Agro-morphological and phenotypic variability of sweet basil (*Ocimum basilicum* L.) genotypes for breeding purposes

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Abstract

The genus Ocimum is very complicated due to the presence of huge morphological variability along with genetic diversity. Basil (Ocimum basilicum L.) has pharmacological properties like headaches, coughs, diarrhea, constipation, warts, worms, kidney malfunction, and its potential as a therapeutic agent in treating various age-related diseases. The present investigation comprised of sixty-one genotypes of basil was undertaken to characterize the genotypes based on morphological and phenological features, herbs and essential oil yield of genotypes. A wide range of variations for traits like days to first cutting (56.92-101.6), plant height (13.67-71.90 cm), branch number (3.28-19.43 number/plant), fresh herb yields (12.94-274.11 g/plant), and essential oil yield (0.04-1.71%) were observed and can be useful for breeding purposes. PI 652070 and PI 296391 genotypes were found superior in case of the highest herbs yield as compared with other genotypes. Overall, in PI 358469 and Ames 32309 genotypes exhibited the highest essential oil content. The constellation analysis was conducted to investigate the genetic diversity of basil genotypes. According to the constellation plot analysis, leaf shape and color were evaluated in 2017 and most of the basil genotypes located in the same main group. In 2018, moonlight and dino cultivars located in the same cluster 1 (C1) with PI 141198 (US/Maryland) genotype and Georgia genotypes located in the same main group and they also

took place in the sub-main group except Ames 32314 genotype depending on UPOV criteria. Each two years, Bolu genotype and midnight were found in the same main group.

Keywords: Basil genotypes; morphology; yield; genetic diversity

1. Introduction

The genus Ocimum comprises more than 150 species that were reported throughout the world, but commercially important basil cultivars mostly belong to the species *O. basilicum*. Sweet basil (*Ocimum basilicum* L. x=n = 12) is an important essential oil crop in the Labiatae family, is an annual plant and is widely used as in food, pharmaceuticals, and cosmetics [1]. Also, the essential oil of obtained from its aerial parts contain linalool, eugenol, methyl chavicol, methyl cinnamate, ferulate, methyl eugenol, triterpenoids, and steroidal glycosides, which has high economic value because it contains important components, such as eugenol, chavicol, and their derivates [2-4]. Traditionally, basil has been used as a medicinal plant in the treatment of headaches, coughs, diarrhea, constipation, warts, worms, kidney malfunction [5], to cure malarial fever [6,7], as well as against mosquito vectors and plasmodium parasites [8,9].

Basil genotypes have a wide variety of properties such as leaf sizes, color (green to dark purple), flower color (white, red, lavender and purple), growth characteristics (shape, height and flowering time) and aroma [10]. Therefore, the standard identifier list (UPOV 2003) has been used in the Guide for Conducting the Differences, Uniformity and Stability Tests (UPOV 2003; available) by the International Association for the Protection of New Plant Varieties (UPOV) to identify the varieties correctly. The UPOV system of plant variety protection based on an individual test guidelines represent an agreed and harmonized approach for the examination of new cultivars of a species of interest. Several studies deal with grouping of basil varieties based on only one nutritional characteristics according to chemotype [11,12], phenolic acid concentration [13,14] etc.

In recent years, the need for standard and quality materials in the sectoral demands of medicinal and aromatic plants has revealed the necessity of cultivating these plants and has also accelerated the variety development activities. Characterization of genetic resources has always remained one of the favorite methods of scientific community for the development of improved cultivars expressing higher yield with better quality and secondary metabolite. Knowledge of the genetic diversity in the germplasm populations is important for the efficient germplasm management and long-term breeding programs.

Industrialized countries can produce high-yield and quality products at low cost by using advanced breeding and agricultural techniques in the agriculture of medicinal and aromatic plants [15]. As in all agricultural products, medicinal and aromatic plants with economic importance are also preferred in certain standards. A good number of studies have been conducted to explain the morphological, phenological, and agronomic variability among local populations of sweet basil in diferent parts of the world [1,4,13,14,16]. In our country, Telci et al. [17] more than 80 local basil genotypes which obtained from different regions in Turkey determined the characterization of morphology, agronomic and technological. Up to now, earlier studies with medicine and aromatic plants have been conducted with local populations, it is necessary to investigate genetically and chemically important overseas genotypes in addition to targeted cultivation and breeding practices for desired morpho-chemotypes.

For this purpose, the present study was conducted in order to compare for the first genetic linkage map of 73 abroad, one local (Bolu) basil genotypes and one cultivar which is expected to facilitate the researches on genetics and breeding in basil cultivars regarding their agro-morphological traits as well as their essential oil yield, and to find the relationships likely to exist between morphological traits and essential oil constituents. Also, in this study, morphological and phenological features of genotypes which show superior characteristics in terms of yield will be determined by characterizing UPOV according to various evaluation criteria. Such information would be important to indicate the effect of geographic origin on agro-morphological and biochemical traits of basil seed cultivars. Promising basil cultivars can be used in various breeding programs and have the potential of enhancing its utilization.

2. Materials and Methods

2.1. Plant Material and Field Experiments

The experimental material comprised of seventyfour genotypes of basil (*Ocimum basilicum*) obtained from different geographical regions of the world (Supplementary Table 1). 73 basil genotypes, received from United States Department of Agriculture (USDA) with 4 commercial cultivars (Dino, midnigh, large sweet, moonlight) and local basil genotype were used in this study. These cultivars were developed through the single plant selection having resistance to various diseases and have been used as standard cultivars. All of them was grown in 2017 growing season, and except 14 genotypes (8 *Ocimum* × *africanum,* 3 *O. americanum and* 3 *O. basilicum*), adapted to Bolu ecological conditions (Table 1). In 2017, 59 genotypes, one local genotype and one cutivar were grown under field conditions in augmented design followed by selfing and single plant selection. Based on the adapted genotype, 50 genotypes were selected, and these genotypes were established in augmented design in 2018.

Table 1. Plan ID, plant name and origin of basil genotypes.

No	Plant ID	Plant name	Origin	Taxonomy
1	PI 368699	Edar	Macedonia	*Ocimum basilicum*
2	Bolu	Bolu pop.	Turkey/Bolu	*Ocimum basilicum*
3	PI 414193	B 49939	US/Maryland	*Ocimum basilicum*
4	Midnight	Cultivar	Turkey	*Ocimum basilicum*
5	PI 211586	12832	Afghanistan/ Kondoz	*Ocimum basilicum*
6	PI 170578	Fesligen	Turkey/Aydın	*Ocimum basilicum*
7	Dino	Cultivar	Turkey	*Ocimum basilicum*
8	PI 253157	Rayhoon	Iran/Esfahan	*Ocimum basilicum*
9	Ames 32314	GE.2013-78	Georgia	*Ocimum basilicum*
10	PI 197442	10126	Ethiopia	*Ocimum basilicum*
11	Moonlight	Cultivar	Turkey	*Ocimum basilicum*
12	PI 296391		Iran	*Ocimum basilicum*

13	PI 368697	Vladimirska	Macedonia	*Ocimum basilicum*
14	Ames 32309	GE.2013-21	Georgia	*Ocimum basilicum*
15	PI 414196	B 49928	US/Maryland	*Ocimum basilicum*
16	PI 296390		Iran	*Ocimum basilicum*
17	PI 368695	Zelen	Macedonia	*Ocimum basilicum*
18	PI 358469	Siten	Macedonia	*Ocimum basilicum*
19	PI 652071	Dark Opal	US/California	*Ocimum basilicum*
20	PI 174284	Reyhan	Turkey/Van	*Ocimum basilicum*
21	Ames 32310	GE.2013-37	Georgia	*Ocimum basilicum*
22	PI 182246	Reyhan	Turkey/Maraş	*Ocimum basilicum*
23	PI 358471	Sitnolisten	Macedonia	*Ocimum basilicum*
24	PI 414195	B 19927	US/Maryland	*Ocimum basilicum*
25	PI 531396	1420	Hungary	*Ocimum basilicum*
26	PI 172997	Reyhan	Turkey/Kars	*Ocimum basilicum*
27	PI 414199	B 49931	US/Maryland	*Ocimum basilicum*
28	Ames 29184	GSMO 2-19	Georgia-South Ossetia	*Ocimum basilicum*
29	PI 358464	Edrolisten	Macedonia	*Ocimum basilicum*
30	Ames 32311	GE.2013-43	Georgia	*Ocimum basilicum*
31	PI 190100	1	Iran	*Ocimum basilicum*
32	PI 652070	Sweet basil	US/Pennsylvania	*Ocimum basilicum*
33	PI 358468	Krupnolisten	Macedonia	*Ocimum basilicum*
34	Ames 32312	GE.2013-50	Georgia	*Ocimum basilicum*
35	PI 368700	Edar	Macedonia	*Ocimum basilicum*
36	PI 652065	Genovese	Italia/Veneto	*Ocimum basilicum*
37	PI 379414	Bel kripen	Macedonia	*Ocimum basilicum*
38	PI 652054	Mrs. Burns Lemon Basil	US/Mexico	*Ocimum basilicum*
39	PI 358466	Krstaten	Macedonia	*Ocimum basilicum*
40	PI 358472	Bitolski	Macedonia	*Ocimum basilicum*
41	PI 173746	Reyhan	Turkey/Malatya	*Ocimum basilicum*
42	PI 172996	Reyhan	Turkey/Kars	*Ocimum basilicum*
43	PI 207498	12648	Afghanistan/Kabul	*Ocimum basilicum*
44	PI 176646	Reyhan	Turkey/Tokat	*Ocimum basilicum*
45	PI 414197	B 49929	US/Maryland	*Ocimum basilicum*
46	PI 379412	Krupen bel	Macedonia	*Ocimum basilicum*
47	PI 414198	B 49930	US/Maryland	*Ocimum basilicum*
48	PI 414194	B 49926	US/Maryland	*Ocimum basilicum*
49	PI 414200	B 49932	US/Maryland	*Ocimum basilicum*
50	Large Sweet	Cultivar	Turkey	*Ocimum basilicum*
51	Ames 32313	GE.2013-68	Georgia	*Ocimum basilicum*
52	PI 170579	2263	Turkey/İzmir	*Ocimum basilicum*
53	PI 170581	3031	Turkey/Çanakkale	*Ocimum basilicum*
54	PI 172998	Reyhan	Turkey/Van	*Ocimum basilicum*
55	PI 174285	Reyhan	Turkey/Elazığ	*Ocimum basilicum*
56	PI 175793	Festagan	Turkey/ Çanakkale	*Ocimum basilicum*
57	PI 172998	Reyhan	Turkey/Van	*Ocimum basilicum*
58	PI 601365	Purple Ruffles	US/Pennsylvania	*Ocimum basilicum*
59	PI 652053	B 51668	US, Maryland	*Ocimum basilicum*
60	PI 652061	NU 62505	India	*Ocimum basilicum*

61	PI 263870		Greece	*Ocimum basilicum*
62	PI 358463	Obicen bosilok	Macedonia	*Ocimum basilicum*
63	PI 358465	Srednolisten	Macedonia	*Ocimum basilicum*
64	PI 358467	Domasen siten	Macedonia	*Ocimum basilicum*
65	PI 358470	Lokalen	Georgia	*Ocimum basilicum*
66	PI 368698	Srednolisten	Macedonia	*Ocimum basilicum*
67	PI 379413	Krupnolisen	Macedonia	*Ocimum basilicum*
68	PI 500943	ZM 1503	Zambia	*Ocimum x africanum*
69	PI 500944	ZM 1551	Zambia	*Ocimum x africanum*
70	PI 500947	ZM 1881	Zambia	*Ocimum x africanum*
71	PI 500949	ZM 1974	Zambia	*Ocimum x africanum*
72	PI 500950	ZM 2044	Zambia	*Ocimum x africanum*
73	PI 500951	ZM 2282	Zambia	*Ocimum x africanum*
74	PI 500953	ZM 2523	Zambia	*Ocimum x africanum*
75	PI 500954	Lwena	Zambia	*Ocimum x africanum*
76	PI 253158	Tokhm Sharbati	Iran, Eşfahān	*Ocimum americanum*
77	PI 254352	K1273	Iraq	*Ocimum americanum*
78	PI 652062	NU 61157	Tanzania	*Ocimum americanum*

*1-78 (except 7, 11, 50) sown in 2017, ** 1-50 sown in 2018

The field experimental site was located at research and application area of Agriculture and Natural Sciences Faculty, is between 40°44′45″N latitude, 31°37′ 46″E longitudes with altitude of 752m. In first experimental year, since genotypes have very few seeds (up to 100), seeds were sown in a mixture of peat and perlite (9:1) on 19 april 2017. When the basil seedlings reached 10 cm in plant height, seedlings were transplanted into pilots on 15 May 2017 at a rate of 5 plants m^2. In second experimental year, seeds were sown directly by hand on the field condition on 15 April 2018, each consisting of 4 m-long rows, row width and intra row spacing were 30 cm and 20 cm, respectively.

