Bangladesh J. Bot. **52**(2): 357-367, 2023 (June) DOI: https://doi.org/10.3329/bjb.v52i2.67037

ESSENTIAL OIL CONTENT AND COMPONENTS IN DIFFERENT PURPLE BASIL GENOTYPES ACCORDING TO THE DIURNAL CHANGES

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Keywords: Ocimum bacilicum L., Genotypes, Harvesting time, Plant parts, Essential oil

Abstract

In the present study the diurnal variations in plant parts of different purple basil genotypes were determined. Three different purple basil genotypes (Arapgir, Piros and Midnight) were used as plant material. Plants were harvested at 06:00, 12:00, 18:00 and 00:00 hrs to determine the diurnal variation within a day at harvesting time. Essential oil ratio among genotypes, harvesting times and parts of plant varied between 0.46-0.95%, 0.60 to 0.92% and 0.14-1.29%, respectively. Essential oil ratios among the triple interactions were found to range from 0.05 to 2.57%. The major essential oil was linalool in all genotypes. Results showed that the higher essential oil ratio can be obtained from dry flowers of Arapgir genotype harvested at 00:00 and also, Midnight genotype contained higher essential oil content than others.

Introduction

Basil (*Ocimum bacilicum* L.) which belongs to the Lamiaceae family, is widely cultivated for essential oil, dry leaves and flowers and ornamental plants (Topalov 1962, Simon *et al*. 1992). The basil plants consist of annual and perennial herbs and is commonly grown in Asia, Africa and tropical and sub-tropical regions of South America (Darrah 1988). Nearly 60 types of basil are known around the world and are cultivated in France, Egypt, Hungary, Indonesia, Morocco, United States of America, Greece and Israel (Srivasta 1980).

Useful parts of the basil plant are its leaves and seeds. Basil has been used in medicinal treatments such as headaches, cough, intestinal ailments, stomach pain and kidney dysfunctions (Simon *et al*. 1992). In addition, both fresh and dry leaves of the plant are commonly used in the food and spice industry (Turkmen 2021). Furthermore, this plant is considered as source of aroma compounds and therefore has a variety of biological properties such as insect repellent, anti-nematode, antibacterial, antifungal and antioxidant (Deshpande and Tipnis 1977, Simon *et al*. 1990, Juliani and Simon 2002, Lee *et al*. 2005).

Beneficial effects of aromatic plants could be related to phenolic or volatile compounds (Dursun et al. 2021; Dursun et al. 2017). The content of essential oil like volatile compounds in basil varies between 0.1 and 0.5% depending on the conditions of climate, soil, plant genotype and plant harvesting time (Ceylan 1997). The essential oil of the basil plant is widely used in the food industry as a flovouring agent, as well as in the perfumery and medical industry (Simon *et al*. 1992, Telci *et al*. 2006). Major components of its essential oil are generally linalool, estragole, methyl cinnemate, eugenol, 1,8-cineole (Juliani and Simon 2002, Lee *et al*. 2005), methyl chavicol, geranial, neral and caryophyllene oxide (Sajjadi 2006).

Basil essential oils exhibit a wide and diverse range of chemical compounds, depending on variations in the chemotypes of plants, leaves and flowers, aroma and origin (Da-Silva *et al*. 2003, Sajjadi 2006). It is a crucial issue to increase the content of essential oil according to the daily

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variation (temperature and light effects) during the cultivation of medicinal and aromatic plants and to investigate the change of the amount of significant components (Brant *et al.* 2009). Major changes may occur in the secondary metabolites contained in plants under different light and temperature conditions (Dickson 1987, Badri *et al.* 2010). In some studies, conducted on various medicinal and aromatic plants, it has been reported that the secondary metabolite content of the plants varies at different times throughout the day in harvest (Angelopoulou *et al.* 2002, Yaldiz *et al*. 2005, Gürbüz *et al.* 2006, Gumuscu *et al.* 2008, Yilmaz *et al.* 2011).

Although diurnal variations on medicinal and aromatic plants have been the subject of intensive research in recent years, there has not been any study on purple basil plant. Therefore, in the present study, essential oil contents and components in different purple basil genotypes according to the diurnal changes were investigated.

