

Genetic Variability Assessment of Ethiopian Caraway (*Trachyspermum ammi* L. Sprague ex Turrill) Genotypes at Mersa, Ethiopia

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Abstract
Thirty-six local accessions of Ethiopian caraway were evaluated to assess their genetic variability and to determine their essential oil contents at Mersa, North Wollo using 6 x 6 lattice designs with three replications. Fourteen parameters were recorded and statistically analyzed The analysis of variance for these parameters indicated that the mean squares due to genotypes were highly significant for days to emergence, days to maturity, plant height, secondary branches/plant, seed yield and essential oil content. Genotypic variance contributed the larger portion of the phenotypic variance in all of the parameters. Moderate values of PCV and GCV were noted for number of secondary branches (15.1% and 14.16%), plant height (12.3% and 10.84%) and essential oil content (16.1% and 15.7%); however, the values of PCV and/or GCV were low for the rest of the parameters. Highest value of heritability were observed for essential oil (94.2%) and secondary branches (87.6%).Genetic advance (GA) and GA% were higher for dry matter, seed yield, secondary branches and plant height. Heritability, GA and GA% were higher for number of secondary branches, plant height and essential oil. Significant positive correlations were observed for number of umbel with number of secondary branches (0.98**), number of seeds per umbel (0.6**) and plant height (0.44**).Genotypically seed yield was positive and highly significant with number of primary branches (0.48**), secondary branches (0.5**), number of umbel per plant (0.8**), number of seeds per umbel (0.98**) and plant height (0.79**).
Keywords: essential oil, harvest index, heritability, variability, genetic advance, correlation,

1. Introduction
Spices play significant role in flavoring of food and generation of income both in local and foreign markets (Girma *et al*., 1996). Spices are used as sources of essential oil for fragrance and in pharmaceutical industries as well as in folk medicine (Digrak *et al*., 1999; Alema *et al*., 2004). Ethiopia has a diverse climate to grow wide variety of spices. While production is normally by subsistence farmers, total area under spices production is estimated to be 90,959 ha. Of this area, 9,204 ha of land were covered by Ethiopian caraway and black Cumin in 2003 with production of 5,887 tons (MoARD, 2003). Out of the total production of the two spice crops, about 56.9% was produced in the Amhara region.
Ethiopian caraway (*Trachyspermum ammi* L. Sprague ex Turrill) belongs to the family Apiaceae, it is an erect and branched annual medicinal spice originating in India and cultivated intensively throughout Ethiopia. It is cultivated in some parts of Ethiopia providing many benefits to growers (Dawit *et al*, 2003). Despite the potential of the crop and fertile policy environment, little attention has been given to improve productivity of Ethiopian caraway other than collecting and preserving indigenous germplasm (MOARD, 2003). Thus, the present study was undertaken to provide basic information on local Ethiopian caraway accessions held by the Ethiopian Institute of Biodiversity. The study was initiated to address the following objectives.
To assess the extent of genetic variability among the available Ethiopian caraway genotypes
To assess the essential oil content of the available Ethiopian caraway genotypes

2. Materials and Methods
The experiment was conducted in 2008/2009 cropping season at Mersa ATVET College experimental field, North Wollo administrative Zone of Amhara region, Ethiopia. Mersa ATVET College experimental field is located at 39038` E longitude and 11035`N latitude at an altitude of
1576 m.a.s.l. It is situated in the semiarid tropical belt of North Eastern Ethiopia. The mean annual rainfall of the area is 850 mm and the mean annual maximum and minimum temperature is 29.50C and 13.50C, respectively. The soil of the experimental site is predominantly clay loam, classified as Vertisol (SARC, 2003). The experiment included 35 accessions of Ethiopian caraway collected from various parts of Ethiopia by Ethiopian

Biodiversity Institute. In addition to these accessions, one local cultivar was used as a check for evaluation, thus 36 accessions were used. The study was carried out in a 6x6 Lattice Design with three replications. The size of the plot was 1.8 m x 2.0 m (3.6 m2) with four rows planted at 30 cm between plants and 40 cm between rows. Parameters recorded were days to 50% emergence, days to 50% flowering, days to 50% fruit setting, days to 50% maturity, Plant height, number of branches, number of umbels per plant, number of seeds per umbel, seed yield per hectare (Kg/ha), thousand seeds weight, determination of dry biomass (kg/ha), harvest index (HI) and essential oil content. The data were subju8cted to analysis of variance using MSTATC (MSTAT, 1989). The variability present in the population was estimated using GCV and PCV as suggested by Burton and De vane (1953).