Average climatic data were recorded 16.08 °C temperature; 41.37 mm rainfall; 69.2% humidity during the vegetation period for 2017 and 17.10 °C temperature; 71.18 mm rainfall; 53.27% humidity in the growing season of 2018 [18]. Sweet basil was regularly irrigated to demonstrate good progress in its period vegetation since irrigation is a very important factor for cultivation of basil. As experimental factors, conventional fertilizer 60 kg ha^{-1} Diammonium phosphate (DAP) and 20 kg ha^{-1} Ammonium sulfate (AS) were applied with sowing all experimental years. Nitrogenous fertilizer as AS (in total 60 kg ha^{-1}) was divided by two and applied to the plants in two splits in sown time and after first harvest of plant.

After each harvested, nitrogenous fertilizer as AS (in total 60 kg ha^{-1}) was applied to the plants in two splits in July and August. Furthermore, when required, irrigation and weed control was made. Field data were collected by cutting randomly 10 plants from each plot, and the yield component of each plant was considered as the average for each plot in 2017 and 2018 years.

Plants were harvested by hand when the plants reached at the beginning of flowering, cutting off the overground part of the stem above its lignified fragments, and in two phases in total, 20-30 cm above the ground level during each growing season. The first harvest was at the beginning of flowering, and started from the first week of July until the third week of August in all experimental years. The second harvest was at the beginning of flowering, and started from the last week of July until the first week of October in all experimental years.

During harvest height of plants, as well as number of branchings in the first row of main stem were measured, as well as the weight of plant overground part. Then the herb was dried in thermal drying compartment in the temperature of 35ºC and the air-dry herb weight was determined.

2.2. Morphological research and descriptor list

Morphological research was carried out during the year 2017 and 2018 in the field trial. Each genotypes was represented by 10 plants and total of 610 and 500 plants were analyzed for morphological traits in 2017 and 2018, respectively. Twenty-three traits were scored according to the Guidelines for the Conduct of Tests for Distinctness, Uniformity and Stability (UPOV 2003) in 2018 in which the qualitative traits were expressed in discontinuous states, while the expression of each quantitative trait was divided into a number of discrete states for the purpose of description (Table 2). All states are necessary to describe the full range of the traits, and every form of expression can be described by a single state. Thus, all the recorded data were qualitative in nature.

Table 2. UPOV information of basil genotypes characteristic.

No	Qualitative/Quantitative or Pseudo-qualitativeCharacteristic	State	Note
1	Plant: habit (PH)	rounded	1
		intermediate	2
		erect	3
2	Plant: density (PD)	loose	3
		medium	5
		dense	7
3	Stem: anthocyanin coloration (SAC)	absent	1
		present	9
4	Stem: intensity of anthocyanin coloration (SIAC)	weak	3
		medium	5
		strong	7
5	Stem: hairiness (SH)	absent	1
		present	9
6	Stem : number of flowering shoots (at full flowering) (SNFS)	one	1
		three	2
		more than three	3
7	Leaf blade: shape (LBS)	broad ovate	1
		ovate	2
		elliptic	3
8	leaf blade: lenght (LBL)	short	3
		medium	5
		long	7
9	Leaf blade: width (LBW)	narrow	3
		medium	5
		broad	7
10	Leaf blade: intensity of anthocyanin coloration of upper side (LBIAC)	weak	3
		medium	5
		strong	7
11	Leaf blade: distribution of anthocyanin (LBDA)	few mottles	1
		many mottles	2
		total surface	3
12	Varieties without anthocyanin only: Leaf blade: green color (LBGC)	light	3
		medium	5
		dark	7
13	Leaf blade: glossiness (LBG)	absent or very weak	1
		weak	3
		medium	5
		strong	7
		very strong	9
14	Leaf blade: blistering (LBB)	absent or very weak	1
		weak	3
		medium	5
		strong	7
15	Leaf blade: profile in cross section (LBPCS)	convex	1
		flat	2
		concave	3
		v-shaped	4
16	Leaf blade: serration of margin	absent	1
		present	9
17	Leaf blade: depth of serration (LBDS)	shallow	3
		medium	5
		deep	7
18	Petiole: length (PL)	short	3
		medium	5
		long	7
19	Flowering stem: average length of internodes (at end of flowering) (FSLI)	short	3
		medium	5
		long	7
20	Flowering stem: total length (at end of flowering) (FSTL)	short	3
		medium	5
		long	7
21	Flowering stem: hairiness of bracts (FSHB)	absent	1
		present	9
22	Flower: color of corolla (FC)	white	1
		pink	2
		dark violet	3
23	Flower: color of style (FCS)	white	1
		light violet	2

2.3. Essential oil extraction and analysis

A Clevenger device was used to obtain essential oil of basil by hydro-distillation. Fifty g of basil flowering aerial parts were taken from each treatment. Afterward, they were roughly crushed and placed in a 1-L glass balloon to which 500 mL of distilled water were added. Distillation was conducted for three h to obtain the essential oil content. Once collected in a sealed glass vials, the essential oil was dehydrated anhydrous sodium sulfate and stored at 4°C in darkness until analyses.

2.4. Data analysis

The differences among the basil genotypes were analysed through least significant differences (LSD) tests at 0.05 level of significance. Statistics included mean, range (minimum, maximum), coefficient of variation (CV) and standard deviations in 2017 and 2018 years. Cluster analysis was performed depending on the leaf shape and color of basil genotypes in 2017 and also, it was carried depending on the UPOV criteria among the basil genotypes using Ward's method and squared Euclidian distance in 2018 experimental year [19,20]. Principal component analysis (PCA) and correlation analysis were conducted to determine the relationships among the morphological and yield properties of basil genotypes obtained in experimental years.

3. Results and Discussion

3.1 Observations

All phenotypic traits showed variation among the genotypes examined. Our results show that with a careful analysis and stringent selection of traits, morphological markers provide an inexpensive and reliable method for routine screening of a large number of genotypes, in order to monitor and manage germplasm collections.

The selection and choice of parents also depends upon the contribution of characters towards the genetic divergence (Table 3 and 4). Among the five characters studied, contribution percentage/fold was recorded maximum for branches/plant (27.69 %), followed by plant height (28.68%), days to 50% flowering (64.37%), oil content (about twenty fold), herb yield/plant (about eighteen fold) in 2017 experimental year, maximum for branches/plant (40.63 %), followed by plant height (32.7%), days to 50% flowering (73.63%), oil content (about twentyseven fold), in 2018 experimental year. Hence, these characters could be given due importance.

Phenological observations of each genotypes were recorded, five a week. The number of days on which observations on seedling were made 2.88-8.38 in 2017, 23 -53 in 2018. Observations on flowering day for first cutting were made 56.92-88.42 in 2017, 73-101.6 in 2018. During harvesting, the dates that basils were collected from each genotypes were recorded in experimantal years.

Our results were also in harmony with Srivastava et al. [21] noted that basil harvest takes about 85-90 days for maturity, when lower leaves start turning yellow and full blooming condition appears. Similarly, Bahl et al. [22] reported that three different basil genotypes (CIM-Saumya, CIM-Snigdha, CIM-Surabhi) matured in 80-100 days.

Leaf shape and leaf color were observed in 61 genotypes in 2017 year. Leaf shape of basil genotypes were divided to 12 different properties (4 entire-big, 1 entire-medium, 5 entire-small, 2 lettuce-serrate-big, 1 lettuce-serrate-small, 5 serrate-big, 5 serrate-medium, 2 serrate-small, 4 true-serrate, 21 true-serrate-big, 7 true-serrate-medium, 4 true-serrate-small). About 35% of basil genotypes had similar leaf shape being true-serrate big. Leaf colors of basil genotypes were found into three categories as green (46 genotypes), purple (4 genotypes) and purple-green (11 genotypes) in 2017 (Table 3).

In a study by Darrah [23], who classified the *O. basilicum* genotypes into seven categories: (1) tall slender types, (the sweet basil group); (2) large-leafed robust types ('lettuc leaf' also called 'Italian' basil); (3) dwarf types, which are short and small leafed ('bush' basil);

(4) compact types, also described *O. basilicum* var. thyrsiflora ('Thai' basil); (5) purpurascens, the purple-colored basil types with traditional sweet basil flavor; (6) purple types ('Dark Opal': hybrid between *O. basilicum* and *O. forskolei* with a sweet basil plus clove-like aroma); and (7) citriodorum types (lemon-flavored basils).

Leaf shape and color of our basil genotypes were found similar with Darrah [25].

Egata et al. [24] recorded the morpho-agronomic variability to further select promising sweet basil accessions in Ethiopia. Singh et al. examined the genetic diversity and clustering pattern among 20 five basil accessions and found oil content was the highest contributing character toward the genetic diversity (56.09%). Srivastava et al. [21] studied 60 *O. basilicum* accessions and found some unique chemotypes which could be further exploited in future breeding programs. Carović-Stanko et al. [16] studied the resolving power of morphological traits for reliable identification of *O. basilicum* accessions and categorized six clusters of basil morphotypes.

3.2. Morphological parameters (plant height and number of branches)

The following morphological parameters were determined the plant height and number of branches. Plant height was determined two times before each sampling by measuring the height of ten randomly selected plants per plot from the soil to the top of the plant and getting an average value for each plot. These quantitative traits were investigated on the basis of the basil descriptors developed by the International Union for the Protection of New Varieties of Plants (UPOV, 2003) and were determined on ten randomly selected plants from the center rows of each cultivar. As can be seen in Table S3 and S4, significant differences were observed between the studied cultivars for growth parameters.

There were statistical significant differences among harvests for different genotypes with respect to the plant height in two experimental years. The presence of difference between the highest and the lowest values indicated that the genotypes included in the present study were quite diverse. In first year, while the highest plant height was obtained from Ames 32312 (57.07 cm) followed by PI 253157 (53.67 cm), and PI 172998 (47.58 cm) in first harvest, the highest plant height was obtained from PI 253157 (44.91 cm) followed by midnight (40.95 cm), and Bolu (40.76 cm) in second harvest. The highest avarage plant heights were recorded in Bolu (47.46 cm), PI 253157 (46.77 cm), Ames 32312 (45.62 cm), midnight (44.40 cm) genotypes. In second year, PI 253157 (71.90 cm) PI 170578 (68.10 cm) and PI 531396 (64.00 cm) genotypes have the highest plant height, whereas PI 173746 (18.00 cm), Moonlight (29.12 cm) have the lowest plant height in first harvest. In the second harvest, the highest plant height was recorded in PI 296390 (64.90 cm), followed by PI 296391 (60.10 cm) and Ames 32314 (52.70 cm) genotypes, while the lowest plant height was Large sweet (16.10 cm) and Moonlight (20.75 cm) cultivars. The highest avarage plant height was found at PI 296390 (58.10 cm) genotype, followed by PI 253157 (56.35 cm) and PI170578 (56.35 cm) genotypes. Especially, PI 253157 genotype have the highest plant height in experimental years.

The analysis of variance indicated the presence of considerable variability among the genotypes for the number of branches which was found to be highly significant (p=0.05) (Table 3). In addition, number of branches showed significant interaction of the different factors that were studied.

