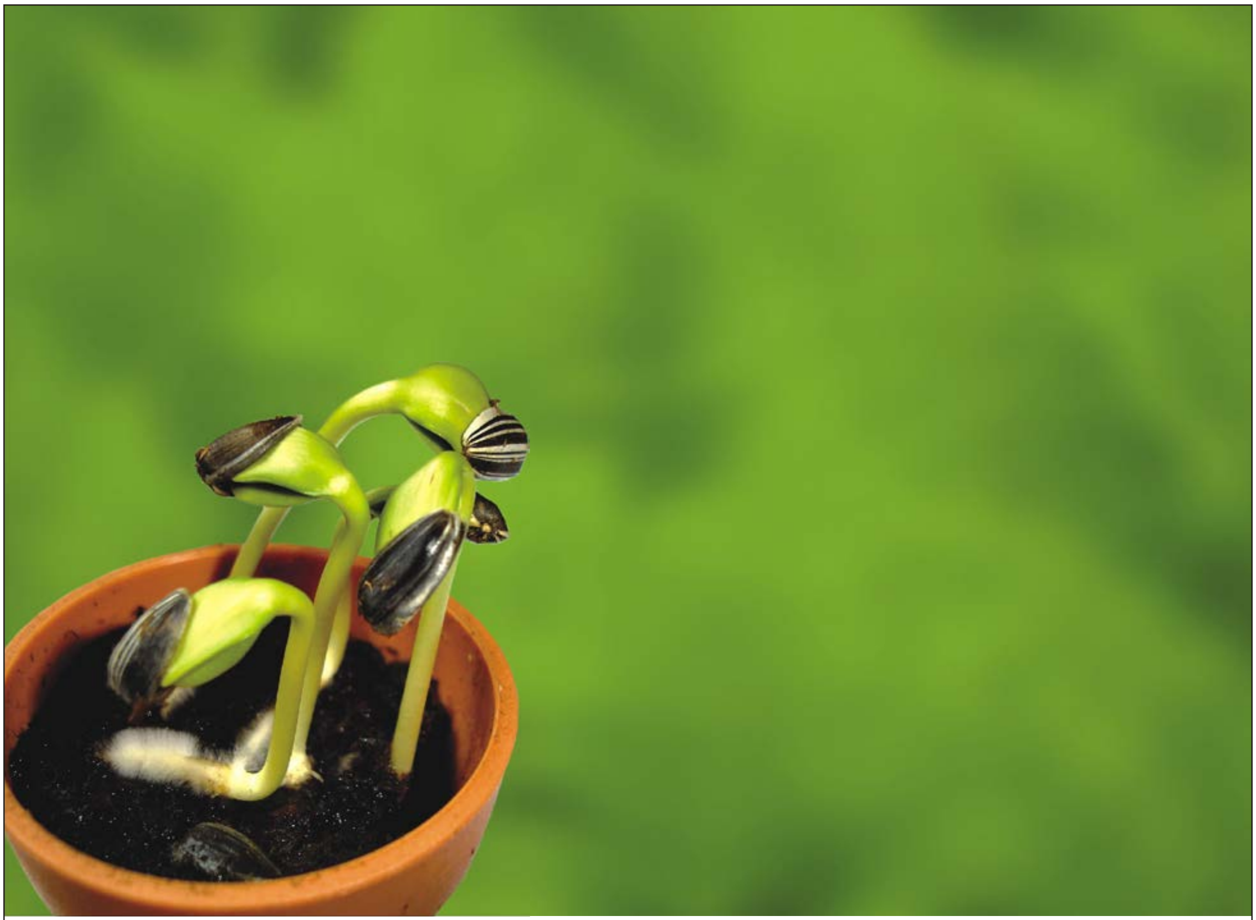

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Variability, Heritability and Genetic Advance for Some Yield and Yield Related Traits and Oil Content in Ethiopian Coriander (*Coriandrum sativum* L.) Genotypes

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ABSTRACT
Coriander is a diploid annual plant, belonging to the Apiaceae/Umbelliferae family and it plays an important role in the Ethiopian domestic spice trade. Eighty one Ethiopian coriander genotypes were evaluated in 9×9 simple lattice designs for genetic variability in seed yield and yield related traits at Adami Tulu Agricultural Research Center during 2011 main cropping season. Data were collected on 21 yield and yield related characters. The analysis of variance showed that genotypes differed significantly for all characters studied with exception of umbel number per plant, number of seeds per plant and number of seeds per umbellete. Highest Genotypic Coefficient of Variation (GCV) was recorded for leaf number per plant followed by plant height at flowering and seed yield per hectare, in contrast lowest GCV were recorded for number of seed per plant, number of seed per umbellete and umbel number per plant. The highest Phenotypic Coefficient of Variation (PCV) was similarly recorded for leaf number per plant followed by, seed yield per hectare, plant height at flowering and harvest index per plant. The highest broad sense heritability values was recorded for days to 50% flowering, days to emergence, days to maturity and days to start of flowering. However, lowest heritability was recorded for umbel number per plant, number of seed per umbellete and number of seed per plant. The highest genetic advance as percent of mean was recorded for leaf number per plant, plant height at flowering and number of secondary branches. While the lowest genetic advance as a percent of mean was recorded for number of seed per plant, number of seed per umbellete and umbel number per plant.

