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SOME AGRONOMIC AND QUALITY CHARACTERISTICS OF TWO *Achillea asplenifolia* Vent. POPULATIONS

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ABSTRACT

The genus of *Achillea* L. consists of herbaceous plants are generally distributed in the northern hemisphere. *Achillea asplenifolia* and *Achillea collina* are the most important group of *A. millefolium* due to their highly effective pharmacological properties. Both species, *A. asplenifolia* and *A. collina* are distributed in the Europen flora but they don't exist in the Turkish flora. The present study aimed to determine some yield and quality characteristics of two populations, *Achillea asplenifolia* - 9602 and *Achillea asplenifolia* – 10403, belonging to *Achillea asplenifolia* Vent. collected from the flora of Bulgaria at Bornova and to select genotypes with high yield and quality. For this purpose a two years of field experiment was conducted in 2009 and 2010. Plant height (cm), green herbage yield (g/plant), drug herbage yield (g/plant), drug flos yield (g/plant) and essential oil content of populations were determined. Based on the results of two years of experiment minimum and maximum drug flos yield were 2 g/plant and 391.4 g/plant in *Achillea asplenifolia* - 9602. Essential oil rate ranged between 0.050-3.30%. Minimum and maximum drug flos yield of *Achillea asplenifolia* (10403) were 0 and 159.8 g/plant respectively and essential oil content ranged between 0-2.5%. A large distribution was found in both population of *Achillea asplenifolia* and especially population *Achillea asplenifolia* - 9602 was more remarkable and promising for selection studies.

Keywords: *Achillea asplenifolia*, essential oil, population

INTRODUCTION

Yarrow (*Achillea* spp.) is widespread and widely used as medicinal plants in the world. The genus *Achillea* (Compositae or Asteracea) had over 100 species worldwide, mainly distributed in the northern hemisphere. The genus *Achillea* is a group of hardly distinguishable species and subspecies. Many components derived from *Achillea* species are highly bioactive (Boskovic et al 2005; Si et al., 2006; Bocevska and Sovova, 2007; Mockute and Judzentiene, 2010; Applequist and Moerman, 2011). The most important species belong to this group is *A. millefolium*. The group is polyploidy and contains diploid and octoploid species. The group of the *Achillea millefolium* is represented with seven species as *Achillea setacea*, *Achillea asplenifolia*, *Achillea rosea-alba*, *Achillea collina*, *Achillea pratensis*, *Achillea millefolium* and *Achillea pannonica* (Rehus and Neugebauerova, 2011). The first agronomical research on these species was conducted by Bayram et al. (2013) in Turkey. They demonstrated that active principles of the species include flavonoids, volatile oils and proazulens. These entire components have been found in *A. asplenifolia*, *A. rosea-alba* and *A. collina* species (Wawrosch et al., 1994). *Achillea asplenifolia* is one of three central European diploid species. It grows in the Czech Republic, Slovakia, Austria, Hungary, Croatia, Serbia, Romania and Bulgaria (Danihelka, 2003; Konakchiev et al., 2005) *Achillea asplenifolia* and *Achillea collina* species which is not existed in the flora of Turkey, can accumulate proazulens. These species are very important for pharmacology and others different purposes due to their proazulene-rich chemical properties.

Achillea species are rarely cultivated under field conditions and there are limited cultivars developed for intensive agricultural systems in the world. Although some studies have previously reported responses of *Achillea* species to main agricultural inputs such as nitrogen (Tatar et al., 2013) and water (Tatar et al., 2016), there are still limited information for under field conditions. On the other hand, new field-adapted proazulen rich varieties need to be developed to improve cultivation of *Achillea* species.

The aim of this study was to select the superior genotypes of *Achillea asplenifolia* for essential oil rate and some others important agronomical traits. We hope that the results of this study could lead to further breeding works on species of *Achillea asplenifolia*.

MATERIALS AND METHODS

Two *Achillea asplenifolia* populations coded as 9602 and 10403 were used in this study. The plant materials were obtained from the Bulgarian Academy of Science (BAS), Institute of Botany. The seeds were sown into the seedbed containing mixture of sand, manure and mulch (1:1:1) in 01.01.2008. Then the seedlings were transplanted to the field (40×30 cm) in 17.04.2009. Each plot had 14 rows and each row containing 19 plants for each populations. Both populations contained 532 different plants. Plants were grown on experimental field of the Field Crops Department, Faculty of Agriculture, Ege University in Izmir-Turkey during the 2008–2009 and 2009-2010 growing seasons. Izmir has typical Mediterranean climate conditions in the western Turkey. Monthly (2009 and 2010) and long term data such as air temperature (°C), humidity (%) and rain amount (mm) in experimental site are shown in Fig 1. Soil texture of the experimental field was generally composed of clay. The first 20 cm of soil were silt-clay with pH of 8.2 while soil of 20-40 cm deep was clay-loamy with pH of 7.8 in experimental area (Sonmez, 2008).