The number of branches was affected by genotypes, and by the interaction of year with genotype and harvest times. The genotype with the more branches was PI 175793 (20.67 number plant^{-1}), followed by the PI 170579 (19.43 number plant^{-1}), PI 358469 (13.48 number plant^{-1}), Ames 32309 (12.96 number plant^{-1}) and PI 368698 (12.95 number plant^{-1}) genotypes. The genotype with the lowest number of branches was PI 652071(5.7 number/plant) followed by the PI 174285 (6.81 number plant^{-1}) and PI 368700 (7.18 number plant^{-1}) genotypes in first year. In the second year, the highest branch numbers were observed in PI 197442 (14.90 number plant^{-1}), PI 211586 (13.50 number plant^{-1}), PI 182426 (12.67 number plant^{-1}) genotypes, the lowest branch numbers were observed in PI176646 (6.0 number plant^{-1}), Dino (6.66 number plant^{-1}), PI174284 (6.70 number plant^{-1}) genotypes in first harvest. Moreover, the genotypes PI 414200 and PI 652054 showed the significantly and remarkably higher branch numbers and ranged between 20.00- 18.67 number whereas, the lower one was observed in the registered genotype PI172996 (5.90 number) in second harvest. In addition, avarage the highest branch number was found at PI 414200 (16.00 number), followed by PI 358472 (13.50 number) and PI 652054 (13.00 number) genotypes.

The mean values of number of branches at the first year were higher than those of the second years, which was related to their height and habit, and all experimental years the highest branche numbers were obtained from first harvests. Based on our experimental results, there were significant differences between the two years of the experiments, and this can be because of the weather conditions as in 2018 the temperature was higher in vegetative growth period and the rainfall was much lower [18].

The examined basil cultivars had significant mean plant height (13.67-71.90 cm) in experimental years.

In earlier studies Egata et al. [24] reported that variability of combined analysis result on quantitative traits of Ethiopian sweet basil genotypes showed wide range in; number of primary branch/plant 6.08 to 8.98, number of internodes/main stem varies from 4.68 to 6.80, plant height 24.43 to 42.24 cm. Likewise, Alemu et al. [26] indicated that plant height was significantly affected by genotype, plant spacing, and they also reported that plant height changed from 52 to and 32 cm. Similarly, the plant height of different basil genotypes found at 20-60 cm [27], 22.9-57.0 cm [12], 40.0-76.9 cm [28], 60.89 cm [29], 65-88 cm [30], 69.7-89.5 cm [31] and 37.9-98.7 cm [32,33], 59.28-62.5 cm [34], 35.40-73.07 cm 35.40-73.07 cm [35], 24.43-42.24 cm [24], 17,16-45.33 cm [36], 74-80 cm [42] under different ecological conditions. Also, the morphological characters of 80 genotypes of *O. basilicum* from different geographical regions (India, Singapore, Tanzania, Thailand, and Slovak Republic) revealed a wide range of variation among themselves, viz. plant height (56-126 cm) [37-41].

The present results that we determined comply with the mentioned results with respect to plant height for two experimental years.

The examined basil cultivars had significant mean branch number (3.28-19.43 number/plant) in experimental years. These data corroborate with those reported by Egata et al. [24] (5.87-9.60 branches plant^{-1}), 11.3-13.5 branches plant^{-1} [31], 10-12 branches plant^{-1} [30], 9.3 to 9.67 branches plant^{-1} [35], however, these data much lower than those of 8-41 branches plant^{-1} [42]. The number of branches was affected by the irrigation, cultivar, and the interaction of cultivar and year, growth stage and year, and the interaction of cultivar, year, and growth stage. Morphological characteristics, such as number of branches, are affected by irrigation, fertilization, and cultivar [43].

3.3. Fresh and dry weight

The analysis of variance revealed that there was an abundant scope for selection of promising lines from the present genetic stock for fresh and dry weight. The fresh and dry herb weights were changed by growth stages, year, and genotypes. The presence of huge difference between the highest and the lowest values indicated that the genotypes included in the present study were quite diverse in all experimental years.

In 2017, the genotypes were collected from Georgia (Ames 32312) and Macedonia (PI 358469) region and the character making it distinct was the high fresh yield plant^{-1} (250.18 g plant^{-1}, 230.02 g plant^{-1}, respectively), in contrast to other genotypes which showed fresh herb yield in the range of 14.24 -156.71 g plant^{-1}. Among the sixty genotypes, the highest dry weight was found Ames 32312 (30.93 g plant^{-1}), followed by PI 414193 (23.70 g plant^{-1}), PI 414199 (23.70 g plant^{-1}), PI 211586 (23.63 g plant^{-1}); however, the lowest dry weight was obtained from PI 652071 (2.04 g plant^{-1}) and PI 379414 (2.15 g plant^{-1}) genotypes.

In 2018, the highest fresh weight was obtained from PI 172997 (274.11 g plant^{-1}), followed by PI358466 (134.78 g plant^{-1}) and Bolu (106.76 g plant^{-1}) genotypes, in contrast to other genotypes which showed herb yield in the range of 12.94-101,83 g plant^{-1} in 2018 experimantal year. The lowest was found at PI 379414(12.94 g plant^{-1}) and PI 176646 (13.17 g plant^{-1}) genotypes The genotype that showed the highest dry weight was PI 172997 (27.49 g plant^{-1}), followed by PI358466 (21.39 g plant^{-1}) and PI379412 (16.25 g plant^{-1}) in second years; however, the lowest dry weight was found PI 531396 (1.0 g plant^{-1}) and PI 414194 (1.27 g plant^{-1}) genotypes. Most of the genotypes had yields greater than 50 g plant^{-1} fresh herbage, which are considered very high. Our results suggest that most basil genotypes can provide high yields under Bolu ecological condition. Especially, PI 172997, Ames 32312, PI 358469 genotypes were foremost in experimental years.

The examined basil cultivars had significant fresh herb yields in first experimental year (17.18-250.18 g/plant) and in second experimental year (12.94-274.11 g/plant) (Table 3 and 4). The examined basil cultivars had significant dry herb yields in first experimental year (2.04-30.93 g/plant) and in second experimental year (1.0-27.49 g/plant) (Table 3 and 4).

The results of the present study are in a good agreement with those of the study by Egata et al. [24], who reported that fresh leaf weight/plant varied from 44.58 g to 231.53 g, and also noted that maximum dry weight/plant ranged from 10.06 to 31.57 g in Ethiopian sweet basil genotypes. Likewise, previous studies have reported a range of values for fresh weight of different basil cultivars from 240.2 to1105.9 g m^{-2} and dry weight was in the range of 47.9-202.8 g m^{-2} [44-46].

Similarly, dry herb weight plant^{-1} varied from 7.26-10.78 g under stress condition [47], and ranged from 5.5-7.1 g grown with different temperature integration doses [48]. Our results agree with those obtained by previous literature.

By contrast, Kalamartzis et al. [49] determined the effect of water stress on five cultivars of basil (Mrs Burns, Cinnamon, Sweet, Red Rubin, Thai) were found to be within the ranges of 378.5-4357.5 g m^{-2} for fresh herb, 65.8-922.5 g m^{-2} for dry herb. In addition, Karaca et al. [36] determined that fresh herb yield and dry herb yield of nine basil genotypes were found to be within the ranges of 195.00-383.99 g $plant^{-1}$, 22.21-46.85 g $plant^{-1}$, respectively. Köse et al. [50] also, indicated that effect of plant density on fresh herbage yield of sweet basil was in the range of 192.00-464.70 g $plant^{-1}$ and dry weight was in range 52.90-9.98 g $plant^{-1}$. Furthermore, Arslan et al. [51] noted the fresh and dry yield of *O. basilicum* in the range of 192.00-464.70, also 24.3-55.2 g under the Eastern Mediterranean condition, respectively.

The observed differences in the fresh and dry plant herb yield across countries may be a result of different environmental and genetic factors, different chemotypes, harvest time, weather conditions and the cultural practices.

3.4. Essential oil content

Essential oil content was affected by growth stages, year, cultivar, and also by their interactions (Table 3, 4). It was found that the significant differences were seen among the used fennel genotypes in terms of essential oil content at $p<0.05$ (Table 3). The highest essential oil content was found at PI 358469 (1.71 %), followed by PI 207498 (1.12%), PI 414199 (0.87%), PI 197442 (0.83 %) in first experimental year. The lowest essential oil content was found at PI 379413 (0.05 %) (Table 3 and 4).

The highest essential oil content was found at Ames 32309 (1.07 %), followed by PI 172996 (0.98%) and large sweet (0.98%) in second years. The lowest essential oil content was found at PI 379414 (0.04 %) and PI 296390 (0.13%) genotypes.

Great variations in the essential oil content of *O. basilicum* across geographic regions might be attributed to variable agroclimatic conditions and different agronomic techniques for cultivating [52,53]. The essential oil yield (0.04-1.71%) in the present study was comparable to that in a study by Egata et al. [24], who found the range of 0.10-1.02 % leaf essential oil content dry weight base for Ethiopian sweet basil genotypes. Similarly, Karaca et al. [36] determined that essential oil content of in nine basil genotypes were found to be within the ranges of 0.25-1.06%. Also Beatovićr et al. [54] reported that the essential oil yields of twelve *Ocimum basilicum* L. cultivars grown in Serbia ranged from 0.65 to 1.90 %.

Likewise, Telci et al. [12] reported values for essential oil content between 18 genotypes ranging from 0.4% to 1.5%. Zheljazkov et al. [4] recorded that essential oil content of the tested 38 genotypes a grown in Mississippi varied from 0.07% to 1.92% in dry herbage in the field experiment. It was reported that essential oil yield of the air-dried overground parts of *Ocimum basilicum* from Turkey as obtained by hydrodistillation was 1.25% [55]. Juliani et al. [56] reported basil oil content from 0.6 to 1.7% dry herbage. The yield of essential oil from different plant parts varies between 0.15-1.59%, and it depends also on the seasonal factor and locality [57-62].

By contrast, Simon et al. [5] reported the essential oil content from 0.04% to 0.70% (v fresh weight^{-1}) in a study of a large number of basil genotypes. In addition, the content and composition of the essential oil have been evaluated in 14 *O. basilicum* genotypes, and reported that varied from 0.59 to 2.30% (genotype no. 6) [63]. Furthermore, in four Ocimum species grown in Tanzania (Runyoro et al., 2010), the essential oil yields ranged from 0.5% to 4%.

According to our study, the USDA genotypes were higher in its content of essential oil in compare with the local genotypes. Based on essential oil content (Table 4), PI 358469 originating from Macedonia and Ames 32309 originating from Georgia are the best genotypes, which are the different from the other genotypes.

In general, the essential oil content of basil genotypes in this study was within the usual content reported in other studies [4,24,64]; however, Runyoro et al. [65] and Akçali Giachino et al. [63] results that were higher than our results. Differences in basil essential oil content between this study and another report from research could be due to differential environmental conditions, their genetics and growth conditions [66,67].

Table 3. Morphological tarits of basil genotypes in 2017.