Key words: GCV, genetic advance, heritability, PCV, seed yield, variability

INTRODUCTION
Coriander (*Coriandrum sativum* L., 2n = 2x = 22) is a diploid annual plant, belonging to the Apiaceae/Umbelliferae family (Parthasarathy *et al*., 2008). It is native to Mediterranean and Western Asian regions (Maroufi *et al*., 2010). There exist very different uses of coriander and these are based on different parts of the plant. The traditional uses of the plant, which are based on the primary products, i.e., the fruits and the green herb, are two folds: Medicinal and culinary. The stems, leaves and fruits all have a pleasant aromatic odor. During industrialization, the specific chemical compounds of coriander were recognized and identified and these became important as raw materials for industrial use and further processing (Farahani *et al*., 2008).

The essential and fatty oils of the fruits are both used in industry, either separately or combined. After extraction of the essential oil, the fatty oil is obtained from the extraction residues either by pressing or by extraction (Diederichesen, 1996; Parthasarathy *et al*., 2008). The green leaves have a fragrant and strongly aromatic taste that lends a characteristic flavor to soups, salads, curries and other Oriental dishes. They are extensively used in Southeast Asian and Chinese cooking to flavor vegetable dishes, fish, meat and as a garnish (Chomchalow, 2002) and it is also rich in vitamins, protein and other minerals and used in vegetables and salad (Singh *et al*., 2005). The roots are often used in Thai cooking (Burdock and Carabin, 2009). The plant is also harvested for its seeds and used as spice for the preparation of either the steam distilled essential oil or the solvent extracted oleoresin. Both products can be used in the flavoring and aroma industries. Essential oils can be fractionated to provide linalool (60-70%), which can be used as a starting material for synthetic production of other flavoring agents, such as citral (Blade and Spencer, 2008).

Coriander is also a good melliferous plant and a study indicates that one hectare of coriander allows honey bees to collect about 500 kg of honey (Romanenko *et al*., 1991; Diederichesen, 1996). In Ethiopia cultivation of coriander as a garden crop is widespread all over the country (altitude range 1500-2500 m.a.s.l). The plant is grown as a crop in Harerge, Shewa, Kefa, Welega and Gondar (Engels *et al*., 1991). The availability of genetic variability among population is most important for judicious selection and breeding to desired plant genotypes (Singh *et al*., 2005). The existence of sufficient level of genetic variability is a prerequisite for further improvement of the crop, hence, detailed appraisal of the accessions for different morphological, agronomic and quality traits is necessary in order to identify useful traits either for direct use or pave a way or other improvement programs (Mengesha and Alemaw, 2010). Similarly, information on the nature of inter-relationship among characters that help in formulating efficient scheme of multiple trait selection is required. Besides this, knowledge of the naturally occurring variability in a population helps to identify groups of genotypes that can be used for hybridization program.

The evaluation of coriander genotypes in Ethiopia has been limited and on a small-scale with the exception of variety development experiments for high seed yield reported from Sinana and Debre Zeit Agricultural Research Centers, Ethiopia (SARC., 2006; MoARD., 2009) and genetic variability studies on 49 coriander accessions reported by Mengesha and Alemaw (2010). Therefore, there is a need to generate information on genetic variability, phenotypic and genotypic variance, coefficient of variation and heritability studies. In view of these, the present study was done with the objectives of: estimating the character of both genotypic and phenotypic variability and coefficients of variation, to estimate the heritability and genetic advance under selection for Ethiopian coriander genotypes at Adami Tulu Agricultural Research Center.

MATERIALS AND METHOD

Description of the study area: The experiment was conducted at Adami Tulu Agricultural Research Center of Oromia Agricultural Research Institute (OARI) with rain fed during 2011 main cropping season. Adami Tulu Agricultural Research Center (ATARC) is located in the Mid Rift Valley of Ethiopia 167 km south of Addis Ababa. It lies at a latitude of 7°9'N and longitude of 38°7'E. It has an altitude of 1650 m.a.s.l and it receives a bimodal unevenly distributed average annual rainfall of 760.9 mm per annum. The long term mean minimum and maximum temperature is 12.6 and 27°C, respectively. The PH of soil is 7.88 and it is fine sandy loam in texture with sand, clay and silt in proportion of 44, 22 and 34%, respectively (Abdissa *et al*., 2012).

