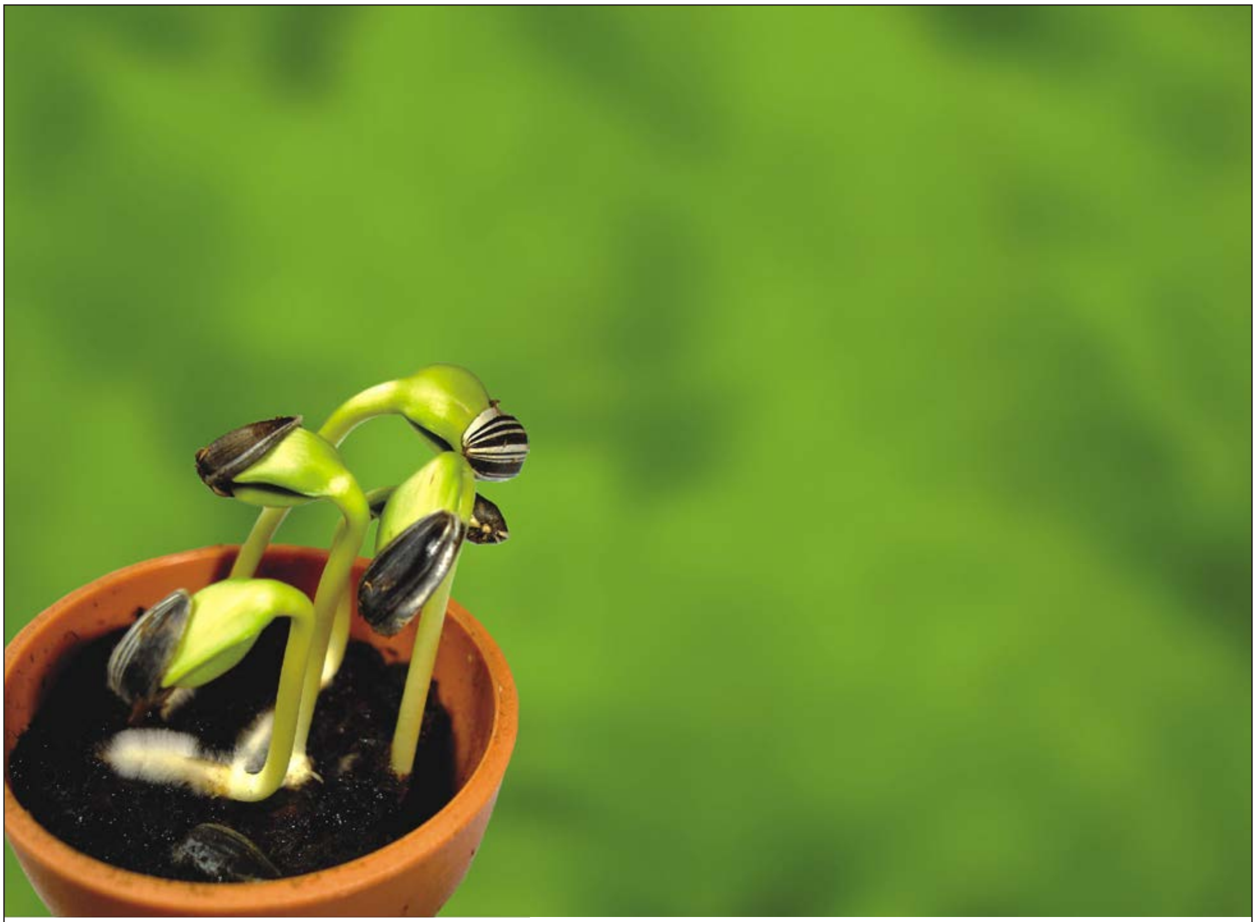

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Correlation and Path Coefficient Analysis Study among Seed Yield and Oil Content in Ethiopian Coriander (*Coriandrum sativum* L.) Genotypes

