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IDENTIFICATION OF CERTAIN AGRICULTURAL TRAITS AND INTER-TRAIT RELATIONSHIPS IN THE *HELIANTHEMUM LEDIFOLIUM* (L.) MILLER VAR. *LASIOCARPUM* (WILLK.) BORNM.

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Abstract

This study was conducted to determine certain plant traits and inter-trait relationships in the *Helianthemum ledifolium* (L.) Miller var. *lasiocarpum* (Willk.) Bornm. which is grown naturally in the protected area at the campus of Dicle University in 2015 and 2016. Two-year average of the research showed that the plant height was 30.04 cm, the number of main stem per plant was 1.02, the main stem diameter was 1.24 mm, the number of branch per plant was 1.06, the capsule number per plant was 4.04, the capsule diameter was 7.21 mm, the seed number per capsule was 158.5, the seed weight per capsule was 0.065 g, the thousand seed weight was 0.421 g, the seed yield per plant was 0.265 g and the germination rate was 0.5%. According to analysis results belonging to dry forage of the plant, the crude protein ratio was determined as 18.79%, ADF ratio as 26.23%, NDF ratio as 49.21%, calcium ratio as 1.14%, magnesium ratio as 0.04%, phosphor ratio as 0.42% and potassium ratio as 3.79%. The correlation analysis results showed that positive and highly significant relation was found between seed yield per plant and plant height, branch number per plant, capsule number per plant, number of seeds per capsule, seed weight per capsule traits. To increase seed yield in *Helianthemum* genotypes, exclusively that traits should be taken into account. Results of the study indicated that forage of *Helianthemum ledifolium* (L.) Miller var. *lasiocarpum* (Willk.) Bornm had sufficient digestibility and nutrient contents for livestock. But, it is recommended that new investigations should be carried out in order to determine the content of harmful substances in the forage of these plants for safely using the forages in the livestock feeding.

Key words: Agronomic characteristics, Correlation, *Helianthemum ledifolium*, Turkey.

Introduction

Natural flora of Turkey has great diversity and it includes many herbaceous and shrub forms plant families (Sayar *et al*., 2015; Basbag *et al.*, 2017). *Cistaceae* is a medium sized family of shrubs, subshrubs, and sometimes herbs which are characteristic of dry, sunny habitats (Proctor, 1978). *Helianthemum* is the largest genus of *Cistaceae* family and includes 110 species comprising shrubs, subshrubs, and annual herbs (Mabberly, 1997; Parejo-Farnés *et al.*, 2013). 16 different taxa of this genus, consisting of 11 perennial and 5 annual species, were recorded from Turkey and 4 of them are endemic (Anon., 2017a). Chromosome number (2n) of these taxa, ranges from 20 to 22 (Yesilyurt *et al*., 2015). *Helianthemum* has three varieties in Turkey (Anon., 2017a). It is reported that this species is classified within "endangered" (EN) category in the Cyprus flora (Anon., 2015).

Helianthemum ledifolium (L.) Miller var. *lasiocarpum* (Willk.) Bornm. is an annual, herbal plant and blossoms in May and June. This plant grows at an altitude from 4 to 1400 m. In Turkey, it is dispersed over dry, calcareous, rocky, slope, shrubbery, vineyard areas in the Western, Southern, and Central Anatolia Region; while it is widespread over Balkans, Caucuses, North and Central Iran, Palestine, and Northern Iraq (Anon., 2017a).

