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Studies on the Yield and Chemical Composition of the Herb of Plants of the Genus *Ocimum* Depending on the Development Stage of the Plant

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Abstract: The research aimed to present the possibility of cultivating selected plants of the genus *Ocimum* in central-eastern Poland and to assess the chemical composition of the obtained raw material, considering the development stage of the plant. The research object consisted of six selected plants from the genus *Ocimum*: *Ocimum basilicum*, *Ocimum basilicum* var. *purpurescens*, *Ocimum basilicum* × *citrodorum*, *Ocimum basilicum* 'Cinnamon', *Ocimum basilicum* 'Siam Queen', *Ocimum basilicum* var. *minimum* 'Minette'. The herb was harvested on the following dates: mid-June (vegetative stage), mid-July (beginning of flowering), late July/early August (full flowering), end of August (late flowering). The research showed that plants of genus *Ocimum* sp. can be successfully introduced to cultivation in central-eastern Poland. The yield of these plants was at a high level (average yield of fresh herb—1.15 kg m^{-2} and average marketable yield—0.14 kg m^{-2}). Plants of genus *Ocimum* sp. accumulated the least essential oil, flavonoids, and tannins in the vegetative stage (mean: essential oil—0.86%, flavonoids—0.60%, tannins—0.41%). The highest content of all tested secondary metabolites was found in the variety *O. basilicum* var. *minimum* "Minette". The variability of the content of the analyzed compounds depending on the growth and flowering stage of the plants under study is diversified. For this reason, the date of harvesting raw materials from these plants should be selected individually to obtain a high-quality product.

Keywords: basil; yield of fresh and dry herbs; essential oils; flavonoids; tannins

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1. Introduction

The *Ocimum* genus includes about 200 species of plants occurring in numerous cultivars and forms, differing in morphology and chemical composition [1–3]. *Ocimum basillicum* is one of Poland's most popular species of spice herbs, which are grown in greenhouse and field crops. Due to the lower costs of field crops, it is advisable to prefer such plantations in our climate zone [1–9]. *O. basilicum* L. is grown in temperate and hot regions [10,11]. In Italy and other Mediterranean countries (e.g., Spain and Turkey), professional basil production is primarily based on soilless cultivation techniques, especially hydroponics [12]. The rich chemical composition and the characteristic taste and aroma of *O. basillicum* L. have been widely used in Polish cuisine as a fresh, frozen, and dried seasoning [13]. Moreover, *O. basilicum* L. has not only spice but also medicinal properties [14–18]. Due to the wide availability of other cultivars and forms of the genus *Ocimum*, they should be popularized in field crops in Poland.

The research aimed to present the possibility of cultivating select development stage cultivars and forms of the genus *Ocimum* in central-eastern Poland and to assess the chemical composition of the obtained raw material, considering the development stage of the plants.

2. Materials and Methods

2.1. Location of the Plantation

The research was conducted from 2017 to 2019. The experiment was established in the Experimental Station of the Department of Vegetable and Herb Crops of the University of Life Sciences in Lublin, located in central-eastern Poland (51.23° N, 22.56° E).

2.2. Plant Material

The research objects of the genus *Ocimum* sp. were:
Ocimum basilicum;
Ocimum basilicum var. *purpurescens* (botanical variety);
Ocimum basilicum × *citrodorum* (hybrid);
Ocimum basilicum 'Cynamon' (breeding variety);
Ocimum basilicum 'Siam Queen' (breeding variety);
Ocimum basilicum var. *minimum* "Minette" (breeding variety).

The basil seedlings were grown in a greenhouse. The seeds were sown on 14 April in seed boxes filled with peat substrate. The sowing was covered with fine sand. The sand layer thickness was 2–3 mm. The first seedlings appeared after two weeks. The seedlings were planted into conical multi-pots on 4 May. In the conical multi-pots, the plants produce a well-developed root system, which facilitates planting in the field. The plants were planted in the field in mid-May, spaced 40 × 40 cm, in four replications. The size of one plot was 3.2 m^{-2}. The experiment was assumed to be two-factorial. The factors were the plants of *Ocimum* sp. and the development stage of the plant (harvest time). The field was prepared following the recommendations of agrotechnics. Mineral fertilization was applied to the optimal level recommended for basil: 70 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1}, and 80 kg K_2O ha^{-1}. The phosphorus and potassium fertilizers were applied when preparing the field before planting the seedlings. Nitrogen fertilizer was applied in two doses: half of the dose was applied during field preparation, and the remaining dose was applied after the seedlings had taken over. During the vegetation period, the weeds were controlled manually by hoes. The herbs were harvested at the following times:

- mid-June (vegetative stage);
- mid-July (beginning of flowering);
- late July/early August (full flowering);
- end of August (late flowering).

The basil herb was cut with a secateur 5–10 cm above the soil surface. Fixing the raw material through drying was carried out in a dryer heated at 35 °C. The drying process took about six days. Then, the basil yield was assessed by determining:

- dry herb yield (kg m^{-2});
- marketable yield (kg m^{-2});
- share of marketable yield in the dry herb (kg m^{-2}).

The marketable yield was obtained by manually separating the leaves from the thick stems. The marketable yield consisted of leaves and top thin fragments of stems.

The research material obtained from the field experiment was subjected to laboratory tests in which the content of essential oil, flavonoids, and tannins was determined.