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ABSTRACT

Eighty one Ethiopian coriander genotypes were evaluated in 9×9 simple lattice design to study correlation and path coefficient analysis for seed yield and oil content at Adami Tulu Agricultural Research Center during 2011/12 cropping season. Data was collected on 21 seed yield and yield related characters. Seed yield per plant was highly and positively correlated with umbel number per plant, biomass yield per plant and number of seeds per plant, while it was negatively correlated with days to start of flowering, days to 50% flowering and plant height at flowering at both genotypic and phenotypic level. Fatty oil content was highly and positively correlated with thousand seed weight, number of primary branch and harvest index per plant, while it is negatively correlated with days to 50% flowering, days to start of flowering and plant height at flowering at both genotypic and phenotypic levels. The path coefficient analysis of seed yield per plant revealed that biomass yield per plant, harvest index per plant and number of seeds per plant were the major positive direct effect contributor, while days to start of flowering, number of primary branch and plant height at flowering exerts high negative direct effect at both genotypic and phenotypic levels. High positive indirect effect were exerted by fatty oil content via harvest index, days to maturity via plant height at flowering and thousand seed weight via days to start of flowering at both phenotypic and genotypic levels. Similarly negative indirect effect were exerted by harvest index per plant via biomass yield per plant, plant height at flowering via thousand seed weight and days to maturity via thousand seed weight. The genotypic and phenotypic path coefficient analysis of fatty oil content showed that, seed yield per plant, thousand seed weight and number of primary branches are the major positive direct effect contributors while, harvest index per plant, plant height at flowering, umbel number per plant and days to 50% flowering exerts high negative direct effect on fatty oil content.

Key words: Coriander, correlation, path coefficient, direct effect, indirect effect

INTRODUCTION

Coriander (*Coriandrum sativum* L., 2n = 2x = 22) is a diploid annual plant, belonging to the Apiaceae/Umbliferae family (Parthasarathy *et al*., 2008). It is believed that coriander originated from the Mediterranean and Western Asian regions (Dinkov and Ivanov, 2010; Burdock and Carabin, 2009). Two species are found: *Coriandrum sativum* and *Coriandrum tordylium*. Only

Coriandrum sativum is cultivated widely, mainly in the tropics. In the lists of centers of origin of cultivated plants, Vavilov (1992) mentioned coriander for central Asia, near east and Abyssinia (Ethiopia). Ivanova and Stoletova (1990) reported more cautiously of centers of formation of different types of coriander and name as cradles for distinct type: (1) India, (2) Northern Africa, (3) Central Asia and (4) Abyssinia (Ethiopia). India has the prime position in the cultivation and production of coriander: It is cultivated over an approximate area of 5.25×10^5 ha with an annual production of 3.10×10^5 t year^{-1} (Peter, 2004). Rapid life cycle of coriander allows it to fit into different growing seasons, making it possible to grow the crop under a wide range of conditions (Lopez *et al.*, 2007). According to Peter (2004) coriander requires a cool and comparatively dry frost free climate, particularly at the time of flowering and seed formation stages, for good quality and high yields. In Ethiopia cultivation of coriander is limited to the highlands (1500-2500 m.a.s.l.), although it can be cultivated in the lowlands if the rain fall is sufficient and it can be grown in the same areas as wheat, barley, sorghum and teff (Jansen, 1981).

Coriander plays an important role in the Ethiopian domestic spice trade and its seeds are used for the flavoring of 'berbere' (which is a spiced, hot red pepper powder used for numerous meat and vegetarian dishes), 'injera', cakes and bread and its leaves added as an aromatic herb to 'wot' and tea (Jansen, 1981). In 'Kefa', seeds are added to cheese and to a porridge made of *Colocasia esculenta*/taro (Engels *et al.*, 1991). In India, the fruits are also extensively employed as a condiment in the preparation of pickling spices, sausages and seasonings and for flavoring of pastry, cookies, buns and cakes, tobacco products and also used in flavoring of several alcoholic beverages i.e., gin (Diederichsen, 1996; Farahani *et al.*, 2008).

Knowledge of the extent and pattern of variability, particularly of genetic variability present in a population of a given crop is absolutely essential for further improvement of the crop. Similarly, information on the extent and nature of interrelationship among characters help in formulating efficient scheme of multiple trait selection. Besides this, knowledge of the naturally occurring diversity in a population helps to identify diverse groups of genotypes that can be used for hybridization program. In Ethiopia, the information on these aspects in coriander is very scarce. Therefore, there is a need to generate information on interrelationships of yield and yield related traits among coriander genotypes. Keeping this in view, the present study was intended to study associations among yield, yield related traits and oil content in Ethiopian coriander genotypes.

MATERIALS AND METHODS

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) while, the released variety (waltai) were released by Sinana

Agricultural Research Center in 2006 after fulfilling the requirements set by the National Variety Release Committee for national production primarily in areas from 1650 to 2400 m.a.s.l. It is typically characterized by average seed yield of 10-24 q ha^{-1} on research field (SARC, 2006).

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 length×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 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 was applied during the trial.

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, umbellate 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.

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).