No	Genotypes	Plant Name	Country/Province	GD (days)	FHPH (cm)	SHPH (cm)	APH (cm)	NB (no plant^{-1})	DFT (days)	FHW 1 (g plant^{-1})	FHW 2 (g plant^{-1})	TFHW (g plant^{-1})	DHW 1 (g plant^{-1})	DHW 2 (g plant^{-1})	TDHW (g plant^{-1})	EO (%)	Leaf Shape	Leaf Color
1	**PI 358466**	**Krstaten**	**Macedonia**	4.88e	33.79j-s	34.52a-ı	34.29d-r	8.21j-r	69.42ıjk	75.98a-d	10.64e-h	86.62c-h	3.63b-e	0.68hıj	4.30r-v	0.08lm	Entire-Medium	Green
2	**PI 652071**	**Dark Opal**	**US/California**	5.88c	28.32n-v	27.22c-r	27.91l-v	5.71r	69.42ıjk	61.73bcd	9.69e-h	71.41c-h	1.36de	0.69hıj	2.04v	0.17e	Serrate-Medium	Purple
3	**PI 172996**	**Reyhan**	**Turkey/Kars**	4.88e	39.79c-l	44.62a	42.34a-f	12.54bcd	61.42r-u	77.91a-d	25.30c-h	103.21c-h	5.09b-e	2.83b-j	7.92l-v	0.50K	Serrate-Medium	Green
4	**PI 174285**	**Reyhan**	**Turkey/Elazığ**	4.88e	40.21c-l	41.82ab	41.15a-g	6.81qr	64.42n-q	88.18a-d	31.85c-h	120.03b-h	4.92b-e	3.33b-j	8.25l-v	0.18d	Lettuce-Serrate-Small	Purple-Green
5	**PI 652065**	**Genovese**	**Italia/Veneto**	5.88c	39.92c-l	35.11a-h	37.65a-l	8.14j-r	67.92jkl	2.77d2	26.28c-h	29.05fgh	0.48e	4.28b-j	4.76p-v	0.06o	True-Serrate-Big	Green
6	**PI 358465**	**Srednolisten**	**Macedonia**	3.88f	31.26l-u	29.11b-p	30.33h-t	8.84f-r	73.92ef	3.64d	106.35a	109.99c-h	0.47e	12.64a	13.10e-o	0.06o	True-Serrate-Big	Green
7	**PI 358467**	**Domasen siten**	**Macedonia**	4.88e	27.82o-v	29.31b-o	28.70k-u	10.44b-o	69.92hıj	4.29cd	13.53e-h	17.82h	1.21de	1.25d-j	2.46uv	0.21b	True-Serrate-Small	Green
8	**PI 170581**	**3031**	**Turkey/Çanakkale**	5.88c	21.72uvy	13.44rs	17.72vy	7.24o-r	73.92ef	8.34cd	19.42e-h	27.76fgh	1.06de	2.60b-j	3.66s-v	0.75E	Entire-Small	Green
9	**PI 379414**	**Bel kripen**	**Macedonia**	4.88e	24.94s-y	15.11p-s	20.17t-y	7.49n-r	65.92l-o	8.85cd	5.39fgh	14.24h	1.80cde	0.34ıj	2.15v	0.23Z	Entire-Big	Green
10	**PI 253157**	**Rayhoon**	**Iran/Esfahan**	5.38d	53.67ab	44.91a	46.77ab	11.84b-h	70.92ghı	50.43bcd	7.54fgh	57.97e-h	11.10a-e	0.70hıj	11.81g-r	0.16f	True-Serrate-Big	Green
11	**PI 414193**	**B 49939**	**US/Maryland**	6.38b	38.27c-m	26.11e-r	29.67ı-u	9.94c-q	69.92hıj	127.68abc	21.95d-h	149.62a-e	21.31ab	2.39b-j	23.70ab	0.07n	True-Serrate-Big	Green
12	**PI 368699**	**Edar**	**Macedonia**	6.38b	34.57ı-s	26.91c-r	28.22k-v	10.84b-l	65.92l-o	77.24a-d	12.29e-h	89.53c-h	15.61a-e	0.77hıj	16.38b-k	0.23Z	True-Serrate-Medium	Green
13	**PI 211586**	**12832**	**Afghanistan/ Kondoz**	8.38a	35.57h-q	26.58e-r	28.56k-u	11.74b-h	64.92m-p	126.49a-d	0.50h	126.99b-h	21.30ab	2.33b-j	23.63ab	0.36R	True-Serrate-Small	Purple-Green
14	**PI 175793**	**Festagan**	**Turkey/ Çanakkale**	6.38b	40.30c-l	33.17a-l	34.22d-r	20.67a	79.92bc	58.67bcd	4.49gh	63.16e-h	12.28a-e	1.99b-j	14.26d-m	0.18d	Entire-Small	Green
15	**PI 368700**	**Edar**	**Macedonia**	4.88e	23.17t-y	17.55n-s	20.50s-y	7.18pqr	65.92l-o	31.89bcd	40.57bh	72.46c-h	3.82b-e	1.92c-j	5.74o-v	0.45L	Entire-Small	Green
16	**PI 652070**	**Sweet basil**	**US/Pennsylvania**	4.88e	44.67b-h	28.88b-p	36.92a-m	10.09c-p	65.92l-o	123.30a-d	64.71bc	188.01abc	15.13a-e	5.35b-ı	20.49b-e	0.22a	Serrate-Big	Green
17	**PI 358468**	**Krupnolisten**	**Macedonia**	4.88e	35.47h-r	19.63k-s	27.69l-v	8.49ı-r	60.92r-u	5.63cd	25.17c-h	30.80fgh	1.87cde	0.82hıj	2.69tuv	0.51J	Serrate-Medium	Green
18	**Ames 32312**	**GE.2013-50**	**Georgia**	4.88e	57.07a	33.88a-j	45.62abc	8.99e-q	67.92jkl	188.96a	61.22bcd	250.18a	26.13a	4.80b-j	30.93a	0.24Y	Serrate-Big	Purple-Green
19	**PI 190100**	**1**	**Iran**	3.88f	38.12c-n	26.63d-r	32.52f-r	12.09b-e	60.92r-u	14.98cd	28.03c-h	43.01e-h	1.27de	1.04f-j	2.31uv	0.09k	Serrate-Medium	Purple-Green

20	**PI 368697**	**Vladimirska**	**Macedonia**	3.88f	26.07q-v	14.18q-s	20.27t-y	7.93k-r	57.92vy	53.66bcd	25.88c-h	79.54c-h	8.42a-e	1.75c-j	10.17ı-t	0.09j	True-Serrate-Small	Green
21	**Ames 32309**	**GE.2013-21**	**Georgia**	4.88e	45.87b-e	24.98f-s	35.57c-p	12.96bc	64.92m-p	104.13a-d	21.67d-h	125.80b-h	6.79b-e	1.59c-j	8.38l-v	0.08kl	True-Serrate-Small	Purple-Green
22	**PI 414196**	**B 49928**	**US/Maryland**	5.88c	47.57abc	22.28g-s	35.07c-q	7.23pqr	61.92q-u	72.83a-d	18.21e-h	91.04c-h	10.58a-e	1.45c-j	12.03g-q	0.16f	Entire-Big	Green
23	**PI 296390**		**Iran**	3.88f	45.77b-f	33.12a-l	39.58a-j	9.83c-q	65.92l-o	115.15a-d	23.59d-h	138.74a-g	18.75a-e	3.71b-j	22.46bc	0.11h	Entire-Big	Purple-Green
24	**PI 368695**	**Zelen**	**Macedonia**	4.88e	27.57o-v	20.38ı-s	24.12r-y	10.33b-p	66.92k-n	101.62a-d	20.05e-h	121.68b-h	15.89a-e	1.16f-j	17.05b-k	0.43N	Entire-Big	Green
25	**Ames 32313**	**GE.2013-68**	**Georgia**	5.88c	19.42vy	19.16l-s	19.43uvy	9.99c-q	60.42s-v	69.53a-d	11.78e-h	81.31c-h	11.53a-e	3.59b-j	15.12c-l	0.19c	Serrate-Small	Green
26	**PI 414195**	**B 19927**	**US/Maryland**	4.88e	25.72r-v	21.56h-s	23.78r-y	10.19c-p	64.42n-q	60.80bcd	11.9e-h	72.73c-h	9.39a-e	2.33b-j	11.72g-r	0.22a	Serrate-Big	Green
27	**PI 531396**	**1420**	**Hungary**	4.88e	30.82l-u	18.56m-s	24.83q-v	10.19c-p	64.42n-q	95.89a-d	20.49d-h	116.38b-h	10.10a-e	1.78c-j	11.88g-r	0.62H	Serrate-Big	Green
28	**PI 368698**	**Srednolisten**	**Macedonia**	4.88e	30.62l-u	21.89g-s	26.40m-v	12.95bc	69.42ıjk	49.07bcd	38.42c-h	87.49c-h	6.70b-e	6.39bc	13.08e-o	0.37Q	True-Serrate	Green
29	**PI 172997**	**Reyhan**	**Turkey/Kars**	4.88e	43.62c-ı	33.36a-k	38.63a-k	7.59m-r	59.42uvy	95.59a-d	16.10e-h	111.70c-h	16.72a-e	5.05b-j	21.78bcd	0.32T	True-Serrate	Green
30	**PI 414199**	**B 49931**	**US/Maryland**	4.88e	35.22h-r	39.36a-e	37.43a-l	10.19c-p	67.92jkl	119.85a-d	36.86c-h	156.71a-e	17.39a-e	6.30bc	23.70ab	0.87C	True-Serrate	Green
31	**Ames 29184**	**GSMO 2-19**	**Georgia/South Ossetia**	4.88e	39.12c-m	38.36a-f	38.88a-k	10.29b-p	66.92k-n	93.26a-d	43.40b-g	136.65a-g	15.80a-e	6.26bcd	22.06bc	0.65G	Serrate-Big	Purple
32	**PI 379413**	**Krupnolisen**	**Macedonia**	4.88e	37.72d-n	29.36b-o	33.68e-r	12.99bc	72.92fg	127.47abc	22.75d-h	150.23a-e	19.42a-d	3.6b-j	23.09b	0.05p	Serrate-Small	Green
33	**Ames 32311**	**GE.2013-43**	**Georgia**	4.88e	45.42b-g	34.56a-h	40.13a-ı	8.69g-r	72.92fg	71.50a-d	42.03b-g	113.52b-h	11.27a-e	5.54b-h	16.81b-k	0.21b	Lettuce-Serrate-Big	Purple
34	**PI 358464**	**Edrolisten**	**Macedonia**	4.88e	30.82l-u	29.36b-o	30.23h-t	7.79l-r	62.92prs	84.64a-d	20.51d-h	105.15c-h	14.65a-e	3.10b-j	17.75b-ı	0.18d	Serrate-Medium	Green
35	**PI 414197**	**B 49929**	**US/Maryland**	3.88f	33.47j-s	30.86a-n	32.30f-r	8.64h-r	62.92prs	94.70a-d	31.85c-h	126.56b-h	12.22a-e	0.11j	12.33g-p	0.12g	True-Serrate-Big	Green
36	**PI 414198**	**B 49930**	**US/Maryland**	2.88g	35.79g-q	32.86a-l	34.46d-r	8.99e-q	60.92r-u	87.95a-d	42.34b-g	130.29b-h	11.94a-e	0.85hıj	12.79f-o	0.08mn	True-Serrate-Big	Green
37	**PI 207498**	**12648**	**Afghanistan/Kabul**	4.88e	46.52bcd	39.86a-e	43.33a-e	8.64h-r	66.92k-u	143.67ab	42.17b-g	185.84a-d	20.40abc	1.01g-j	21.41bcd	1.12B	True-Serrate-Big	Green
38	**PI 176646**	**Reyhan**	**Turkey/Tokat**	4.88e	37.68d-n	35.11a-h	36.53b-n	8.66h-r	56.92y	78.03a-d	41.00b-h	119.03b-h	11.47a-e	0.57hıj	12.04g-q	0.35S	True-Serrate-Big	Green
39	**PI 379412**	**Krupen bel**	**Macedonia**	4.88e	35.47h-r	35.86a-g	35.80c-o	8.70f-r	61.92q-u	57.37bcd	44.47b-g	101.84c-h	8.27a-e	1.22e-j	9.50k-v	0.10ı	True-Serrate-Big	Green
40	**PI 170579**	**2263**	**Turkey/İzmir**	4.88e	36.54e-o	27.66b-q	32.24f-r	19.43a	88.42a	12.52cd	42.01b-g	54.53e-h	1.52cde	5.19b-ı	6.71m-v	0.11h	Entire-Small	Green
41	**PI 172998**	**Reyhan**	**Turkey/Van**	4.88e	47.58abc	31.26a-n	39.56a-j	11.60b-ı	62.42p-t	2.88d	19.55e-h	22.44gh	1.91cde	5.46b-h	7.37m-v	0.28V	True-Serrate-Medium	Purple-Green
42	**PI 414194**	**B 49926**	**US/Maryland**	4.88e	47.24bcd	32.06a-m	39.79a-j	11.90b-f	63.42opr	4.51cd	38.21c-h	42.72e-h	0.41e	5.95b-g	6.36n-v	0.18d	True-Serrate-Medium	Purple-Green

