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Full Length Research Paper

Investigation of morphophysiological variation in field bindweed (*Convolvulus arvensis* L.) populations of Karaj, Varamin, and Damavand in Iran

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Diversity in field bindweed (*Convolvulus arvensis* L.) populations collected from Karaj, Varamin, and Damavad during 2006 (for seed collection) to 2007 (for seed germination and plant growth in green-house) at the Weed Research Department, Iranian Plant Protection Research Institute for identification of morphophysiological variation using multivariate analysis methods. The most important variables were shoot dry weight, leaf dry weight, and leaf area, respectively. Results showed 11, 15 and 16 biotypes in Karaj, Varamin, and Damavand populations, respectively. Varamin was clustered near to Damavand, but both these populations had significant differences with Karaj population.

Key words: Biodiversity, ecotype, biotype, principal component analysis, cluster analysis, field bindweed, *Convolvulus arvensis*.

INTRODUCTION

Field bindweed (*Convolvulus arvensis*) is one of the 10 noxious weeds in the world and 54 countries reported that it is found as a weed in 32 different crops (Swan, 1980; Holm et al., 1991). This is considered as one of the problematic weeds in Iran (Shimi and Termeh, 2004) and found in a wide range of habitats (Weaver and Riley, 1982). This species have a broad geographical range, often include either ecotypes or biotypes (Klingaman and Oliver, 1996). It is self-incompatible species which may play an important role in maintaining the high degree of phenotypic variation (Westood, and Weller, 1997).

Numerous examples of intraspecific variation in growth and morphology of weed species have been reported (Degennaro and Weller, 1984). Morphological parame-ters are generally used as a tool for investigation of diver-sity and genetic relatedness (Hubner et al., 1998). Seve-ral morphologically distinct biotypes of field bindweed have been identified and more than one biotype often exists in the same infested area. The morphological variability in the species is thought responsible for diff-erential response of field bindweed to herbicides (Duncan and Weller, 1987). Variation in morphology and herbicide susceptibility of field bindweed has been observed by various researchers (Degennaro and Weller, 1984).

The objective of this investigation is to determine the differences in morphophysiological characteristics of field bindweed biotypes or ecotypes in these regions.

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MATERIALS AND METHODS

Seed of field bindweed (*C. arvensis* L.) were collected from Karaj, Varamin, and Damavand in Tehran province in September 2006. In March 2007, after seed scarification with sulfuric acid 97%, these were planted in plastic pots having mixtures of sterilized clay, sand, manure and perlite in a ratio of 1:5:5:0.5, respectively. The plants were maintained in a greenhouse for 22 wks under day/night temp-eratures of 30/18 ± 4ºC and 500 µmol.m^{-2}.s^{-1} with supplemental lighting (incandescent and fluorescent) to provide a 14 h day length with 45% relative humidity. Plants were irrigated weekly, and as needed with a nutrient solution containing 200 ppm N, 100 ppm P, and 100 ppm K (Samadani and Minbashi, 2004).

Morphophysiological characteristics studied

At the end of flowering (154 days after sowing), 60 plants were randomly collected from each population and observations were recorded on traits like. shoot number, shoot fresh weight, shoot dry weight, shoot water content, stem dry weight, leaf dry weight, root dry weight, whole plant dry weight, whole plant biomass, collar (crown) diameter, leaf number, leaf area, chlorophyll concentration,

Table 1. Total variance of eigenvalue explained for 12 components of Karaj, Varamin and Damavand.

Component	Karaj		Varamin		Damavand	
	% of Variance	Cumulative %	% of Variance	Cumulative %	% of Variance	Cumulative %
1	**25.025**	25.025	**23.757**	23.757	**22.059**	22.059
2	**12.253**	37.278	**16.220**	39.977	**11.888**	33.947
3	9.462	46.740	7.167	47.144	10.833	44.780
4	5.998	52.739	6.804	53.948	7.815	52.595
5	5.759	58.498	5.408	59.356	6.171	58.766
6	4.658	63.156	4.867	64.223	5.154	63.920
7	4.488	67.644	4.440	68.663	4.456	68.376
8	4.106	71.750	4.016	72.679	3.816	72.192
9	3.634	75.384	3.450	76.129	3.402	75.594
10	3.009	78.393	3.185	79.314	3.042	78.636
11	2.614	81.007	2.721	82.035	2.642	81.278
12	2.425	**83.432**	2.488	**84.523**	2.517	**83.795**

Extraction Method: Principal component analysis.

shoot/root ratio, specific leaf weight, specific leaf area, specific leaf chlorophyll weight, leaf weight ratio, stem weight ratio, root weight ratio, leaf length, leaf width, leaf length/width ratio, leaf basal lobe length, leaf basal lobe width, leaf basal lobe length/width ratio, petiole length, leaf tip angle, leaf apex degree (ºD), trichome density, leaf color, leaf b coefficient, flower (petal) color, flower diameter, flower outer line color, stigma-anther arrangement, stigma length, anther length, anther color, flower length, calyx (corolla) diameter, pedicel length, total flowering rate, flowering time, time to flowering.

