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Influence of variability and association on essential oil content of German chamomile (*Chamomilla recutita* (L.) Rauschert)

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Abstract

The nature and extent of variability, association, co-heritability and path coefficients were studied for 8 economic traits in 48 accessions of German chamomile (*Chamomilla recutita*) assembled from India and abroad. The genotypic correlations were higher than phenotypic correlations for all the traits except dry flower yield, oil content and branches per plant. Fresh flower yield was significantly and positively correlated with branches per plant, dry flower yield, spread area and oil yield at both genotypic and phenotypic levels. Oil content and dry flower yield were also associated with oil yield. All the traits exhibited high heritability, the highest being spread area and lowest for oil content. The genetic advance over mean was the highest for oil yield and lowest for spread area. The highest direct contribution to essential oil yield was by fresh flower yield (0.335) followed by oil content (0.286), plant height (0.144), dry flower yield (0.050) and spread area (0.013), respectively. Dry flower yield indirectly contributed maximum to essential oil yield. The correlations between plant height and oil content had the maximum co-heritability value (1.306) followed by days to flower (50%) with dry flower yield (1.186) and plant height (1.129). These traits may form a good selection criterion for improvement of essential oil yield in German chamomile.

Key words : *Chamomilla recutita,* German chamomile, heritability, variability.

Introduction

German chamomile [*Chamomilla recutita* (L.) Rauschert] (Asteraceae) is a natural source of essential oil and flavonoids which are used in pharmaceuticals, flavours, perfumes and cosmetics. Chamomile, a native of Europe has a wide range of adaptability to climate and is now widely cultivated in India. A large number of collections/ accessions of chamomile were assembled at Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow, India, from India and abroad and the genetic variation for different traits in them was studied. This allowed the gathering of genetic information about correlations among the traits and the contribution of various yield components to be recognized, thus aiming for improvement in quality of this crop by increasing the yield of both flowers and essential oil.

Materials and methods

Forty eight indigenous and exotic collections/ accessions of chamomile of diverse origin-38 from India [31-Lucknow, 4-Sahadatganj, 2-Pantnagar (Udham Singh Nagar), 1-Delhi] and 10 from abroad (4-Bulgaria and 3 each from Germany and Romania) were evaluated in the field for three consecutive years in a randomized block design replicated twice at the Research Farm of Central Institute of Medicinal and Aromatic Plants, Lucknow. The plots were single rows, each 3 m long and 50 cm apart and the plant to plant distance was 30 cm. The crop received normal intercultural operations, and fertilizer applications of 60 kg N, 30 kg P_2O_5 and 30 kg K_2O per ha.

Morphometric observations namely, days to flower (50%), plant height, branches per plant, spread area, fresh flower yield, dry flower yield, oil content and oil yield were recorded on five randomly selected plants in each plot for eight traits each year. The mean values pooled over three years for all the characters of 48 accessions were subjected to simple analyses for various parameters, correlation and path coefficients based on Dewey & Lu (1959). Oil estimation was done in shade dried flowers by hydrodistillation using a clevenger apparatus for 12 h.

Results and discussion

The analysis of variance indicated that all the traits registered highly significant effects (P<0.01) in all the three years. The mean performance and range of the genetic stocks/accessions pooled over three years are presented in Table 1. The accessions/collections also differed significantly for all the traits examined over years except days to flower (50%) for years and replications x years for spread area, fresh flower yield, dry flower yield and oil content (Table 2). The existence of such variations in chamomile was also noticed by Gasic *et al.* (1989), Marczal & Petri (1988), Massoud & Franz (1990) and Salamon & Honcariv (1994).

The genotypic and phenotypic CV (sampling variance) was high for spread area (32.87% and 32.83%) followed by branches per plant (29.71% and 29.42%) and fresh flower yield (25.33% and 24.88%). It was moderate for plant height (15.86% and 15.36%) followed by days to flower 50% (13.09% and 12.76%) and low for oil yield per plot (0.129%) (Table 3). Heritability in broad sense was generally large (90.31–99.74%) for all the traits. Therefore, all the characters were apparently very little influenced by environmental factors. Medium to high heritablity was also reported by Massoud & Franz (1990) for flower head weight, oil content, chamazulene content and α-bisabilol content in this crop. A high heritability estimate with correspondingly high genetic advance (GA) is more reliable for selection than that with low genetic advance. The three most important traits, namely, branches per plant, dry flower yield and oil content had high heritability and high genetic advancement (Table 3). Therefore, these traits might be highly amenable to direct selection for their genetic improvement over a short span of time.