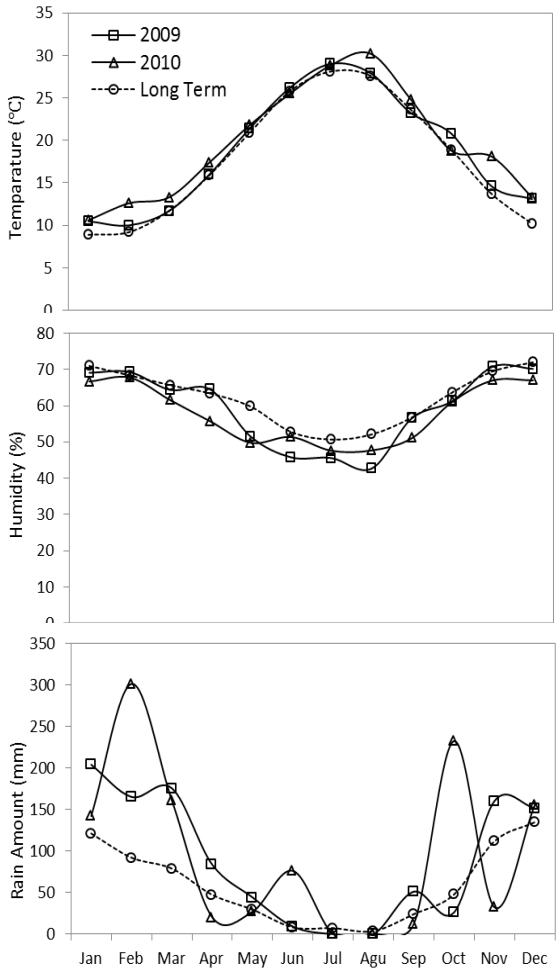

Figure 1. Means of monthly (2009 and 2010) and long term air temperature (°C), humidity (%) and rain (mm) in the experimental site.

Weeds were eliminated by hand. The soil moisture content was kept around the field capacity using with drip irrigation system. Approximately 250 plants were harvested 5 cm above the soil surface at the flowering stage, twice in 2009 and once in 2010 (Table 1). Flower (flos), leaves and stems of the plants were separated and dried at 35°C. Then fresh herbage yield, drug herbage yield, fresh flos yield and drug flos yield of each plant were determined. Dry flos materials (10 g) were subjected to a 3-h water-distillation using a Neo-Clevenger apparatus. Essential oil ratios of the plants were determined as volumetric (ml/100 g) (Wichtl, 1971).

Table 1. Harvesting dates of two populations belonging to *Achillea asplenifolia* in 2009 and 2010

Populations	2009		2010	
	I. Harvest	II. Harvest	I. Harvest	II. Harvest
Achillea asplenifolia - 9602	6 July	11 August	29 June	-
Achillea asplenifolia - 10403	19 June	11 August	11 June	19 August

RESULTS AND DISCUSSION

Population Achillea asplenifolia - 9602

The plants of *Achillea asplenifolia* - 9602 population's minimum, maximum and average values are shown in Table 2. The findings indicated that all parameters in 2010 were higher than 2009. The average plant height was found for 47.5 cm in 2009 and 82.9 cm in 2010. Mean of fresh herbage yield ranged between 229.8 g/plant and 443.0 g/plant in 2009 and 2010 respectively. The average drug herbage yield was 80.9 g/plant in 2009 and 176.30 g/plant in 2010. The maximum fresh flos yield was 285.2 g/plant while minimum was 14.4 g/plant in the first year whereas maximum value was 869.6 g/plant while minimum was 3.5 g/plant in the second year. The average essential oil content of the *Achillea asplenifolia* (9602) was 0.40 % in 2009 and 0.64 % in 2010.

Table 2. Means, maximum and minimum and C.V. values of *Achillea asplenifolia* - 9602. Based on Sample Size of 266 plants in 2009 and 191 plants in 2010.