Materials and Methods

In the present study, three different purple basil genotypes were used as plant material (Table 1). Plants were grown in three separate plantations in the research field (36° 18 '21'' N, 36° 13' 30'' E, 86 m altitude) at Hatay Mustafa Kemal University, Faculty of Agriculture, Department of Field Crops in 2020 growing season. The field soil property was clay loam with pH 7.12 (slightly alkaline), organic matter 1.93% (low), P 7.41 mg/kg soil (moderate), lime 6.45% (moderate) and total salt 0.0078% (low) (Yılmaz *et al.* 2018, Ertekin *et al.* 2020). Seeds belonging to purple basil genotypes were sown in 1/1 perlite and peat medium on 1 April. On April 6, the plant emergence in trays was completed and on April 30, seedlings belonging to the plant genotypes were planted in separate plantations in the research area. Before planting, 5 kg NPK fertilization was applied on the field. Genotypes were planted in the field with 40 cm spacing between rows and 30 cm spacing among seedlings in rows. During the growing period, weed control was done mechanically when necessary. Irrigation of plants was carried out through the drip irrigation system.

Table 1. Some information on purple basil genotypes used as plant material in the present study.

Abbreviations	Genotypes	Leaf types	Origin
G1	Arapgir	Elongation	Turkey
G2	Piros	Oval	Hungary
G3	Midnight	Oval	France

All genotypes were harvested by pruning shears when they reached full blooming stage (45 days after planting). Plants were harvested at 06:00, 12:00, 18:00 and 00:00 hrs to determine the diurnal variation within a day at harvesting time. Fresh flowers and leaves were separated from harvested plants and the essential oil from fresh flowers and leaves (25 g for each sample) was extracted by hydro-distillation method. On the other hand, 200 g fresh sample for each flower and leaf were dried in a drying cabinet at 30°C. Dried 25 g flower and leaf for each genotype were extracted by hydro-distillation method. The essential oils used in the present study were obtained from purple basil fresh and dry herbals by hydro-distillation method by means of Clevenger apparatus with distillation for 2.5 hrs. Essential oils obtained from hydro-distillation were stored in dark coloured glass at +4°C until their analysis.

Detection of fresh and dry herbal essential oil components of basil was determined by gas-chromatographic (Thermo Scientific ISQ Single Quadrupole GC/MS, Milan, Italy) method. TR-FAME model, 5% Phenyl Polysilphenylene-siloxane, 0.25 mm inner diameter x 60 m length, 0.25 µm film thickness column was used. Helium (99.9%) was used as the carrier gas at a flow

rate of 1 ml/min. Ionization 22 energy and the mass range m/z was set at 70 eV and 1.2-1200 amu, respectively. Scan Mode was used for data collection. MS transfer line temperature, MS ionization temperature and injection port temperature was 250, 220 and 220°C, respectively. Column temperature was initially 50°C and increased to 220°C with a temperature rise rate of 3°C min^{-1}. The structure of each compound was defined by the Xcalibur program using mass spectra (Wiley 9).

The essential oil ratio data obtained from this study were subjected to ANOVA test with three factors (genotype, harvest time, plant part). TUKEY pairwise test was conducted for essential oil ratios that were found to be significant ($p < 0.05$) according to the factors.

Results and Discussion

Essential oil ratios of genotypes, harvesting times and parts of plant present in Table 2. Effects of genotypes, harvesting times and parts of plant on essential oil ratios were statistically significant. Essential oil ratio among genotypes varied between 0.46-0.95%. While the highest essential oil ratio was recorded in Arapgir genotype, the lowest value was determined in Midnight genotype. In a study investigating ontogenetic and diurnal variations in an *Ocimum* type, the essential oil ratio was observed to be between 0.80-0.86% (Paulus *et al*. 2019). Yaldiz *et al*. (2015) reported that the essential oil ratio of purple basil ranged from 0.80 to 1.39 according to the harvesting times in a day. In addition, Ekren *et al*. (2012) stated that the essential oil ratio of purple basil was recorded as 0.91-1.10%. In the present study, essential oil ratio was a few low compared to the literature reports. Such a result may have been obtained probably due to differences in genotypes and cultivation conditions and experimental factors.

