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Full Length Research Paper

Determination of the effective traits on essence percent and dry flower yield in German chamomile (*Matricaria chamomilla* L.) populations

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Determination of the best indirect selection criteria for genetic improvement of essence percent and dry flower yield of German chamomile (*Matricaria chamomilla* L.) populations was investigated using some morphological and phonological characteristics. Randomized complete block design was used. Analysis of variance showed significant differences among chamomile populations for all the traits. This indicates genetic diversity for all the traits. Correlation coefficients analysis revealed positive and significant relation of majority of the traits with dry flower yield as well as some traits with essence percent. Path analysis indicated high genetic efficiency of indirect selection through days to 50% flowering; No. of flower plant^{-1}, fresh flower yield plant^{-1} and days to budding for genetic improvement of dry flower yield. The traits 50% flowering and; No. of flower plant^{-1} also were introduced as the best indirect selection criteria for improvement of essence percent in German chamomile populations based on results given by path analysis.

Key words: German chamomile, genetic diversity, indirect selection, selection index, path analysis.

INTRODUCTION

German chamomile (*Matricaria chamomilla* L., syn. *Chamomilla recutita,* L. Rauschert) is an important and frequently cultivated medicinal plant belonging to Asteraceae family. Wild chamomile is an annual herb originally from Europe which has dispersed and naturalized on almost every continent. The branched stem is somewhat erect, round, hollow and grows to about 20 inches tall. The leaves are bipinnate, finely divided, light green and feathery. The flowers are daisy-like and bloom from May to October (Salamon, 1992; Gardiner, 1999). Chamomile flowers are used in alternative medicine as anodyne, anti-inflammatory, vulnerary, deodorant, bacteriostatic, antimicrobial, anticatarrhal, carminative, seclative, antiseptic and spasmolytic properties. Several applications of dry powder for medicinal effect such as fevers, sore throats, the aches and pains due to cold, flu and allergies have also been reported by McKay and Blumberg (2006). About 120 chemical constituents have been identified in chamomile as secondary metabolites. The world market currently has chamomile drug of various origins and therapeutic values. With regard to increasing demands of drug and cosmetic industries, breeding German chamomile to gain talent cultivars with high yielding potential and homogeneity is necessary. Studies on genetic diversity of available germplasm have been conducted as first, essential and fundamental step of several breeding programs of German chamomile

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(Cirecelav et al., 1993; Taviana, 2001; D'Andrea, 2002). Determination of the effective traits as well as relationship between these traits with dry flower yield and essence percent is very important in chamomile breeding. Flower yield is the complex and low heritable trait. Therefore, indirect selection through its components has higher genetic efficiency than direct selection for improvement of this trait per se. Correlation coefficient analyses help researchers to distinguish significant relationship between traits. Step-wise regression can reduce effect of non-important traits in regression model; in this way traits accounted for considerable variations of dependent variable are determined. Path analyses that were present by Li (1956) have been extensively used for segregating correlation between yield and its components in field crops. Path analysis is used to determine the amount of direct and indirect effects of the variables on the dependent variable.

Zeinali et al. (2008) investigated the regression model for dry flower yield as dependent variable and the other traits as independent in German chamomile. Results showed the traits days to 50% flowering, No. of flower plant^{-1} and plant height entered to model and accounted for 73, 8 and 3% of dry flower yield variation, respectively. Path analysis based on these traits indicated that the most direct effects on dry flower yield are relevant to No. of flower plant^{-1} and plant height. Thus, genetic improvement of dry flower yield through indirect selection through these traits have high efficacy. Letchamo (1993) and Jamshidi (2000) emphasize on the traits No. of flower, flower weight and No. of flowering sub-branches as the most important dry flower yield components in German chamomile. In the other research, has been reported the significant and positive relationship of the traits, No. of flower plant^{-1}, fresh flower yield, 100 flower weight, days to flowering and plant height with essence percent (Pirkhezri et al., 2008). In this investigation, the correlation of essence percent with flowering duration was negative. Taviana (2001) assessed the genetic diversity exist in 13 German chamomile accessions collected from centre and northern Italy. D'Andrea (2002) investigated the genetic correlation between flower yield and essence components with the different morphological attributes in two harvesting times. Tetraploid cultivars have the highest flower diameter and weight, while the diploids dry and fresh flower yield. Results of Cirecelav et al. (2002) revealed that essence components in the different chamomile biotypes were significantly different. These biotypes were entitled as chemo types. Alexander (2005) compared morphological and chemical characteristics of German chamomile in Hungarian accessions and one advanced cultivar. Accessions were classified in three groups based on essence constituents. In this research, the traits No. of flower, plant height and days to flowering were determined as the best and most effective traits on flower yield. Mahdikhani et al. (2007) compared 25 German chamomile ecotypes using morphological traits. The results revealed high phenotypic variation for the traits biological yield, dry flower yield, No. of flower plant^{-1} and essence percent. The phenological traits showed the least diversity. Also, biological yield and No. of flower were introduced as the most effective traits on flower yield and essence percent. Zeinali et al. (2007) evaluated the German chamomile genotypes and found that plant height, flower diameter and No. of flower plant^{-1} have the least, while dry and fresh flower yield the most variation.