3. Result and discussion

$\sigma_p^2 = \sigma_g^2 + \sigma_e^2$ (Falconer, 1990). Where; σ_p^2=Phenotypic variance, σ_g^2=Genotypic variance, σ_e^2 = Environmental variance/error mean square

$$\sigma_g^2 = \frac{MS_g - MS_e}{r}$$

MS_g = Mean Square of treatments MS_e = Mean Square of error
r = Replication
Coefficients of phenotypic and genotypic variations were analyzed using the method described by Burton and De Vane (1953).

$$PCV = \frac{\sqrt{\sigma_p^2}}{\overline{X}} \times 100 \qquad GCV = \frac{\sqrt{\sigma_g^2}}{\overline{X}} \times 100$$

Where: PCV = Phenotypic Coefficient of Variation, GCV = Genotypic Coefficient of Variation, $\overline{X}$ = Grand mean, $\sigma^2{}_p$, $\sigma^2{}_g$ = Phenotypic and genotypic variance respectively

3.1 Analysis of variance

The results of ANOVA for the 14 parameters are presented at Table 1. It can be seen that mean square due to genotypes lines were highly significant for all the traits studied except for days to flowering and number of seeds per umbel indicating the existence of sufficient genetic variability. Number of primary branches, dry matter and harvest index showed significant difference at 5%.

3.2 Range

The result of the present investigation on the estimates of range and mean for the characters studied are presented in Table 4. The range for days to emergence was 13.3 for accession 223062 and 17.3 for accession 242231; the mean value was 15.3+0.9 and most of the accessions were above the mean value. The range of values for days to flowering was 79.7 for the local accession, and 88.8 for accession 242235. Days to fruit setting showed a narrow range 110 for the local accession and 115.3 for 242239.

3.3 Estimates of Phenotypic and genotypic Coefficient of variation

Phenotypic coefficient of variation (PCV) was generally equal to genotypic coefficient of variation (GCV) or only slightly higher for all the characters considered (Table 2), suggesting lesser influence of environmental factors on the phenotypic appearance of the crop. The range for PCV was from1.4% for days to fruit setting to 16.1% for essential oil; as to the GCV, it ranged from 1.1% for days to flowering to 15.7% for essential oil. Moderate PCV was also observed for characters like numbers of secondary branches (15.1%) and plant height (12.3%). GCV was also moderate for numbers of secondary branches (14.2%) and plant height (10.8%). For characters like days to maturity, days to flowering, thousand seeds weight, number of seeds per umbel, which had low PCV and GCV, selection for such characters could be difficult. This suggested that genotypically and phenotypically there was no more differences between the collected accessions regarding those characters. This was in agreement with the finding of Sharma *et al*., (1990) who reported relatively high estimates of PCV than GCV for most of the characters in fenugreek.

3.4 Estimates of Heritability (h2)

Broad sense heritability (h2), an estimate of total genetic variance as a portion of the total phenotypic variance, which was worked out in respect of the fourteen characters of Ethiopian caraway ranged from 6.6% for number of umbels per plant to 94.2% for essential oil contents (Table 2). Higher heritability were obtained for essential oil (94.2%) and number of secondary branches (87.58%), in which these characters also had moderate PCV and GCV and, thus, there could be of much significance in selection. Adam (2006), in similar study on black cumin, had reported moderate heritability for days to maturity and plant height.