	2009					
	Plant height (cm)	**Fresh herbage yield (g/plant)**	**Drug herbage yield (g/plant)**	**Fresh flos yield (g/plant)**	**Drug flos yield (g/plant)**	**Essential oil rate (%)**
Maximum	75.1	499.1	167,6	285.2	98.3	1.275
Minimum	27.5	19.2	7.4	14.4	6.1	0.075
Mean	47.5	229.8	80,9	142	48	0.400
CV (%)	13.9	53.3	30.4	33.8	33.1	45.8
	2010					
	Plant height (cm)	**Fresh herbage yield (g/plant)**	**Drug herbage yield (g/plant)**	**Fresh flos yield (g/plant)**	**Drug flos yield (g/plant)**	**Essential oil rate (%)**
Maximum	110	1655.4	891.6	869.6	391.4	3.300
Minimum	44	6.61	2.5	3.5	2	0.050
Mean	82.9	443	176.3	201,2	73.7	0.640
CV (%)	15.2	65.2	69.8	66.3	71.2	50.1

Frequency distributions of plant height, drug herbage yield, drug flos yield and essential oil ratio for *Achillea asplenifolia* - 9602 population are given Table 3. The plant height varied between 28.0 and 75.0 cm in 2009 and varied between 44.0 and 101.0 cm in 2010. In the first year, 78.2% of drug herbage yield of the population ranged between 55.3-119.7 g. The 94.2% of the population had drug herbage yield between 89.2 g/plant and 356.6 g/plant in 2010. Drug flos yield is widely accepted as one of the most important traits for plant breeders. In the present study, drug flos yield of *Achillea asplenifolia* - 9602 varied between 9.8 and 98.0 g/plant in 2009 while ranged from 39.1 to 391.4 g in 2010. In 2009, 79.3% of drug flos yield of the population were between 29.4 and 68.6 g/plant, this was the largest group in the population in 2009. On the other hand, the largest group (86.4%) for drug flos yield ranged from 0 to 117.4 g/plant in 2010. Essential oil content is another important character for medicinal and aromatic plants. It is a primary quality indicator of the yield. Essential oil ratio per plant ranged from 0.075 to 1.27% in the first year of experiment and 88.7 % of the genotypes contained essential oil between 0.075-0.554%. In the second year, essential oil ratio varied between 0 and 3.3% and 90.1% of the population had essential oil ratio between 0 and 0.99% in the second year.

Table 3. Frequency distributions of plant height, drug herbage yield, drug flos yield and essential oil of *Achillea asplenifolia* - 9602

Plant Heigt (cm)						
	2009			2010		
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	28.000-32.699	6	2.256	0.000-10.999	0	0
2	32.700-37.399	34	12.782	11.000-21.999	0	0
3	37.400-42.099	51	19.173	22.000-32.999	0	0
4	42.100-46.799	45	16.917	33.000-43.999	0	0
5	46.800-51.499	43	16.165	44.000-54.999	4	2.094
6	51.500-56.199	37	13,91	55.000-65.999	17	8.901
7	56.200-60.899	25	9.398	66.000-76.999	35	18.325
8	60.900-65.599	17	6.391	77.000-87.999	70	36.649
9	65.600-70.299	5	1.88	88.000-98.999	44	23037
10	70.300-74.999	3	1.128	99.000-109.999	21	10.995
Drug HerbageYield (g/plant)						
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	7.000-23.099	3	1.128	0.000-89.159	44	23.037
2	23.100-39.199	14	5.263	89.160-178.319	55	28.796
3	39.200-55.299	22	8.271	178.320-267.479	56	29.319
4	55.300-71.399	60	22.556	267.480-356.639	25	13.089
5	71.400-87.499	71	26.692	356.640-445.799	7	3.665
6	87.500-103.599	44	16.541	445.800-534.959	1	0.524
7	103.600-119.699	33	12.406	534.960-624.119	1	0.524
8	119.700-135.799	10	3.759	624.120-713.279	0	0
9	135.800-151.899	6	2.256	713.280-802.439	1	0.524
10	151.900-167.999	3	1.128	802.440-891.599	1	0.524
Drug Flos Yield (g/plant)						
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	0.000-9.799	2	0.755	0.000-39.139	51	26.702
2	9.800-19.599	6	2.264	39.140-78.279	64	33.508
3	19.600-29.399	21	7.925	78.280-117.419	50	26.178
4	29.400-39.199	52	19.623	117.420-156.559	16	8.377
5	39.200-48.999	62	23.396	156.560-195.699	5	2.618
6	49.000-58.799	61	23.019	195.700-234.839	3	1.571
7	58.800-68.599	35	13.208	234.840-273.979	0	0
8	68.600-78.399	15	5,66	273.980-313.119	1	0.524
9	78.400-88.199	8	3.019	313.120-352.259	0	0
10	88.200-97.999	3	1.132	352.260-391.399	1	0.524
Essential Oil Rate (%)						
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	0.075-0.194	38	14.286	0.000-0.329	20	10.471
2	0.195-0.314	71	26.692	0.330-0.659	97	50.785
3	0.315-0.434	73	27.444	0.660-0.989	55	28.796
4	0.435-0.554	54	20.301	0.990-1.319	15	7.853
5	0.555-0.674	21	7.895	1.320-1.649	3	1.571
6	0.675-0.794	5	1.88	1.650-1.979	0	0
7	0.795-0.914	1	0.376	1.980-2.309	0	0
8	0.915-1.034	1	0.376	2.310-2.639	0	0
9	1.035-1.154	1	0.376	2.640-2.969	0	0
10	1.155-1.274	1	0.376	2.970-3.299	1	0.524