Omid (1999) showed the lower essence percent and kamazulene of the local varieties in comparison with the advanced cultivars. Therefore, the aims of this research were assessment relationships of dry flower yield and essence percent with the other traits as well as determination of the best indirect selection criteria in order to the genetic improvement of these valuable traits in German chamomile populations.

MATERIALS AND METHODS

This experiment was achieved in research station of Islamic Azad University, Khorasgan branch during 2009 to 2010 on nine German chamomile populations collected from different regions of Iran. Experimental design is randomized complete block design with replications. The farm located at 51º 23′ northern latitude and 32º 32′ eastern longitude. Elevation from sea level is 1590 m. Climate is semi-dry and dry with heat and dry summer based on Copene method. Annual mean of precipitation and temperature were 130 mm and 14ºC, respectively. Field capacity and wilting point were 38 and 9% of weighted humidity. The land was under clover cultivation in previous year. Soil texture was silty-loam with 1.5% of organic carbon, 0.02% of nitrogen, 20 p.p.m of available phosphorus, 504 p.p.m of available potassium, acidity of 7.8 and 3.5 mmohs/cm electrical conductivity in 0 to 30 cm depth. Seeds were sown in 3 to 4 m length rows in each plot. Distances about 0.3 and 0.1 m were considered between rows and within rows, respectively. Irrigation was performed every three days until plantlet establishment and every six days after this stage. Weed control was conducted during growing season. Any pest was observed on chamomile plants. At full flowering stage, ten plants were selected from middle row by eliminating border effects. Then, the traits; No. of flowering stems, plant height (cm), days to budding, days to 50% flowering, days to 100% flowering and No. of fertile tiller plant^{-1} were measured on these plants. The flowers were gradually harvested and weighted for determination of fresh flower yield. The individual plant samples of each population were conditioned in plastic bags and transported to the laboratory under refrigeration. Samples (~200 g) were air-dried at room temperature (20 to 25ºC) and maintained in a refrigerated chamber (10ºC) until extraction. Each sample used in this survey was deposited in the IAU Herbarium, Islamic Azad University, Isfahan (Khorasgan) branch (Iran). The air-dried samples (100 g) were subjected to water distillation for 2 h using a Clevenger-type apparatus. The oil obtained was separated from water and dried over anhydrous Na_2SO_4. This essence was weighted for measuring the essence percent.

Analysis of variance was done based on randomized complete block design model. Then, correlation and path coefficient analysis were achieved in order to determination of the relationship between all the traits as well as direct and indirect effects of the traits on dry flower yield and essence percent. Statistical analyses were

Table 1. Analysis of variance for measured traits in German chamomile populations.

S.V	d.f	Mean of squares				
		No. of flower plant^{-1}	Fresh flower yield plant^{-1}	Dry flower yield plant^{-1}	Days to budding	Days to 50% flowering
Blocks	2	48.91	9.61	1.86	0.04	23.46*
Treatments	8	147432.73**	1374.34**	213.05**	147.61**	50.37**
Error	16	67.04	5.32	1.6	1.39	4.18
S.V	**d.f**	**Days to 100% flowering**	**Plant height**	**No. of flowering stems**	**No. of fertile tillers plant^{-1}**	**Essence percent**
Blocks	2	2.42	2.94	$1.3*10^{-4}$	$3.8*10^{-4}$	1.09
Treatments	8	67.87**	259.36**	2*10-3**	1.620**	2.40**
Error	16	2.73	0.85	$3.75*10^{-5}$	0.008	0.54

*, **: Significant at 5 and 1% probability levels, respectively.