Table 2. Means of essential oil content (%) according to the genotypes, harvesting times and parts of plant.

Genotypes (G)	Essential oil content (%) ± SE	p values
Arapgir	0.95±0.11 a	<.0001
Piros	0.82±0.08 b	
Midnight	0.46±0.04 c	
Harvesting times (HT)		
00:00	0.92±0.14 a	<.0001
06:00	0.75±0.08 b	
12:00	0.60±0.07 c	
18:00	0.71±0.09 b	
Parts of Plant (PP)		
Dry flower	1.29±0.08 a	<.0001
Dry leaf	1.07±0.09 b	
Fresh flower	0.47±0.03 c	
Fresh leaf	0.14±0.01 d	
G×HT		<.0001
G×PP		<.0001
FT×PP		<.0001
G×HT×PP		<.0001

SE: Standard error.

Essential oil ratio among the harvesting times was found to range from 0.60 to 0.92%. The highest essential oil ratio was detected at 00:00 whereas the lowest at 12:00 hrs. Padalia *et al.* (2017) reported that the essential oil ratio of different basil chemo-types was higher harvested at the cooler hours of a day. It was reported that essential oil ratio in basil plants change according to seasonal variations and is lower in summer months (Hussain *et al.* 2008).

Essential oil ratio among the fresh and dry parts of plant varied between 0.14-1.29%. The highest essential oil ratio was obtained from dry flowers while the lowest value was determined in fresh leaves. In short, higher essential oil ratio was obtained from dry parts of plant compared to fresh plant parts. Kothari *et al*. (2005) reported that essential oil ratio in *Ocimum tenuiflorum* plant changes according to parts of plant.

Interactions of all treated factors in this study were statistically significant (Table 2). As the genotype and harvesting time interactions (Fig. 1), the highest essential oil ratio was detected in Arapgir genotype at 00:00 hr. The lowest essential oil ratio was found in Midnight genotype at 12:00 hrs. However, the Midnight genotype harvested at 18:00 hrs was statistically included in the same group. The essential oil yield of aromatic plants varies during a single day (Padalia *et al.* 2017). In addition, the essential oil ratio and component of *Ocimum* taxa are very complex and indicate wide variations due to different genotypes and chemo-types (Padalia *et al*. 2013, Runyoro *et al*. 2010).

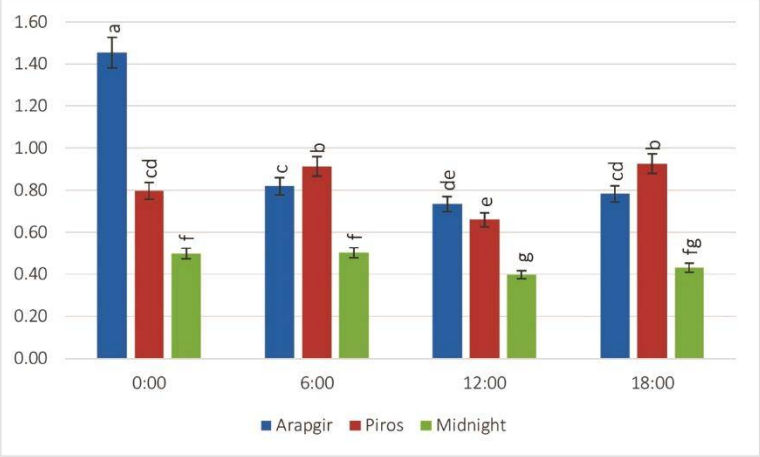

Fig. 1. Variation of essential oil contents according to the genotypes and harvesting times interactions.

The highest essential oil ratio among the genotype and parts of plant interactions (Fig. 2) was determined in dry flowers of Arapgir genotype. The lowest value was obtained from fresh leaves of Midnight genotype. The essential oil ratio was determined between 0.1 and 1.9 % in previous investigations on basil essential oil ratio (Lee and Yang 2005; Hussain *et al.* 2008, Zheljazkov *et al*. 2008). It was reported that essential oil ratios in basil vary according to genotypes and parts of plant (Makri and Kintzios 2008). As a matter of fact, in the present study, it was determined that essential oil ratios changed according to plant part and genotype.