Estimation of phenotypic and genotypic correlation coefficients: Phenotypic and genotypic correlations between yield and yield related traits were estimated using the method described by Miller *et al*. (1958):

$$rpxy = \frac{COVpxy}{\sqrt{\sigma^2 px.\sigma^2 py}}$$

Where:

rpxy = Phenotypic correlation coefficient between character x and y
COVpxy = Phenotypic covariance between character x and y
σ^2px = Phenotypic variance for character x
σ^2py = Phenotypic variance for character y

$$rgxy = \frac{COVgxy}{\sqrt{\sigma^2 gx.\sigma^2 gy}}$$

Where:
rgxy = Genotypic correlation coefficient between character x and y
COVgxy = Genotypic covariance between character x and y
σ^2gx = Genotypic variance for character x
σ^2gy = Genotypic variance for character y

The coefficient of correlation at phenotypic level was tested for their significance by comparing the values of correlation coefficients with tabulated r-value at g-2 degree of freedom, where 'g' is no of genotypes. However, the coefficients of correlations at genotypic level were tested for their significance using the equation described by Robertson (1959):

$$t = \frac{(rgxy)}{SErgxy}$$

The calculated 't' value was compared with the tabulated' value at g-2 degree of freedom at 5% level of significance. Where, g is the number of genotypes, rgxy is the genotypic correlation coefficient and Sergxy is the standard error of genotypic correlation coefficient between character x and y which is calculated as:

$$SErgxy = \sqrt{\frac{(1-r^2)^2}{2H_x^2 \cdot H_y^2}}$$

Where:
SErgxy = Standard error of genotypic correlation coefficient between character x and y
H_x = Heritability value of character x
H_y = Heritability value of character y

Path coefficient analysis: The phenotypic and genotypic correlation coefficients were further analyzed by path coefficient analysis, which involves partitioning of the correlation coefficients into direct and indirect effects through alternate characters or pathways. Such analysis leads to identification of important component traits useful in indirect selection for complex traits like yield and yield related traits. This analysis was done using the method described by Dewey and Lu (1959) with the following equation:

$$rij = Pij+\Sigma rikpkj$$

Where:
rij = Mutual association between the independent (i) and dependent character (j) as measured by the correlation coefficient
Pij = Component of direct effects of independent character (i) and dependent character (j) as measured by the path coefficient

Σrikpkj = Summation of components of indirect effect of a given independent character (i) on the given dependent character (j) via all other independent character (k)

The residual effect was estimated by the equation:

$$\sqrt{1-R^2}$$

$$R^2 = \Sigma pij*rij$$

Where:

pij = Component of direct effects of the independent character (i) and dependent character (j) as measured by the path coefficient

rij = Mutual association between the independent character (i) and dependent character (j) as measured by the correlation coefficient

RESULTS AND DISCUSSION

Estimate of genotypic and phenotypic correlation coefficient: Improvement for a target character can be achieved by indirect selection via other characters that are more heritable and easy to select. This selection strategy requires understanding the interrelationship of the characters among themselves and with the target characters. Estimates of genotypic and phenotypic correlations among characters are useful in planning and evaluating breeding programs. Knowledge of correlations that exist between economically important characters may facilitate the interpretation of results already obtained and provide the basis for planning more efficient programs for the future. The estimates of genotypic and phenotypic correlation coefficients between all possible pairs of studied traits of coriander genotypes grown at Adami Tulu are presented in (Table 1).

Estimation of genotypic correlation coefficients (rg)

Correlation coefficients of seed yield per plant with other characters: Seed yield per plant was highly significant ($p<0.01$) and positively correlated with umbel number per plant and number of seed per plant ($r = 0.781$) which implies that, accessions with high number of seed per plant and umbel number per plant provides high seed yield per plant. Similarly, biomass yield per plant ($r = 0.748$), thousand seed weight ($r = 0.621$), number of primary branch ($r = 0.501$) and harvest index per plant ($r = 0.48$) also positively correlated with seed yield per plant (Table 1). Similar findings have been also reported by Bhandari and Gupta (1993), Cosge *et al.* (2009) and Singh *et al.* (2006). On the other hand, seed yield per plant was highly significant ($p<0.01$) and negatively correlated with days to start of flowering ($r = -0.409$), days to 50% flowering ($r = -0.316$) and plant height at flowering ($r = -0.278$) which indicated that, accessions with long days to start of flowering, days to 50% flowering and attain maximum height provides low seed yield per plant which result in negative correlation coefficient with seed yield per plant. The results of the current study agrees with the findings of Singh *et al.* (2006), who reported on genetic variability studies of 360 Indian coriander genotypes.

Correlation coefficients of essential oil content with other characters: Essential oil content is highly significant and positively correlated with days to emergency, while non significant correlation was observed with the rest characters at genotypic level in this study (Table 1).