The variables were standardized and subjected to multivariate statistical analysis as reported earlier by Legendre and Legendre (1998).

Statistical analysis

Three types of analysis were performed on the data:

(1) Principal components analysis (PCA).
(2) Hierarchical cluster analysis.
(3) Jaccard similarity coefficient.

In order to determine the most variable morphological characters among the populations, factor analysis based on principal component analysis (PCA) was performed (Johnson, 1998; Manly, 1994) . Hierarchical clustering was performed to classify field bind-weed biotypes and populations, based on squared Euclidean dis-tances using SPSS Ver.13.

RESULTS AND DISCUSSION

Factor analysis based on PCA, revealed that first twelve factors contributed about 83-84% of total variation for field bindweed of Karaj, Varamin, and Damavand (Table 1).

In Karaj, in the first factor with about 25% of total variation contributed by, characters such as shoot dry weight, leaf dry weight, stem dry weight, whole plant dry weight, leaf area, leaf number, shoot fresh weight, and root dry weight, whereas specific leaf chlorophyll weight possessed the highest negative correlation. In the second factor about 12% of total variation resulted by characters such as leaf weight ratio, shoot root ratio, and root weight ratio, stem weight ratio possessed the highest negative correlation. Third factor indicated about 10% of total variation (Tables 1 and 2).

In Varamin, in the first factor with about 24% of total variation contributed by leaf dry weight, shoot dry weight, leaf area, stem dry weight, leaf number, whole plant dry weight, and specific leaf chlorophyll weight whereas, shoot fresh weight possessed the highest negative correlation. In the second factor with about 16% of total variation resulted by shoot root ratio, stem weight ratio, and root weight ratio, Leaf weight ratio possessed the highest negative correlation. Third factor indicated about 8% of total variation (Tables 1 and 2).

In Damavand, in the first factor with about 22% of total variation possessed by leaf area, leaf dry weight, shoot dry weight, specific leaf chlorophyll weight, stem dry weight, and whole plant dry weight, whereas leaf number, possessed the highest negative correlation. In the second factor with about 12% of total variation, characters such as root weight ratio, stem weight ratio, and shoot root ratio, possessed the highest negative correlation. Third factor indicated about 11% of total variation (Tables 1 and 2).

In general, shoot dry weight, leaf dry weight, and leaf area were the most important variables for distinction and separation in field bindweed biotypes in Karaj, varamin, and Damavand respectively. Degennaro and Weller (1984) also identified five 5 biotypes among field bindweed clones collected from a field in Indiana that showed variations in leaf morphology, floral characteristics, flowering capacity, phenology, vegetative reproduction potential, and accumulation of shoot and root biomass when

Table 2. Principal component analysis of morphophysiological characters in field bindweed populations of Karaj, Varamin, and Damavand.