2.3. Obtaining the Essential Oil

The hydrodistillation was performed in the Clevenger apparatus. For the determination, a sample of 20 g of the dry herb (marketable) was taken, placed in a round bottom flask, and 400 mL of distilled water was added. The mixture was brought to a boil, and the distillation rate was adjusted. The distillation was carried out for 3 h. After this time, the heating was turned off, and after 10 min, the volume of the oil collected in the calibration tube was read [19].

2.4. Flavonoid Determination

Flavonoids were determined spectrophotometrically (model UV-Vis Hitachi U-2900), after their extraction from the raw material. Samples of a raw material powder weighing an average 0.5 g and sieved by 0.315 mm sieve were placed in a round bottom flask. Then, solvents in the required amount were added to plant material according to the method described in the Polish Pharmacopoeia V [20]; they were 20 mL of acetone (Chempur, Piekary Śląskie, Poland), 2 mL of hydrochloric acid (250 $g \cdot L^{-1}$, Chempur, Piekary Śląskie, Poland), and 1 mL methenamine (5 $g \cdot L^{-1}$, Merck, Poznań, Poland). The research material prepared in this way was maintained for 30 min under reflux on a water bath. The extract was filtered through cotton wool into a volumetric flask of 100 mL, and then together with the cotton pellet placed in a flask. Then, 20 mL of acetone was added to hydrolysate and heated again at boiling point for 10 min. The plant extracts were filtered back into a 100 mL volumetric flask. The missing amount of the extract was made up to 100 mL with acetone. Then, 20 mL of extract and 20 mL of water were dispensed into a separatory funnel and extracted with ethyl acetate (Chempur, Piekary Śląskie, Poland) by 15 mL portions and three times with 10 mL. The combined organic layers were washed twice with 40 mL of water, filtered into a volumetric flask of 50 mL, and supplemented with ethyl acetate. To determine the two samples, 2 mL of a solution of aluminium chloride (20 $g \cdot L^{-1}$, Chempur, Piekary Śląskie, Poland) was added to 10 mL of the stock solution and supplemented with a mixture (1:19) of acetic acid (1.02 $kg \cdot L^{-1}$, Chempur, Piekary Śląskie, Poland) of methanol to 25 mL. The comparative solution was supplemented with 10 mL of the mixture (1:19) of acetic acid (1.02 $kg \cdot L^{-1}$) of methanol to 25 mL. After 45 min, the absorbance of the solutions was measured at a wavelength of 425 nm using the reference solution. The total content of flavonoids (%) was expressed in terms of quercetin, according to the formula:

$$X = (A \cdot k)/m$$

A—the absorbance of the solution of the research;
k—convection factor for quercetin; k = 0.875;
m—the sample with the raw material in g [20].

2.5. Tannins Determination

Tannins were determined spectrophotometrically (model UV-Vis Hitachi U-2900), after their extraction from the dried raw material, according to the method described in the Polish Pharmacopoeia IX [19]. 1 g of finely powdered (0.16 mm sieve) raw material was weighed into a volumetric flask with a capacity of 250 mL, 150 mL of water was added and kept for 30 min in a boiling water bath. The mixture was cooled under a stream of water, quantitatively transferred to a volumetric flask with a capacity of 250 mL, filled up with water, and allowed the total raw material to sediment. The extract was filtered through filter paper; the first 50 mL was discarded, and the remaining filtrate was used for the determination. 5 mL of the obtained filtrate was moved to a flask and made up to 25 mL with water. Then, 1.0 mL of tungsten molybdenum phosphoric reagent (VWR Chemicals, Gdańsk, Poland) and 10.0 mL of water and sodium carbonate solution (290 $g \cdot L^{-1}$, Merck, Poznań, Poland) were added to 2 mL of the solutions to 25.0 mL. After 30 min, the absorbance was measured at a wavelength of 760 nm, using water as a reference (A_1). In order to determine that polyphenols are not associated with hide powder, 10.0 mL of 0.10 g of hide powder (Merck, Poznań, Poland) was added to the filtrate, shaken vigorously for 1 h, and filtered. Then, 5.0 mL of the filtrate was downloaded and supplemented with water to 25.0 mL, and then 2.0 mL of this solution was added 1.0 mL of tungsten molybdenum phosphoric reagent, then 10.0 mL of water, to make 25.0 mL sodium carbonate solution (290 $g \cdot L^{-1}$). After a further 30 min, the absorbance was measured at 760 nm using water as a reference (A_2). Comparative A solution was prepared: just before the assay, 50.0 mg of pyrogallol (Merck, Poznań, Poland) was dissolved in water and made up to 100.0 mL with water. 5 mL of the resulting solution was supplemented

with water to 100.0 mL; 1.0 mL of tungsten molybdenum phosphoric reagent and 10.0 mL of water, were added to 2.0 mL of this solution to make 25.0 mL sodium carbonate solution (290 $g \cdot L^{-1}$). After the next 30 min, the absorbance was measured at 760 nm, using water as a reference (A_3). Tannin content (%) was calculated based on the pyrogallol:

$$\frac{62.5\ (A_1 - A_2)\ m_2}{A_3\ m_1}$$

A_1—absorbance of polyphenols in the test solution,
A_2—absorbance of polyphenols was not associated with powder leather in the test solution,
A_3—absorbance of the solution comparative pyrogallol,
m_1—starting weight of raw material,
m_2—the sample with pyrogallol in g [19].