Experimental material: Eighty population of Ethiopian coriander genotypes along with one released variety (waltai) were used in this study. The genotypes were collected from different agro-ecologies of varying altitude, rainfall, temperature and soil type by Institute of Biodiversity Conservation of Ethiopia (IBC).

Experimental design: Genotypes were arranged in a 9×9 simple lattice design with two replications. Each replication contained 81 plots divided into 9 incomplete blocks. Each incomplete block contains nine plots with an area of 2.4 m^2 (1.5 m lengths×1.6 m width). The respective spacing between rows was 40 cm and seeds were drilled in the rows. The trial was planted on September 06/2012. Thinning was done to 10 cm spacing between plants after seedlings attain true leaves. There were four rows per plot and the middle two rows were used for data collection in order to remove the boarder effect. Weeding and other cultural practices were employed as required and no fertilizer and chemicals were applied.

Data collection: A total of 21 quantitative traits (days to emergency, days to start of flowering, days to 50% flowering, days to maturity, seed yield per plant and per hectare, number of seed per plant, thousand seed weight, biomass yield per plant, harvest index per plant, plant height at flowering, plant height at maturity, number of primary and secondary branches, longest basal leaf length, leaf number per plant, umbel number per plant, umbellete number per umbel, number of seed per umbellete, essential and fatty oil content) were collected according to International Plant Genetic Resource Institute (IPGRI., 1996) to evaluate the genotypes.

Essential Oil Content (EOC): A seed sample was taken from each plot to determine the essential oil content (%) and it was determined by hydro-distillation as illustrated by Guenther (1972). Hydro-distillation is a distillation method in which the coriander seed comes in direct contact with boiling water. Heat was provided by electro mantle. The emerging vapor from the flask containing the volatile essential oil was led to a condenser for condensation and collected in the oil separate unit (Clevenger), this analysis was done at JIJE LABOGLASS plc, Ethiopia.

Fatty Oil Content (FOC): Fatty oil content (%) was determined from an oven dried 22 g composite seed samples taken from each plot by subjecting into the Nuclear Magnetic Spectrometer Reader (NMRS) and this analysis was done at Holeta Agricultural Research Center (HARC), Ethiopia.

Genotypic and phenotypic variance and coefficient of variation: The variability present in the population was estimated by simple measure, namely range, mean, phenotypic and genotypic variance and coefficient of variation. The phenotypic and genotypic variance and coefficient of variation was estimated according to the method suggested by Burton and DeVane (1953) as follows:

$$\sigma^2p = \sigma^2g + \sigma^2e$$

$$\sigma^2g = \frac{Mg - Me}{r}$$

Where:
σ^2p = Phenotypic variance
σ^2g = Genotypic variance

σ^2e = Environmental (error) variance (Error mean square)
Mg = Mean square of genotypes
Me = Mean square of error
r = Number of replication

Phenotypic coefficient of variation:

$$PCV = \frac{\sqrt{\delta^2 p}}{\bar{X}} \times 100$$

Genotypic coefficient of variation:

$$GCV = \frac{\sqrt{\delta^2 g}}{\bar{X}} \times 100$$

where, $\bar{x}$ is the population mean.

Estimate of heritability: Heritability in Broad sense (H^2) for all characters was computed using the formula adopted by Allard (1960) and Falconer (1990) as:

$$H^2 = \frac{\sigma^2 g}{\sigma^2 p} \times 100$$

$$\sigma^2 p = \sigma^2 g + \sigma^2 e$$

Where:
σ^2g = Genotypic variance
σ^2p = Phenotypic variance
σ^2e = Error variance

Estimation of expected genetic advance: Genetic Advance as part of the Mean (GAM) for each characters was computed using the formula adopted from (Johnson *et al*., 1955; Allard, 1960):

$$GA = (k)\ (\sigma p) \times (H^2)$$

and:

$$GA\ (\text{as \% of the mean}) = \frac{GA}{\bar{X}} \times 100$$

Where:
k = Selection differential (k = 2.06 at 5% selection intensity)
p = Phenotypic standard deviation
H^2 = Heritability (Broad sense)
$\bar{x}$ = Grand mean

Statistical analysis: Results obtained during study were analyzed by analysis of variance (ANOVA) and p<0.05 was considered statistically significant.

RESULTS AND DISCUSSION

The results of the analysis of variance indicated that the mean squares due to genotypes were significant for all characters studied at (p<0.05), with the exceptions of umbel number per plant, number of seed per plant and number of seed per umbellete (Table 1). The range for seed yield per plant was 1.5-14.5 g with mean value of 7.62 g (Table 2). Accession 212830 gave the highest seed yield per plant (14.5 g) followed by accession 90304 (13 g) and accession 240552 (12.5 g). The lowest seed yield per plant was registered for accession 90307 and 207516 (1.5 g). Bhandari and Gupta (1993) reported lower seed yield per plant range (0.1-5.9 g) in Indian coriander genotypes. Similarly Singh *et al*. (2006) reported 1.05-14.83 g range for seed yield per plant in 360 Indian coriander genotypes which agrees with the current findings.