Characters	Component					
	Karaj		Varamin		Damavand	
	1	2	1	2	1	2
Shoot Number	0.495	-0.081	0.251	-0.175	0.426	-0.030
Shoot Fresh Weight	**0.856**	0.170	**0.821**	0.143	**0.705**	-0.066
Shoot Dry Weight	**0.958**	0.112	**0.936**	0.153	**0.906**	0.050
Shoot Water Content	-0.304	0.119	-0.238	-0.017	-0.290	-0.116
Stem Dry Weight	**0.950**	0.073	**0.922**	0.164	**0.864**	0.170
Leaf Dry Weight	**0.955**	0.149	**0.944**	0.140	**0.909**	-0.079
Root Dry Weight	**0.854**	-0.394	**0.728**	-0.532	0.685	-0.646
Whole Plant Dry Weight	**0.945**	-0.170	**0.885**	-0.325	**0.858**	-0.426
Collar (Crown) Diameter	0.318	-0.028	0.413	-0.185	0.063	-0.451
Leaf Number	**0.897**	0.200	**0.921**	0.024	**0.836**	-0.003
Leaf Area	**0.920**	0.299	**0.929**	-0.086	**0.936**	-0.124
Chlorophyll Concentration	0.314	-0.169	-0.042	0.601	-0.217	-0.223
Shoot Root Ratio	-0.091	**0.918**	-0.011	**0.872**	-0.073	**0.801**
Specific Leaf Weight	0.102	-0.631	-0.162	0.736	-0.229	0.243
Specific Leaf Area	-0.073	0.696	0.233	-0.687	0.245	-0.159
Specific Leaf Chlorophyll Weight	**-0.830**	-0.331	-0.837	0.309	**-0.893**	0.049
Leaf Weight Ratio	-0.156	**0.922**	-0.035	**0.853**	-0.092	**0.796**
Stem Weight Ratio	-0.204	**0.839**	-0.090	**0.872**	-0.081	**0.823**
Root Weight Ratio	0.183	**-0.911**	0.066	**-0.871**	0.088	**-0.840**
Leaf Length	0.675	0.253	0.580	0.192	0.588	0.281
Leaf Width	0.362	-0.020	0.580	0.003	0.386	0.462
Leaf Length Width Ratio	0.184	0.227	-0.093	0.135	0.092	-0.250
Basal Lobe Length	0.541	0.139	0.431	0.313	0.236	0.381
Basal Lobe Width	-0.085	-0.016	0.669	0.214	0.548	0.428
Basal Lobe Length Width Ratio	0.178	0.084	-0.234	0.162	-0.174	0.078
Petiole Length	0.648	0.075	0.569	-0.161	0.509	-0.064
Leaf Tip Angle, Leaf Apex Degree	0.175	-0.072	0.082	-0.104	0.171	0.306
Trichome Density	0.147	0.114	0.177	0.481	0.130	0.218
Leaf Color	0.163	-0.297	0.059	0.468	-0.092	-0.083
Leaf b Coefficient	-0.653	-0.032	**-0.700**	-0.235	-0.463	-0.559
Flower (Petal) Color	0.187	-0.333	0.282	-0.095	-0.122	-0.100
Flower Diameter	0.199	0.067	0.052	0.195	0.436	0.229
Flower Outer Line Color	0.300	-0.242	0.127	0.023	-0.158	-0.321
Stigma - Anther arrangement	0.025	0.033	-0.060	0.379	-0.072	0.022
Stigma Length	0.074	0.291	-0.267	-0.030	0.375	0.203
Anther Length	0.015	-0.239	0.074	0.037	0.335	0.035
Anther Color	0.071	-0.019	0.064	-0.125	0.023	-0.075
Flower Length	0.329	0.047	0.231	0.076	0.614	0.122
Calyx (Corolla) Diameter	0.139	-0.120	0.189	0.337	0.185	0.182
Pedicel Length	-0.093	0.092	0.172	0.041	0.313	-0.059
Total Flowering Rate	0.507	-0.064	0.216	0.558	0.184	-0.078
Flowering Time	0.401	-0.090	0.306	0.583	0.227	-0.080
Time to Flowering	-0.264	0.072	-0.386	-0.444	-0.238	0.112

Extraction Method: Principal component analysis.
a 12 components extracted for each populations.