2.6. Statistical Analysis

The obtained results are presented as means that were statistically analyzed by ANOVA according to a completely randomized design, and the averages were compared using Tukey's HSD test at the probability level $\alpha = 0.05$. Statistical analyses were calculated using Statistica 13.3 PL software (StatSof Inc., Tulsa, OK, USA).

3. Results

Based on the data in Table 1, it is shown that the yield of fresh and dry herb of the examined basil forms and cultivars was significantly influenced by the harvest date, which was determined by the plant development stage. The highest average yield of the fresh herb was obtained from the plants in the late flowering stage (1.55 kg m^{-2} on average) and the smallest from the plants harvested in the vegetative stage (0.62 kg m^{-2} on average). Analyzing the examined basil forms and cultivars, the highest average yield of the fresh herb was found in *O. basilicum* 'Siam Queen' (1.40 kg m^{-2}). A smaller yield of the fresh herb was collected in *O. basilicum* × *citrodorum*, *O. basilicum* 'Cinnamon', and *O. basilicum*, which were 1.29 kg m^{-2}, 1.26 kg m^{-2}, and 1.06 kg m^{-2}, respectively. On the other hand, the lowest yield of fresh herb (less than 1 kg m^{-2}) was obtained from *O. basilicum* var. *purpurescens* and *O. basilicum* var. *minimum* 'Minette'.

Table 1. Yield of the plants of *Ocimum* sp. depending on the development stage of the plant (average for 2017–2019).

***Ocimum* sp.**	**Development Stage of the Plant**	**Yield of Fresh Herb (kg m^{-2})**				**Dry Herb Yield (kg m^{-2})**			
		2017	**2018**	**2019**	**Mean**	**2017**	**2018**	**2019**	**Mean**
Ocimum basilicum	Vegetative stage	0.44 jk *	0.55 f–h	0.62 lm	0.54 kl	0.06 g	0.07 ef	0.09 g–i	0.08 jk
	Beginning of flowering	1.11 e–h	1.13 c–e	1.09 g–j	1.11 e–h	0.25 b–e	0.29 c–e	0.23 d–g	0.26 d–g
	Full flowering	1.12 e–h	1.14 c–e	1.27 d–h	1.18 ef	0.20 c–g	0.27 c–f	0.43 bc	0.30 de
	Late flowering	1.58 bc	1.31 b–d	1.42 b–g	1.44 cd	0.35 b	0.27 c–f	0.30 cd	0.31 de
	Mean	1.06 C	1.03 C	1.10 B	1.06 C	0.22 BC	0.23 B	0.26 AB	0.23 B
Ocimum basilicum var. *purpurascens*	Vegetative stage	0.4 k	0.70 e–h	0.32 m	0.47 l	0.06 g	0.07 ef	0.03 i	0.05 k
	Beginning of flowering	0.9 1g–i	1.11 c–f	0.78 i–l	0.93 hi	0.15 d–g	0.22 c–f	0.14 e–i	0.17 g–j
	Full flowering	1.2 d–g	1.19 c–e	0.97 h–l	1.12 e–h	0.30 b–d	0.23 c–f	0.20 d–h	0.24 e–h
	Late flowering	1.3 c–e	1.52 a–c	1.21 e–h	1.35 de	0.23 b–f	0.40 bc	0.19 d–h	0.28 d–f
	Mean	0.95 C	1.13 BC	0.82 C	0.97 D	0.19 BC	0.23 B	0.14 C	0.19 C
Ocimum basilicum × *citrodorum*	Vegetative stage	0.6 i–k	0.73 e–h	0.69 k–m	0.67 j–l	0.09 fg	0.10 d–f	0.08 hi	0.09 jk
	Beginning of flowering	1.25 c–f	1.05 c–g	1.32 c–h	1.21 de	0.18 c–g	0.20 c–f	0.21 d–h	0.20 f–i
	Full flowering	1.42 b–e	1.93 a	1.59 a–d	1.65 bc	0.29 b–d	0.32 cd	0.30 cd	0.31 de
	Late flowering	1.53 b–d	1.87 ab	1.49 b–f	1.63 bc	0.32 bc	0.40 bc	0.32 cd	0.35 d
	Mean	1.20 B	1.40 A	1.27 A	1.29 B	0.22 BC	0.26 B	0.23 B	0.24 B
Ocimum basilicum 'Cinnamon'	Vegetative stage	0.7 i–k	0.43 h	0.62 lm	0.59 kl	0.08 fg	0.05 f	0.07 hi	0.07 k
	Beginning of flowering	1.16 e–h	1.07 c–g	1.12 f–i	1.12 e–h	0.19 c–g	0.15 d–f	0.11 f–i	0.15 h–k
	Full flowering	1.53 b–d	1.51 a–c	1.79 ab	1.61 bc	0.69 a	0.62 b	0.64 a	0.65 b
	Late flowering	1.7 ab	2.01 a	1.52 b–e	1.74 ab	0.81 a	1.72 a	0.44 bc	0.99 a
	Mean	1.27 B	1.26 AB	1.26 A	1.26 B	0.44 A	0.39 A	0.32A	0.47 A