When the interactions of harvesting time and part of plant were viewed (Fig. 3), the highest essential oil ratio was obtained from 00:00 harvesting time of dry flowers, while the lowest value was determined in 00:00 hr harvesting time of fresh leaf. The higher essential oil ratio was recorded in dry plant parts compared to fresh plant parts in all harvesting times. It is known that

the plant parts of basil are consumed as both fresh and dry (Makri and Kintzios 2008). It was reported that the essential oil ratio of basil harvested at different times during the day varies according to the plant parts (Chang *et al*. 2009). Results obtained from this study are similar to the findings of Chang *et al*. (2009).

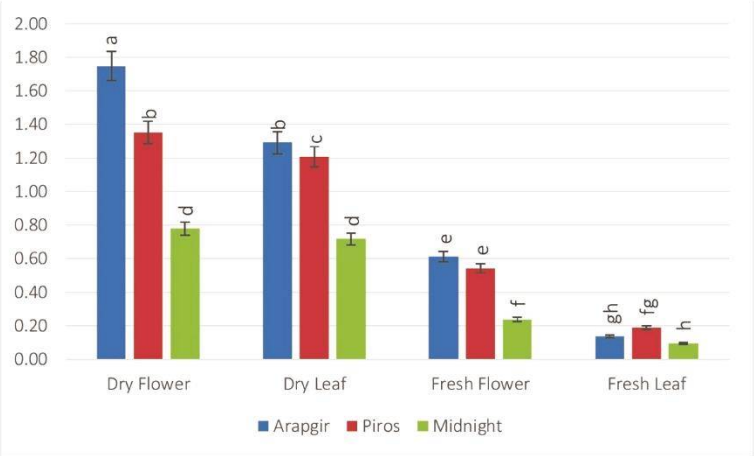

Fig. 2. Variation of essential oil contents according to the genotypes and parts of plant interactions.

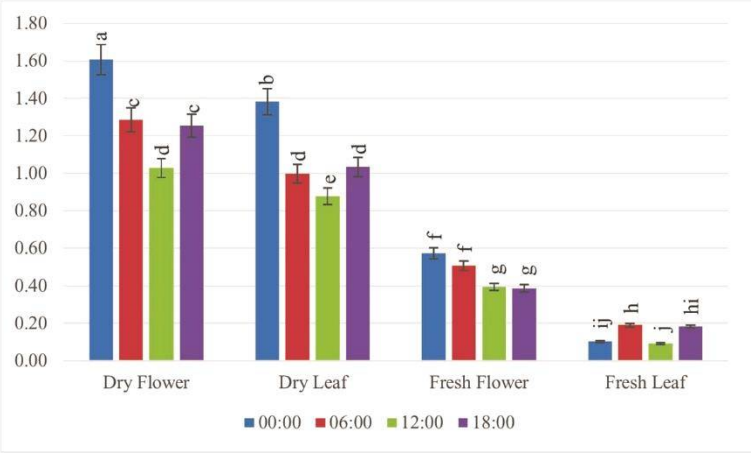

Fig. 3. Variation of essential oil contents according to the harvesting times and parts of plant interactions.

Essential oil ratios among the triple interactions were found to range from 0.05 to 2.57% (Table 3). The highest essential oil ratio was found in dry flowers of Arapgir genotype harvested at 00:00 hr. The lowest value was determined in fresh leaves of Arapgir genotype harvested at 12:00 hrs and of Piros genotype harvested at 00:00 hr (0.05%). Padalia *et al*. (2017) reported that the essential oil ratio of basil genotypes harvested at different times during the day changed greatly. It was determined that essential oil ratios of medicinal and aromatic plants vary according to genotype, harvesting time and plant parts (Toncer *et al*. 2009, Padalia *et al*. 2013).

Table 3. Means of essential oil contents according to the genotypes, harvesting times and parts of plant interactions.