3.5 Estimates of Expected Genetic Advance (GA)

The expected genetic advance as percent of the mean in the present study for Ethiopian caraway varied from 0.7% for plant height to 31.4% for that of essential oil. High expected genetic dvance as percent of the mean were also noted for plant height (19.7%) and number of secondary branches (27.3%). Abraham *et al*. (2007) got a more or less similar result in ginger in which the genetic advance as percent of mean varied from 3.8 % for plant height to 25.88 % for dry weight of rhizome.

3.6 Correlation Studies

3.6.1 Phenotypic correlations (rp)

Phenotypic correlation tells us the relationship between two or more characters based on their physical appearance. As described in Table 3, some of the characters are positively correlated while others are negatively correlated. Number of umbels per plant was positively and significantly correlated with most of the characters, such as primary (0.34**) and secondary branches (0.86**), plant height (0.78**) and seed yield (0.5**) while it is negatively and insignificantly correlated with days to maturity (-0.2ns). This shows that as number of branches and plant height increase the number of umbels per plant increase but the number of days to which the crop reaches physiological maturity decrease because there are many more umbels on secondary branches which do not mature at same time with umbels on primary branches and this delay the stage of 50% maturity.

3.6.2 Genotypic correlation coefficient (r_g)

Seed yield was positively and significantly correlated with primary (0.48^{**}) and secondary (0.5^{**}) branches, number of umbel per plant (0.8**), plant height (0.79**); so by improving these traits, there is a possibility of improving the yield of Ethiopian caraway genotypes. Bemnet and Getinet (2010), in their study on coriander (*Coriandrum sativum* L.) observed that Seed yield/plant was strongly and positively correlated with number of basal leaves, plant height, number of seeds/plant and thousand seed weight.

3.6.3 Path Coefficient analysis

Dry matter and Harvest index contributed their major effects as direct effect (Table 4). These traits could be considered as the major components of selection in a breeding program to obtain high seed yield. Those characters direct positive effect on yield are number of primary branches per plant (0.007), number of umbels per plant (0.025), and plant height (0.012). In a similar study on fenugreek Feysal (2006) reported that maximum positive direct effect was exerted on seed yield per plot by biomass yield per plant (0.459) followed by seed yield per plant (0.404), biomass per plot (0.401). The residual effect was very small (r= 0.109) indicating that high percent of variability in seed yield was accounted by the fourteen traits included in the present study.

Number of primary branches per plant had high (0.238) direct effect on essential oil content. This implies that number of primary branches is the most important trait for selection criteria to improve essential oil content. Days to flowering (0.158) and days to maturity (0.128) also had positive direct effect on the content of essential oil. However number of primary branches per plant had a negative indirect impact on essential oil through days to flowering and maturity (Table 6). Days to flowering had positive indirect effect through days to maturity but negative indirect effect through number of primary branches on the yield of essential oil. Days to maturity had an indirect negative effect on number of primary branches, and positive effect on days to flowering.

4. Conclusions

Analysis of variance computed for fourteen characters studied indicated that the mean squares due to genotypes were highly significant for days to emergence, number of secondary branches, plant height, number of umbel per plant, seed yield, days to flowering, maturity and essential oil content, at 0.01 probability level, which shows the existence of sufficient variability that supports variety development of Ethiopian caraway. When the GCV and PCV of Ethiopian caraway was examined, relatively higher values were noted for essential oil, number of secondary branches and plant height. Generally the values ranged from 1.1% (days to flowering) to 15.7% (essential oil) for GCV and from 1.4% (days to fruit setting) to 16.1% (essential oil) for PCV. Estimation of heritability values for Ethiopian caraway at Mersa were ranged from 6.6% to 94.2%. The highest values were noted for essential oil, number of secondary branches, days to maturity, plant height and number of umbels per plant. There is large scope of simultaneous improvement of some of the traits through selection. Hybridization among the different accessions identified in this study could lead to considerable genetic improvement by following appropriate selection strategies in the segregating generations.