Table 2. Correlation coefficients between measured traits in German chamomile populations.

Variables	-1	-2	-3	-4	-5	-6	-7	-8	-9
No. of flower plant^{-1}									
Fresh flower yield plant^{-1}	0.923**								
Dry flower yield plant^{-1}	0.793**	0.884**							
Days to budding	0.733*	0.820**	0.948**						
Days to 50% flowering	0.565	0.679*	0.899**	0.949**					
Days to 100% flowering	0.727*	0.814**	0.947**	0.979**	0.965**				
Plant height	-0.064	0.212	0.234	0.15	0.171	0.168			
No. of flowering stems	0.491	0.623	0.766*	0.708*	0.702*	0.702*	0.661		
No. of fertile tillers plant^{-1}	-0.435	-0.368	-0.583	-0.645	-0.629	-0.699*	0.028	-0.378	
Essence percent	0.708*	-0.01	-0.065	-0.216	0.762*	-0.245	0.677*	-0.069	0.680*

*, **: Significant at 5 and 1% probability levels, respectively.

performed by SPSS and SAS softwares.

RESULTS AND DISCUSSION

Analysis of variance (Table 1) showed significant difference between chamomile genotypes for all the studied traits. These revealed existence of genetic diversity between German chamomile genotypes for all the measured traits in this research. Pirkhezri et al. (2008) observed significant differences between chamomile genotypes for all the traits except stomata length. Mahdikhani et al. (2007) also reported high phenotypic variation for biological yield, economic yield, No. of flower plant^{-1} and essence percent in German chamomile accessions. Existence of genetic diversity is one of the most important factors for increasing genetic efficiency of selection and obtaining superior genotypes in breeding programs. Correlation coefficient analysis (Table 2) indicated positive and significant relationship of No. of flower plant^{-1}, fresh flower yield plant^{-1}, days to budding, days to 50% flowering, days to 100% flowering and No. of flowering branches with dry flower yield. Path analysis was conducted for dry flower yield as dependent variable and traits aforementioned as independent variables (Table 3). The traits fresh flower yield plant^{-1} and days to 50% flowering have positive and direct effects on dry flower yield. On the other hands, direct effect of these traits on dry flower yield is the highest amount of their correlations with this. Therefore, these traits suggest as the best traits for genetic improvement of dry flower yield through indirect selection in chamomile genotypes. Denial et al. (2008) found the traits, No. of flower plant^{-1} and plant height as the best indirect selection criteria for breeding dry flower yield in German chamomile that is inconsistent with result of this research. Overall, yield is the complex trait which derivate from yield components. Decrease in each of the yield components may compensate by increase in the others. Therefore, yield production usually save in determine amount (Darzi, 2002). Letchamo (1993) and Jamshidi

Table 3. Path analysis for dry flower yield (dependent variable) based on the other traits (independent variables)*.

Variables	No. of flower plant^{-1}	Fresh flower yield plant^{-1}	Days to budding	Days to 50% flowering	Days to 100% flowering	No. of flowering stems	Sum of effects
No. of flower plant-^{1}	0.135	0.307	0.091	0.289	-0.102	0.069	
Fresh flower yield plant^{-1}	0.125	0.333	0.102	0.347	-0.114	0.087	0.712
Days to budding	0.099	0.273	0.124	0.486	-0.137	0.099	0.884
Days to 50% flowering	0.076	0.226	0.118	0.512	-0.135	0.098	0.948
Days to 100% flowering	0.098	0.27	0.122	0.494	-0.139	0.098	0.898
No. of flowering stems	0.066	0.207	0.088	0.359	-0.098	0.14	0.947
Residual effects	0.204						0.765

*: Data on diagonal show the direct effect and the others are the indirect effects on dry flower yield.