It is stated that certain annual and perennial *Helianthemum* taxa, due to *mycorrhizae* operating in their roots, considerably enhance soil fertility, to prevent erosion and desertification to eliminate soil salinity (Awameh, 1981; Chevalier *et al.*, 1984; Alsheikh, 1985; Dexheimer *et al.*, 1985; Ravolanirina, 1986; Roth-Bejerano *et al.*, 1990; Honrubia *et al*., 1992; Morte *et al.*, 1994; Alsheikh, 1995; Dickie *et al.*, 2004; Slama *et al*., 2012). Moreover, it is manifested in the abovementioned studies that some species (*H. hirtum*, *H. kahiricum*, *H. lippii*) of *Helianthemum* is resistant to soil salinity (Halofit) (Al-Oudat & Qadir, 2011; Nedjimi *et al.*, 2012); some species (*H. appenninum*, *H. canum*, *H. grandiflorum*, *H. nummularium*, *H. kahiricum*, *H. sessiliflorum*) are grazed by animals at meadows (Fischer & Wipf, 2002; Proctor & Lambert, 2006; Poschlodl *et al.*, 2011; Abdallah & Chaieb, 2014;Gamoun, 2014); bees utilize some species (*H. appenninum*, *H. canum*, *H. caput-felis*, *H. nummularium*) as a nectar and pollen source (Ricciardelli & Sommeijer, 2000; Proctor & Lambert, 2006; Anon., 2017b), and some species (*H. lippii*, *H. ledifolium*) are resistant to drought (Zaman *et al.*, 2009).

It is found that some species (*H. apenninum*, *H. cinereum*, *H. croceum*, *H. hirtum*, *H. juliae*, *H. ledifolium*, *H. leptophyllum*, *H. macranthum*, *H. marifolium*, *H. nummularium*, *H. nummularium* ssp. *berteroanum*, *H. nummularium* ssp. *glabrum*, *H. nummularium* ssp. *grandiflorum*, *H. nummularium* ssp. *nummulariun*, *H. nummularium* ssp. *obscurum*, *H. nummularium* ssp. *pyrenaicum*, *H. nummularium* ssp. *tomentosum*, *H. oelandicum*, *H. oelandicum* ssp. *canum*, *H. piliferum*, *H. pilosum*, *H. salicifolium*, *H. scoparium*, *H. squamatum*, *H. stipulatum*, *H. ventosum*, *H. vesicarium*) are hard-crusted (Thanos *et al.*, 1992).

Thanos *et al*., (1992) reported that thousand seed weight of *Helianthemum* taxa were found between 0.32-1.74 g. Zaman *et al*., (2009) reported that germination rates of *Helianthemum* species were found between 1-13% in control group.

This research was conducted with the aim of identifying agricultural traits and inter-trait relationships of *Helianthemum ledifolium* var. *lasiocarpum* (L.) Miller taxon.

Materials and Methods

In order to determine forage quality of *Helianthemum ledifolium* var. *lasiocarpum*, the plant samples were collected at flowering period of the plant from protected area (37º93'41.43''N, 40º27'75.65''E and altitude 731 m) in the campus of Dicle University (10-15 May), during 2015 and 2016 years (Fig. 1). The collected plant samples were properly dried, and dried forage samples were subjected to analyze at Dicle University Science and Technology Application and Research Center Laboratory, In this context, crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), calcium (Ca), magnesium (Mg), phosphor (P) and potassium (K) contents of the forages were determined by using NIRS (Near Infrared Spectroscopy - Foss Model 6500) device. On the other hand, in order to determine the plant seed yield and seed related traits, the plant collection was carried out during the last ripening period of the seeds (15-20 July) in both of the years in the University Campus areas. The collection of plant samples was done by "random sampling method" and a total of 50 plant samples per year were uprooted. Observations and analysis in the plant material were performed at the Seed Laboratory of the Faculty of Agriculture of Dicle University. Plant height, main stem number, main stem diameter, branch number, and capsule number were measured for each of the plant samples. Then, capsule diameter and seed number per capsule were obtained by pulling a seed capsule off from center of each plant. These seeds were weighted with a 0.000 g scales, and seed weight per capsule and thousand seed weight, and seed yield per plant were calculated.