Table 1. *Cont.*

Ocimum sp.	Development Stage of the Plant	Yield of Fresh Herb (kg m^{-2})				Dry Herb Yield (kg m^{-2})			
		2017	2018	2019	Mean	2017	2018	2019	Mean
Ocimum basilicum 'Siam Queen'	Vegetative stage	0.85 hi	0.50 gh	0.72 j–l	0.69 j–l	0.12 e–g	0.09 d–f	0.10 g–i	0.10 i–k
	Beginning of flowering	1.30 c–e	1.35 b–d	1.25 d–h	1.30 de	0.19 c–g	0.20 c–f	0.33 cd	0.24 e–h
	Full flowering	1.72 ab	1.54 a–c	1.67 a–c	1.64 bc	0.31 bc	0.24 c–f	0.27 de	0.27 d–f
	Late flowering	1.96 a	2.01 a	1.91 a	1.96 a	0.33 bc	0.59 b	0.49 b	0.47 c
	Mean	1.46 B	1.35 AB	1.39 A	1.40 A	0.24 B	0.28 B	0.30A	0.27 B
Ocimum basilicum var. *minimum* 'Minette'	Vegetative stage	0.76 ij	0.80 d–h	0.72 j–l	0.76 i–k	0.11 e–g	0.12 d–f	0.10 g–i	0.11 i–k
	Beginning of flowering	0.93 f–i	0.78 d–h	0.81 i–l	0.84 ij	0.11 e–g	0.23 c–f	0.10 g–i	0.15 h–k
	Full flowering	0.89 g–i	0.99 c–h	1.01 h–k	0.96 f–i	0.13 e–g	0.18 c–f	0.20 d–h	0.17 g–j
	Late flowering	1.21 d–g	1.32 b–d	1.20 e–h	1.24 de	0.30 b–d	0.40 bc	0.25 d–f	0.32 de
	Mean	0.94 C	0.97 C	0.94 C	0.95 D	0.16 C	0.23 B	0.16 C	0.19 C
Mean	Vegetative stage	0.63 J	0.61 J	0.62 I	0.62 J	0.09 J	0.08 J	0.08 I	0.08 J
	Beginning of flowering	1.10 I	1.09 I	1.06 H	1.09 I	0.18 I	0.22 I	0.19 H	0.19 I
	Full flowering	1.31 H	1.41 H	1.38 G	1.37 H	0.32 H	0.31 H	0.34 G	0.32 H
	Late flowering	1.55 G	1.64 G	1.46 G	1.55 G	0.39 G	0.46 G	0.33 G	0.40 G
	Mean	1.15 XY	1.19 X	1.13 Y	1.15	0.24 Y	0.27 X	0.23 Y	0.25

* Means followed by the same letter in the columns do not differ significantly by the Tukey test at 5% of probability. The means being compared are marked with successive, capital, or lowercase letters.

Analyzing the research results on dry herb (Table 1) and marketable yield (Table 2), it is shown that the raw material collected from plants in the full-flowering and late-flowering stages were at the highest level. The yield of dry herb obtained from plants in the full-flowering and late-flowering stages were 0.40 and 0.32 kg m^{-2} on average, while the marketable yields were 0.21 and 0.18 kg m^{-2}, respectively. Considering the forms and cultivars of basil, the highest amount of dry herb was obtained from *O. basilicum* 'Cinnamon' (0.47 kg m^{-2} on average). This cultivar of basil was also characterized by the highest marketable yield (average 0.19 kg m^{-2}).

Table 2. Marketable yield of the plants of *Ocimum* sp. depending on the development stage of the plant (average for 2017–2019).

Ocimum sp.	Development Stage of the Plant	Marketable Yield (kg m^{-2})				Share of Grated in the Dry Herb (%)			
		2017	2018	2019	Mean	2017	2018	2019	Mean
Ocimum basilicum	Vegetative stage	0.05 gh *	0.05 g–i	0.07 f–h	0.06 m–o	83.3	71.4	77.8	77.5
	Beginning of flowering	0.19 cd	0.18 b–g	0.16 c–f	0.18 d–f	76.0	62.1	69.6	69.2
	Full flowering	0.10 c–h	0.12 d–i	0.32 a	0.18 c–f	50.0	44.4	74.4	56.3
	Late flowering	0.20 bc	0.15 c–i	0.14 c–g	0.16 d–g	57.1	55.6	46.7	53.1
	Mean	0.14 B	0.13 C	0.17 A	0.15 B	66.6	58.4	67.1	64.0
Ocimum basilicum var. *purpurascens*	Vegetative stage	0.03 h	0.04 hi	0.02 h	0.03 o	50.0	57.1	66.7	57.9
	Beginning of flowering	0.08 e–h	0.12 d–i	0.09 f–h	0.10 i–n	53.3	54.5	64.3	57.4
	Full flowering	0.15 c–f	0.19 a–g	0.10 e–h	0.15 e–j	50.0	82.6	50.0	60.9
	Late flowering	0.10 c–h	0.19 a–f	0.12 c–g	0.14 e–k	43.5	47.5	63.2	51.4
	Mean	0.11 C	0.17 BC	0.08 C	0.11 C	49.2	60.4	61.0	56.9
Ocimum basilicum × *citrodorum*	Vegetative stage	0.07 f–h	0.09 e–i	0.07 f–h	0.08 k–o	77.8	90.0	87.5	85.1
	Beginning of flowering	0.14 c–g	0.12 d–i	0.13 c–g	0.13 f–l	77.8	60.0	61.9	66.6
	Full flowering	0.19 bc	0.21 a–e	0.22 a–c	0.21 cd	65.5	65.6	73.3	68.2
	Late flowering	0.18 c–e	0.23 a–d	0.16 c–f	0.19 c–e	56.3	57.5	50.0	54.6
	Mean	0.15 B	0.16 A–C	0.15 AB	0.15 B	69.3	68.3	68.2	68.6
Ocimum basilicum 'Cinnamon'	Vegetative stage	0.07 f–h	0.03 i	0.04 gh	0.05 no	87.5	60.0	61.4	69.6
	Beginning of flowering	0.10 c–h	0.12 d–i	0.07 f–h	0.10 h–n	52.6	80.0	63.6	65.4
	Full flowering	0.29 b	0.27 a–c	0.31 ab	0.29 ab	42.0	43.5	48.4	44.7
	Late flowering	0.42 a	0.31 ab	0.21 b–d	0.31 a	51.9	43.1	47.7	47.5
	Mean	0.22 A	0.18 AB	0.16 AB	0.19 A	58.5	56.7	55.3	56.8
Ocimum basilicum 'Siam Queen'	Vegetative stage	0.09 d–h	0.08 f–i	0.07 f–h	0.08 k–o	75.0	88.9	70.0	78.0
	Beginning of flowering	0.08 e–h	0.17 c–h	0.2 c–e	0.15 d–i	42.1	85.0	60.6	62.6
	Full flowering	0.17 c–e	0.19 a–f	0.12 d–h	0.16 d–h	54.8	79.2	44.4	59.5
	Late flowering	0.19 cd	0.32 a	0.22 b–d	0.24 bc	57.6	54.2	44.9	52.2
	Mean	0.13 B	0.19 A	0.15 AB	0.16 B	57.4	76.8	55.0	63.1