Genotypes	Harvesting times	Parts of plant			
		Dry Flower	Dry Leaf	Fresh Flower	Fresh Leaf
		Essential oil content±SE			
Arapgir	00:00	2.27±0.05 b	2.57±0.04 a	0.81±0.04 h-k	0.17±0.03 tu
	06:00	1.64±0.06 c	0.85±0.04 hij	0.63±0.04 l-o	0.16±0.02 tu
	12:00	1.51±0.06 cde	0.82±0.05 h-k	0.56±0.03 m-p	0.05±0.01 u
	18:00	1.58±0.04 cd	0.92±0.01 h	0.45±0.03 pqr	0.18±0.04 stu
Piros	00:00	1.66±0.03 c	0.92±0.02 hi	0.56±0.03 m-p	0.05±0.01 u
	06:00	1.47±0.04 de	1.28±0.02 f	0.63±0.03 l-o	0.28±0.02 st
	12:00	0.92±0.02 hi	1.10±0.08 g	0.48±0.02 opq	0.15±0.01 tu
	18:00	1.37±0.04 ef	1.54±0.06 cde	0.51±0.04 n-q	0.28±0.02 rst
Midnight	00:00	0.90±0.01 hi	0.66±0.01 k-n	0.35±0.01 qrs	0.09±0.01 u
	06:00	0.75±0.03 i-l	0.86±0.02 hij	0.27±0.01 st	0.13±0.03 tu
	12:00	0.66±0.03 k-n	0.72±0.05 j-m	0.14±0.02 tu	0.08±0.01 u
	18:00	0.81±0.03 h-k	0.64±0.02 l-o	0.20±0.03 stu	0.08±0.01 u

SE: Standard error.

When the essential oil components of Arapgir genotype harvested at different times during the day were examined, major components of essential oil were determined as linalool and methyl cinnemate (Table 4). In addition, α-muurolol, eugenol and eucalyptol components were found higher than others. The highest linalool (54.51%) between the plant part and harvesting time was detected in dry flowers harvested at 00:00 hr. The lowest linalool (16.22%) was determined in fresh leaf harvested at 18:00 hrs. Moreover, the highest methyl cinnemate (69.50%) was recorded in fresh leaf harvested at 18:00 in contrast to the linalool compound. The lowest methyl cinnemate (21.57%) was found in fresh flower harvested at 00:00. When the harvesting times and plant parts were examined, the highest linalool compound in all plant parts was determined at 00:00 hr harvest while the lowest value was at 06:00 hrs harvest. The highest methyl cinnamate compound in all plant parts except for fresh leaf was recorded at 06:00 hrs. The lowest methyl cinnamate was determined at 00:00 hr. When the essential oil components of Piros genotype harvested at different times during the day were investigated, major components of essential oil were detected as linalool, methyl cinnemate, eugenol and eucalyptol (Table 5). The highest linalool compound was found in dry flower harvested at 06:00 hrs while the lowest value was determined in fresh leaf at 18:00 hrs similar to the results for the Arapgir genotype (Table 4). In the Midnight genotype, when the essential oil components were examined at the all harvesting time for different parts of the plant, major component was detected as linalool (Table 6). In addition, methl cinnemate, α-muurolol, eugenol and eucalyptol components were found to be higher than others. Between the plant parts, the highest linalool (79.26%) was found in the dry flowers harvested at 06:00 hrs. On the other hand, the lowest linalool content was recorded in fresh leaves harvested at 18:00 like Arapgir and Piros genotype (Table 4 and 5). Eugenol compound was found to be higher in fresh leaves at all harvest hours compared to other plant parts. Kaya *et al*. (2012 , 2013) reported that the essential oil components varied according to the diurnal variation in *Lavandula stoechas* and *Thymbra spicata*, respectively. Yaldiz *et al*. (2005) reported that the essential oil component of Turkish Oregano varied according to the diurnal variation. Results obtained from current study are more similar to previous literature reports.

Table 4. Essential oil components of Arapgir genotype cut at different harvesting times according to parts of plant.