In addition to heritability and genetic advance, the genetic associations among characters also have a direct bearing on the success of a selection. The magnitude of correlations were larger than phenotypic correlations for nearly all the traits except dry flower yield and oil content with branches per plant (Table 4). The associations among diverse traits revealed that fresh flower yield was significantly and positively associated with branches per plant (0.395**, 0.380**), dry flower yield (0.543**, 0.514**), spread area (0.274*, 0.267*) and oil yield (0.308*, 0.299*) at both genotypic and phenotypic levels. Oil content was also positively and significantly associated with spread area (0.379**, 0.363*), days to flower 50% (0.305*, 0.275*), branches per plant (0.261*, 0.242*) and oil yield (0.253*, 0.239*). On the other hand, dry flower yield was also associated with oil yield (0.307*, 0.302*) and spread area with branches per plant (0.291*, 0.288*). Therefore, selection of fresh flower yield, dry flower yield, oil content, spread area and branches per plant will influence directly or indirectly the yield of essential oil.

Plant height and oil content had the maximum co-heritability value (1.306) followed by days to flower 50% with dry flower yield (1.186) and plant height (1.129). The lowest co-heritability value was found for the association of days to flower 50% and branches per plant (0.646) (Table 4). Higher co-heritability value of a character combination suggests that increases in one of the character of that combination will also increase in its co-heritable characters (Singh 1988). Hence for plant height and oil content, days to flower 50% and dry flower yield per plot should be taken in to consideration for genetic improvement because of the higher co-heritability value that existed between these characters.

The path coefficient study revealed that the highest direct contribution to essential oil yield was by fresh flower yield (0.335) and oil content (0.286), followed by plant height (0.144), dry flower yield (0.050) and spread area (0.013). Days to flower 50% and branches per plant made negative direct contributions (Table 5). Dry flower yield indirectly contributed maximum to essential oil yield followed by branches per plant under residual effect (R=0.752), although most of the indirect values in path coefficient are negligible or very low. From these values one cannot predictably say that the contributions of a particular character is through indirect effects. Fresh flower yield has a significant and positive correlation with oil yield, high heritability and highest direct contribution to oil yield but has a low genetic advance which indicates the roles of environment/genotype x environmental interactions. The residual effects (R=0.752) though higher, indicates that besides the characters studied, there may be some other attributes which also contribute