Table 1: Estimates of correlation coefficients at genotypic (above diagonal) and phenotypic (below diagonal) levels of 21 characters in coriander landraces studied at Adami Tulu Agricultural Research center, 2011/12

Traits	DE	DSF	DF	DM	SYPH	TSW	PHF	PHM	NPB	NSB
DE		0.551**	0.607**	0.527**	-0.319**	-0.511**	0.520**	0.363**	-0.359**	0.360**
DSF	0.512**		0.925**	0.755**	-0.531**	-0.745**	0.855**	0.666**	-0.390**	0.674**
DF	0.576**	0.875**		0.856**	-0.459**	-0.753**	0.880**	0.713**	-0.360**	0.696**
DM	0.491**	0.703**	0.821**		-0.260**	-0.653**	0.762**	0.837**	-0.224*	0.676**
SYPH	-0.303**	-0.468**	-0.378**	-0.197**		0.546**	-0.326**	-0.072	0.626**	-0.251*
TSW	-0.448**	-0.630**	-0.622**	-0.520**	0.496**		-0.665**	-0.557**	0.446**	-0.447**
PHF	0.465**	0.753**	0.847**	0.709**	-0.218**	-0.537**		0.750**	-0.183	0.718**
PHM	0.329**	0.532**	0.632**	0.776**	0.071	-0.425**	0.691**		-0.068	0.599**
NPB	-0.327**	-0.317**	-0.301**	-0.210**	0.501	0.393**	-0.168*	-0.067		-0.017
NSB	0.290**	0.585**	0.626**	0.597**	-0.132	-0.340**	0.661**	0.510**	-0.008	
UNP	0.001	-0.253**	-0.179*	-0.068	0.495**	0.230**	-0.085	0.066	0.250**	-0.072
UNU	-0.282**	-0.127	-0.097	-0.105	0.266**	0.209**	0.032	0.039	0.254**	0.108
NSU	-0.266**	-0.253**	-0.296**	-0.318**	0.261**	0.331**	-0.244**	-0.218**	0.258**	-0.083
NSP	0.145	-0.092	0.034	0.141	0.492**	0.114	0.076	0.201**	0.206**	0.077
SYP	-0.094*	-0.381**	-0.270**	-0.124*	0.666**	0.616**	-0.200**	-0.028*	0.396**	-0.046*
LBLL	-0.092	0.258**	0.327**	0.332**	0.145	-0.184**	0.466**	0.483**	0.255**	0.364**
LN	0.488**	0.632**	0.698**	0.582**	-0.147	-0.450**	0.780**	0.575**	-0.118	0.577**
BYPt	-0.014	-0.098	0.014	0.103	0.512**	0.234**	0.044	0.223**	0.344**	0.122
HI	-0.140	-0.407**	-0.414**	-0.309**	0.267**	0.614**	-0.370**	-0.351**	0.145	-0.221**
FOC	-0.371**	-0.446**	-0.461**	-0.316**	0.378**	0.530**	-0.379**	-0.200**	0.441**	-0.121
EOC	0.207**	-0.055	-0.039	-0.042	0.081	-0.044	-0.070	-0.026	-0.071	-0.065

Variables	UNP	UNU	NSU	NSP	SYP	LBLL	LN	BYPt	HI	FOC	EOC
DE	-0.031	-0.368**	-0.342**	0.187	-0.078	-0.106	0.544**	-0.004	-0.138	-0.465**	0.264**
DSF	-0.327**	-0.112	-0.330**	-0.049	-0.409**	0.302**	0.711**	-0.052	-0.518**	-0.536**	-0.072
DF	-0.282**	-0.100	-0.362**	0.030	-0.316**	0.359**	0.770**	0.028	-0.504**	-0.562**	-0.043
DM	-0.156	-0.096	-0.323**	0.176	-0.152	0.366**	0.674**	0.170	-0.454**	-0.361**	-0.040
SYPH	0.608**	0.243*	0.165	0.549**	0.697**	0.154	-0.267**	0.544**	0.285**	0.376**	0.121
TSW	0.395**	0.202	0.354**	0.149	0.621**	-0.208	-0.610**	0.240*	0.631**	0.533**	0.029
PHF	-0.230*	0.034	-0.324**	0.028	-0.278**	0.505**	0.866**	0.017	-0.443**	-0.471**	-0.066
PHM	-0.082	-0.006	-0.325**	0.177	-0.104	0.562**	0.671**	0.233*	-0.478**	-0.275**	-0.037
NPB	0.410**	0.289**	0.201	0.343**	0.501**	0.289**	-0.165	0.394**	0.198	0.431**	-0.130
NSB	-0.194	0.124	-0.161	0.057	-0.094	0.395**	0.631**	0.145	-0.299	-0.191	-0.133
UNP		0.063	0.067	0.772**	0.781**	-0.083	-0.159	0.689**	0.253*	0.132	0.165
UNU	0.136		0.370**	0.149	0.195	0.384**	-0.046	0.170	-0.007	0.219*	-0.155
NSU	0.115	0.341**		0.084	0.203	-0.004	-0.385**	0.058	0.263**	0.237*	-0.003
NSP	0.725**	0.204**	0.155*		0.781**	0.058	0.070	0.754**	0.119	0.065	0.176
SYP	0.673**	0.255**	0.279**	0.751**		-0.029	-0.145	0.748**	0.480**	0.316**	0.145
LBLL	-0.001	0.274	-0.010	0.063	-0.049		0.527**	0.264**	-0.432**	-0.057	-0.200
LN	-0.104	-0.026	-0.236**	0.058	-0.063	0.404**		0.063	-0.333**	-0.381**	-0.047
BYPt	0.646**	0.246**	0.162*	0.719**	0.752**	0.214**	0.079		-0.194	0.039	0.087
HI	0.131	-0.016	0.192**	0.130	0.479**	-0.344**	-0.215**	-0.180*		0.407**	0.110
FOC	0.042	0.219**	0.265**	-0.004	0.302**	-0.054	-0.259**	0.070	0.326**		-0.107
EOC	0.045	-0.150	0.025	0.096	0.020	-0.115	-0.068	0.049	-0.022	-0.072	