Rt	Ri	Compound names	Essential oil components (%)															
			Dry flower				Dry leaf				Fresh flower					Fresh leaf		
			00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00
6.6	1069	α-pinene	0.09	0.07	0.09	0.09	0.16	0.09	0.14	0.11	0.10	0.05	0.10	0.07	0.12	0.06	0.09	0.15
8.43	1190	β-pinene	0.11	nd	0.15	nd	0.23	0.18	0.24	0.17	0.11	0.09	0.15	0.10	0.21	0.12	0.20	nd
8.72	1208	Sabinene	0.06	nd	nd	nd	0.11	nd	nd	0.08	0.06	nd	nd	nd	0.07	nd	nd	nd
8.98	1224	Myrcene	0.03	nd	0.04	0.03	0.08	0.06	nd	0.06	0.03	nd	0.03	nd	0.09	0.04	nd	0.08
10.04	1282	Limonene	0.07	nd	0.06	0.04	0.11	0.05	0.09	0.07	0.07	nd	0.05	nd	0.10	0.04	0.10	0.06
12.05	1381	Eucalyptol	1.92	1.82	1.94	1.33	3.88	2.72	4.11	2.67	1.63	1.15	1.86	1.29	3.00	1.68	2.02	1.20
15.06	1523	3-octanone	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.04	nd	nd
20.6	1812	Linalool	54.51	40.33	38.78	41.51	50.48	37.70	29.68	38.78	54.21	43.48	41.89	39.95	45.61	26.56	28.74	16.22
21.79	1869	Trans-α-bergamotene	0.17	nd	0.24	nd	0.48	0.31	0.32	0.24	nd	0.13	nd	nd	0.32	nd	0.17	0.16
22.28	1891	α-guaiene	0.22	0.19	0.23	0.17	0.08	0.08	nd	0.10	0.22	0.27	0.22	nd	0.05	0.08	0.13	0.06
22.61	1906	β-elemene	1.24	1.25	1.69	1.16	0.46	0.44	0.40	0.56	1.85	1.46	1.44	1.48	0.43	0.52	0.56	0.29
25.96	2051	δ-guaiene	0.99	0.45	0.63	0.55	0.38	nd	nd	0.30	0.96	nd	0.52	nd	nd	0.17	0.25	0.10
26.96	2093	α-terpineol	0.29	0.24	0.27	0.20	0.47	0.34	0.50	0.36	0.24	0.62	0.25	nd	0.40	0.31	0.37	0.13
26.52	2075	Humulene	0.62	0.50	0.60	0.46	0.49	nd	0.18	0.45	0.62	0.52	0.51	0.63	0.39	0.38	0.54	0.06
28.53	2149	Bicyclogermacrene	0.60	0.41	0.57	0.37	0.18	nd	nd	nd	nd	0.48	0.49	0.35	0.22	0.24	0.18	nd
29.63	2185	Germaccrene D	1.58	1.13	1.58	1.30	0.39	0.50	0.53	0.57	1.54	1.02	0.95	1.45	0.32	0.52	0.61	nd
37.92	2579	Methyl cinnamate	28.23	49.44	38.55	44.60	33.84	52.32	46.82	47.22	21.57	43.66	41.65	42.75	27.84	63.32	43.30	69.50
40.23	2666	α-muurolol	2.73	1.54	2.66	2.61	2.05	1.29	1.61	1.44	2.45	1.40	1.87	2.34	2.96	1.28	3.52	1.91
40.4	2672	Eugenol	3.62	0.86	9.90	3.74	3.26	1.85	12.81	5.23	10.61	3.52	5.93	6.37	15.04	3.08	16.68	7.23

Table 5. Essential oil components of Piros genotype cut at different harvesting times according to parts of plant.