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Table 1. ANOVA of 14 parameters of Ethiopian caraway grown at Mersa, North Wollo

SV	Df	DE	NPB	NSB	NUMB	NSPUM	PHT	DF	DFS	DMT	SY	DM	HI	TSW	EO
Rep	2	0.6	0.96	0.58	1.3	537.2	20.6	24.9	0.4	0.4	15258.0	36024	18.63	0.0015	0.1
Acc	35	4.4**	0.4*	207.2**	107.1**	101.7ns	128.7**	11.1ns	5.55**	10.1**	16899.0**	48778*	37.38*	0.004**	1.3**
Error	70	0.9	0.2	9.4	11.0	83.9	11.4	8.5	0.9	0.8	4224.0	21835.0	4.6	0.0	0.0
CV (%)		6.4	5.1	5.3	3.5	8.3	5.8	3.4	0.8	0.7	6.3	5.3	7.5	3.8	3.9

** and * = significant at 1% and 5% probability level respectively; ns= not significant

DE = days to emergence, NPB and NSB=number of primary and secondary branches respectively, NSPUM=number of seeds per umbel, PHT = plant height, DF= days to flowering, DFS= days to fruit setting, DM= dry matter, DMT= days to maturity, SY= seed yield, DM= dry matter, HI= harvest index, TSW= 1000 seeds weight and EO= Essential oil

Table 2. Phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV), phenotypic (σ^2_p) and genotypic variances (σ^2g), heritability (h^2), genetic advance (GA) and genetic advance as percent of the mean of the 14 characters of Ethiopian caraway grown at Mersa, Ethiopia

Characters	σ^2_p	σ^2g	PCV (%)	GCV (%)	h^2 (%)	GA	GA (%)
DE	2.09	1.14	9.45	6.99	54.79	1.63	10.68
NPB	0.28	0.05	5.64	2.45	18.79	0.20	2.19
NSB	75.43	66.06	15.10	14.20	87.58	15.69	27.34
NUMB	43.03	32.03	6.89	5.94	74.43	10.07	10.58
NSPUM	89.83	5.93	8.54	2.19	6.60	1.29	1.16
PHT	50.47	39.11	12.30	10.80	77.49	11.36	19.69
DF	9.32	0.86	3.60	1.10	9.26	0.58	0.69
DFS	2.45	1.55	1.40	1.12	63.27	2.04	1.83
DMT	3.89	3.09	1.46	1.30	79.43	3.23	2.39
SY	8449.00	4225.00	8.85	6.26	50.01	94.83	9.13
DM	52079.00	15178.00	6.31	3.41	29.14	137.21	3.79
HI	10.06	2.28	8.48	4.04	22.64	1.48	3.96
TSW	0.00	0.00	4.86	3.03	38.80	0.04	3.89
EO	0.44	0.41	16.10	15.70	94.23	1.28	31.36

Table 3. Genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficient of Ethiopian caraway grown at Mersa