The plant samples belonging to *Helianthemum ledifolium* var. *lasiocarpum* were collected from a protected area (37º93'41.43''N, 40º27'75.65''Eand altitude 731 m) in the campus of Dicle University in 2015 and 2016 (Fig. 1). The plant was identified in the Department of Biology at the University of Dicle. The collection was carried out in the last ripening period of seeds (15-20 July) in both years. The collection of plant samples was done by "random sampling method" and a total of 50 plant samples per year were uprooted. Observations and analysis in the plant material were performed at the Seed Laboratory of the Faculty of Agriculture of Dicle University. Plant height, main stem number, main stem diameter, branch number, and capsule number were measured for each of the plant samples. Then, capsule diameter and seed number per capsule were obtained by pulling a seed capsule off from center of each plant. These seeds were weighted with a 0.000 g scales, and seed weight per capsule and 1000 seed weight, and seed yield per plant were calculated.

For the germination test, the seeds gathered from all of the plants in each year were mixed. Then, 4x100 of these seeds were selected randomly and put homogenously in Petri dishes on which paper towels were laid out, placed into the germination cabinet (Growth Chamber, GC400) after moistening with purified water. The germination cabinet was regulated at 20ºC, 70% humidity, in light mode for 12 hours and in dark mode for 12 hours. Germination counts were carried out in 7th and 12th days and the sum of these two counts was taken (Basbag *et al.*, 2009; Basbag *et al.*, 2010; Basbag *et al.*, 2011a).

Climate data has been obtained from the General Directorate of Meteorology. The long-term climate data of Diyarbakir province are given in Fig. 2 (Anon., 2017c). The average monthly temperature values (15.9ºC in 2015 and 16.1ºC in 2016) are similar to the long term average (15.8ºC), while the relative humidity values are higher than the long term average (54.1%) in the first year (59.1%) and slightly lower in the second year (52.7%). The amounts of precipitation in two years (460.3 mm in 2015 and 458.6 mm in 2016) are close to each other and lower than the long term average (490.1 mm). The amount of precipitation in March, April, and May when plants grow actively is above the long term average (180.5 mm) in the first year (193.1 mm) and below in the second year (95.8 mm).

Fig. 1. Pictures taken at different periods (flower, capsule and seed) of*Helianthemum ledifolium* (L.) Miller var. *lasiocarpum* (Willk.) Bornm taxon

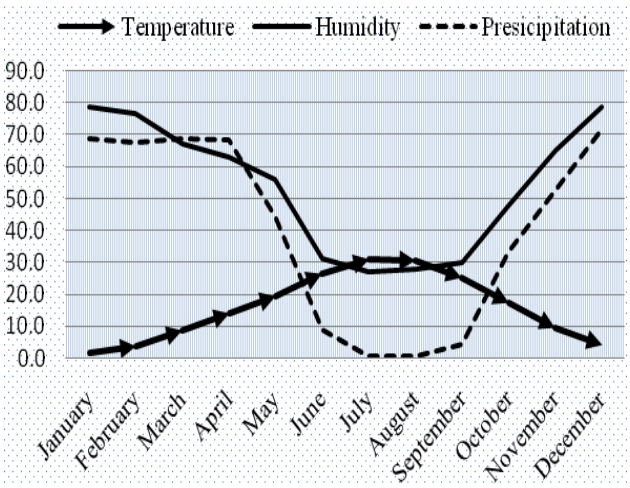

Fig. 2. The long-term climate data of Diyarbakir province.

Results and Discussion

The plant height varied from 14.0 to 50.0 cm in the first year (avg. 30.85 cm), from 12.0 to 48.0 cm in the second year (avg. 29.22 cm), and from 12.0 to 50.0 cm for two years average (avg. 30.04 cm). Likewise, the main stem number per plant was between 1.0 and 2.0 in the first year (avg. 1.04), from 1.0 to 2.0 in the second year and between 1.0 and 2.0 in the two years average (avg. 1.02) (Table 1).