*, **Significant at 0.05 and 0.01 probability level respectively, DE: Days to emergence, DSF: Days to start of flowering, DF: Days to 50% flowering, DM: Days to maturity, SPPL: Seed yield/plot (g), SYPH: Seed yield/hectare (kg), TSW: Thousand seed weight (g), BMYP: Biomass yield/plot (kg), PHF: Plant height at flowering (cm), PHM: Plant height at maturity (cm), NPB: Number of primary branches, NSB: No. of secondary branches, UNP: Umbel number/plant, UNU: Umbellate number/umbel, NSU: Number of seed/umbellate, NSP: No. of seed/plant, SYP: Seed yield/plant (g), HI: Harvest index (%), FOC: Fatty oil content (%) and EOC: Essential oil content (%) (v/w dry based)

Mengesha (2008) reported negative correlation between essential oil content and longest basal leaf number, plant height and thousand seed weight, while non significant correlation with all studied characters with the exception of days to end flowering at genotypic level in 49 Ethiopian coriander genotypes. This finding partially agrees with the current findings.

Correlation coefficients of fatty oil content with other characters: Fatty oil content was highly significant and positively correlated with thousand seed weight (r = 0.533), number of primary branches (r = 0.43), harvest index per plant (r = 0.40) and seed yield per plant (r = 0.316). This result showed that, accessions with high seed yield per plant, harvest index per plant and thousand seed weight contains high fatty oil content which contributes for its strong positive correlation coefficient.

On the other hand, highly significant and negative correlation coefficient was observed with days to 50% flowering (r = -0.562), days to start of flowering (r = -0.536), plant height at flowering (r = -0.471), leaf number per plant (r = -0.381), days to maturity (r = -0.361) and plant height at maturity (r = -0.275) (Table 1). This result showed that, accessions with long days to maturity, high plant height at flowering were low in seed yield per plant, low harvest index and thousand seed weight which contributes to low fatty oil content and result in negative correlation coefficient. Mengesha (2008) reported negative and significant correlation of fatty oil content with plant height, thousand seed weight, number of umbels per plant and number of seeds per umbellete, while low and positive association was observed between fatty oil content with essential oil content and number of seed per plant.

Estimation of phenotypic correlation coefficients (rp)

Correlation coefficients of seed yield per plant with other characters: The phenotypic correlation coefficient for seed yield per plant was highly significant and positive for number of seed per plant (r = 0.78), umbel number per plant (r = 0. 78), biomass yield per plant (r = 0.74), seed yield per hectare (r = 0.69) and thousand seed weight (r = 0.62) (Table 1). This indicated that, accessions with high umbel number per plant and number of seed per plant have high seed yield per plant which contributes strong positive correlation coefficient. Similarly, accessions with maximum thousand seed weight contributes for high seed yield per plant and biomass yield per plant which leads to strong positive correlation with seed yield per plant.

On the other hand, days to start of flowering (r = -0.40), days to 50% flowering (r = -0.31) and plant height at flowering (r = -0.27) showed highly significant and negative correlation with seed yield per plant. Kahrizi *et al.* (2011) reported high and positive correlation between seed yield per plant with number of seed per plant (r = 0.79), number of umbel per plant (r = 0.77), number of seed per umbel (r = 0.80) and thousand seed weight (r = 0.80) in cumin at genotypic level, which strongly agrees with the present study.

Correlation coefficients of essential oil content with other characters: Essential oil content is highly significant and positively correlated at phenotypic level only with days to emergency (r = 0.207), while it is not significantly correlated with the rest of the characters (Table 1). Similarly, Mengesha (2008) reported significant and negative correlation of essential oil content with thousand seed weight and non significant with other studied characters in coriander.

