05
Terpineol(alpha-)	1198	0.54	0.65	0.40	0.51	0.62	0.57	0.42	0.56
Bornyl acetate	1286	0.75	0.51	0.27	0.84	0.95	0.87	0.78	1.13
Cubebene(alpha-)	1348	0.05	-	-	Tr.	Tr.	Tr.	0.06	Tr.
Eugenol	1356	0.48	0.81	0.27	0.31	0.43	0.36	0.28	0.53
Copaene(alpha-)	1377	0.13	0.07	0.05	0.11	0.13	0.12	0.14	0.11
Unidentified	1384	-	-	-	-	Tr.	-	-	-
Bourbonene(beta-)	1385	-	-	-	-	Tr.	-	-	-
Elemene(beta-)	1391	0.63	0.62	0.29	0.62	0.69	0.72	0.74	0.55
Caryophyllene(E-)	1422	0.08	-	-	0.06	0.08	0.07	0.07	0.06
Bergametene(alpha-trans-)	1434	3.50	5.82	3.10	2.72	3.12	3.58	3.17	2.86
Guaiene(alpha-)	1437	0.65	0.06	0.40	0.61	0.65	0.72	0.76	0.54
Unidentified	1455	-	0.09	0.07	-	0.12	0.09	0.12	-
Humulene(alpha-)	1458	0.58	0.24	0.25	0.34	0.54	0.48	0.54	0.38
Murrola-4(14),5-diene(cis-)	1465	0.29	0.28	0.14	0.22	0.29	0.29	0.31	0.29
Germacrene D	1484	0.99	0.68	0.45	0.92	1.09	1.00	1.13	0.94
Unidentified	1486	0.16	0.26	0.14	0.14	0.16	0.16	0.19	0.15
Bicyclogermacrene	1498	0.69	0.28	0.26	0.63	0.78	0.68	0.73	0.57
Bulnesene(alpha-)	1504	0.92	0.47	0.51	0.95	1.01	1.03	1.15	0.83
Germacrene A	1510	0.29	0.06	0.16	0.31	0.35	0.35	0.38	0.27
Cadinene(gamma-)	1516	2.09	1.46	1.27	1.80	2.17	2.02	2.22	2.13
Cadinene(delta-)	1521	0.05	Tr.	Tr.	0.05	Tr.	Tr.	0.05	Tr.
Calamenene(trans-)	1523	0.15	0.13	0.12	0.13	0.15	0.15	0.16	0.16
Unidentified	1533	-	0.08	-	-	0.06	-	-	-
Cadinene(alpha-)	1540	-	Tr.	-	-	Tr.	Tr.	-	0.05
Spathulenol	1581	0.55	0.25	0.25	0.55	0.58	0.52	0.54	0.49
Cubenol(1,10-di-epi-)	1619	0.50	0.35	0.30	0.44	0.55	0.49	0.49	0.56
Cadinol(epi-alpha-)	1646	5.60	4.25	3.73	5.24	5.80	5.21	5.34	6.14
Unidentified	1660	0.19	0.14	0.07	0.07	0.17	0.16	0.13	0.23
Unidentified	1663	-	-	-	-	0.07	0.07	0.07	-
Sum		100.0	99.78	99.89	99.82	99.75	99.84	100.0	99.87

Tr. - trace amount.

confirmed in numerous studies carried out by other authors (El-Naggar et al., 2015; El-Sheref et al., 2019; Esmaielpour et al., 2017; Mohamed et al., 2017; Rahmanian et al., 2017; Sirousmehr et al., 2014; Taie et al., 2010; Yaldız et al., 2019).

The basil raw material was characterized by high content of L-ascorbic acid (Table 2). The synthesis of this compound was correlated with the dose and type of the organic fertilizer. A significantly higher concentration of L-ascorbic acid was noted in plants fertilized with cattle manure than in the chicken manure fertilization variant. The highest amount of L-ascorbic acid (70.67 mg 100 g^{-1}) was determined in plants fertilized with the highest dose of cattle manure (200 g m^{-2}).

The increasing dose of the organic fertilizer had a significant effect on the extract content in the analyzed material (Table 2). The highest value of this parameter, i.e., 5.93% and 5.43%, was exhibited by herb from objects fertilized with cattle manure and from the chicken manure fertilization variant, respectively, applied at a dose of 100 g m^2.