The main stem diameter varied from 0.73 to 2.36 mm in the first year (avg. 1.195 mm), from 0.67 to 1.77 mm in the second year (avg. 1.286) and from 0.67 to 2.36 mm for two years average (avg. 1.24 mm). The number of branch per plant was between 0.0 and 4.0 in the first year (avg.1.00), between 0.0 and 4.0 in the second year (avg. 1.04) and between 0.0 and 4.0 in the two years year average (avg. 1.02).The capsule number per plant varied from 1.0 to 9.0 in the first year (avg. 4.12), from 2.0 to 9.0 in the second year (avg. 3.96) and from 1.0 to 9.0 for two years average (avg. 4.04) (Table 1).

The capsule diameter was between 5.83 and 8.28 mm in the first year (avg. 7.049), between 5.59 and 8.48 mm in the second year (avg. 7.363) and between 5.59 and 8.48 for two years average (avg. 7.206 mm). The seed number per capsule varied from 82.0 to 222.0 in the first year (avg. 163.6), from 92.0 to 254.0 for second year (avg. 153.4) and from 82.0 to 254.0 for two years average (avg. 158.5). The seed weight per capsule was between 0.026 and 0.094 g in the first year (avg. 0.066 g), between 0.035 and 0.087 g in the second year (avg. 0.064 g) and between 0.026 and 0.094 g for two years average (avg. 0.065 g) (Table 2).

The thousand seed weight varied from 0.145 to 0.703 g in the first year (avg. 0.420 g), from 0.217 to 0.663 g for second year (avg. 0.422 g) and 0.421 g for two years average. The seed yield per plant was 0.272 g in the first year, 0.258 g in the second year and between 0.063 and 0.704 g for two years average (avg. 0.265 g). The germination rate was 0.25% for the first year, 0.75% for the second year and 0.50% for two years average (Table 2).

As a result of the analyzes that made for the dry forage of these plants, it was revealed that forage quality parameters as the follows; the crude protein ratio was found as 18.79%, ADF ratio 26.23%, NDF ratio 49.21%, calcium ratio 1.14%, magnesium ratio 0.04%, phosphorous ratio 0.42% and potassium ratio 3.79% (Table 3). Many researchers reported that for a good forage quality should be higher protein content and lower ADF and NDF contents are desired in animal feeding (Başbag *et al.*, 2011b; Moinuddin *et al.*, 2012; Sayar *et al*., 2014).

The values of thousand seed weight in this study are close to those of Thanos *et al*., (1992)'s findings. However, other agricultural traits of the same species could not be compared since these were not found in the literature.

The fact that plant height, capsule number per plant, and seed number per capsule were higher in the first year resulted probably due to the total amount precipitation (Fig. 2) in the months when plants grew actively was higher than those of the second year and long term average. Kendal *et al*., (2016) reported that environmental conditions particularly climatic ones are greatly effective on plant yield and yield components. Also, they emphasized that there may be major changes in plant traits depending on climatic diversity from year to year.

Certain significant relationships were detected in the paired correlations among traits of *Helianthemum ledifolium* var. *Lasiocarpum* taxon, which were examined for two years (Table 4). A highly significant and positive relationship was found between plant height and branch number per plant, number of capsules per plant, seed yield per plant; main stem diameter and capsule diameter; branch number and capsule number per plant, seed number per capsule, seed yield per plant; capsule number per plant and seed number per capsule, seed yield per plant; seed number per capsule and seed weight per capsule, seed yield per plant; seed weight per capsule and thousand seed weight, seed yield per plant at $p<0.01$. On the other side, a positive and significant relationship was identified between plant height and seed number per capsule at $p<0.05$.

Furthermore a negative but very significant relationship was detected between main stem diameter and seed number per capsule; seed number per capsule and thousand seed weight at $p<0.01$; and between main stem number and capsule diameter; main stem diameter and seed weight per capsule, seed yield per plant; branch number and thousand seed weight at $p<0.05$.