Seed yield per hectare ranged from 160.4 kg (accession 90307) to 3045.8 kg (accession 240552) with the mean performance of 1577.1 kg (Table 2). Mengesha and Alemaw (2010) also reported seed yield per hectare range of 910.6-3099.9 kg which is in agreement with the current study and Diederichesen (1996) also reported similar findings. The range for seed number per plant was 377.5 (accession 90307) to 2206.1 (accession 240571) with the mean of 793.7 (Table 2).

The variation with respect to plant height at flowering ranged from 22.4-83.8 cm, showing broad variability among the genotypes. Accession 240561 gave the highest plant height at flowering (83.8 cm) followed by accession 240562 (79.4 cm) and accession 240551 (76.7 cm), while accession 230576 gave the lowest plant height at flowering (22.4 cm) followed by accession 242918 (23.6 cm). Similar ranges were reported by Diederichesen (1996) and Peter (2004) in coriander. Mengesha (2008) also reported plant height range from 49.65-97.3 cm in 49 Ethiopian coriander

Table 1: Analysis of variance for 21 characters of coriander landraces studied at Adami Tulu Agricultural Research center, 2011-2012

Traits	MSR (1)#	MSG (80)	Blocks with in rep (16)	Intra block error (64)	CV (%)
DE	20.05**	9.90**	6.70**	0.40	5.1
DSF	426.90**	133.32**	43.00**	13.04	8.9
DF	309.70**	206.73**	60.87**	5.85	4.3
DM	466.80**	207.10**	131.89**	17.82	4.2
SYPH	7446532.23**	773121.10**	1907759.70**	270237.10	32.9
TSW	209.32**	11.35**	8.84^{NS}	5.74	25.1
PHF	409.61**	452.70**	227.02**	51.20	16.1
PHM	694.40**	269.40**	676.20**	53.45	11.1
NPB	19.63**	3.45**	4.92**	1.80	14.7
NSB	39.30^{NS}	129.07**	201.91**	14.88	13.5
UNP	51.68^{NS}	171.80^{NS}	277.37^{NS}	149.55	31.2
UNU	1.48*	0.93**	1.15**	0.28	9.1
NSU	18.06**	2.60^{NS}	2.07^{NS}	2.18	18.0
NSP	0.015^{NS}	0.041^{NS}	0.068*	0.031	6.1
SYP	4.02**	0.52**	0.714**	0.27	19.0
LBLL	11.98*	10.40**	14.14**	3.12	14.6
LN	564.40^{NS}	2430.80**	838.10^{NS}	452.80	30.7
BYPt	2.70^{NS}	2.35*	3.30*	1.36	18.5
HI	240.77**	57.27**	45.60^{NS}	32.40	30.3
FOC	191.64**	6.36**	10.57**	2.80	19.9
EOC	0.01^{NS}	0.037**	0.01^{NS}	0.01	17.9

#Figures in parenthesis indicates the degrees of freedom, *,**Significant at 0.05 and 0.01 probability level, respectively and NS: Non significant, MSR: Mean square of due to replication, MSG: Mean square due to genotype, CV (%): Coefficient of variation, LSD: Least significance difference, DE: Days to emergence, DSF: Days to start of flowering, DF: Days to 50% flowering, DM: Days to maturity, SYPH: Seed yield ha^{-1} (kg), TSW: Thousand seed weight (g), PHF: Plant height at flowering (cm), PHM: Plant height at maturity (cm), NPB: No. of primary branches, NSB: No. of secondary branches, UNP: Umbel number/plant, UNU: Umbellete number/umbel, NSU: No. of seed/umbellete, NSP: No. of seed/plant, SYP: Seed yield/plant (g), LBLL: Longest basal leaf length (cm), LN: Leaf number, BYPt: Biomass yield/plant (g), HI: Harvest index (%), FOC: Fatty oil content (%) and EOC: Essential oil content (%) (v/w dry based)

Table 2: Estimates of minimum, mean and maximum value, variances at phenotypic, genotypic and environment and coefficient of variation at phenotypic, genotypic level, heritability in broad sense (H^2 %), genetic advance in absolute and percent of mean for 21 traits of *Coriandrum sativum* L. land races studied at Adami Agricultural Tulu Research Center, 2011-2012