Table 2. *Cont.*

Ocimum sp.	Development Stage of the Plant	Marketable Yield (kg m^{-2})				Share of Grated in the Dry Herb (%)			
		2017	2018	2019	Mean	2017	2018	2019	Mean
Ocimum basilicum var. *minimum* 'Minette'	Vegetative stage	0.09 d–h	0.05 g–i	0.09 f–h	0.09 j–o	81.8	75.0	80.0	78.9
	Beginning of flowering	0.07 f–h	0.09 e–i	0.08 f–h	0.07 l–o	63.6	21.7	80.0	55.1
	Full flowering	0.1 c–h	0.12 d–i	0.13 c–g	0.12 g–m	76.9	66.7	65.0	69.5
	Late flowering	0.19 c	0.21 a–e	0.19 c–e	0.20 c–e	63.3	52.5	76.0	63.9
	Mean	0.11 C	0.12 C	0.12 BC	0.12 C	71.4	54.0	75.3	66.9
Mean	Vegetative stage	0.07 J	0.06 J	0.06 I	0.06 J	75.9	73.7	73.9	74.5
	Beginning of flowering	0.11 I	0.13 I	0.12 H	0.12 I	60.9	60.6	66.7	62.7
	Full flowering	0.17 H	0.18 H	0.20 G	0.18 H	56.6	63.7	59.3	59.8
	Late flowering	0.21 G	0.24 G	0.17 G	0.21 G	54.9	51.7	54.7	53.8
	Mean	0.14 X	0.15 X	0.14 X	0.14	62.1	62.4	63.6	62.7

* Means followed by the same letter in the columns do not differ significantly by the Tukey test at 5% of probability. The means being compared are marked with successive, capital, or lowercase letters.

Interestingly, the average yield of fresh *O. basilicum* herb (1.06 kg m^{-2}) was not the highest among the tested samples (Table 1). *O. basilicum* is the most widespread cultivation in Poland. Therefore, considering the high yield value of other forms and cultivars of the genus *Ocimum* (*O. basilicum* 'Siam Queen', *O. basilicum* × *citrodorum*, *O. basilicum* 'Cinnamon'), it is advisable to propagate them on production plantations.

When assessing the quality of raw basil yield, the share of the grated herb in dry form should be considered (Table 2). In all the examined forms and cultivars of basil, the highest share of marketable yield in dry herb was found during the harvesting of plants in the vegetative stage. It was, on average, 74.5%. Basil raw materials obtained from plants harvested during late flowering and full flowering were characterized by the lowest share of the marketable yield in dry herb (53.8% and 59.8%, respectively). The research showed the highest share of the marketable yield in the dried *O. basilicum* × *citrodorum* (68.6%).

As an aromatic plant, basil owes its fragrance to essential oils. The conducted research shows the significantly highest content of oil in *O. basilicum* (average 1.60%) and *O. basilicum* var. *minimum* 'Minette' (average 1.48%) (Table 3). In other forms and cultivars of basil, the average level of essential oil was above 1%. Considering the development stage of the plant, it was shown that the least of this substance accumulates at the beginning of flowering (0.86% on average). The oil level rises until the plants full-flowering stage (average 1.49%) and then decreases (average 1.32%).

The conducted research shows that the content of flavonoids and tannins in the raw materials of all forms and cultivars of basil was also significantly the lowest in the vegetative stage (Table 3). With the development of the plant, the content of these compounds increased. The highest content of flavonoids was shown by plants in the fully flowering stage (0.73% on average), and the highest tannin content at the beginning and fully flowering stages (0.57% and 0.56% on average). The assessment of the effect of selected botanical, breeding, and hybrid varieties of the genus *Ocimum* sp. and the development stage of the plant on the yield and the content of essential oil, flavonoids, and tannins is presented in Table 4.

Table 3. The content of essential oil, flavonoids, and tannins in the herb of plants of *Ocimum* sp. depending on the development stage of the plant (average for 2017–2019).