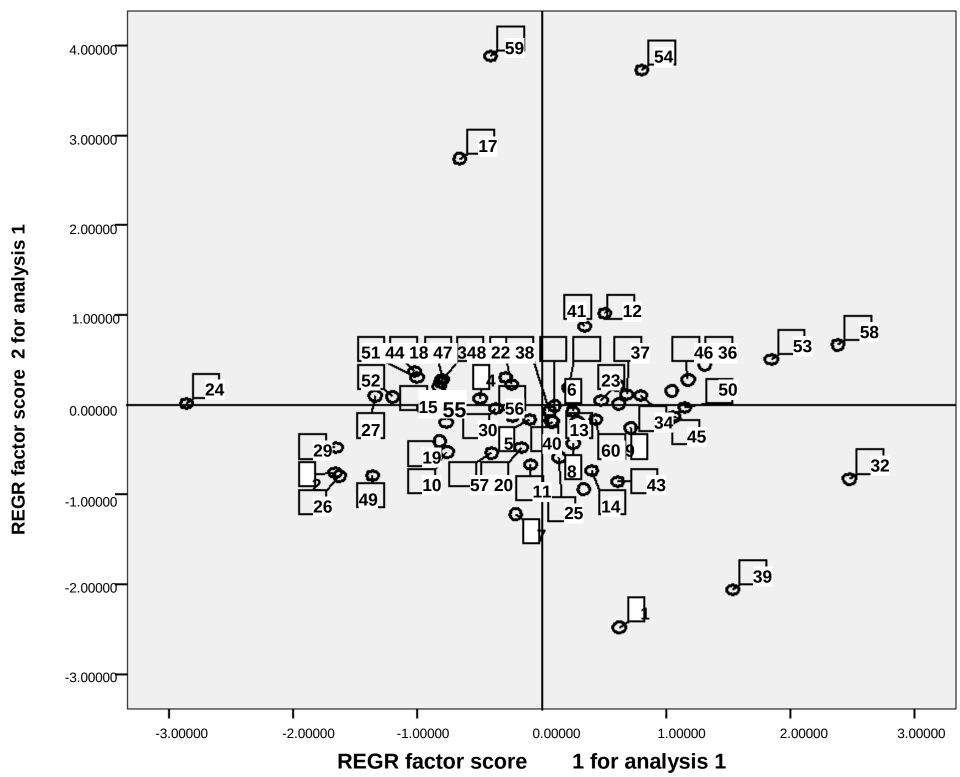

Figure 1a. Varamin-

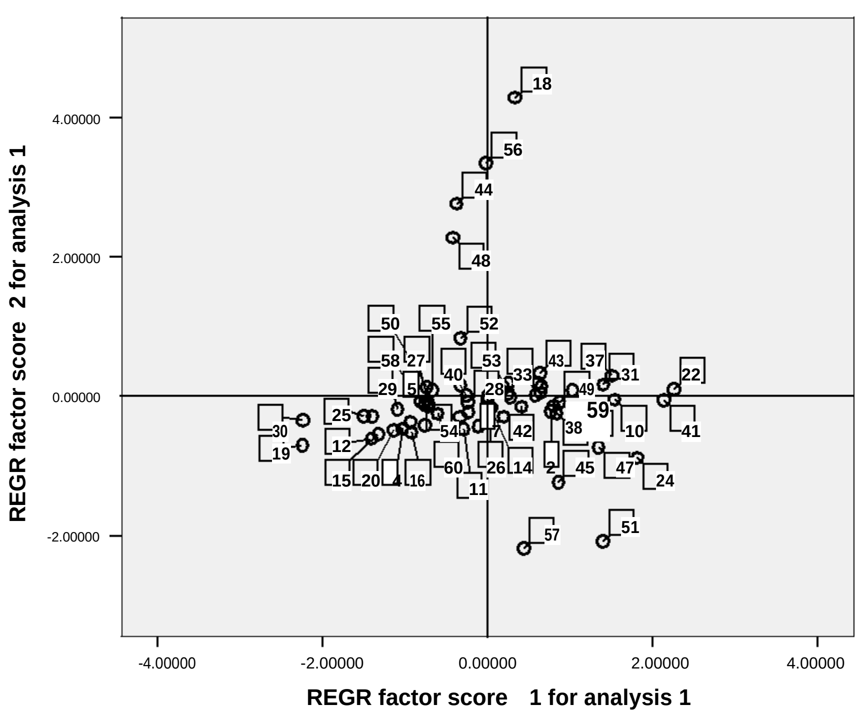

Figure 1b. Karaj

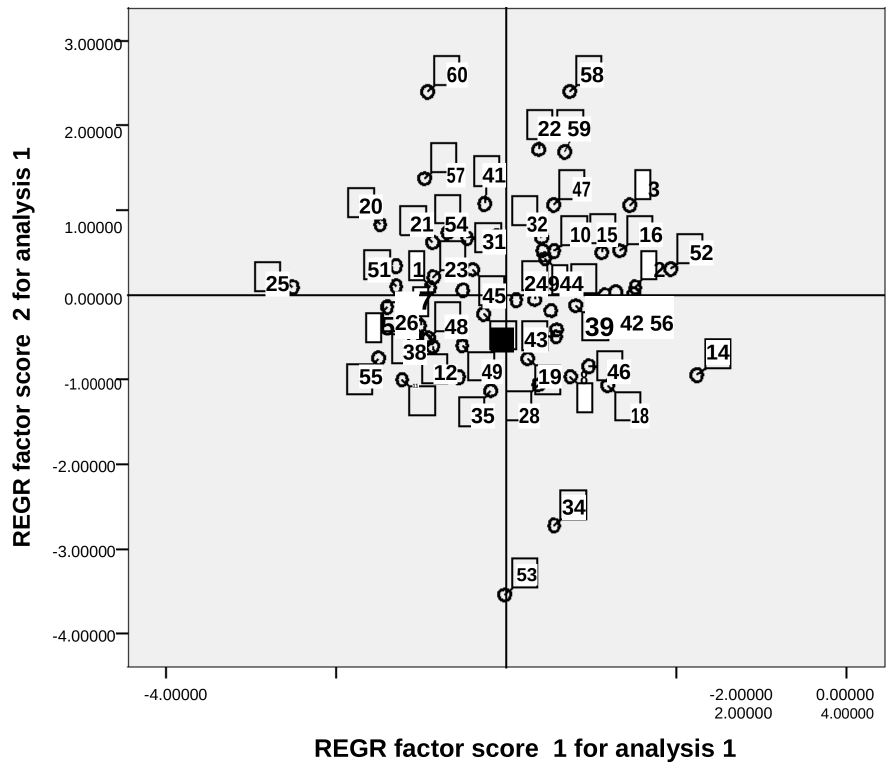

Figure 1. Scattergram regression of two principal components for field bindweed populations.

grown in a controlled environment. Whitworth (1964) found that clones of field bindweed which differed in leaf shape and growth vigor also varied in sensitivity to foliar 2,4-D applications.

The diversity of field bindweed populations in Karaj population was less compared to Damavand populations. Cluster analysis also confirmed these findings. The hierarchical structuring of the investigated populations was shown in three dendrograms (Figures 2, 3 and 4). In cluster analyses, biotypes were clearly distinguished from each other. Cluster analysis grouped of 11 biotypes for Karaj (Figure 2), 15 biotypes for Varamin (Figure 3), and 16 biotypes for Damavand populations (Figure 4). These results showed that field bindweed of Damavand had greater morphological variations.

To elucidate the relationship among the three field bindweed populations, a cluster-based mean separation of populations was performed. Field bindweed population of Varamin clustered near to Damavand, whereas Karaj clustered faraway from both the populations (Figure 5). Interestingly, morpho-physiological characters of Karaj population were very different from the other populations (Figure 3). Jaccard similarity coefficient was 0.42 for biotypes of Damavand with Karaj, 0.44 for biotypes of Varamin with Karaj, and 0.48 for biotypes of Damavand with Varamin confirmed, that Varamin was closer to Damavand groups.

In this investigation, characters such as root /shoot ratio, leaf weight ratio, stem weight ratio, and root weight ratio were most effective in separating and comparison of field bindweed populations. In such type of comparisons, environmental factors were eliminated and only plant by plant will be compared. For example, strategy of growth pattern in Karaj population was based on development of aboveground (shoot) but in Varamin and Damavand was vice versa (Figure 6).

Strong selection pressure has been shown to select morphological, phenological, or biochemical traits that increase plant fitness in the environment (Mercer et al., 2002, Jordan, 1989).

Shoot dry weight was the most important variable for classification of field bindweed biotypes in Karaj (Table 2). A high shoot dry weight is a appropriate strategy for more aboveground competition in cropping systems (Figure 6).

Leaf dry weight was the most important variable for classification of field bindweed biotypes in Varamin (Table 2). A high leaf dry weight is an appropriate strategy for water stress tolerance, and underground competition for water in the semiarid regions (Figure 5).

Leaf area, was the most important variable for classification of field bindweed biotypes in Damavand (Table 2). A high leaf area is an appropriate strategy for more above ground competition in orchards systems of the semi-humidity regions.