Traits	Min.	Mean	Max.	$\sigma^2 g$	$\sigma^2 e$	$\sigma^2 p$	GCV (%)	PCV (%)	H^2 (%)	GA	GAM (%)
DE	8.5	12.52	17.5	4.75	0.4	5.15	17.41	18.13	92.20	4.31	34.44
DSF	28.5	40.48	64	60.14	13.04	73.18	19.16	21.13	82.20	14.48	35.78
DF	37	55.74	79	100.44	5.85	106.29	17.98	18.50	94.50	20.07	36.00
DM	80	99.95	121	94.64	17.82	112.46	9.73	10.61	84.20	18.38	18.39
SYPH	160.4	1577.11	3045.8	251442	270237	521679	31.79	45.80	48.20	717.10	45.47
TSW	3.25	9.5	14.14	2.805	5.74	8.545	17.63	30.77	32.80	1.98	20.81
PHF	22.4	44.3	83.8	200.75	51.2	251.95	31.98	35.83	79.70	26.05	58.81
PHM	38.8	65.81	92.8	107.975	53.45	161.425	15.79	19.31	66.90	17.51	26.60
NPB	5.1	9.6	12.8	0.825	1.8	2.625	9.46	16.88	31.40	1.05	10.93
NSB	16.4	28.41	59.5	57.095	14.88	71.975	26.60	29.86	79.30	13.86	48.80
UNP	20.65	39.16	60.1	11.125	149.55	160.675	8.52	32.37	6.92	1.81	4.62
UNU	4.4	5.87	8.2	0.325	0.28	0.605	9.71	13.25	53.70	0.86	14.66
NSU	5.5	8.2	10.8	0.21	2.18	2.39	5.59	18.85	8.79	0.28	3.41
NSP	377.5(2.56)	793.76(2.85)	2206.1(3.27)	0.005	0.031	0.036	2.48	6.66	13.90	0.05	1.90
SYP	1.5(1.4)	7.62(2.77)	14.5(3.77)	0.125	0.27	0.395	12.76	22.69	31.70	0.41	14.79
LBLL	7.1	12.05	18.5	3.64	3.12	6.76	15.83	21.58	53.90	2.88	23.93
LN	14.4	69.11	195.75	989	452.8	1441.8	45.50	54.94	68.60	53.66	77.64
BYPt	15(3.8)	41.84(6.3)	81.5(8.7)	0.495	1.36	1.855	11.17	21.62	26.70	0.75	11.88
HI	6	18.75	31.8	12.435	32.4	44.835	18.81	35.71	27.70	3.83	20.40
FOC (%)	4.85	8.5	11.9	1.78	2.8	4.58	15.70	25.18	38.90	1.71	20.16
EOC (%)	0.45	0.71	0.9	0.013	0.01	0.023	16.36	21.59	57.40	0.181	25.55

Figures in parenthesis indicates transformed data values, DE: Days to emergence, DSF: Days to start of flowering, DF: Days to 50% flowering, DM: Days to maturity, SYPH: Seed yield ha^{-1} (kg), TSW: Thousand seed weight (g), PHF: Plant height at flowering (cm), PHM: Plant height at maturity (cm), NPB: No. of primary branches, NSB: No. of secondary branches, UNP: Umbel number/plant, UNU: Umbellete number/umbel, NSU: Number of seed/umbellete, NSP: No. of seed/plant, SYP: Seed yield/plant (g), LBLL: Longest basal leaf length (cm), LN: Leaf number, BYPt: Biomass yield/plant (g), HI: Harvest index (%), FOC: Fatty oil content (%) and EOC: Essential oil content (%) (v/w dry based)

genotypes. Cosge *et al.* (2009) reported 40.08-80.36 cm range for plant height at flowering in sweet fennel. Days to 50% flowering ranged from 37 (accession 240560) to 79 days (accession 240547) followed by accession 240561 and accession 240562 (77.5 and 76.5 days, respectively). While days to maturity ranged from 80.5 (accession 230576) to 121 days (accession 240561) followed by accession 240547 (120) and accession 240554 (119). Qureshi *et al.* (2009) reported ranges of 190-194 for days to maturity in coriander genotypes studied in Pakistan while, Bhandari and Gupta (1993) reported 65-118 ranges for days to 50% flowering and 112-145 ranges for days to maturity in Indian coriander genotypes, in which the Ethiopian genotypes are earlier in both days to flowering and days to maturity.