***Ocimum* sp.**	**Development Stage of the Plant**	**Essential Oil (%)**				**Flavonoids (%)**				**Tannins (%)**			
		2017	**2018**	**2019**	**Mean**	**2017**	**2018**	**2019**	**Mean**	**2017**	**2018**	**2019**	**Mean**
Ocimum basilicum	Vegetative stage	0.95 de *	1.05 e–h	0.85 f–h	0.95 fghij	0.55 e–g	0.47 j–l	0.60 f–h	0.54 ij	0.30 jk	0.20 o	0.70 cd	0.40 ij
	Beginning of flowering	2.05 a	2.10 ab	1.98 a	2.04 a	0.83 c	0.74 de	0.93 c	0.83 e	0.42 f–h	0.57 f–h	0.49 h–j	0.49 e–g
	Full flowering	1.73 ab	2.17 a	1.92 ab	1.94 a	0.71 c–e	0.65 e–g	0.82 d	0.73 f	0.47 d–f	0.50 g–i	0.43 i–k	0.47 f–h
	Late flowering	1.20 b–e	1.53 a–g	1.72 a–c	1.48 b–d	0.63 d–f	0.59 f–i	0.65 ef	0.62 gh	0.40 f–i	0.35 lm	0.42 jk	0.39 ij
	Mean	1.48 A	1.71 A	1.62 A	1.60 A	0.68 B	0.61 C	0.75 B	0.68 B	0.40 D	0.41 E	0.51 BC	0.44 D
Ocimum basilicum var. *purpurascens*	Vegetative stage	0.70 e	0.58 h	0.64 h	0.64 j	0.4 gh	0.42 k–m	0.39 lm	0.40 mn	0.45 ef	0.39 k–m	0.52 gh	0.45 gh
	Beginning of flowering	1.25 b–e	0.69 gh	1.32 c–f	1.09 e–i	0.58 d–g	0.64 e–g	0.53 h–j	0.58 hi	0.50 de	0.45 i–k	0.53 f–h	0.49 e–g
	Full flowering	1.78 ab	1.34 a–h	1.29 c–f	1.47 b–d	0.69 c–e	0.70 d–f	0.68 e	0.69 fg	0.52 d	0.47 i–k	0.60 ef	0.53 de
	Late flowering	0.88 de	1.32 b–h	1.74 a–c	1.31 c–f	0.55 e–g	0.47 j–l	0.6 f–h	0.54 ij	0.37 g–i	0.45 i–k	0.32 l	0.38 j
	Mean	1.15 B–D	0.98 C	1.25 BC	1.13 C	0.56 DE	0.56 D	0.55 D	0.55 D	0.46 C	0.44 D	0.49 C	0.46 C
Ocimum basilicum × *citrodorum*	Vegetative stage	0.9 de	1.13 c–h	0.83 f–h	0.95 f–j	0.60 d–f	0.74 de	0.55 g–i	0.63 gh	0.45 ef	0.32 mn	0.41 k	0.39 ij
	Beginning of flowering	1.40 b–d	1.57 a–f	1.32 c–f	1.43 b–e	0.74 cd	0.80 d	0.59 f–h	0.71 f	0.35 ij	0.40 k–m	0.69 cd	0.48 fg
	Full flowering	1.03 de	1.12 c–h	1.07 d–h	1.07 e–i	0.60 d–f	0.52 h–k	0.47 jk	0.53 ij	0.35 h–j	0.40 j–m	0.54 f–h	0.43 hi
	Late flowering	0.92 de	0.73 f–h	1.21 c–g	0.95 f–j	0.58 d–g	0.63 e–h	0.55 g–i	0.58 hi	0.5 de	0.49 h–j	0.52 gh	0.50 ef
	Mean	1.06 CD	1.14 BC	1.11 C	1.10 C	0.63 BC	0.67 B	0.54 D	0.61 C	0.41 D	0.40 E	0.54 B	0.45 CD
Ocimum basilicum 'Cinnamon'	Vegetative stage	1.02 de	0.93 e–h	0.71 gh	0.88 h–j	0.36 h	0.43 k–m	0.38 lm	0.39 mn	0.27 k	0.26 no	0.19 m	0.24 l
	Beginning of flowering	1.43 b–d	1.62 a–e	1.08 d–h	1.38 b–e	0.55 e–g	0.48 i–l	0.6 fg	0.55 ij	0.74 b	0.93 a	0.20 m	0.63 c
	Full flowering	1.20 b–e	1.54 a–g	1.7 a–c	1.48 b–d	0.6 d–f	0.40 lm	0.53 g–j	0.51 jk	0.42 fg	0.59 fg	0.63 de	0.55 d
	Late flowering	1.39 b–d	1.27 b–h	1.45 a–e	1.37 b–e	0.46 f–h	0.47 j–l	0.32 m	0.42 lm	0.36 g–j	0.50 g–i	0.32 l	0.39 ij
	Mean	1.26 A–C	1.34 B	1.24 BC	1.28 B	0.49 E	0.45 E	0.46 E	0.47 E	0.45 C	0.57 C	0.34 D	0.45 CD
Ocimum basilicum 'Siam Queen'	Vegetative stage	0.79 e	0.75 f–h	0.83 f–h	0.79 ij	0.28 h	0.32 m	0.42 lk	0.34 n	0.3 jk	0.42 i–l	0.29 l	0.34 k
	Beginning of flowering	0.76 e	0.90 e–h	1.30 cd–f	0.99 f–j	0.36 h	0.66 e–g	0.42 lk	0.48 j–l	0.75 b	0.60 f	0.50 hi	0.62 c
	Full flowering	1.05 de	1.70 a–e	0.95 e–h	1.24 d–h	0.42 gh	0.55 g–j	0.50 ij	0.49 jk	0.70 b	0.85 ab	0.92 a	0.82 a
	Late flowering	1.12 c–e	1.12 d–h	1.55 a–d	1.26 d–g	1.2 b	1.02 c	1.35 a	1.19 C	0.70 b	0.75 cd	0.82 b	0.76 b
	Mean	0.93 D	1.12 BC	1.16 BC	1.07 C	0.57 CD	0.64 BC	0.67 C	0.63C	0.61 B	0.66 B	0.63 A	0.64 B
Ocimum basilicum var. *minimum* 'Minette'	Vegetative stage	0.93 de	1.03 e–h	0.84 f–h	0.93 g–j	1.28 b	1.23 b	1.35 a	1.29 b	0.61 c	0.71 de	0.59 e–g	0.64 c
	Beginning of flowering	1.65 a–c	2.02 ab	1.36 b–f	1.68 a–c	0.87 c	0.95 c	1.13 b	0.98 d	0.72 b	0.69 de	0.73 c	0.72 b
	Full flowering	1.28 b–e	1.94 a–d	1.97 a	1.73 ab	1.47 a	1.4 a	1.32 a	1.4 a	0.51 de	0.64 ef	0.48 h–k	0.55 d
	Late flowering	1.45 b–d	1.97 a–c	1.28 c–f	1.57 b–d	0.35 h	0.42 k–m	0.55 g–i	0.44 k–m	0.89 a	0.80 bc	0.74 c	0.81 a
	Mean	1.33 AB	1.74 A	1.36 B	1.48 A	0.99 A	1.00 A	1.09 A	1.03A	0.68 A	0.71 A	0.64 A	0.68 A
Mean	Vegetative stage	0.88 I	0.91 I	0.78 H	0.86 I	0.58 I	0.60 H	0.62 I	0.60 J	0.40 J	0.38 I	0.45	0.41 J
	Beginning of flowering	1.42 G	1.48 GH	1.39 G	1.44 G	0.66 H	0.71 G	0.70 G	0.69 H	0.58 G	0.61 G	0.52	0.57 G
	Full flowering	1.35 G	1.64 G	1.48 G	1.49 G	0.75 G	0.70 G	0.72 G	0.73 G	0.50 I	0.58 H	0.60	0.56 H
	Late flowering	1.16 H	1.32 H	1.49 G	1.32 H	0.63 HI	0.60 H	0.67 H	0.63 I	0.54 H	0.56 H	0.52	0.54 I
	Mean	1.20 Y	1.34 X	1.29 X	1.28	0.65 Y	0.65 Y	0.68 X	0.66	0.50 Y	0.53 X	0.52 X	0.52