Population Achillea asplenifolia - 10403

Plant height, fresh herbage yield, drug herbage yield, fresh flos yield, drug flos yield and essential oil rate of *A. asplenifolia* – 10403 population are presented in Table 4. The values in Table 4 indicated that all parameters were higher in 2010 than those of in 2009. The mean of plant height was 41.2 cm in 2009 and 66.9 cm in 2010. Fresh and drug herbage yields were 143.0 g/plant and 48.3 g/plant respectively in the first year. For the second year they were 228.8 g/plant and 83.6 g/plant respectively. In the first year, fresh and drug flos yield of the genotypes were 53.3 g/plant and 18.6 g/plant while 113.5 g/plant and 40.1 g/plant in the second year respectively. As a very

important yield component of *Achillea asplenifolia*, drug flos yield reached to maximum value (159.8 g/plant) in 2010 and minimum (2.9 g/plant) in 2009. The average essential oil rates of the genotypes were 0.30% in 2009 and 0.42% in 2010. However, variation in the essential oil rate of the population increased and reached maximum at 2.5% in 2009 growing season.

Table 4. Means, maximum and minimum and C.V. values of *Achillea asplenifolia* - 10403. Based on Sample Size of 261 plants in 2009 and 237 plants in 2010.

	2009					
	Plant height (cm)	**Fresh herbage yield (g/plant)**	**Drug herbage yield (g/plant)**	**Fresh flos yield (g/plant)**	**Drug flos yield (g/plant)**	**Essential oil rate (%)**
Maximum	62	449.6	148.2	189.1	45	2.500
Minimum	22.5	12.9	5.1	5.9	2.9	0.000
Mean	41.2	143	48.3	53.3	18.6	0.300
CV (%)	11.2	61.4	33.4	47.6	42.7	69
	2010					
	Plant height (cm)	**Fresh herb yield (g/plant)**	**Drug herb yield (g/plant)**	**Fresh flos yield (g/plant)**	**Drug flos yield (g/plant)**	**Essential oil rate (%)**
Maximum	95	881.8	291.9	406.6	159.8	0.950
Minimum	14	11	5.6	7.6	3.7	0.050
Mean	66.9	228.8	83.6	113.5	40.1	0.419
CV (%)	16.2	62	61	63.8	62.6	33

Frequency distributions of some agronomic and quality traits of *Achillea asplenifolia* - 10403 are shown in Table 5. The plant height of 79.3% of the population ranged from 31.0 cm to 49.6 cm in 2009 and 93.7% of the population height ranged from 47.5 cm to 85.5 cm in 2010. Drug herbage yield of 80.8 % of the population varied between 14.8 g/plant and 74.0 g/plant first year while it was mostly (78.9%) between 0 and 116.8 g/plant in 2010. Drug flos yield of 85.8% of the *Achillea asplenifolia* - 10403 ranged from 9.0 to 31.5 g/plant; this was the largest frequency distribution group in 2009. In the second experimental year, 85.2% of the genotypes had drug flos yield between 0 to 63.9 g/plant. Frequency analysis showed that essential oil rate of genotypes mostly (74.3%) distributed between 0.14% and 0.35% in 2009 whereas mostly (86.1%) 0.19% and 0.57% in 2010.

Ogretmen (2014) evaluated some yield and quality parameters of *Achillea asplenifolia* under Aydin province-Turkey conditions. The maximum and minimum value of plant height (1.3-147 cm), drug herbage yield (11-1.276 g/plant), drug flos yield (0.05-937 g/plant) and essential oil rate (0-1.25%) were found. Similar study conducted with *Achillea collina* populations by Bayram et al. (2013) with single plants under the Aegean Region conditions of Turkey. They reported the following results for plant height (11-80 cm), drug herbage yield (0-329 g/plant), drug flos yield (0-212 g/plant) and essential oil ratio (0-0.850%) in their studies. On the other hand, Nemeth et al, (2008) obtained essential oil rate ranged from 0.07 to1.77% from *Achillea collina* populations while Bozin et al. (2008) obtained 0.73% of essential oil from the same sub-species. Konakchiev et al. (2005) reported that essential oil content of *A. asplenifolia* was 0.30% which is confirmed the earlier report of Wawrosch and Kubelka (1994) found 0.32% of essential oil. The result of present study showed that the essential oil rate of these two populations were higher than that of Wawrosch and Kubelka, 1994; Konakchiev et al., 2005; Bozin et al., 2008 and Nemeth et al., 2008. On the other hand similar results were found with Bayram et al., (2013) and Ogretmen (2014).