43	**PI 414200**	**B 49932**	**US/Maryland**	3.88f	41.68c-k	33.66a-k	37.81a-l	11.00b-k	67.42j-m	48.48bcd	30.46c-h	78.94c-h	6.88b-e	4.69b-j	11.57g-r	0.09k	True-Serrate-Big	Green
44	**PI 173746**	**Reyhan**	**Turkey/Malatya**	3.88f	41.38c-k	39.66a-e	40.66a-h	10.20c-p	68.42ı-l	37.09bcd	29.15c-h	66.24e-h	5.35b-e	4.54b-j	9.90j-u	0.41P	True-Serrate-Big	Green
45	**Ames 32314**	**GE.2013-78**	**Georgia**	4.88e	41.95c-k	26.53e-r	34.39d-r	9.67d-q	67.92jkl	84.49a-d	24.29c-h	108.79c-h	12.40a-e	4.76b-j	17.16b-j	0.32T	True-Serrate-Big	Green
46	**PI 358470**	**Lokalen**	**Georgia**	4.88e	31.10l-u	19.70k-s	25.54o-v	9.87c-q	59.92tuv	44.90bcd	8.66fgh	53.57e-h	6.52b-e	1.98b-j	8.50l-v	0.12h	True-Serrate-Big	Purple-Green
47	**PI 197442**	**10126**	**Ethiopia**	4.88e	32.20k-t	19.80j-s	26.14n-v	11.87b-g	80.92bc	82.29a-d	25.41c-h	107.70c-h	12.17a-e	5.01b-j	17.18b-j	0.83D	True-Serrate-Big	Purple-Green
48	**PI 296391**		**Iran**	3.88f	47.70abc	31.60a-n	39.79a-j	9.17e-q	65.92l-o	100.65a-d	17.13e-h	117.77b-h	16.15a-e	4.14b-j	20.29b-f	0.29U	True-Serrate-Big	Green
49	**PI 263870**		**Greece**	4.88e	25.10s-y	16.20o-s	20.79s-y	10.87b-l	75.92de	63.05bcd	27.37c-h	90.41c-h	5.21b-e	2.77b-j	7.98l-v	0.02q	True-Serrate-Medium	Green
50	**PI 170578**	**Fesligen**	**Turkey/Aydın**	5.88c	15.37y	11.68s	13.67y	12.94bc	81.92b	60.74bcd	42.12b-g	102.86c-h	11.37a-e	6.04b-f	17.41b-j	0.44M	Entire-Small	Green
51	**PI 182426**	**Reyhan**	**Turkey/Maraş**	4.88e	32.37k-t	26.08e-r	29.37j-u	11.14b-j	70.92ghı	74.45a-d	41.92b-g	116.36b-h	11.56a-e	6.21b-e	17.77b-ı	0.44M	True-Serrate-Big	Purple-Green
52	**Ames 32310**	**GE.2013-37**	**Georgia**	4.88e	27.07o-v	25.88e-r	26.62m-v	10.14c-p	69.92hıj	65.4a-d	45.81b-f	111.21c-h	12.23a-e	6.98b	19.21b-g	0.20c	True-Serrate-Big	Green
53	**PI 174284**	**Reyhan**	**Turkey/Van**	3.88f	36.67e-o	27.68b-q	32.32f-r	10.84b-l	67.92jkl	43.94bcd	24.61c-h	68.55d-h	9.50a-e	3.93b-j	13.43e-n	0.21b	True-Serrate-Medium	Green
54	**PI 358436**	**Obicen bosilok**	**Macedonia**	5.88c	29.36m-u	19.98j-s	25.76o-v	10.73b-m	63.42opr	46.00bcd	23.92c-h	69.92d-h	5.27b-e	1.27d-j	21.50bcd	0.11h	True-Serrate-Medium	Green
55	**PI 358469**	**Siten**	**Macedonia**	4.88e	42.36c-j	29.66b-o	37.10a-m	13.48b	73.42efg	150.10ab	79.92ab	230.02ab	15.63a-e	5.87b-g	7.79l-v	1.71A	True-Serrate	Green
56	**PI 652054**	**Mrs. Burns Lemon Basil**	**US/Mexico**	5.88c	36.03f-p	31.48a-n	34.84d-q	11.48b-ı	72.42fgh	60.61bcd	36.71c-h	97.31c-h	6.40b-e	1.39c-j	11.23h-s	0.68F	True-Serrate-Big	Green
57	**PI 358472**	**Bitolski**	**Macedonia**	5.88c	26.46p-v	23.78g-s	26.21n-v	10.68b-n	74.42ef	63.14bcd	37.70c-h	100.84c-h	9.58a-e	1.65c-j	4.45q-v	0.42O	True-Serrate-Big	Green
58	**PI 601365**	**Purple Ruffles**	**US/Pennsylvania**	5.88c	35.86g-q	23.98g-s	31.01g-s	11.48b-ı	78.42cd	39.36bcd	20.80d-h	60.16e-h	3.66b-e	0.78hıj	18.69b-h	0.10ı	Lettuce-Serrate-Big	Purple
59	**PI 358471**	**Sitnolisten**	**Macedonia**	3.88f	21.97uvy	27.88b-q	25.07p-v	10.34b-p	66.9k-n2	65.80a-d	35.98c-h	101.77c-h	13.24a-e	5.45b-h	6.54n-v	0.41P	True-Serrate-Medium	Green
60	**Bolu**	**Bolu pop.**	**Turkey/Bolu**	5.92bc	53.59ab	40.76a-d	47.46a	11.87b-g	67.17j-n	120.34a-d	29.42c-h	149.76a-e	17.68a-e	5.53b-h	16.74b-k	0.51I	True-Serrate-Big	Green
61	**Midnight**	**Cultivar**	**Turkey**	5.83cd	47.84abc	40.95abc	44.40a-d	11.30b-j	68.67ı-l	94.31a-d	50.29b-e	144.61a-f	13.87a-e	2.88b-j	23.21b	0.17e	True-Serrate-Big	Green
			Average	5.02	36.17	28.48	32.33	10.36	67.79	70.14	29.87	100.01	9.93	3.29	13.22	0.31		
			Minimum	2.880	15.370	11.680	13.670	5.710	56.920	2.772	0.500	14.240	0.410	0.110	2.040	0.020		
			Maximum	8.380	57.070	44.910	47.460	20.670	88.420	188.960	106.350	250.180	26.130	12.640	30.930	1.710		
			LSD (5%)	0.47	9.82	14.17	10.70	10.70	2.80	123.76	40.80	117.46	18.89	52.16	19.48	0.005		
			CV %	3.47	8.46	15.15	10.18	10.18	1.80	50.37	44.72	34.86	52.31	5.02	42.59	1.78		
			Standart devision	0.857	8.929	7.987	7.720	2.516	6.101	41.042	18.088	47.212	6.301	2.335	6.913	0.292		

GD: Germination day, FHPH: First Harvest Plant Height, SHPH: Second Harvest Plant Height, APH: Average Plant Height, NB: Number of Branch, DFT: Days to Flowerinf Time, FHW 1: Fresh Herb Weight 1, FHW 2: Fresh Herb Weight 2, TFHW: Total Fresh Herb Weight, DHW 1: Dry Herb Weight 1, DHW 2: Dry Herb Weight 2, THDW: Total Dry Herb Weight, EO: Essential Oil.