* Means followed by the same letter in the columns do not differ significantly by the Tukey test at 5% of probability. The means being compared are marked with successive, capital, or lowercase letters. Results represent the mean ± SD of three independent measurements.

Table 4. Evaluation of the effect of selected botanical, breeding, and hybrid varieties of the genus *Ocimum* sp. and the development stage of the plant on the yield, and essential oil, flavonoids, and tannins content.

	Yield of Fresh Herb	Dry Herb Yield	Marketable Yield	Essential Oil	Flavonoids	Tannins
Ocimum sp.	***	***	***	***	***	***
Development stage of the plant	***	***	***	***	***	***
Year	*	***	n.s.	**	**	***
Ocimum sp. × Development stage of the plant	***	***	***	***	***	***
Ocimum sp. × Year	***	***	***	***	***	***
Development stage of the plant × Year	**	***	***	***	***	***
Ocimum sp. × Development stage of the plant × Year	***	***	***	***	***	***

Legends: *: significant difference at $p < 0.05$; **: significant difference at $p < 0.01$; ***: significant difference at $p < 0.001$; n.s.: not significant.

4. Discussion

One of the most important crops in the world containing oil, flavonoids, phenolic acids, and polyphenols is *O. basilicum* [9,21–25]. The quality of *O. basilicum* raw material is determined by climatic conditions, harvest time, plant spacing, fertilization, and irrigation [26,27].

In central-eastern Poland, the green-leaved *O. basilicum* and the purple-leaved form *O. basilicum* var. *purpurescens* are most commonly grown. Plantations are established less frequently, cultivating other forms and species of the genus *Ocimum*. This is due to the habits of producers and consumer preferences.

In all the examined forms and cultivars of basil, the highest yields of fresh herb were obtained from plants harvested in the full and late-flowering stages. This tendency was also visible in dry herb and marketable yields. The research by Zawiślak [28] on medical hyssop found a relationship between the plant's development stage and yielding. The author showed a significantly higher yield of fresh herb, dry herb, and marketable yield from late-flowering plants. Literature data show that the relationship between the yielding of herbal plants and the plant's development stage was found in thyme [29] and oregano [30].

The yield of fresh herbs depends on the form and cultivar of basil [6]. Majkowska-Gadomska et al. [6], in studies on the yield of selected forms and cultivars of basil harvested at the beginning of flowering, showed a lower yield of fresh and dry herbs than that obtained in the experiment. Only the yield of fresh herb *O. basilicum* var. *minimum* 'Minette' was 1.05 kg m^{-2} and was higher than that obtained in central-eastern Poland. A similar tendency was visible in the yield of dry herbs.