Table 1. Mean performance of German chamomile accessions

Acc. No.	Days to flower (50%)	Plant height (cm)	Branches /plant	Spread area (sq/cm)	Fresh flower yield (g/plot)	Dry flower yield (g/plot)	Oil content (%)	Oil yield (g/plot)
GC-1	57.56	35.67	7.44	2568	450	122.39	0.67	0.82
GC-2	56.11	35.78	14.22	1044	368	29.09	0.55	0.16
GC-3	56.33	36.33	7.00	453	260	37.89	0.37	0.14
GC-4	58.11	21.67	12.22	1150	268	27.45	0.51	0.14
GC-5	57.11	26.00	8.78	2004	419	77.08	0.48	0.37
GC-6	53.67	22.78	15.00	2667	459	118.87	0.53	0.63
GC-7	53.22	25.78	13.33	575	413	91.23	0.57	0.52
GC-8	55.56	22.44	13.32	1875	389	82.43	0.74	0.61
GC-9	52.89	31.56	14.27	2400	363	75.61	0.41	0.31
GC-10	51.78	35.56	18.56	2550	459	164.52	0.31	0.51
GC-11	52.89	37.11	23.22	3055	458	100.00	0.59	0.59
GC-12	67.00	35.56	14.78	2383	483	108.70	0.69	0.75
GC-13	84.67	28.44	15.00	3103	471	26.39	0.72	0.19
GC-14	69.44	31.67	15.11	2172	478	68.42	0.57	0.39
GC-15	56.11	35.33	9.00	3208	400	40.98	0.61	0.25
GC-16	75.11	33.33	12.33	3376	340	88.71	0.62	0.55
GC-17	82.44	27.33	12.33	2528	410	77.36	0.53	0.41
GC-18	57.78	26.55	17.11	2904	420	81.82	0.55	0.45
GC-19	52.78	28.89	15.11	2914	420	82.46	0.57	0.47
GC-20	52.56	29.89	17.89	2320	360	39.29	0.56	0.22
GC-21	49.67	27.22	11.89	2637	483	66.07	0.56	0.37
GC-22	53.33	32.55	14.11	2663	390	46.94	0.49	0.23
GC-23	56.00	26.11	11.55	2882	268	54.69	0.64	0.35
GC-24	53.33	25.89	13.44	1577	414	44.44	0.45	0.20
GC-25	56.67	28.89	15.44	3694	236	40.43	0.47	0.19
GC-26	54.22	27.89	13.33	2677	407	46.00	0.50	0.23
GC-27	54.22	27.56	12.78	1389	342	50.00	0.36	0.18
GC-28	49.78	33.37	10.11	1944	420	51.16	0.43	0.22
GC-29	46.89	29.78	12.89	2628	419	30.00	0.50	0.15
GC-30	57.22	31.33	16.00	2498	416	47.83	0.46	0.22
GC-31	53.44	37.33	16.22	3549	487	66.04	0.53	0.35
GC-32	54.11	35.33	13.89	2928	346	48.28	0.58	0.28
GC-33	59.11	35.67	10.11	2993	444	52.00	0.75	0.39
GC-34	51.67	34.11	9.11	1612	362	67.86	0.56	0.38
GC-35	63.44	26.78	9.67	1926	480	117.02	0.47	0.55
GC-36	51.67	35.67	12.11	2768	380	137.50	0.48	0.66
GC-37	52.44	31.33	10.11	2133	330	119.05	0.42	0.50
GC-38	55.67	28.11	12.11	1882	330	75.00	0.49	0.36
GC-39	51.78	34.11	9.00	2176	250	27.59	0.29	0.08
GC-40	53.49	28.33	14.22	1285	420	100.00	0.50	0.50
GC-41	55.67	27.78	8.33	228	177	07.55	0.53	0.04
GC-42	55.67	25.00	9.67	1764	207	23.44	0.64	0.15
GC-43	60.22	25.11	8.89	1843	172	45.83	0.48	0.22
GC-44	64.22	29.44	8.44	2130	120	12.28	0.57	0.07
GC-45	59.11	26.56	17.11	1335	306	60.00	0.40	0.24
GC-46	58.33	35.00	10.33	2220	224	33.33	0.51	0.17
GC-47	61.78	35.56	17.67	1026	342	83.33	0.48	0.40
GC-48	60.11	34.33	26.33	3259	438	51.46	1.03	0.53
Range	49.67–	21.67–	7.00–	453–	120–	07.55–	0.29–	0.04–
	84.67	39.33	26.33	3694	487	164.52	1.03	0.82
Mean	57.76	30.52	13.06	2275.9	368.7	57.30	0.54	0.41
CD (1%)	8.75	7.64	10.80	764.42	320.50	31.70	0.39	0.19

Values are means of 3 years

Table 2. Analysis of variance over years for economic traits in German chamomile

Source	df.	Days to flower (50%)	Plant height (cm)	Branches/ plant	Spread area (sq cm)	Fresh flower yield (g/plot)	Dry flower yield (g/plot)	Oil content (%)	Oil yield (g/plot)
Treatments	47	497.36**	202.08**	133.62**	5027508.00**	77007.91**	1474.23**	0.13**	2.520**
Years	2	7.88	673.97**	140.21**	5810688.00**	25648.00**	1367.63**	0.15**	0.010**
Replications x years	6	29.23**	15.46**	5.59**	8661.33	2760.00	9.81	0.01	0.003**
Treatments x years	94	216.25**	105.03**	94.71**	1390091.00**	49791.75**	817.63**	0.11**	0.040**
Error	282	9.01	4.71	1.15	5598.41	1608.16	16.47	0.01	0.001

** = $P < 0.01$

Table 3. Variability of genetic parameters over years in German chamomile

Genetic parameter	Days to flower (50%)	Plant height (cm)	Branches/ plant	Spread area (sq cm)	Fresh flower (g/plot)	Dry flower (g/plot)	Oil content (%)	Oil yield (g/plot)
Variance components								
Phenotypic (p)	57.20	23.43	15.04	559588.30	8854.71	161.56	0.015	0.28
Genetic (g)	54.29	21.97	14.75	558126.30	8407.33	161.92	0.013	0.28
Environmental (e)	9.01	4.71	1.15	55.98	16.08	16.47	0.010	0.01
Coefficients of variations at								
Phenotypic (Cvp)	13.09	15.86	29.71	32.87	25.53	22.59	22.64	0.13
Genotypic(Cvg)	12.76	15.36	29.42	32.83	24.88	22.21	21.52	0.13
Heretability in								
broad sense (hBS%)	94.92	93.77	98.07	99.74	94.95	96.64	90.31	90.99
Genetic advance [GA (%/X)]	24.95	29.65	59.42	0.67	4.64	44.21	40.74	265.85
Population mean (X)	57.76	30.52	13.06	2275.90	386.58	57.29	0.54	0.41
SE	6.07	2.85	4.03	28.52	11.96	11.83	0.14	0.07

p, g and e = Variance components - phenotypic, genotypic and environment; Cvg and Cvp = Coefficients of variation at genotypic and phenotypic levels; h(BS) = Estimates of heritability broad sense; GA = Genetic advance