No	Genotypes	Plant name	Country	GD (days)	FHPH (cm)	SHPH (cm)	APH (cm)	FHNB (no/plant)	SHNB (no/plant)	ANB (no/plant)	DFT (day)	FHW 1 (g/plant)	FHW 2 (g/plant)	TFHW (g/plant)	DHW 1 (g/plant)	DHW 2 (g/plant)	TDHW (g/plant)	EO (%)
1	**Ames 32311**	**GE.2013-43**	**Georgia**	24fg	53.93c-g	37.20c-k	45.57a-k	9.80a-h	10.13e-n	9.96c-q	81cd	34.49f-m	18.05g-o	52.54e-r	3.60n-u	2.25f-k	5.85o-t	0.32h-m
2	**Ames 29184**	**GSMO 2-19**	**Georgia/South Osetya**	24fg	50.34d-k	38.30c-j	44.32a-l	11.60a-g	10.10e-n	10.85b-m	83bcd	43.45c-l	23.51f-j	66.96c-m	5.55k-s	3.11e-h	8.66l-o	0.30ı-m
3	**Ames 32309**	**GE.2013-21**	**Georgia**	33b-g	45.00g-n	29.00e-l	37.00f-p	7.80c-h	7.00k-q	7.40m-r	87bcd	25.44h-m	6.87q-u	32.31k-r	5.92ı-q	0.61l-p	6.53n-s	1.07a
4	**Ames 32310**	**GE.2013-37**	**Georgia**	25efg	52.39d-ı	35.10c-k	43.75a-l	8.10c-h	8.10j-p	8.10j-r	82bcd	37.6e-m	17.28h-p	54.89e-q	6.62ı-o	4.72bcd	11.34ı-l	0.14k-m
5	**Ames 32312**	**GE.2013-50**	**Georgia**	48ab	58.75bcd	46.00b-e	52.38a-f	9.75a-h	5.00pq	7.38m-r	94abc	18.97j-m	17.28h-p	36.25j-r	3.58n-u	2.08f-l	5.66o-u	0.67b-h
6	**Ames 32314**	**GE.2013-78**	**Georgia**	27c-g	45.30f-n	52.70abc	49.00a-h	10.30a-h	7.80j-p	9.05e-r	82bcd	25.44h-m	18.82g-n	44.26g-r	2.09p-u	1.04j-p	3.13t-z	0.70b-g
7	**Bolu pop.**	**Local genotype**	**Turkey/Bolu**	24fg	63.76abc	45.50b-f	54.63a-d	7.20fgh	7.20k-q	7.20n-r	90abcd	70.88b-f	35.89cd	106.76bc	11.11d-g	4.74bc	15.85def	0.29ı-m
8	**Dino**	**Çeşit**	**Turkey**	25fg	40.80k-p	30.12d-l	35.46h-p	6.66gh	6.64m-q	6.65pqr	97abc	46.59c-l	13.61j-s	60.2d-o	3.53n-u	1.11j-p	6.64n-s	0.68b-h
9	**Large sweet**	**Çeşit**	**Turkey**	27c-g	37.00n-r	16.10l	26.55n-q	9.00b-h	3.28q	6.14r	93abcd	10.21k-m	6.81q-u	17.02o-r	1.57stu	0.68l-p	2.25vyz	0.98a-b
10	**Midnight**	**Çeşit**	**Turkey**	41a-f	51.40d-j	29.33e-l	40.37c-p	8.15c-h	6.12n-q	7.13n-r	97.4abc	47.25c-k	4.68r-u	51.93e-r	5.57j-s	1.67g-p	7.24n-q	0.56c-ı
11	**Moonlight**	**Çeşit**	**Turkey**	41a-f	29.12rs	20.75jkl	24.94pq	7.45e-h	5.94opq	6.69o-r	101.6ab	39.93c-m	10.34m-u	50.27e-r	13.62cde	2.38f-k	16c-f	0.40g-m
12	**PI 141198**	**B 49930**	**USA/Maryland**	33b-g	42.00ı-p	27.71g-l	34.86h-p	12.00a-f	8.14j-p	10.07b-p	110a	38.47d-m	9.04n-u	47.51f-r	5.93ı-q	1.31ı-p	7.24n-q	0.77a-f
13	**PI 170578**	**Fesligen**	**Turkey/Aydın**	24fg	68.10ab	44.60b-g	56.35ab	10.60a-h	6.10n-q	8.35ı-r	91abcd	59.64b-I	19.31g-m	78.94c-j	9.69e-ı	2.44f-j	12.13ıjk	0.55d-ı
14	**PI 172996**	**Reyhan**	**Turkey/Kars**	33b-g	54.50c-g	36.80c-k	45.65a-k	7.10fgh	5.90opq	6.50qr	84bcd	32.00g-m	27.82d-g	59.82d-o	4.54n-t	3.32c-f	7.86m-p	0.98a-b
15	**PI 172997**	**Reyhan**	**Turkey/Kars**	42a-e	71.67a	36.67c-k	54.17a-e	10.00a-h	15.33bc	12.67a-d	83bcd	239.64a	34.47cde	274.11a	22.91a	4.58b-e	27.49a	0.33h-m
16	**PI 173746**	**Reyhan**	**Turkey/Malatya**	49ab	18.00t	20.00kl	19.00q	8.00c-h	9.00h-p	8.50g-r	90abcd	5.57m	4.16stu	9.73r	1.03tu	0.51m-p	1.54yz	0.83a-e
17	**PI 174284**	**Reyhan**	**Turkey/Van**	28c-g	46.24e-n	32.90d-l	39.57d-p	6.70gh	12.30c-ı	9.50c-r	85bcd	41.72c-m	34.37cde	76.09c-k	5.10l-s	2.04f-m	7.14n-q	
18	**PI 176646**	**Reyhan**	**Turkey/Tokat**	48ab	58.00bcd	39.10c-ı	48.55a-h	6.00h	9.40g-o	7.70k-r	90abcd	10.39klm	2.78tu	13.17q-r	2.02q-u	0.27p	2.29vyz	0.95a-b
19	**PI 182426**	**Reyhan**	**Turkey/Maraş**	43a-d	41.17j-p	28.00f-l	34.58h-p	12.67a-d	7.75j-p	10.21b-o	89bcd	21.86j-m	7.03q-u	28.89l-r	5.10l-s	0.89j-p	5.99n-t	0.39g-m
20	**PI 190100**	**1**	**Iran**	48ab	63.50abc	47.00bcd	55.25abc	10.00a-h	7.00k-q	8.50g-r	96abc	30.24g-m	6.79q-u	37.03j-r	16.95bc	2.14f-l	19.09bc	
21	**PI 197442**	**10126**	**Ethiopia**	25efg	46.40e-n	33.40d-l	39.90c-p	14.90a	10.83d-k	12.87a-d	82bcd	45.53c-l	42.23bc	87.77c-g	7.00h-o	2.09f-l	9.09k-n	0.27ı-m
22	**PI 207498**	**12648**	**Afganistan/Kabil**	29c-g	55.00c-g	32.33d-l	43.67a-l	11.50a-g	11.40c-j	11.45b-j	89bcd	42.49c-m	19.54g-m	62.03d-n	6.85ı-o	1.86f-o	8.71l-o	0.57c-ı
23	**PI 211586**	**12832**	**Afganistan/ Kondoz**	29c-g	53.85c-g	32.30d-l	43.08a-m	13.50ab	8.90h-p	11.20b-k	81cd	60.99b-h	32.54c-f	93.52b-e	9.14f-l	1.68g-p	10.82j-m	0.55d-j
24	**PI 253157**	**Rayhoon**	**Iran/Esfahan**	24fg	71.90a	40.80c-h	56.35ab	9.20b-h	7.60j-p	8.40ı-r	90abcd	75.17bcd	26.02d-h	101.19bcd	12.11def	3.14e-h	15.25d-h	
25	**PI 296390**		**Iran**	23g	37.20m-r	64.90a	58.10a	8.80b-h	10.75d-l	9.78c-q	73d	34.34f-m	46.98ab	81.32c-I	4.39n-t	8.33a	12.72g-j	0.13l-m
26	**PI 296391**		**Iran**	23g	56.10cde	60.10ab	51.05a-g	12.40a-e	7.90j-p	10.15b-p	85bcd	35.01f-m	54.41a	89.42c-f	4.24n-t	8.20a	12.44hıj	0.92a-c
27	**PI 358464**	**Edrolisten**	**Macedonia**	42a-e	55.67c-f	38.00c-j	46.83a-ı	8.67b-h	9.00h-p	8.83g-r	91abcd	32.27g-m	19.78g-m	52.05e-r	6.12ı-p	1.30ı-p	7.42n-q	
28	**PI 358466**	**Krsaten**	**Macedonia**	34b-g	50.10d-k	33.00d-l	41.55b-n	11.56a-g	9.50f-o	10.53b-n	87bcd	88.55b	46.24ab	134.78b	17.98b	3.41c-f	21.39b	0.88a-d
29	**PI 358468**	**Krupnolisten**	**Macedonia**	27c-g	29.10rs	26.14h-l	27.62m-q	9.90a-h	9.86f-o	9.88c-q	83bcd	13.78j-m	24.33e-I	38.11I-r	0.79tu	2.78f-ı	3.57s-z	0.33h-m
30	**PI 358469**	**Siten**	**Macedonia**	26defg	39.60l-q	23.70h-l	31.65ı-q	9.30b-h	8.50ı-p	8.90f-r	89bcd	20.19j-m	6.83q-u	27.02m-r	5.32l-s	1.04j-p	6.36n-s	0.46f-l
31	**PI 358471**	**Sitnolisten**	**Macedonia**	32b-g	25.33st	24.50h-l	24.92pq	9.67b-h	7.50j-p	8.58g-r	92abcd	13.95j-m	5.3q-u	19.25n-r	4.08n-t	0.67l-p	4.75p-v	0.88a-d
32	**PI 358472**	**Bitolski**	**Macedonia**	53a	34.00o-s	27.50g-l	30.75j-q	13.50ab	13.50c-f	13.50ab	98abc	73.68b-e	18.98g-n	92.66b-e	14.14bcd	3.17d-g	17.31cd	0.67b-h
33	**PI 368695**	**Zelen**	**Macedonia**	32b-g	55.70c-f	28.00f-l	41.85b-n	10.40a-h	15.20bc	12.80a-d	83bcd	49.59c-j	12.03l-u	61.62d-n	9.56e-k	1.46ı-p	11.02jkl	0.38g-m
34	**PI 368697**	**Vladimirska**	**Macedonia**	24fg	47.50e-m	34.70d-k	41.10b-o	12.40a-e	12.60c-h	12.50a-e	73d	30.10g-m	22.49f-k	52.59e-r	9.61e-k	4.72bcd	14.33d-ı	
35	**PI 368699**	**Edar**	**Macedonia**	34b-g	30.08qrs	21.80ı-l	25.94opq	12.83abc	7.40j-p	10.12b-p	89bcd	26.62h-m	6.93q-u	33.55k-r	4.64m-t	0.87k-p	5.51p-u	0.37g-m
36	**PI 368700**	**Edar**	**Macedonia**	53a	34.00o-s	32.00d-l	33.00ı-q	10.00a-h	8.90h-p	9.45d-r	95abc	36.20f-m	21.06g-l	57.26e-p	5.62j-s	2.08f-l	7.7m-p	
37	**PI 379412**	**Krupen bel**	**Macedonia**	35b-g	58.03bcd	34.60d-k	46.31a-ı	9.57b-h	12.40c-ı	10.99b-l	81cd	70.10b-f	14.82I-r	84.92c-g	11.73def	4.52b-e	16.25c-e	0.56c-ı
38	**PI 379414**	**Bel kripen**	**Macedonia**	44abc	56.00cde	30.00d-l	43.00a-m	10.00a-h	14.80bcd	12.40b-f	86bcd	9.68lm	3.26tu	12.94qr	1.81r-u	0.39op	2.2vyz	0.04m-m
39	**PI 414193**	**B 49939**	**USA/Maryland**	33b-g	32.14p-s	27.78g-l	29.96l-q	10.20a-h	6.70l-q	8.45h-r	88bcd	23.02I-m	11.7l-u	34.72k-r	3.39o-u	0.92j-p	4.31q-y	0.42f-l
40	**PI 414194**	**B 49926**	**USA/Maryland**	47ab	51.00d-k	22.00ı-l	36.50g-p	10.00a-h	14.00cde	12.00b-g	82bcd	11.69klm	2.58u	14.27pqr	0.93tu	0.34op	1.27yz	
41	**PI 414195**	**B 19927**	**USA/Maryland**	40a-g	52.50d-h	39.00c-ı	45.75a-k	10.40a-h	13.50c-f	11.95b-h	81cd	25.38h-m	7.61p-u	32.99k-r	3.06o-u	0.86k-p	3.92r-z	0.52e-j
42	**PI 414196**	**B 49928**	**USA/Maryland**	25efg	28.00rst	25.67h-l	26.83n-q	8.50b-h	13.33c-g	10.92b-l	87bcd	22.8I-m	10.77m-u	33.58k-r	5.74ı-r	1.59h-p	7.33n-q	0.23ı-m
43	**PI 414197**	**B 49929**	**USA/Maryland**	23g	52.70d-h	39.10c-ı	45.90a-j	12.10a-f	9.40g-o	10.75b-m	73d	61.62b-h	40.21bc	101.83bcd	9.64e-j	6.07b	15.71d-g	0.3ı-m

Table 4. Morphological traits of basil genotypes in 2018.

44	**PI 414199**	**B 49931**	**USA/Maryland**	32b-g	49.60d-l	28.71e-l	39.16e-p	9.80a-h	10.40e-m	10.10b-p	83bcd	76.46bc	15.32I-q	91.78b-e	11.01d-h	1.97f-n	12.98f-j	0.22ı-m
45	**PI 414200**	**B 49932**	**USA/Maryland**	48ab	54.00c-g	38.00c-j	46.00a-j	12.00a-f	20.00a	16.00a	82bcd	12.21klm	5.17q-u	17.39o-r	2.13p-u	0.45nop	2.58uz	0.23ı-m
46	**PI 531396**	**1420**	**Hungary**	32b-g	64.00abc	45.00b-g	54.50a-e	8.00c-h	9.00h-p	8.50g-r	87bcd	15.77j-m	4.61r-u	20.39n-r	0.08u	0.92j-p	1.00z	
47	**PI 652054**	**Mrs. Burns Lemon Basil**	**USA/Mexico**	44abc	43.00h-o	31.75d-l	37.38f-p	7.33e-h	18.67ab	13.00abc	88bcd	26.33h-m	12.97k-t	39.3h-r	5.11l-s	1.67g-p	6.78n-r	0.35g-m
48	**PI 652065**	**Genovese**	**Italia/Veneto**	29c-g	45.00g-n	38.00c-j	41.50b-n	7.60d-h	7.60j-p	7.60l-r	88bcd	39.42c-m	7.97o-u	47.39f-r	5.42l-s	0.65l-p	6.07n-t	0.48e-k
49	**PI 652070**	**Sweet basil**	**USA/Pennsylvania**	35c-g	58.60bcd	38.57c-ı	48.59a-h	12.10a-f	7.00k-q	9.55c-r	81cd	64.71b-g	17.52h-p	82.22c-h	8.68f-m	2.41f-k	11.09jkl	0.2j-m
50	**PI 652071**	**Dark Opal**	**USA/California**	26d-g	34.10o-s	26.50h-l	30.30k-q	10.60a-h	12.80c-h	11.70b-ı	93a-d	39.10d-m	32.33c-f	71.43c-l	7.53g-n	5.65b	13.18e-j	0.67b-h
			Average	34.00	47.82	34.21	41.02	9.91	9.74	9.83	87.32	41.13	18.23	59.36	6.68	2.38	9.06	0.51
			Minimum	23.00	18.00	16.10	19.00	6.00	3.28	6.14	73.00	5.57	2.58	9.73	0.08	0.27	1.00	0.04
			Maximum	53.00	71.90	64.90	58.10	14.90	20.00	16.00	110.00	239.64	54.41	274.11	22.91	8.33	27.49	1.07
			LSD (5%)	17.10	16.08	17.63	15.47	5.20	4.07	3.51	20.07	37.30	10.21	43.89	4.07	1.56	3.12	0.36
			CV (%)	23.56	18.61	33.54	22.26	30.48	33.95	24.20	9.46	47.48	52.79	44.82	30.71	48.97	48.97	24.85
			Standart devision	8.66	12.11	9.98	9.67	2.09	3.59	2.23	7.06	37.40	13.54	44.83	4.60	2.00	5.61	0.27

GD: Germination day, FHPH: First Harvest Plant Height, SHPH: Second Harvest Plant Height, APH: Average Plant Height, FHNB: First Harvest Number of Branch, SHNB: Second Harvest Number of Branch, ANB: Average Number of Branch, DFT: Days to Flowerinf Time, FHW 1: Fresh Herb Weight 1, FHW 2: Fresh Herb Weight 2, TFHW: Total Fresh Herb Weight, DHW 1: Dry Herb Weight 1, DHW 2: Dry Herb Weight 2, THDW: Total Dry Herb Weight, EO: Essential Oil

3.5. Correlation analysis and principal component analysis

Correlation analysis assists in selecting the effective properties in order to an indirect selection of superior genotypes. In addition to this, principal component analysis is an appropriate multivariate technique to identify and assessment of independent principle components depending on influential plant characteristics. These two analysis methods contribute to the plant breeding program to help breeders [68,69].