Majdi et al. [31] indicated *O. basilicum* × *citrodorum* and *O. basilicum* 'Cinnamon' as natural sources of bioactive compounds, both in the form of direct consumption and infusions. The experiment showed a higher content of essential oil in cinnamon basil (1.28% on average) than in lemon basil (1.10% on average); these differences were statistically significant.

Zheljazkov [32], analyzing the content of essential oil in the dry herb of 38 genotypes of *O. basilicum*, indicated large fluctuations in the oil content (0.07–1.92%). In the experiment, the average oil content ranged from 0.86 to 1.49%. In all the tested forms and cultivars of basil, the lowest essential oil content was found in plants harvested in the vegetative stage. The oil content then increased until the plants started flowering (*O. basilicum* and *O. basilicum* × *citrodorum*) or until full flowering (*O. basilicum* var. *purpurescens*, *O. basilicum* 'Cinnamon', *O. basilicum* var. *minimum* 'Minette'). The decrease in the oil content in the raw material was observed in all forms and varieties of basil harvested after flowering, with the exception of *O. basilicum* 'Siam Queen'.

Zawiślak [33] also showed a significant relationship between the plant development stage and the oil content in research on *Hyssopus officinalis*. The essential oil level in the hyssop herb increased from the vegetative to the full-flowering stage of the plant.

Seidler-Łożykowska et al. [34] showed the highest essential oil content in the herb *O. basilicum* of 'Kasia' and 'Wala' cultivars in full and late-flowering stages. Earlier research by Seidler-Łożykowska [34] showed oil levels in *O. basilicum* cultivars from 0.23% ('Red Rubin') to 1.67% ('Kasia').

5. Conclusions

The herb yield of plants of genus *Ocimum* sp. was diversified: the largest yield of fresh herb was obtained from *O. basilicum* 'Siam Queen' (average 1.40 kg m^{-2}), and yield of dry herb and marketable yield from *O. basilicum* 'Cinnamon' (0.47 kg m^{-2} and 0.19 kg m^{-2}, respectively). *O. basilicum* 'Cinnamon' had the highest yield of dry raw material and marketable yield from fresh raw material, which may indicate lower costs of obtaining it due to the need to evaporate smaller amounts of water, especially when harvested during full or late flowering. In light of the research carried out, *O. basilicum* var. *purpurascens* and *O. basilicum* var. *minimum* 'Minette' should not be considered very effective. The delay in harvesting until late flowering contributed to the higher yield of fresh and dry herb, as well as the marketable yield.

Basil is perceived as an aromatic plant; therefore, the content of essential oil is decisive for the quality of the raw material. The greatest amount of oils was found in *O. basilicum* (average 1.60%) and *O. basilicum* var. *minimum* "Minette" (average 1.48%). On the other hand, the content of essential oils in *Ocimum* sp. plants varied depending on the flowering stage. In *O. basilicum* × *citrodorum*, the higher oil content was found at the beginning of flowering, in *O. basilicum* at the beginning and in full flowering, and in *O. basilicum* var. *purpurascens* and *O. basilicum* 'Siam Queen' during the full and late-flowering stages, while in *O. basilicum* 'Cinnamon' and *O. basilicum* var. *minimum* "Minette" throughout the flowering period. Maintaining a high oil content for a longer period of time should be considered a beneficial feature, as it allows us to extend the period of harvesting the raw material. The studied plants of the genus *Ocimum* sp. also differed in the content of flavonoids; their highest content was found in the herb *O. basilicum* var. *minimum* "Minette" (average 1.03%), and the least in *O. basilicum* "Cinnamon" (average 0.47%). As in the case of essential oils, changes in the content of these compounds during the growth and flowering of plants had different variability, e.g., *O. basilicum* 'Cinnamon' contained a higher amount of flavonoids from the vegetative stage (average 0.63%) to the beginning of flowering (average 0.71%), while *O. basilicum* 'Siam Queen' during the late-flowering stage (average 1.19%).

In terms of tannin content, the studied plants of the genus *Ocimum* sp. can be divided into two groups. The first with a lower average tannin content (0.44–0.46%) (*O. basilicum*, *O. basilicum* var. *purpurascens*, *O. basilicum* × *citrodorum* and *O. basilicum* 'Cinnamon'), and the second with an average content of tannins over 0.60% (*O. basilicum* 'Siam Queen' and *O. basilicum* var. *minimum* 'Minette'). Most often, the lowest levels of these compounds were found in the vegetative stage and at the end of the flowering period, and the highest at the beginning and in full flowering; however, for example, in *O. basilicum* × *citrodorum* and *O. basilicum* var. *minimum* 'Minette', the highest level of tannins was found in the late-flowering period. The studied plants of the genus *Ocimum* sp. show significant differences in terms of both the yield and the content of essential oil, flavonoids, and tannins in the herb. The highest content of all tested secondary metabolites was found in the variety *O. basilicum* var. *minimum* "Minette". The variability of the content of the analyzed compounds depending on the growth and flowering stage of the plants is diversified. For this reason, the time of harvesting raw materials from these plants should be chosen individually to obtain a high-quality product. Harvesting of raw material with a high content of essential oils of the studied plants of the genus *Ocimum* sp. allows us to obtain raw material with an intense smell, which can be used as a spice. The tannins, flavonoids, and essential oils contained in the raw materials can be an indicator of the use of basil in phytotherapy.

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