Correlation coefficients of fatty oil content with other characters: Fatty oil content was highly significant and positively correlated with thousand seed weight (r = 0.53), number of primary branches (r = 0.43), harvest index per plant (r = 0.40) and seed yield per plant (r = 302). This showed that accessions with high number of branches accommodate high number of seed per plant which result in high seed yield per plant and harvest index per plant and contributes strong positive correlation with fatty oil content. Similarly accessions with high thousand seed weight contribute high dry matter which includes fatty oil.

On the other hand, fatty oil content is highly significant and negatively correlated with days to 50% flowering (r = -0.56), days to start of flowering (r = -0.53), plant height at flowering (r = -0.47) and days to maturity (r = -0.36) (Table 1). Mengesha (2008) reported low positive correlation coefficient of fatty oil content with essential oil content, number of seed per plant and plant height, while high negative non significant correlation of fatty oil content with days to maturity and number of umbel per plant in 49 Ethiopian coriander genotypes.

Path coefficient analysis: The phenotypic and genotypic correlation coefficients were further analyzed by path coefficient analysis, which involves partitioning of the correlation coefficients into direct and indirect effects through alternate characters or pathways. Such analysis leads to identification of important component traits useful in indirect selection for complex traits like yield, fatty oil and essential oil content.

Phenotypic path coefficients

Estimation of direct and indirect effects of various characters on seed yield per plant at phenotypic level: The path coefficient analysis at phenotypic level revealed that, the highest favorable positive direct effect was exerted on seed yield per plant by biomass yield per plant (0.62) followed by harvest index per plant (0.44) and number of seed per plant (0.16) (Table 2). The highest correlation between seed yield per plant and biomass yield per plant (rp = 0.75) was contributed from the highest direct effect of biomass yield per plant on seed yield per plant. The other traits that had positive direct effect on seed yield per plant includes thousand seed weight (0.14), umbellete number per umbel (0.04), days to 50% flowering (0.02), umbel number per plant (0.024), fatty oil content (0.018) and number of seed per umbellete (0.006).

Those high positive direct effects indicate that a given other traits are kept constant, increasing one of these characters will increases seed yield, which implies that these characters are the major contributors for the improvement of seed yield per plant at phenotypic level. In contrast Singh *et al.* (2006) and Dalkani *et al.* (2011) reported that, highest positive direct effect was exerted on seed yield per plant by umbels number per plant followed by branch number per plant and plant height in coriander and ajowan, respectively, which is in partial agreement with the current study. The highest negative direct effects on seed yield per plant were exerted by days to start of flowering (-0.060) followed by longest basal leaf length (-0.05), plant height at flowering (-0.02) and number of primary branch (-0.009), in which it is not in agreement with the findings of Singh *et al.* (2006) and Dalkani *et al.* (2011), who reported highest negative direct effect were exerted by days to 50% flowering and leaf number per plant on seed yield per plant in coriander and ajowan, respectively. Kahrizi *et al.* (2011) also reported high positive direct effect on seed yield per plant by biomass yield per plant, harvest index per plant, number of seed per umbel and number umbel per plant in cumin genotypes in Iran, which confirms the current findings. Cosge *et al.* (2009) also reported highest negative direct effect on seed yield per plant by biomass yield per plant, number of umbels and essential oil content in sweet funnel.

The highest positive indirect effect on seed yield per plant were exerted by fatty oil content via harvest index (0.14) followed by biomass yield per plant via number of seed per plant (0.11), days to maturity via plant height at maturity (0.10) and days to maturity via plant height at maturity (Table 3). Days to maturity have low negative correlation with seed yield per plant (rp = -0.27) with

Table 2: Estimates of direct (*diagonal) and indirect effects (off diagonal) at phenotypic level of 19 traits on seed yield per plant in 81 coriander genotypes tested at adami tulu agricultural research center, 2011/12