The variation in umbel number per plant ranged from 20.65-60.1 showing wide variability among the accessions for this character. Accession 212830 gave the highest umbel number per plant (60.1), followed by accession 242241 and 90304 (59.7 and 56.3, respectively). Singh *et al.* (2006) reported low umbel number per plant range (3.1-9) in Indian coriander accessions, while Bhandari and Gupta (1993) reported 3.2-39.3 range of umbel number per plant in Indian coriander genotypes which is very low as compared to the Ethiopian germplasms. Qureshi *et al.* (2009) reported higher range (121-336) for umbel number per plant in coriander genotypes studied in Pakistan. Minimum variability among the genotypes was observed for umbellete number per umbel as compared to other traits (Table 2). Accession 90311 gave the highest umbellete number per umbel (8.2) followed by accession 90312 and 208766 (7.5 and 7.3, respectively). Accession 230576 and 242918 gave the lowest umbellete number per umbel (4.4 and 4.9, respectively). Bhandari and Gupta (1993) reported 7.1-177.8 range for umbellete number per umbel, which is higher as compared to the current findings. Singh *et al.* (2006) reported 2-7 ranges for umbellete number per umbel in Indian coriander genotypes, which is very low as compared to the Ethiopian coriander genotypes. Similarly, Cosge *et al.* (2009) reported umbellete number per umbel range 10.33-18.8 in sweet fennel.

Harvest index per plant ranged from 6-31.8% with mean value of 18.7% (Table 2). The highest harvest index per plant was obtained from accession 223066 (31.8%) followed by accession 242918 (31.55%) and accession 242241 (31.35%), while accession 207516 and accession 240561 gave the lowest harvest index per plant (6 and 7.1% respectively). Bhandari and Gupta (1993) reported 8.9-84.8% range for harvest index per plant in coriander genotypes which is higher as compared to the current findings. The range for thousand seed weight was 3.25-14.14 g with mean of 9.5 g. Accession 240550 gave highest thousand seed weight (14.14 g) followed by accession 223066 and 240568 (14.02 and 13.22 g, respectively) and accession 207516 gave the lowest thousand seed weight (3.25 g) followed by accession 90307 and 240561 (3.86 and 4.28 g, respectively). Bhandari and Gupta (1993) reported thousand seed weight range of 5-22.1 g in coriander. Mengesha and Alemaw (2010) reported 9.8-12.8 g thousand seed weight range in coriander genotypes. Cosge *et al.* (2009) reported 3.57-15.72 g range in thousand seed weight in sweet fennel. Similar findings were also reported by Parthasarathy *et al.* (2008).

Fatty oil content was ranged from 4.85-11.9%, with mean value of 8.5%. The highest fatty oil content was obtained from accession 240558 (11.9%) followed by accession 240560 (11.8%) and accession 223066 (11.7%). The lowest fatty oil content was obtained from accession 240561 (4.85%). The range for essential oil content was varied from 0.45-0.9% with mean performance of 0.71% Table 2. Diederichesen (1996) reported the existence of a wide variability of coriander fatty oil up to 27%. Mengesha and Alemaw (2010) reported a range of 11.1-16.3 fatty oil content and 0.25-0.85% essential oil content among the 49 Ethiopian coriander accessions. Burdock and Carabin (2009) and Peter (2004) reported range of fatty oil (16-28%) and essential oil (0.5-1.5%) with small fruited cultivars (up to 2.0%) and states as this amount can vary with cultivar, season and maturity at harvest. Olle and Bender (2010) reported 13-20% fatty oil content range and 0.2-1.5% of essential oil content range in coriander genotypes in Estonia. As compared to other findings, the fatty oil content of the studied accessions in this trial was lower.

Estimated variance components, Phenotypic Coefficient of Variation (PCV) and Genotypic Coefficient of Variation (GCV) of the 21 studied traits of coriander genotypes are presented in Table 2. The estimated phenotypic coefficient of variability was relatively greater than the genotypic coefficient of variation in magnitude for all characters considered. The highest phenotypic coefficient of variation (54.94%) was observed for leaf number per plant followed by seed yield per hectare (45.8%), plant height at flowering (35.83%), harvest index per plant (35.71%), thousand seed weight (30.77%) and number of secondary branch (29.86%). While it was lower for number of seed per plant (6.66%), days to maturity (10.61%), umbellete number per umbel (13.25%), number of primary branch (16.88%) and days to emergence (18.13%). The estimated values of phenotypic variance were in the range of 0.023 for essential oil content to 521679.1 for seed yield per hectare, similar findings were reported by Singh *et al.* (2006) and Bhandari and Gupta (1993) for coriander.

The highest Genotypic Coefficient of Variation (GCV) was obtained for leaf number per plant (45.50%) followed by plant height at flowering (31.98%), seed yield per hectare (31.79%), number of secondary branch (26.6%), days to start of flowering (19.16%) and harvest index per plant (18.81%). Genotypic coefficient of variation is lower for number of seed per plant (2.48%), number of seed per umbellete (5.59%), umbel number per plant (8.52%), number of primary branch (9.46%), umbellete number per umbel (9.71%) and days to maturity (9.73%) (Table 2). The lowest and highest genotypic variance were found for number of seed per plant (0.005) and seed yield per hectare (251442), respectively (Table 2). However, Mengesha and Alemaw (2010) reported lowest genotypic variance for essential oil content (0.01) and highest genotypic variance for number of seed per plant (300628.8) in 49 Ethiopian coriander genotypes.