Traits	DE	NPB	NSB	NUB	NSPU	PHT	DF	DFS	DMT	SY	DM	HI	TSW	EO
DE		-0.03^{ns}	-0.14^{ns}	-0.4^{ns}	0.24^{**}	-0.2^{ns}	0.19^{**}	0.08^{**}	-0.1	-0.0^{ns}	-0.22	0.27^{**}	-0.1^{ns}	0.02^{ns}
NPB	-0.08		0.284	0.88^{**}	0.6^{**}	0.44^{**}	0^{ns}	-0.01	-0.4^{ns}	0.48^{**}	0.92^{**}	-0.04^{ns}	0^{ns}	0.26^{**}
NSB	-0.09	0.128^{**}		0.98^{**}	0.89^{**}	0.56^{**}	0.21^{**}	0.21^{**}	0.13^{**}	0.5^{**}	0.5^{**}	0.41^{**}	-0.04^{ns}	0.01^{ns}
NUB	-0.27	0.34^{**}	0.86^{**}		0.97^{**}	0.97^{**}	0.13^{**}	0.19^{**}	-0.2^{ns}	0.8^{**}	0.69^{**}	0.65^{**}	0^{ns}	0.09^{**}
NSPU	0.10^{**}	0.12	0.23^{**}	0.48^{**}		0.74^{**}	0^{ns}	0.16^{**}	-0.4^{ns}	0.98^{**}	0.75^{**}	0.78^{**}	0.53^{**}	-0.4^{ns}
PHT	-0.08	0.137^{**}	0.48^{**}	0.78^{**}	0.25^{**}		-0.1^{ns}	0.17^{**}	0.19^{**}	0.79^{**}	0.66^{**}	0.7^{**}	0.07^{**}	-0.2^{ns}
DF	0.07^{ns}	-0.26^{ns}	0.12^{**}	0.05^{ns}	-0.14	0.02^{ns}		0.98^{**}	0.87^{**}	-0.6^{ns}	-0.63^{ns}	-0.1^{ns}	-0.64^{ns}	0.9^{**}
DFS	0.07^{ns}	-0.02^{ns}	0.16^{**}	0.13^{**}	0.01^{ns}	0.06^{ns}	0.27^{**}		0.6^{**}	-0.3^{ns}	-0.54^{ns}	0.74^{**}	-0.13^{ns}	0.12^{**}
DMT	-0.08	-0.12^{ns}	0.12^{**}	-0.2^{ns}	-0.2^{ns}	0.17^{**}	0.26^{**}	0.47^{**}		-0.3^{ns}	-0.34^{ns}	-0.3^{ns}	-0.36^{ns}	0.22^{**}
SY	0.03^{ns}	0.22^{**}	0.35^{**}	0.5^{**}	0.19^{**}	0.5^{**}	-0.1^{ns}	-0.1^{ns}	-0.2^{ns}		0.86^{**}	0.88^{**}	0.33ns	-0.1^{ns}
DM	-0.14	0.12^{**}	0.22^{**}	0.33^{**}	0.06^{ns}	0.23^{**}	0.00^{ns}	-0.2^{ns}	-0.1^{ns}	0.39^{**}		0.5^{**}	0.52^{**}	-0.3^{ns}
HI	0.17^{**}	0.14^{**}	0.2^{**}	0.27^{**}	0.18^{**}	0.34^{**}	-0.1^{ns}	0.48^{**}	-0.1^{ns}	0.78^{**}	-0.27^{ns}		0.1^{**}	0.06^{ns}
TSW	-0.09	-0.13^{ns}	0.01^{ns}	0.02^{ns}	0.05^{ns}	0.05^{ns}	0.04^{ns}	-0.13	-0.2^{ns}	0.09^{*}	0.21^{**}	0^{ns}		-0.1^{ns}
EO	-0.0^{ns}	0.2^{**}	0.01^{ns}	0.08^{*}	-0.1^{ns}	-0.2^{ns}	0.24^{**}	0.08*	0.2^{**}	-0.1^{ns}	-0.14^{ns}	0.01^{ns}	0.00^{ns}	

Table 4. Phenotypic direct (bold face) and indirect effect of various characters on seed yield

Traits	NPB	NSB	NUMB	NSPUM	PHT	DM	HI	r_p
NPB	**0.007**	0.001	0.002	0.001	0.001	0.001	0.001	0.22
NSB	-0.001	**-0.010**	-0.008	-0.002	-0.005	-0.002	-0.002	0.35
NUMB	0.009	0.022	**0.025**	0.012	0.020	0.008	0.007	0.50
NSPUM	-0.002	-0.004	-0.009	**-0.018**	-0.005	-0.001	-0.003	0.19
PHT	0.002	0.006	0.009	0.003	**0.012**	0.003	0.004	0.50
DM	0.074	0.136	0.205	0.037	0.143	**0.620**	-0.167	0.39
HI	0.132	0.188	0.254	0.047	0.320	0.320	**0.940**	0.78

Fig. 1 Ethiopian caraway (*Trachyspermum ammi* L. Sprague ex Turrill) at flowering stage