3.5.1. Correlation analysis of basil genotypes

The assessment of correlation analysis values among the all examined properties for 2017 and 2018 years were shown in table 5 and table 6. This analysis was conducted to determine the relationship among the examined properties in 2017 and 2018 years. There was found 27 positives and one negative correlations totally which out of the 17 highly significant and positive correlations were observed between r=0.328-0.926, 8 positive correlations were seen between r= 0.273-0.320 and only one negative correlation was found between GD and FHW 2 with r=-0.325 in the 2017 year (Table 5). The highest positive correlation was noted between the PHPH and APH with r=0.926. Other high positive correlations were found between the FHPH and SHPH, FHW 1, TFHW and TDHW. Similarly, SHPH had positive correlation with APH. APH had recorded positive correlated with FHW 1 and TFHW. NB had only one correlation with DFT (r=0.547). FHW 1 correlated with TFHW, DHW and TDHW. FHW2 correlated with TFHW, DHW 2 and TFHW correlated with DHW 1, TDHW and EO. DHW1 had only one correlation with TDHW (r=0.822). Positive correlations also were obtained between the FHPH and DHW 1, and SHPH was found positive correlation with FHW1 and TFHW. DFT was found correlation with DHW 2. FHW 1 and FHW 2 had correlation with EO and DHW2 correlated with TDHW (r=0.274). EO of basil genotypes was correlated only fresh weight among the examined properties and most of correlations were found in yield properties fresh and dry weight in 2017 year.

Forty-three correlations were found among the 15 examined properties in fifty basil genotypes as positive and negative in 2018 year. 26 high significant positive, 4 high significant negative, 7 positive and 6 negative correlations were obtained in correlation analysis of 2018 year. According to GD headings, data had a highly significant negative correlation with FHW 2 (r=-0.463) and DHW2 (r=-0.411) and positive correlation with DFT (r=0.354). Concerning to FHPH, data showed highly significant positive correlation with SHPH, APH, FHW 1 and TFHW with r=0.548, 0.886, 0.428, 0.414, respectively. It also gave positive correlation with DHW (r=0.345) and TDHW (r=0.341). As for SHPH, it showed highly significant positive correlation coefficient with APH (r=0.855), FHW 2 (r=0.498) and DHW 2 (r=0.537) while recorded negative correlation with DFT (r=0.341). Regarding APH, it showed a correlation with DFT (r=-0.337) as negatively and FHW 1 (r=0.335) and TDHW (r=0.332) as positively. Moreover, it gave highly significant positive correlation with FHW 2 (r=0.365), TFHW (r=0.389) and DHW 2 (r=0.383). FNB had one highly significant positive correlation with ANB (r=0.61) and one positive correlation with FHW2 with r=0.282. Although SNB showed a negative correlation with DFT and EO with r=-0.361 and r=-0.339, respectively, it had highly significant positive correlation with ANB (r=0.883). ANB had highly significant negative correlation with DFT (r=-0.382) and negative correlation with EO (r=-0.302). DFT had highly significant negative correlation with FHW 2 (r=-0.367) and negative correlation with DHW2 (r=-0.352). It also showed positive correlation coefficient with EO (r=0.3). Highly significant positive correlations were obtained for FHW 1 with FHW 2, TFHW, DHW 1, DHW 2 and TDHW with r=0.44, 0.961, 0.801, 0.378 and 0.791, respectively. FHW 2 had highly significant positive correlation with other yield values as TFHW (r=0.671), DHW 1 (r=0.369), DHW 2 (r=0.798) and TDHW (r=0.57). TFHW showed highly significant and positive correlation with DHW 1, DHW 2 and TDHW with r=0.775, 0.558 and 0.828, respectively. DHW 1 had highly significant positive correlation with DHW2 (r=0.382) and TDHW (r=0.951). At the same time, DHW 2 was also recorded as highly significant positive correlation with TDHW (r=0.646).

Table 5. Correlation analysis among the examined properties of basil genotypes in 2017.

	GD (days)	FHPH (cm)	SHPH (cm)	APH (cm)	NB (no $plant^{-1}$)	DFT (days)	FHW 1 (g $plant^{-1}$)	FHW 2 (g $plant^{-1}$)	TFHW (g $plant^{-1}$)	DHW 1 (g $plant^{-1}$)	DHW 2 (g $plant^{-1}$)	TDHW (g $plant^{-1}$)	EO (%)
GD (days)	1	-0.045	-0.116	-0.13	0.178	0.224	0.101	-0.325*	-0.037	0.143	-0.193	0.17	0.075
FHPH (cm)	-0.045	1	0.703**	0.926**	0.126	-0.128	0.368**	0.123	0.367**	0.32*	0.097	0.328**	0.008
SHPH (cm)	-0.116	0.703**	1	0.91**	0.068	-0.116	0.285*	0.176	0.315*	0.234	0.128	0.209	0.049
APH (cm)	-0.13	0.926**	0.91**	1	0.083	-0.138	0.348**	0.2	0.379**	0.274*	0.139	0.277*	0.051
NB (no $plant^{-1}$)	0.178	0.126	0.068	0.083	1	0.547**	-0.019	0.01	-0.013	0.045	0.167	0.076	0.063
DFT (days)	0.224	-0.128	-0.116	-0.138	0.547**	1	-0.076	0.188	0.006	-0.06	0.293*	0.044	0.148
FHW 1 (g $plant^{-1}$)	0.101	0.368**	0.285*	0.348**	-0.019	-0.076	1	0.146	0.925**	0.888**	0.012	0.696**	0.312*
FHW 2 (g $plant^{-1}$)	-0.325*	0.123	0.176	0.2	0.01	0.188	0.146	1	0.51**	0.069	0.617**	0.155	0.273*
TFHW (g $plant^{-1}$)	-0.037	0.367**	0.315*	0.379**	-0.013	0.006	0.925**	0.51**	1	0.799**	0.246	0.665**	0.376**
DHW 1 (g $plant^{-1}$)	0.143	0.32*	0.234	0.274*	0.045	-0.06	0.888**	0.069	0.799**	1	0.089	0.822**	0.244
DHW 2 (g $plant^{-1}$)	-0.193	0.097	0.128	0.139	0.167	0.293*	0.012	0.617**	0.246	0.089	1	0.274*	0.155
TDHW (g $plant^{-1}$)	0.17	0.328**	0.209	0.277*	0.076	0.044	0.696**	0.155	0.665**	0.822**	0.274*	1	0.043
EO (%)	0.075	0.008	0.049	0.051	0.063	0.148	0.312*	0.273*	0.376**	0.244	0.155	0.043	1

*5%, **1%; GD: Germination day, FHPH: First Harvest Plant Height, SHPH: Second Harvest Plant Height, APH: Average Plant Height, NB: Number of Branch, DFT: Days to Flowerinf Time, FHW 1: Fresh Herb Weight 1, FHW 2: Fresh Herb Weight 2, TFHW: Total Fresh Herb Weight, DHW 1: Dry Herb Weight 1, DHW 2: Dry Herb Weight 2, THDW: Total Dry Herb Weight, EO: Essential Oil

Table 6. Correlation analysis among the examined properties of basil genotypes in 2018.

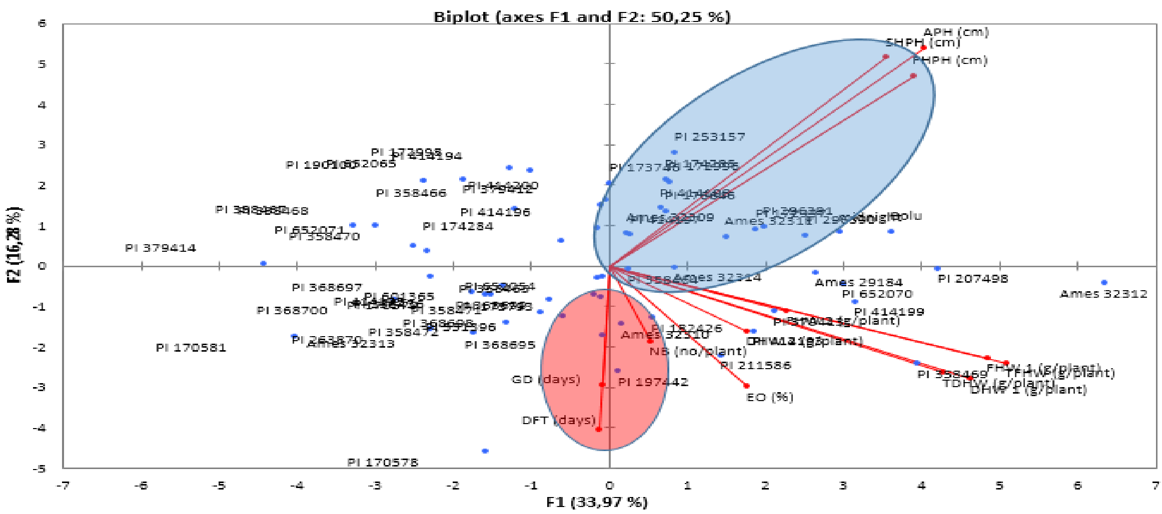
	GD (days)	FHPH (cm)	SHPH (cm)	APH (cm)	FNB (no $plant^{-1}$)	SNB (no $plant^{-1}$)	ANB (no $plant^{-1}$)	DFT (day)	FHW 1 (g $plant^{-1}$)	FHW 2 (g $plant^{-1}$)	TFHW (g $plant^{-1}$)	DHW 1 (g $plant^{-1}$)	DHW 2 (g $plant^{-1}$)	TDHW (g $plant^{-1}$)	EO (%)
GD (days)	1	-0.053	-0.211	-0.139	-0.047	0.237	0.168	0.354*	-0.05	-0.463**	-0.184	0.033	-0.411**	-0.116	-0.019
FHPH (cm)	-0.053	1	0.548**	0.886**	0.011	0.066	0.058	-0.223	0.428**	0.197	0.414**	0.345*	0.179	0.341*	-0.234
SHPH (cm)	-0.211	0.548**	1	0.855**	0.008	-0.05	-0.036	-0.341*	0.126	0.498**	0.258	0.065	0.537**	0.23	-0.142
APH (cm)	-0.139	0.886**	0.855**	1	-0.015	0.029	0.016	-0.337*	0.335*	0.365**	0.389**	0.252	0.383**	0.332*	-0.257
FNB (no $plant^{-1}$)	-0.047	0.011	0.008	-0.015	1	0.167	0.61**	-0.193	0.14	0.282*	0.202	0.204	0.156	0.209	-0.061
SNB (no $plant^{-1}$)	0.237	0.066	-0.05	0.029	0.167	1	0.883**	-0.361*	0.152	0.012	0.129	0.068	0.029	0.059	-0.339*
ANB (no $plant^{-1}$)	0.168	0.058	-0.036	0.016	0.61**	0.883**	1	-0.382**	0.189	0.144	0.2	0.152	0.097	0.147	-0.302*
DFT (day)	0.354*	-0.223	-0.341*	-0.337*	-0.193	-0.361*	-0.382**	1	-0.091	-0.367**	-0.189	0.061	-0.352*	-0.057	0.3*
FHW 1 (g $plant^{-1}$)	-0.05	0.428**	0.126	0.335*	0.14	0.152	0.189	-0.091	1	0.44**	0.961**	0.801**	0.378**	0.791**	-0.068
FHW 2 (g $plant^{-1}$)	-0.463**	0.197	0.498**	0.365**	0.282*	0.012	0.144	-0.367**	0.44**	1	0.671**	0.369**	0.798**	0.57**	-0.021
TFHW (g $plant^{-1}$)	-0.184	0.414**	0.258	0.389**	0.202	0.129	0.2	-0.189	0.961**	0.671**	1	0.775**	0.558**	0.828**	-0.063
DHW 1 (g $plant^{-1}$)	0.033	0.345*	0.065	0.252	0.204	0.068	0.152	0.061	0.801**	0.369**	0.775**	1	0.382**	0.951**	-0.102
DHW 2 (g $plant^{-1}$)	-0.411**	0.179	0.537**	0.383**	0.156	0.029	0.097	-0.352*	0.378**	0.798**	0.558**	0.382**	1	0.646**	-0.073
TDHW (g $plant^{-1}$)	-0.116	0.341*	0.23	0.332*	0.209	0.059	0.147	-0.057	0.791**	0.57**	0.828**	0.951**	0.646**	1	-0.103
EO (%)	-0.019	-0.234	-0.142	-0.257	-0.061	-0.339*	-0.302*	0.3*	-0.068	-0.021	-0.063	-0.102	-0.073	-0.103	1