Organic fertilizers are a source of many plant nutrients, including nitrogen, which has an impact on the amount and quality of yields. The concentration of total nitrogen in the basil plants was only slightly altered by the fertilizers and ranged from 2.51 to 2.67% d.w. Similarly, the protein content varied only slightly under the influence of the experimental factors. The highest protein content, i.e. 16.63% and 16.69%, was exhibited by plants fertilized with the dose of 200 g m^2 of both cattle and chicken manure, respectively (Table 3). In turn, the content of nitrates in the fresh basil herb depended on the experimental factors. A very interesting relationship was found, i.e. the amount of nitrates in the plant material decreased with the increase in the dose of both cattle manure and chicken manure. Additionally, the type of the fertilizer was found to exert a significant effect on the concentration of nitrates in the basil herb. Plants fertilized with chicken manure had a higher amount of nitrates than the herb from the cattle manure fertilization variant. Upon application of 120 g m^2 of chicken manure, Teliban et al. (2020) reported a level of 254 mg $N\text{-}NO_3$ kg f.w. in basil plants. The authors found that the type of fertilization had a significant impact on the accumulation of nitrates and emphasized the substantially lower content of nitrates in plants treated with organic fertilizers than those subjected to chemical fertilization and mycorrhizal inoculation. In their analyses of the effect of various fertilizers on nitrate content in basil herb, Bergstrand et al. (2019) found the slowest release of nitrates into the substrate in variants with organic fertilizers compared to treatments with mineral fertilizers. On the other hand, organic fertilizers release increased amounts of ammonia, especially within a short time after fertilization, which may result in reduction of plant yields with increasing doses of these fertilizers (Bufalo et al., 2015). This phenomenon was observed in the present study, as a lower herb yield was obtained after the treatment with the higher organic fertilizer dose. Interestingly, the increase in the cattle and chicken manure doses was accompanied by a decline in the content of nitrates. As shown by Bergstrand et al. (2019), soil is more easily aerated than peat and the nitrification process occurs readily, which may suggest that the nitrate content should increase with the increasing fertilizer doses.

Among the identified essential oil compounds, the dominant compound was linalool with a concentration ranging from 66.48% to 78.22%. The concentration of other basil oil components, i.e., cineole (1,8-), bergametene (alpha-trans-), cadinene (gamma-), and cadinol (epi-alpha-), exceeded 1%. The research objects fertilized with 150 g m^{-2} of chicken manure were characterized by the highest concentration of linalool and the lowest concentration of cineol(1,8-), cadinene(gamma-), and cadinol(epi-alpha-). Both the increasing dose of the natural fertilizer and the fertilizer type had an effect on the amount of the essential oil components in the basil herb. Toaima et al. (2022) used composted manure to fertilize basil at a dose of 24 m^3 ha and found that 1,8-cineole (56.86%), l-linalool (11.13%), and cinnamic acid methyl ester (8.45%) were the main compounds in local basil from the second harvest. In turn, after treatment with a higher manure dose (48 m^3 ha), the following concentrations of the main components of basil oil were determined: 1,8-cineole (46.47%), cinnamic acid methyl ester (22.53%), and l-linalool (10.04%). The essential oil analyzed in the present study was found to represent the linalool chemotype. Secondary metabolites produced by herbal plants are very important for human health. Linalool-rich essential oils have various biological effects, i.e., they exhibit antimicrobial, anti-inflammatory, anticancer, and antioxidant properties and have an impact on the nervous system.

5. Conclusion

The dose of manure used for fertilization had a significant impact on the fresh weight of *O. basilicum* L. A significant effect of the type and dose of manure on the content of L-ascorbic acid was noted as well, and the fertilizer dose exerted a significant effect on the extract content in the analyzed plants. Significantly higher basil yields were achieved in the fertilization variant with 50 g m^{-2} and 100 g m^{-2} of the manure. The concentration of essential oil in the plants did not change under the influence of the applied manure dose. The experimental factors did not have an effect on the content of essential oil with its main component (linalool) and the total nitrogen and protein content in the basil herb. The highest content of linalool in the *O. basilicum* L. herb (78.22%) was detected in the variant of fertilization with 150 g m^{-2} of chicken manure. Based on the analysis of basil yield quantity and quality parameters, the use of 50–100 g m^2 of natural fertilizer (cattle or chicken manure) is recommended in field cultivation. The obtained research results have theoretical and application significance for common basil producers.

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