In general, our results indicated that there was a high

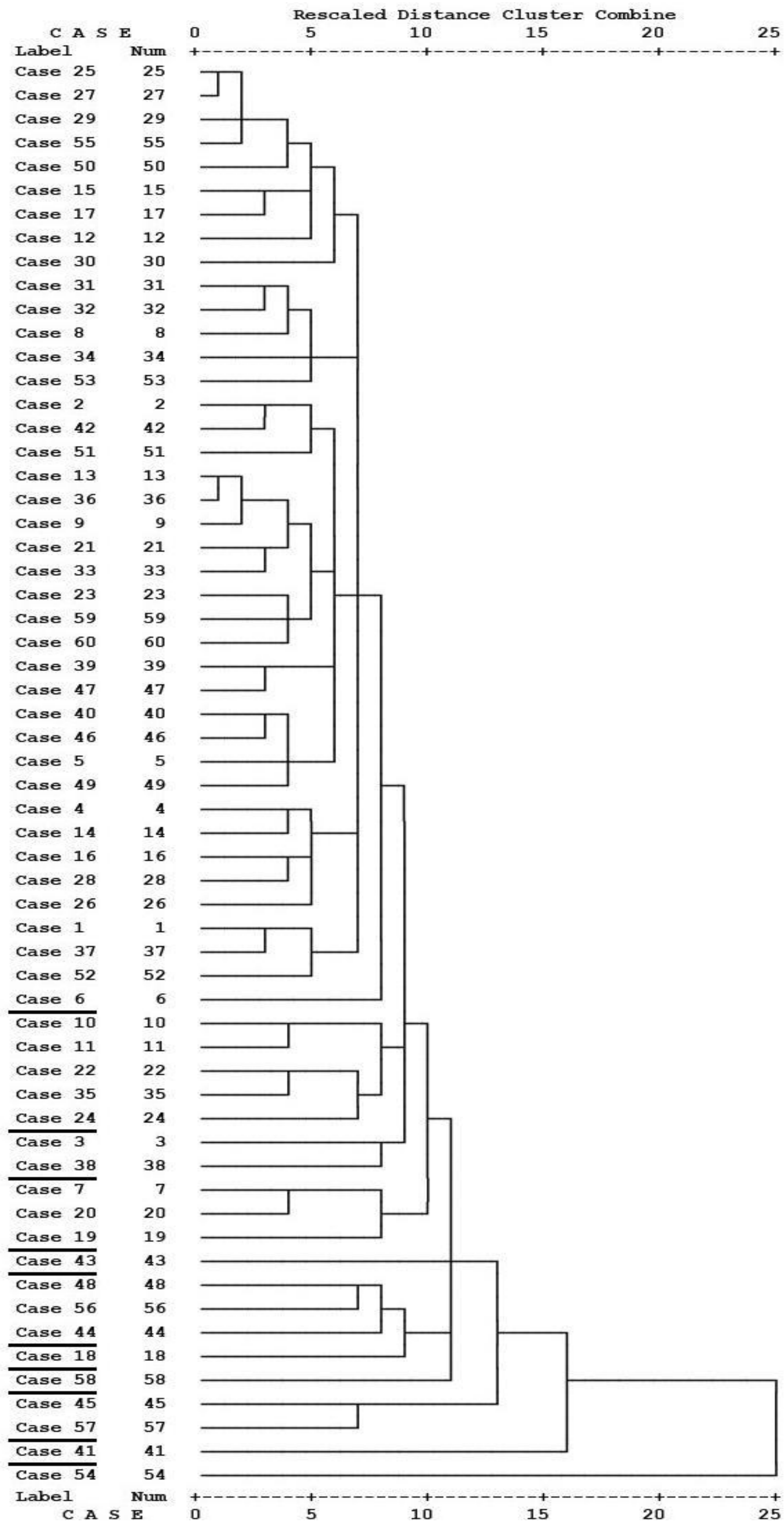

Figure 2. Dendrogram of cluster analysis for field bindweed biotypes of Karaj.