Genotypic coefficient of variation provides information on the genetic variability present in various quantitative characters, but it is not possible to determine the amount of the variation that was heritable only from the genotypic coefficient of variation. Genetic coefficient of variation together with heritability estimates would give the best picture of the amount of advance to be expected from selection (Burton and DeVane, 1953). Thus, the heritable portion of the variation could be more useful with the help of heritability estimates. Robinson *et al*. (1949) categorize range of heritability as low (0-20%), medium (20-60%) and high (above 60%) in corn. The results that are presented in Table 2, showed that the estimates of heritability in broad sense were high for days to 50% flowering (94.5%) followed by days to emergence (92.23%), days to maturity (84.15%), days to start of flowering (82.18%), plant height at flowering (79.68%), number of secondary branches (79.33%), leaf number per plant (68.59%) and plant height at maturity (66.89%). This confirms the findings of Bhandari and Gupta (1993) for estimates of broad sense heritability in 200 coriander genotypes in India. However, in findings of Mengesha and Alemaw (2010), the highest broad sense heritability was observed for seed yield per plant followed by seed number per plant in Ethiopian coriander landraces which is in partial agreement with the current study. These characters therefore, will respond effectively to phenotypic selection. Moreover, moderate heritability was observed for longest basal leaf length (53.85%) followed by umbellete number per umbel (53.72%), seed yield per hectare (48.20%), fatty oil content (38.86%), seed yield per plant (31.65%), number of primary branch (31.43%), harvest index (27.74) and biomass yield per plant (26.68%). However, low values of heritability in broad sense were observed for umbel number per plant (6.92%), number of seed per umbellete (8.79%) and number of seed per plant (13.89%), indicating limited possibility of improvement for those characters through selection.

There was high genetic advance for traits such as seed yield per hectare (173.04), leaf number per plant (53.66), plant height at flowering (26.05), days to 50% flowering (20.07), days to maturity (18.38), plant height at maturity (17.51), days to start of flowering (14.48) and number of secondary branch (13.86). Intermediate genetic advance were noted for days to emergence (4.31), harvest index (3.83), longest basal leaf length (2.88) and thousand seed weight (1.98). In contrast, low genetic advance were observed for number of seed per plant (0.05), essential oil content (0.18), number of seed per umbellete (0.28), seed yield per plant (0.41), biomass yield per plant (0.75) and for umbellete number per umbel (0.86) (Table 2).

Genetic gain that is expected from selecting the top 5% of the genotypes, as a percent of mean varied from 1.90% for number of seed per plant to 77.64% for leaf number per plant. This may indicates an increase of the same magnitude can be made by selection based on these traits under similar conditions. Better gains were also recorded for plant height at flowering (58.81%), number of secondary branches (48.8%), seed yield per hectare 45.47%, days to 50% flowering (36%), days to start of flowering (35.78%), days to emergence (34.44%), plant height at maturity (26.6%), essential oil content (25.5%), longest basal leaf length (23.93%) and thousand seed weight (20.81%) (Table 2). Intermediate genetic gain values were obtained for days to maturity (18.39%), seed yield per plant (14.79%), umbellete number per umbel (14.66%), while low values were obtained for number of seed per plant (1.9%), number of seed per umbellete (3.41%) and umbel number per plant (4.62%). Mengesha and Alemaw (2010) and Singh *et al*. (2006) reported high genetic advance as percent of mean for seed number per plant, seed yield per hectare and umbels number per plant which partially agrees with the current findings.

CONCLUSION

The present investigation indicated that there is wide range of genetic variability in the tested germplasm for most of the characters studied, therefore simultaneous improvement can be attained in seed yield as well as oil content through selection in Ethiopian Coriander genotypes.

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REFERENCES

Abdissa, T., N. Dechassa and Y. Alemayehu, 2012. Sweet potato growth parameters as affected by farmyard manure and phosphorus application at Adami Tulu, Central Rift Valley of Ethiopia. Agric. Sci. Res. J., 2: 1-12.

Allard, R.W., 1960. Principles of Plant Breeding. John Wiley and Sons Inc., New York, USA., ISBN-13: 9780471023159, Pages: 663.

Bhandari, M.M. and A. Gupta, 1993. Association analysis in coriander. Indian J. Genet., 53: 66-70.

Blade, S. and R. Spencer, 2008. Practical information for Alberta's agriculture industry/coriander. Alberta Agriculture and Rural Development Fact Sheet, pp: 101-105.

Burdock, G.A. and I.G. Carabin, 2009. Safety assessment of coriander (*Coriandrum sativum* L.) essential oil as a food ingredient. Food Chem. Toxicol., 47: 22-34.

Burton, G.W. and E.H. DeVane, 1953. Estimations of heritability in tall festca (*Festuca arundinacea*) from replicated clonal materials. Agron. J., 45: 478-481.