Table 5. Frequency distributions of plant height, drug herbage yield, drug flos yield and essential oil of genotypes belonging to *Achillea asplenifolia* - 10403.

Plant Heigt (cm)						
	2009			2010		
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	0.000-6.199	0	0	0.000-9.499	0	0
2	6.200-12.399	0	0	9.500-18.999	2	0.844
3	12.400-18.599	0	0	19.000-28.499	0	0
4	18.600-24.799	1	0.383	28.500-37.999	0	0
5	24.800-30.999	19	7.28	38.000-47.499	3	1.266
6	31.000-37.199	56	21.456	47.500-56.999	34	14.346
7	37.200-43.399	88	33.716	57.000-66.499	81	34.177
8	43.400-49.599	63	24.138	66.500-75.999	73	30.802
9	49.600-55.799	27	10.345	76.000-85.499	34	14.346
10	55.800-61.999	7	2.682	85.500-94.999	10	4.219
Drug HerbageYield (g/plant)						
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	0.000-14.799	13	4.981	0.000-29.199	28	11.814
2	14.800-29.599	42	16.092	29.200-58.399	57	24.051
3	29.600-44.399	62	23.755	58.400-87.599	63	26.582
4	44.400-59.199	73	27.969	87.600-116.799	39	16.456
5	59.200-73.999	34	13.027	116.800-145.999	22	9.283
6	74.000-88.799	24	9.195	146.000-175.199	13	5.485
7	88.800-103.599	9	3.448	175.200-204.399	8	3.376
8	103.600-118.399	2	0.766	204.400-233.599	4	1.688
9	118.400-133.199	1	0.383	233.600-262.799	1	0.422
10	133.200-147.999	1	0.383	262.800-291.999	2	0.844
Drug Flos Yield (g/plant)						
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	0.000-4.499	5	1.969	0.000-15.979	29	12.236
2	4.500-8.999	15	5.906	15.980-31.959	80	33.755
3	9.000-13.499	55	21.645	31.960-47.939	57	24.051
4	13.500-17.999	49	19.291	47.940-63.919	36	15.19
5	18.000-22.499	53	20.866	63.920-79.899	15	6.329
6	22.500-26.999	33	12.992	79.900-95.879	13	5.485
7	27.000-31.499	28	11.024	95.880-111.859	4	1.688
8	31.500-35.999	11	4.331	111.860-127.839	1	0.422
9	36.000-40.499	4	1.575	127.840-143.819	1	0.422
10	40.500-44.999	1	0.394	143.820-159.799	1	0.422
Essential Oil Rate (%)						
Scale	**Limit values**	**Piece**	**%**	**Limit values**	**Piece**	**%**
1	0.000-0.069	4	1.533	0.000-0.094	2	0.844
2	0.070-0.139	22	8.429	0.095-0.189	2	0.844
3	0.140-0.209	77	29.502	0.190-0.284	29	12.236
4	0.210-0.279	75	28.736	0.285-0.379	63	26.582
5	0.280-0.349	42	16.092	0.380-0.474	69	29.114
6	0.350-0.419	22	8.429	0.475-0.569	43	18.143
7	0.420-0.489	10	3.831	0.570-0.664	20	8.439
8	0.490-0.559	4	1.533	0.665-0.759	6	2.532
9	0.560-0.629	4	1.533	0.760-0.854	0	0
10	0.630-0.699	1	0.383	0.855-0.949	3	1.266

CONCLUSIONS

According to German Pharmacopoeia (DAP), essential oil content of Herbage *millefolii* should be at least 0.2% (flower 0.5 %, stem and leaves 0.2-0.7%). In the present study, it was found that *Achillea asplenifolia* population had higher values than those. The results showed that both *Achillea asplenifolia* populations in this study 9602 and 10403 had remarkable variation for drug flos yield and essential oil content. In this study, suitable genotypes to grow under the Aegean conditions were identified. They might be used successfully for the selection and improvement of cultivars in the future studies.

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