Rt	Ri	Compound names	Essential oil components (%)															
			Dry flower				Dry leaf				Fresh flower				Fresh leaf			
			00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00
6.6	1069	α-pinene	0.27	0.25	0.27	0.08	0.50.	0.65	0.57	0.19	0.16	0.28	0.20	0.07	0.16	0.44	0.36	0.19
8.43	1190	β-pinene	0.38	0.36	0.36	0.04	0.69	0.90	0.75	0.23	0.19	0.29	0.22	0.08	0.29	0.60	0.50	0.17
8.72	1208	Sabinene	0.16	0.15	0.19	0.05	0.32	0.44	0.36	0.10	0.09	0.14	0.18	0.03	0.09	0.29	0.26	0.09
8.98	1224	Myrcene	0.27	0.37	0.29	0.04	0.65	1.13	0.76	0.20	0.13	0.23	0.14	0.04	0.37	0.68	0.48	0.14
10.04	1282	Limonene	0.20	0.18	0.23	0.07	0.39	0.53	0.42	0.18	0.12	0.16	0.13	0.06	0.27	0.34	0.33	0.14
12.05	1381	Eucalyptol	4.97	4.27	4.95	0.63	10.23	12.65	10.44	4.09	2.96	4.03	3.26	1.03	3.37	7.32	5.72	2.37
15.06	1523	3-octanone	Nd	Nd	0.04	Nd	0.10	Nd	Nd	Nd	Nd	0.05	0.03	Nd	Nd	0.04	0.03	0.02
20.6	1812	Linalool	73.29	77.87	63.30	25.96	70.19	63.81	72.15	27.07	74.58	73.02	65.92	31.30	38.39	50.38	53.99	25.21
21.79	1869	Trans-α-bergamotene	0.26	0.20	0.33	0.13	0.13	0.16	0.15	0.26	0.57	0.19	0.40	0.54	0.54	0.85	0.09	0.15
22.28	1891	α-guaiene	0.43	0.48	0.74	0.20	0.15	0.15	0.16	Nd	0.43	0.35	0.38	0.30	0.52	0.12	0.08	0.04
22.61	1906	β-elemene	1.81	2.08	3.15	1.18	0.73	0.88	0.64	0.22	2.48	1.77	0.84	1.79	3.30	0.64	0.33	0.19
25.96	2051	δ-guaiene	Nd	Nd	2.71	0.62	0.43	Nd	Nd	Nd	1.57	1.92	1.40	0.90	1.36	Nd	Nd	0.37
26.96	2093	α-terpineol	0.87	Nd	0.90	0.10	1.05	1.55	1.07	0.68	0.54	0.77	0.69	0.11	Nd	1.11	0.95	0.32
26.52	2075	Humulene	0.30	0.73	1.25	0.53	Nd	Nd	0.47	Nd	0.49	0.74	0.78	0.75	0.88	Nd	Nd	0.07
28.53	2149	Bicyclogermacrene	0.59	0.47	0.80	0.33	Nd	Nd	Nd	0.08	0.58	0.46	Nd	0.29	Nd	Nd	Nd	0.11
29.63	2185	Germacrene D	1.89	2.26	3.10	0.03	0.82	0.70	0.90	Nd	1.75	1.83	0.81	1.47	4.56	0.64	Nd	0.05
37.92	2579	Methyleugenol	Nd	1.13	0.54	Nd	0.41	2.66	0.51	Nd	Nd	0.63	0.35	Nd	Nd	2.22	0.50	0.26
40.23	2666	Methyl cinnamate	Nd	Nd	0.04	57.75	Nd	0.03	0.10	59.15	Nd	0.08	0.03	48.39	Nd	0.08	0.10	61.69
40.4	2672	α-muurolol	2.75	1.70	4.68	4.98	2.76	2.80	2.72	3.10	1.87	1.96	2.94	4.51	7.85	2.15	2.48	1.50
40.65	2681	Eugenol	6.20	1.51	7.31	0.43	6.64	5.16	3.79	1.16	9.00	8.34	17.52	4.62	35.10	27.30	29.60	4.07

Table 6. Essential oil components of Midnight genotype cut at different harvesting times according to parts of plant.