(2000) reported the traits No. of flower, flower weight and No. of flowering branches as the dry flower yield components. These results also have agreement with present research's findings. Correlation analysis also showed that essence percent have significant and positive relation with the traits No. of flower plant^{-1}, days to 50% flowering, plant height and No. of tiller plant^{-1}. Because of that, path analysis for essence percent as dependent variable was achieved based on these traits as independent variables. The other traits have no significant correlation with essence percent. Pirkhezri et al. (2008) also reported significant and positive relationship of No. of flower plant^{-1}, fresh flower yield, 100 flower weights, days to flowering initiation and plant height and negative relation of flowering duration with essence percent. Result of path analysis of essence percent are shown in Table 4.

The traits No. of flower plant^{-1}, days to 50% flowering, plant height and No. of tiller plant^{-1} indicated positive and considerable direct effect on essence percent. Amongst, the traits No. of flower plant^{-1} and days to 50% flowering are the traits also were suggested in order to the improvement of dry flower yield. Therefore, by considering positive and significant correlation, also positive and considerable direct effect of these traits with dry flower yield and essence percent, selection for higher amounts of these traits have suitable genetic efficacy for improvement of dry flower yield and essence percent. These results are highly inconsistent with findings of Cirecelav et al. (2008), Zeinali et al. (2008), Alexandra (2005) and Marinho (2006) on German chamomile genotypes and accessions. These dedicate efficiency of indirect selection for breeding of dry flower yield and essence percent in chamomile. Of course, study of heredity and narrow-sense heritability of indirect selection criteria is very important in this breeding procedure. Falconer (2002) emphasizes on higher narrow-sense heritability of indirect selection criteria versus the trait that selection is done for its improvement. In this point of view because of significant interaction between environment and genotypes for these traits, determination of the best planting date should be done for obtaining maximum days to 50% flowering and No. of flower plant^{-1}. Zeinali et al. (2008) investigated the effect of planting date in chamomile. They reported that on 5th March increase in the traits No. of flower plant^{-1}, days to 50% flowering, dry flower yield and essence percent in comparison with 20 March and 5 April. Indeed, delay planting and impact of flowering stage with temperatures above 23ºC causes florets infertility and finally flower yield deficiency. Also, delay planting causes shortening of vegetative period and days to flowering because of terminal heat stress. These can reduce dry matter reserve in vegetative and germinative organs, No. of flower, flower yield and essence percent (Vildova and Stolcova, 2005; Hajseyedhadi et al., 2004). Yield is the quantitative and complex trait. Because of that, yield affected by different environmental factor such as planting density and pattern, irrigation method and interval, fertilizers, planting date, temperature and sun light as well as plant genotypes. Altogether, genotypes with late maturity have higher flower yield and essence percent more than others if the important factor

Table 4. Path analysis for essence percent (dependent variable) based on the other traits (independent variables)*

Variables	No. of flower plant^{-1}	Days to 50% flowering	Plant height	No. of fertile tillers plant^{-1}	Sum of effects
No. of flower plant^{-1}	0.732	0.839	0.027	-0.836	0.708
Days to 50% flowering	0.413	1.485	0.071	-1.209	0.762
Plant height	-0.047	0.254	0.417	0.053	0.677
No. of fertile tillers plant^{-1}	-0.319	-0.935	0.011	1.921	0.680
Residual effects	0.380				

*: Data on diagonal show the direct effect and the others are the indirect effects on essence percent.

such as high temperature does not decrease these traits at maturity stage. Also, some researchers reported the effect of environmental stresses such as drought stress on increasing essence percent, but due to decreasing flower yield plant^{-1} in these circumstances, essence yield will deficit that it is not satisfactory for farmers.

Mirzaie et al. (2001) using correlation and path analysis on some Menta species found that for improvement essence percent of flower, the best procedure is indirect selection for the traits days to flowering, leaf length and main stem diameter. Measurement of these traits is easy and non-expensive. Amongst, days to flowering and leaf length have the most positive direct effect as well as positive and significant correlation with essence percent of flower. Therefore, these traits were introduced as the most effective traits on essence percent of flower in Menta species. In conclusion, the traits days to 50% flowering and No. of flower plant^{-1} were determined as the most promising and efficient indirect selection criteria for genetic improvement of dry flower yield and essence percent. These traits are the most important and economic characteristics in German chamomile. Although, the traits fresh flower yield and days to budding have also high potential which is introduced as selection criteria in order to the improvement of dry flower yield.

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