Conclusions

Helianthemum ledifolium (L.) Miller var. *lasiocarpum* (Willk.) Bornm. has great importance in many aspects for rangeland and meadow lands of Southeastern Anatolia Region of Turkey. Particularly, the species ensure soil protection in sloping and erosion exposed rangelands and the other natural lands of the region. Additionally, it not only has positive effect on microorganism activities of the flora but also increase

species richness in flora in these areas. Results of the study were revealed that forage of the species had a good digestibility and nutrition content for livestock. Also, correlation analysis revealed that there were positive and highly significant relations between seed yield per plant and branch number per plant, capsule number per plant, number of seeds per capsule, seed weight per capsule traits. To increase seed yield in *Helianthemum* genotypes, exclusively the traits should be taken account. Finally, new researches to be done are recommended on the plant species. Especially, researches should be carried out on determining forage yield performance of the plant and on determining harmful substances content in the forage of the plant for safely using in the livestock feeding.

Table 1. Plant height, number of main stems, main stem diameter, number of branch and number of capsule of *Helianthemum ledifolium* (L.) Miller var. *lasiocarpum* (Willk.) Bornm.

Years	Plant height (cm)	Number of main stems per plant	Main stem diameter (mm)	Number of branch per plant	Number of capsule per plant
2015	30.85	1.04	1.195	1.00	4.12
2016	29.22	1.00	1.286	1.04	3.96
Average	**30.04**	**1.02**	**1.24**	**1.02**	**4.04**
Min.	12.00	1.00	0.67	0.00	1.00
Max.	50.00	2.00	2.36	4.00	9.00
St. Error	0.693	0.014	0.028	0.110	0.179
Variance	48.00	0.020	0.081	1.212	3.211

Table 2. Capsule diameter, number of seeds per capsule, seed weight per capsule, thousand seed weight, seed yield per plant and germination rate of *Helianthemum ledifolium* (L.) Miller var. *lasiocarpum* (Willk.) Bornm.

Years	Capsule diameter (mm)	Number of seeds per capsule	Seed weight per capsule (g)	Thousand seed weight (g)	Seed yield per plant (g)	Germination rate (%)
2015	7.049	163.6	0.066	0.420	0.272	0.25
2016	7.363	153.4	0.064	0.422	0.258	0.75
Ort.	**7.206**	**158.5**	**0.065**	**0.421**	**0.265**	**0.50**
Min.	5.590	82.00	0.026	0.145	0.063	--
Max.	8.480	254.00	0.094	0.703	0.704	--
St. Error	0.054	3.130	0.001	0.010	0.014	--
Variance	0.294	979.65	0.000	0.011	0.020	--

Table 3. Crude Protein, ADF, NDF, Ca, Mg, P and K ratios of *Helianthemum ledifolium* (L.) Miller var. *lasiocarpum* (Willk.) Bornm (%).

Crude protein	ADF	NDF	Calcium	Magnesium	Phosphor	Potassium
18.79	26.23	49.21	1.14	0.04	0.42	3.79

Table 4. Relations between properties of *Helianthemum ledifolium* (L.) Miller var. *lasiocarpum* (Willk.) Bornm taxon.

	1	2	3	4	5	6	7	8	9
1. Plant height (cm)									
2. Main stems per plant	-0.021								
3. Stem diameter (mm)	-.0.006	-0.144							
4. Branch number per plant	0.33**	-0.003	0.103						
5. Capsule number per plant	0.364**	-0.043	-0.163	0.43**					
6. Capsule diameter (mm)	-0.031	-0.190*	0.253**	0.035	0.075				
7. Number of seeds per capsule	0.214*	0.009	-0.307**	0.257**	0.332**	-0.125			
8. Seed weight per capsule (g)	0.045	0.123	-0.244*	0.006	0.104	-0.181	0.273**		
9. Thousand seed weight (g)	-0.12	0.092	-0.01	-0.202*	-0.167	-0.073	-0.53**	0.646**	
10. Seed yield per plant (g)	0.305**	0.009	-0.24*	0.355**	0.884**	0.021	0.362**	0.522**	0.162

* Significant at $p<0.05$, ** Significant at $p<0.01$

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