Variables	DE	DSF	DF	DM	TSW	PHF	PHM	NPB	NSB	UNP	UNU	NSU	NSP	LBLL	LN	BYPt	HI	EOC	FOC	Rp.
DE	0.020*	-0.031	-0.035	-0.029	0.027	-0.028	-0.020	0.020	-0.017	0.0001	0.017	0.016	-0.009	0.005	-0.029	0.001	0.008	-0.012	0.022	-0.09*
DSF	0.010	-0.060*	0.017	0.014	-0.013	0.015	0.011	-0.006	0.012	-0.005	-0.003	-0.005	-0.002	0.005	0.013	-0.002	-0.008	-0.001	-0.009	-0.38**
DF	0.012	-0.052	0.020*	0.004	-0.003	0.004	0.003	-0.002	0.003	-0.001	0.0001	-0.001	0.0001	0.002	0.003	0.0001	-0.002	0.001	-0.002	-0.27**
DM	0.010	-0.042	0.016	0.005*	-0.073	0.099	0.109	-0.029	0.084	-0.009	-0.015	-0.045	0.020	0.047	0.081	0.014	-0.043	-0.006	-0.044	-0.12*
TSW	-0.009	0.038	-0.012	-0.003	0.140*	0.011	0.009	-0.008	0.007	-0.005	-0.004	-0.007	-0.002	0.004	0.009	-0.005	-0.012	0.001	-0.011	0.62**
PHF	0.009	-0.045	0.017	0.004	-0.075	-0.020*	0.001	0.0001	0.001	0.0001	0.0001	0.0001	0.0001	0.0001	0.001	0.0001	0.0001	0.0001	0.001	-0.20**
PHM	0.007	-0.032	0.013	0.004	-0.060	-0.014	0.001*	0.001	-0.005	-0.001	0.0001	0.002	-0.002	-0.004	-0.005	-0.002	0.003	0.0001	0.002	-0.03*
NPB	-0.007	0.019	-0.006	-0.001	0.055	0.003	0.0001	-0.009*	0.0001	0.003	0.003	0.003	0.003	0.003	-0.002	0.004	0.002	-0.001	0.006	0.40**
NSB	0.006	-0.035	0.013	0.003	-0.048	-0.013	0.001	0.0001	0.013*	-0.002	0.003	-0.002	0.002	0.009	0.014	0.003	-0.005	-0.002	-0.003	-0.05*
UNP	0.0001	0.015	-0.004	0.0001	0.032	0.002	0.0001	-0.002	-0.001	0.024*	0.005	0.005	0.029	0.0001	-0.004	0.026	0.005	0.002	0.002	0.67**
UNU	-0.006	0.008	-0.002	-0.001	0.029	-0.001	0.0001	-0.002	0.001	0.003	0.040*	0.002	0.001	0.001	0.001	0.001	0.0001	-0.001	0.001	0.25**
NSU	-0.005	0.015	-0.006	-0.002	0.046	0.005	0.0001	-0.002	-0.001	0.003	0.014	0.005*	0.025	-0.002	-0.038	0.026	0.031	0.004	0.042	0.28**
NSP	0.003	0.006	0.001	0.001	0.016	-0.002	0.0001	-0.002	0.001	0.017	0.008	0.001	0.160*	-0.003	-0.003	-0.036	-0.006	-0.005	0.0001	0.75**
LBLL	-0.002	-0.016	0.007	0.002	-0.026	-0.009	0.0001	-0.002	0.005	0.0001	0.011	0.0001	0.010	-0.050*	0.036	0.019	-0.031	-0.010	-0.005	-0.05ns
LN	0.010	-0.038	0.014	0.003	-0.063	-0.016	0.001	0.001	0.007	-0.002	-0.001	-0.001	0.009	-0.020	0.090*	0.050	-0.135	-0.043	-0.162	-0.06ns
BYPt	0.0001	0.006	0.0001	0.001	0.033	-0.001	0.0001	-0.003	0.002	0.016	0.010	0.001	0.115	-0.011	0.007	0.626*	-0.079	0.022	0.031	0.75**
HI	-0.003	0.024	-0.008	-0.002	0.086	0.007	0.0001	-0.001	-0.003	0.003	-0.001	0.001	0.021	0.017	-0.019	-0.113	0.440*	0.0001	-0.003	0.48**
EOC	0.004	0.003	-0.001	0.0001	-0.006	0.001	0.0001	0.001	-0.001	0.001	-0.006	0.0001	0.015	0.006	-0.006	0.031	-0.010	-0.010*	-0.001	0.02ns
FOC	-0.007	0.027	-0.009	-0.002	0.074	0.008	0.0001	-0.004	-0.002	0.001	0.009	0.001	-0.001	0.003	-0.023	0.044	0.143	0.001	0.018*	0.30**

Residual = 0.360, DE: Days to emergence, DSF: Days to start of flowering, DF: Days to 50% flowering, DM: Days to maturity, SPPL: Seed yield/plot (g), SYPH: Seed yield/hectare (kg), TSW: Thousand seed weight (g), BMYP: Biomass yield/plot (kg), 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, EOC: Essential oil content (%) (v/w dry based), rp: Phenotypic correlation

Table 3: Estimates of direct (*diagonal) and indirect effects (off diagonal) at phenotypic level of 21 traits on fatty oil content in 81 coriander genotypes tested at Adami tulu agricultural research center, 2011/12