Rt	Ri	Compound names	Essential oil components (%)															
			Dry flower				Dry leaf				Fresh flower				Fresh leaf			
			00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00	00:00	06:00	12:00	18:00
6.6	1069	α-pinene	0.09	0.17	0.24	0.20	0.33	0.54	0.37	0.42	0.09	0.17	0.24	0.20	0.16	0.19	0.21	0.37
8.43	1190	β-pinene	0.17	0.23	0.33	0.32	0.61	0.77	0.63	0.79	0.17	0.23	0.33	0.32	0.31	0.36	0.30	0.53
8.72	1208	Sabinene	0.08	0.12	0.17	0.17	0.29	0.35	0.30	0.36	0.08	0.12	0.17	0.17	0.11	0.08	nd	0.21
8.98	1224	Myrcene	0.10	0.16	0.20	0.17	0.53	0.61	0.52	0.67	0.10	0.16	0.20	0.17	0.28	0.34	nd	0.27
10.04	1282	Limonene	0.07	nd	0.11	0.10	0.24	0.29	0.22	0.28	0.07	nd	0.11	0.10	0.16	0.05	nd	0.19
12.05	1381	Eucalyptol	3.03	3.17	4.61	3.86	9.62	10.43	7.96	11.87	3.03	3.17	4.61	3.86	4.74	5.52	5.69	4.45
15.06	1523	3-octanone	nd	nd	0.03	nd	0.03	nd	nd	nd	nd	nd	0.03	nd	nd	0.04	0.73	0.17
20.6	1812	Linalool	62.79	79.26	69.45	72.19	68.47	68.41	67.57	66.31	62.79	79.25	69.45	72.19	56.36	54.29	53.64	39.93
21.79	1869	Trans-α-bergamotene	4.75	2.82	5.70	5.20	3.88	3.20	2.58	5.56	4.75	2.82	5.70	5.20	3.93	2.92	4.06	2.04
22.28	1891	α-guaiene	0.39	0.29	0.45	0.44	0.13	0.14	0.15	0.16	0.39	0.29	0.45	0.44	0.09	0.20	0.20	0.21
22.61	1906	β-elemene	2.49	2.45	3.25	2.33	0.57	0.91	0.86	0.63	2.49	2.45	3.25	2.33	0.88	1.05	0.94	1.37
25.96	2051	δ-guaiene	1.05	0.85	0.93	0.99	0.30	0.40	0.28	0.39	1.05	0.85	0.93	0.99	0.36	0.56	0.36	0.47
26.96	2093	α-terpineol	0.63	nd	nd	0.55	1.02	1.31	0.93	1.09	0.63	nd	nd	0.55	0.81	1.00	nd	nd
26.52	2075	Humulene	0.80	0.58	0.71	0.77	0.55	0.49	nd	nd	0.80	0.58	0.71	0.77	nd	nd	0.64	0.10
28.53	2149	Bicyclogermacrene	0.78	0.56	0.50	0.61	0.18	0.27	0.23	0.20	0.78	0.56	0.50	0.61	0.45	0.71	nd	0.69
29.63	2185	Germacrene d	2.12	1.34	1.73	2.02	0.55	0.32	0.64	0.76	2.12	1.34	1.73	2.02	0.80	1.65	nd	1.21
37.92	2579	Methyleugenol	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
40.23	2666	Methyl cinnamate	8.66	nd	2.83	nd	3.75	nd	8.79	nd	8.66	nd	2.83	nd	nd	nd	0.83	7.31
40.4	2672	α-muurolol	5.13	2.08	4.12	4.35	3.83	3.28	3.58	4.52	5.13	2.08	4.12	4.35	5.86	4.16	9.05	9.91
40.65	2681	Eugenol	2.06	1.45	0.86	1.42	2.65	5.16	1.38	1.76	2.06	1.45	0.86	1.42	20.82	23.01	13.10	26.05

The highest essential oil contents among the genotypes, harvesting times and parts of the plant was detected in Arapgir, at 00:00 hr and in dry flowers, respectively. Among the genotypes, Arapgir excelled in both harvesting times and plant parts. Linalool in Arapgir genotype was lower than others. It was found that the higher essential oil ratio can be obtained from dry flowers of Arapgir genotype harvested at 00:00 hr and also, Midnight genotype contained higher essential oil content than others.

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(Manuscript received on 10 March, 2022; revised on 10 June, 2023)