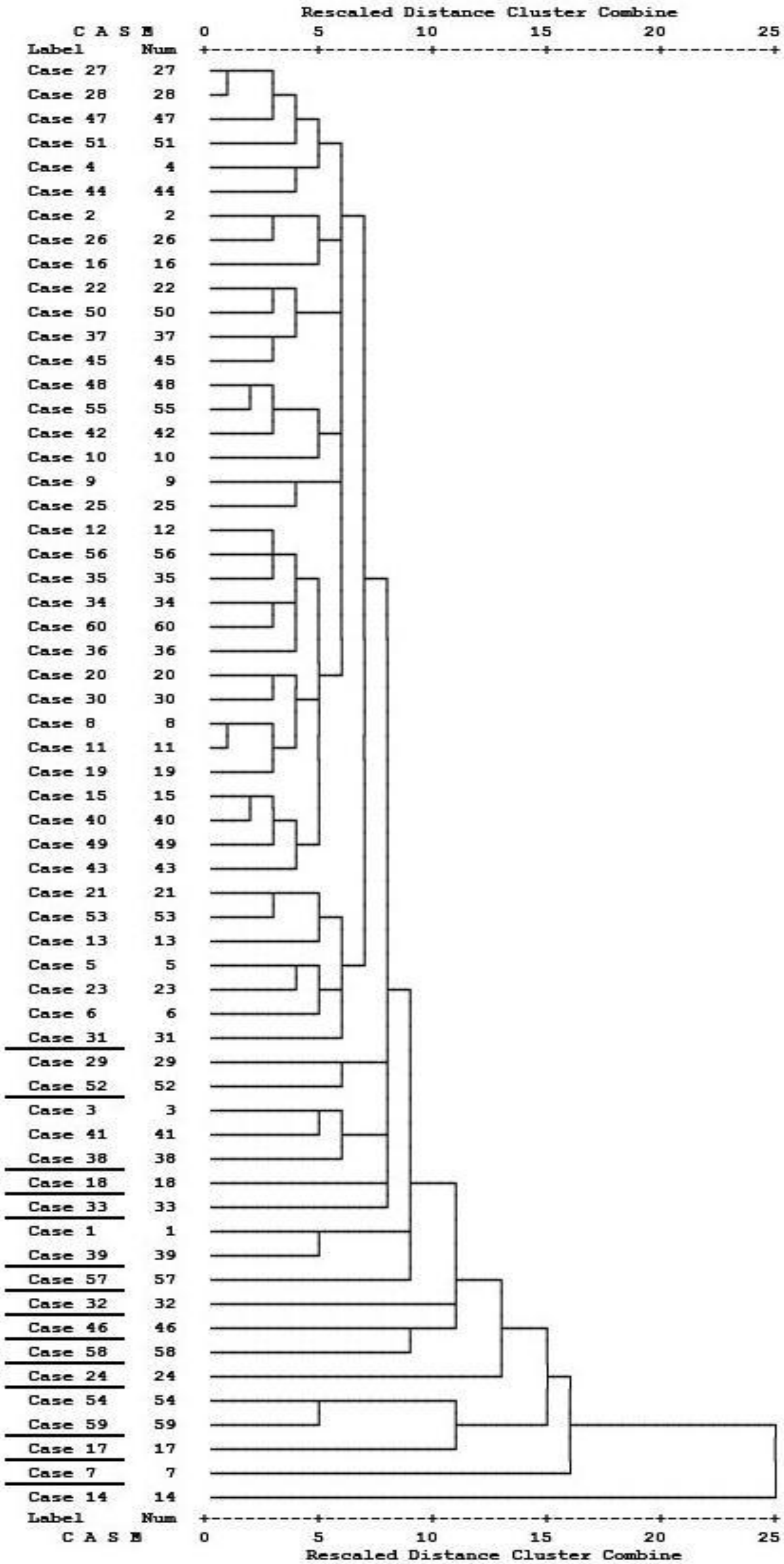

Figure 3. Dendrogram of cluster analysis for field bindweed biotypes of Varamin.