Chomchalow, N., 2002. Production of herbs in Asia: An overview. Assum. Univ. J. Technol., 6: 95-108.

Cosge, B., A. Ipek and B. Gurbuz, 2009. Some phenotypic selection criteria to improve seed yield and essential oil percentage of sweet fennel (*Foeniculum vulgare* Mill. var. dulce). Tarim Bilimleri Dergis, 15: 127-133.

Diederichesen, A., 1996. Coriander: *Corianderum Sativum* L. Promoting the Conservation and use of Underutilized and Neglicated Crops. Vol. 3. Bioversity International, Rome, Italy, ISBN-13: 9789290432845, Pages: 83.

Engels, J.M.M., J.G. Hawkes and M. Worede, 1991. Plant Genetic Resources of Ethiopia. Cambridge University Press, Cambridge, ISBN-13: 9780521384568, Pages: 383.

Falconer, D.S., 1990. Introduction to Quantitative Genetics. 3rd Edn., John Wiley and Sons Inc., New York, USA., Pages: 450.

Farahani, A., H. Lebaschi, M. Hussein, S.A. Hussein, V.A. Reza and D. Jahanfar, 2008. Effects of arbuscular mycorrhizal fungi, different levels of phosphorus and drought stress on water use efficiency, relative water content and proline accumulation rate of Coriander (*Coriandrum sativum* L.). J. Med. Plants Res., 2: 125-131.

Guenther, E., 1972. The Production of Essential Oils: Methods of Distillation, Effleurage, Maceration and Extraction with Volatile Solvents. In: The Essential Oils: History-Origin in Plants Production Analysis, Guenther, E. (Ed.). Krieger Publ. Co., Malabar, FL., pp: 85-188.

IPGRI., 1996. Promoting the Conservation and Use of Underutilized and Neglected Crops. International Plant Genetic Resources Institute, Rome, Italy, Pages: 83.

Johnson, H.W., H.F. Robinson and R.E. Comstock, 1955. Estimates of genetic and environmental variability in soybeans. Agron. J., 47: 314-318.

Maroufi, K., H.A. Farahani and H.H. Darvishi, 2010. Importance of coriander (*Coriandrum Sativum* L.) between the medicinal and aromatic plants. Adv. Environ. Biol., 4: 433-436.

Mengesha, B., 2008. Phenotypic characterization and evaluation of coriander (*Corianderum sativum* L.) accessions for seed yield, essential and fatty oil contents at Delbo watershed and Wondo genet southern Ethiopia. M.Sc. Thesis, Awassa College of Agriculture, School of Graduate Studies, University of Hawassa, Hawassa, Ethiopia.

Mengesha, B. and G. Alemaw, 2010. Variability in Ethiopian coriander accessions for agronomic and quality traits. Afr. Crop Sci. J., 18: 43-49.

MoARD., 2009. Animal and plant health regulatory directorates. Ministry of Agricultural and Rural Development, Crop Variety Register, Issue No. 12, Addis Ababa, Ethiopia, June 2009, pp: 1-183.

Olle, M. and I. Bender, 2010. The content of oils in umbelliferous crops and its formation. Agron. Res., 8: 687-696.

Parthasarathy, V.A., B. Chempakam and T.J. Zachariah, 2008. Chemistry of Spices. CABI Publishing, USA., Pages: 445.

Peter, K.V., 2004. Handbook of Herbs and Spices. Vol. 2, Woodhead Publishing, Cambridge, UK., ISBN-13: 1855737213, Pages: 375.

Qureshi, S.N., R. Anwar, M. Kashif and A. Ghafoor, 2009. Evaluation of winter vegetables for genetic divergence and characterization of genotypes. Pak. J. Bot., 41: 1117-1126.

Robinson, H.F., R.E. Comstock and P.H. Harvey, 1949. Estimates of heritability and the degree of dominance in corn. Agron. J., 41: 353-359.

Romanenko, L.G., N.V. Nevkrytaja and E.J.U. Kuznecova, 1991. Features of pollination in coriander. Moscow, Russia, pp: 16-17.

SARC., 2006. Annual report on seed spices crop research at Sinana. Horticultural Crop Research Division, Sinana Agricultural Research Center (SARC), Ethiopia.

Singh, S.P., R.S. Katiyar, S.K. Rai, S.M. Triphathi and J.P. Srivastva, 2005. Genetic divergence and its implication in breeding of desired plant types in coriander (*Coriandrum sativum* L.). Genetika, 37: 155-163.

Singh, D., U.K. Jain, S.S. Rajput, V. Khandelwal and K.N. Shiva, 2006. Genetic variation for seed yield and its components and their association in coriander (*Coriandrum sativum* L.) germplasm. J. Spices Aromat. Crops, 15: 25-29.