Table 4. Genetic (G), phenotypic (P) and environmental (E) correlations and coheritability in broad sense [(COH(B)] over years in economic traits in German chamomile

Character	r and COH	Days to flower (50%)	Plant height (cm)	Branches/ plant	Spread area (Sq cm)	Fresh flower yield (g/plot)	Dry flower yield (g/plot)	Oil content (%)	Oil yield (g/plot)
Days to flower	G	-	-0.114	-0.003	0.170	0.084	-0.021	0.305*	0.029
(50%)	P		-0.096	-0.005	0.166	0.084	-0.017	0.275*	0.028
	E		0.219	-0.055	0.012	0.083	0.076	-0.099	-0.001
	COH(B)		1.129	0.646	0.999	0.950	1.186	1.025	1.000
Plant height	G		-	0.076	0.083	0.158	0.166	-0.013	0.187
(cm)	P			0.071	0.081	0.144	0.165	-0.009	0.181
	E			-0.064	0.031	-0.091	0.140	0.024	0.081
	COH(B)			1.031	0.995	1.035	0.961	1.306	0.997
Branches/plant	G			-	0.291*	0.395**	0.012	0.261*	-0.096
	P				0.288*	0.380**	0.130	0.242*	-0.095
	E				-0.047	-0.0.41	0.036	-0.086	0.814
	COH(B)				1.001	1.003	0.929	1.015	1.003
Spread area (sqcm)	G				-	0.274*	0.174	0.379**	0.129
	P					0.267*	0.171	0.363*	0.129
	E					0.093	-0.071	0.231	0.026
	COH(B)					0.996	1.004	0.990	0.999
Fresh flower	G					-	0.543**	0.179	0.308*
yield (g/plot)	P						0.514**	0.163	0.299*
	E						-0.140	0.039	0.221
	COH(B)						1.011	1.017	1.005
Dry flower	G						-	0.178	0.307*
yield (g/plot)	P							0.174	0.302*
	E							0.132	0.127
	COH(B)							0.957	0.998
Oil content	G							-	0.253*
(%)	P								0.239*
	E								-0.073
	COH (B)								1.003
Oil yield	G								-
(g/plot)	P								
	E								
	COH (B)								

*, ** = $P < 0.05$ and $P < 0.01$, respectively

towards oil yield. Therefore, choice of traits, dry flower yield and branches per plant on a selection criterion for improvement of essential oil might be a rewarding proposition in chamomile, though

Table 5. Direct (in bold) and indirect effects of yield components on oil yield over years in German chamomile

Character	Days to flower (50%)	Plant height (cm)	Branches/ plant	Spread area (sq cm)	Fresh flower yield (g/plot)	Dry flower yield (g/plot)	Oil content (%)	rg with oil yield
Days to flower (50%)	-0.073	-0.016	0.001	0.002	0.028	-0.001	0.087	0.029
Plant height (cm)	0.008	**0.144**	-0.024	0.001	0.053	0.008	-0.004	0.187
Branches/plant	0.0002	0.011	**-0.319**	0.004	0.132	0.001	0.075	-0.096
Spread area (sq cm)	-0.012	0.012	-0.093	**0.013**	0.092	0.009	0.108	0.129
Fresh flower yield (g/plot)	-0.006	0.023	-0.126	0.004	**0.335**	0.027	0.051	0.308*
Dry flower yield (g/plot)	0.002	0.024	-0.004	0.002	0.182	**0.050**	0.051	0.037*
Oil content (%)	-0.022	-0.002	-0.083	0.005	0.060	0.009	**0.286**	0.253*

Residual effect (R = 0.752); rg = genetic correlation
* = $P < 0.05$

selection for essential oil yield per se is more dependable.

However, improvement of essential oil yield is not the only factor in improvement of chamomile. Better quality essential oil is of great importance in trade. Thus, while selecting for high essential oil yield, quality parameters should also be taken into consideration.

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