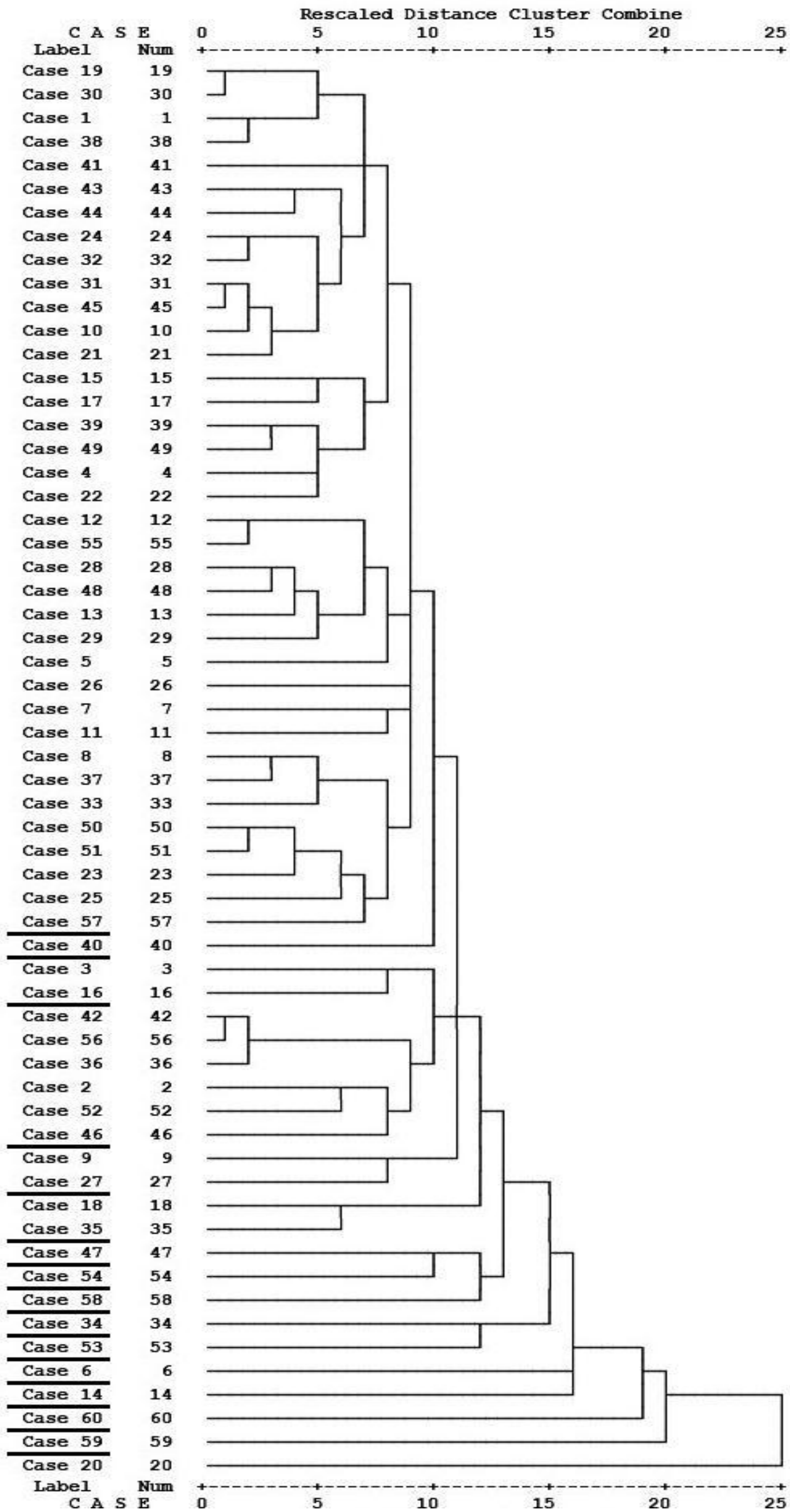

Figure 4. Dendrogram of cluster analysis for field bindweed biotypes of Damavand.

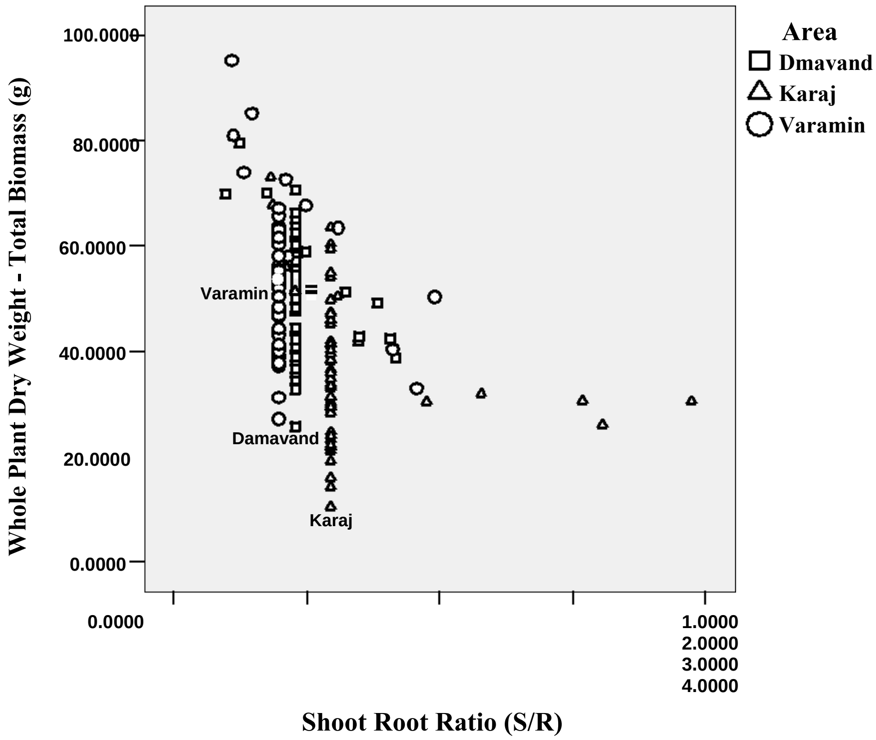

Figure 5. Comparison strategy populations by root shoot ratio (S/R) in Karaj, Varamin, and Damavand.

diversity in the populations of field bindweed in Tehran province. This feature leads us to think how to facile management of genetic resources. Field bindweed is morphologically and genetically variable over various geographical regions. The genetic variation of field bindweed as a species and the array of environments in which it is found indicate that selection in these different environments could lead to differentiation among field bindweed populations. This study showed different level of diversity within and between field bindweed populations sampled from three regions. The variability in growth and morphology observed in field bindweed populations may explain the survival and adaptability to prevailing environmental conditions and control practices. The present studies increase the knowledge concerning the variation in growth and biology between differing plants of the same species and help in understanding weed morphology and diversity which could be offered scope in weed management strategy.

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