*5%, **1%; GD: Germination day, FHPH: First Harvest Plant Height, SHPH: Second Harvest Plant Height, APH: Average Plant Height, FHNB: First Harvest Number of Branch, SHNB: Second Harvest Number of Branch, ANB: Average Number of Branch, DFT: Days to Flowerinf Time, FHW 1: Fresh Herb Weight 1, FHW 2: Fresh Herb Weight 2, TFHW: Total Fresh Herb Weight, DHW 1: Dry Herb Weight 1, DHW 2: Dry Herb Weight 2, THDW: Total Dry Herb Weight, EO: Essential Oil

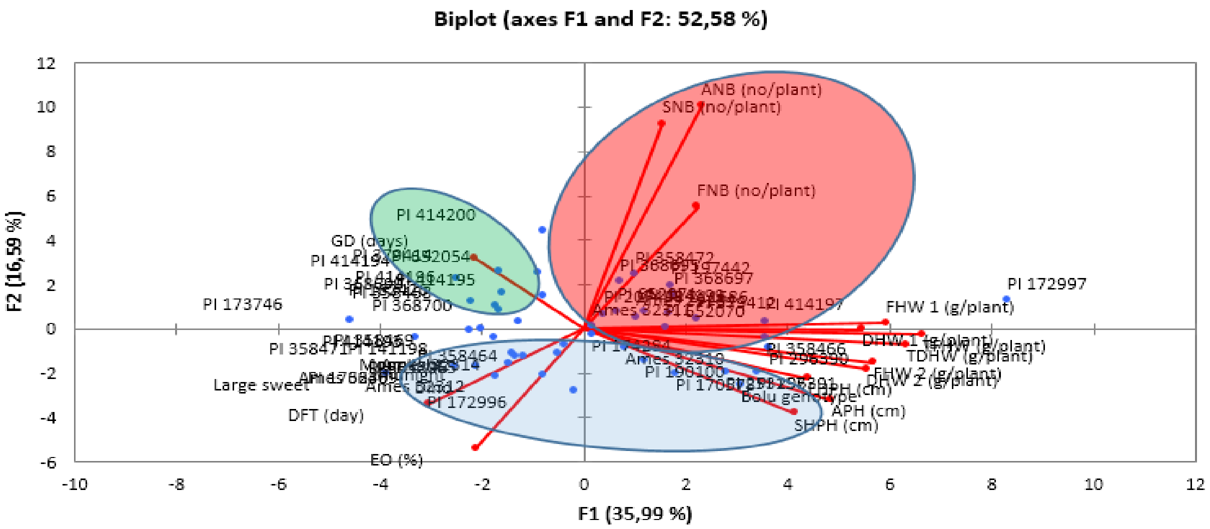
3.5.2. Principal component analysis (PCA) of basil genotypes

PCA analysis carried out to separate the number of highly diverse genotypes of basil to support the breeders in crossing and selection breeding successful programs. Thus, prominent genotypes can be used as good parents in development programs of basil [70].

All basil morphological properties were evaluated together with in figure 1a and 1b for 2017 and 2018 years, respectively. PCA showed PC1 accounted for 33.97% of variation with GD, NB, DFT, FHW1, FHW2, DHW1, DHW2, TFHW and EO in 2017 year. FHW1, FHW2 and TFHW were the major factors for PC1. These properties were found closely on the same side of loading factor. PC2 showed 16.28% as an accounted and it had FHPH, SHPH and APH properties. PHPH was the major factors for PC2. PCA had 52.58% as totally in 2018. PC1 accounted for 35.99% of variation with FHW1 and DHW1 being the major factors. PC2 accounted for 16.59% variation with GD being the major contributor. FNB, SNB and ANB located on the same side of plot loading and DFT and EO located opposite side of these properties.



a



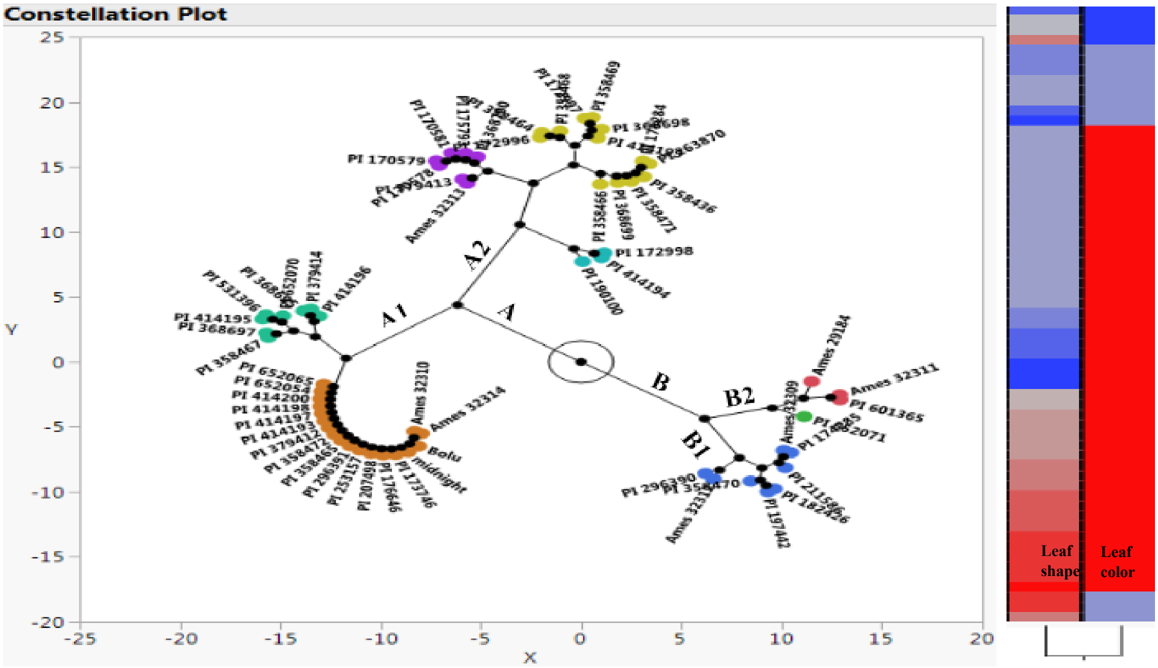
b

Figure 1. PCA analysis of basil genotypes in 2017 (a) and 2018 (b).

3.5.3. Genetic diversity of basil genotypes

It was reported that plant properties depending on UPOV descriptor are highly heritable and reliable for the first classification of genotypes into different morphotypes. Morphological markers ensure a simple and cheap method for routine screening of many of genotypes to identify morphotypes and manage the germplasm collection of plants [16]. For this reason, a hierarchical cluster analysis (HCA) was performed to get the best classification depending on leaf color and leaf shape for 2017 and UPOV criteria by using the 2018 data. We selected the agglomeration method by using the Ward method for 2018. Constellation plot provided the best results to discrimination of genetic diversity among the basil cultivars and genotypes (figure 2a, b). The constellation plot showed the genetic diversity among the 61 basil genotypes in 2017 (figure 2a). This plot was divided two main groups as A and B. These main groups also divided two sub-groups as A1, A2, B1 and B2. The most of the basil genotypes (49 genotypes) located in group A. The sub-group A1 had the most genotypes (26 genotypes) including Bolu genotype and midnight cultivarcompared to sub-group A2. Twenty-three genotypes located in sub-group A2. The main gropu B included 12 basil genotypes and B1 sub-group had 8 basil genotypes and B2 had only 4 genotypes. B group (B1 and B2 sub-groups) showed differences depending on leaf color than A group (A1 and A2). In experiment 2018 depending UPOV criteria, constellation plot had genetic differences among the 50 basil genotypes in 2018. This plot was also split the two main groups as A and B. These groups were also divided into two main subgroups as A1, A2, and B1 and B2. The first group (group A) had 17 genotypes (two cultivars and 15 basil genıotypes). The subgroup A1 had two cultivars (dino and moonlight) and one genotype and subgroup A2 had 14 genotypes. The second group (group B) had 33 genotypes including two cultivars. The subgroup B1 had two basil cultivars (midnight and large sweet) and 16 genotypes and subgroup B2 had 15 basil genotypes. The constellation plot consisted of 6 clusters and group A had two clusters as C1 and C2, and group B had four clusters as C3, C4, C5 and C6. Basil cultivars took place three different clusters as C1, C3 and C4. Group A2 or C2 had the highest basil genotype counts as well as group A1 or C1 had the lowest basil genotype counts (Figure 2b). 7, 11, 47 basil cultivars and genotype located in group A1 and they showed differences in terms of SH compared the other genotypes. C6 had differences based on PL and FSLI and this cluster took place in different part. It was determined that PH, LBPCS and LBSM properties had no effect to separation the genetic diversity of basil genotypes. These properties were found similar in all basil genotypes.

Carovic-stanko et al. [16] conducted a study on 27 morphological properties of basil genotypes. It was reported that 46 *Ocimum basilicum* genotypes were divided to 6 clusters depending on 25 morphological properties and same leaf color located different place in dendrogram analysis. Our 2017 and 2018 experimental results showed similar with previous literature.



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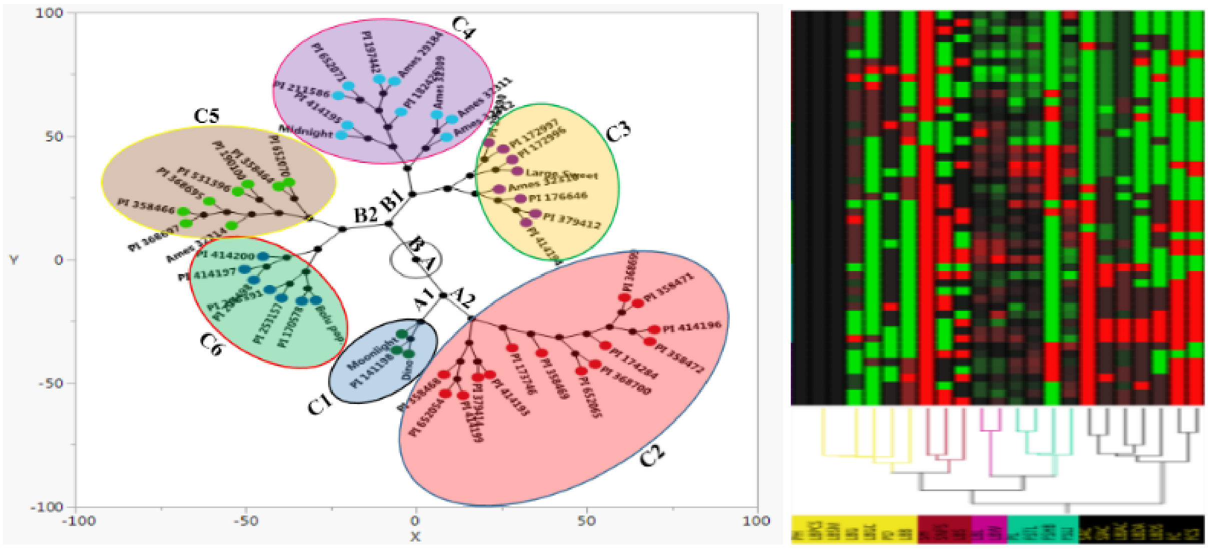

b

Figure 2. Constellation plot pf basil genotypes (a: 2017 genotypes, b: 2018 genotypes)

4. Conclusions

On the influence of different genotypes on *Ocimum basilicum* morphology, yield and essential oil values was provided in this study. All morphological parameters evaluated were affected by different *Ocimum basilicum* genotypes. Sizeable variation was observed between individual genotypes which was predominantly due to differences in essential oil and herb yield, and the prospect of selectively breeding for this novel trait. Correlation analysis and PCA showed differences in each year. There was found correlation between yield component and essential oil content in 2017, however in 2018, there was not correlation between these treatments. PCA had totally over than 50% in 2017 and 2018 years. The constellation plot showed genetic diversity and variation appeared depending on leaf shape and color in 2017 and UPOV criteria in 2018. The overall the results of this study was suggested that PI 652070 and PI 296391 genotypes had the highest herbs yield. In addition, PI 358469 and Ames 32309 genotypes had the highest essential oil content. So, genotypes of this later group might be good parents to be used in improvement programs of basil.

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