Variables	DE	DSF	DF	DM	TSW	PHF	PHM	NPB	NSB	UNP	UNU	NSU	NSP	SYP	LBLL	LN	BYPt	HI	EOC	Rp.
DE	-0.030*	-0.05	-0.06	-0.05	0.04	-0.05	-0.03	0.03	-0.03	0.001	0.03	0.03	-0.01	0.01	0.01	-0.05	0.001	0.01	-0.020	-0.37**
DSF	-0.020	-0.10*	-0.18	-0.15	0.13	-0.16	-0.11	0.07	-0.12	0.05	0.03	0.05	0.02	0.08	-0.05	-0.13	0.020	0.09	0.010	-0.45**
DF	-0.020	-0.09	-0.21*	0.10	-0.07	0.10	0.08	-0.04	0.08	-0.02	-0.01	-0.04	0.001	-0.03	0.04	0.08	0.001	-0.05	0.001	-0.46**
DM	-0.010	-0.07	-0.17	0.12*	0.01	-0.014	-0.016	0.004	-0.012	0.001	0.002	0.006	-0.003	0.002	-0.007	-0.012	-0.002	0.006	0.001	-0.32**
TSW	0.010	0.06	0.13	-0.06	0.29*	-0.07	-0.06	0.05	-0.04	0.03	0.03	0.04	0.01	0.08	-0.02	-0.06	0.030	0.08	-0.010	0.53**
PHF	-0.010	-0.08	-0.18	0.09	-0.16	-0.24*	0.08	-0.02	0.07	-0.01	0.001	-0.03	0.01	-0.02	0.05	0.09	0.001	-0.04	-0.010	-0.38**
PHM	-0.010	-0.05	-0.13	0.09	-0.12	-0.17	0.11*	-0.02	0.13	0.02	0.01	-0.05	0.05	-0.01	0.12	0.14	0.06	-0.09	-0.010	-0.2**
NPB	0.010	0.03	0.06	-0.03	0.11	0.04	-0.01	0.25*	0.001	0.03	0.04	0.04	0.03	0.06	0.04	-0.02	0.05	0.02	-0.010	0.44**
NSB	-0.010	-0.06	-0.13	0.07	-0.10	-0.16	0.06	0.001	0.14*	0.01	-0.01	0.01	-0.01	0.01	-0.04	-0.07	-0.01	0.03	0.010	-0.12ns
UNP	0.001	0.03	0.04	-0.01	0.07	0.02	0.01	0.06	-0.01	-0.12*	0.01	0.01	0.04	0.04	0.001	-0.01	0.04	0.01	0.001	0.04ns
UNU	0.010	0.01	0.02	-0.01	0.06	-0.01	0.001	0.06	0.02	-0.02	0.06*	0.01	0.01	0.01	0.01	0.001	0.01	0.001	-0.010	0.22**
NSU	0.010	0.03	0.06	-0.04	0.10	0.06	-0.02	0.06	-0.01	-0.01	0.02	0.04*	-0.01	-0.01	0.001	0.01	-0.01	-0.01	0.001	0.27**
NSP	0.001	0.01	-0.01	0.02	0.03	-0.02	0.02	0.05	0.01	-0.09	0.01	0.01	-0.05*	0.32	0.03	0.02	0.30	0.05	0.040	0.001**
SYP	0.001	0.04	0.06	-0.01	0.18	0.05	0.001	0.10	-0.01	-0.08	0.02	0.01	-0.04	0.42*	0.001	0.01	-0.06	-0.04	0.001	0.3**
LBLL	0.001	-0.03	-0.07	0.04	-0.05	-0.11	0.05	0.06	0.05	0.001	0.02	0.001	0.001	-0.02	-0.08*	0.05	0.03	-0.04	-0.010	-0.05ns
LN	-0.010	-0.06	-0.15	0.07	-0.13	-0.19	0.06	-0.03	0.08	0.01	0.001	-0.01	0.001	-0.03	-0.03	0.13*	-0.04	0.10	0.030	-0.26**
BYPt	0.001	0.01	0.001	0.01	0.07	-0.01	0.02	0.09	0.02	-0.08	0.01	0.01	-0.04	0.32	-0.02	0.01	-0.46*	0.05	-0.010	0.07ns
HI	0.001	0.04	0.09	-0.04	0.18	0.09	-0.04	0.04	-0.03	-0.02	0.001	0.01	-0.01	0.20	0.03	-0.03	0.08	-0.27*	0.001	0.33**
EOC	-0.010	0.01	0.01	-0.01	-0.01	0.02	0.001	-0.02	-0.01	-0.01	-0.01	0.001	0.001	0.01	0.01	-0.01	-0.02	0.01	-0.030*	-0.07ns

Residual = 0.89, DE: Days to emergence, DSF: Days to start of flowering, DF: Days to 50% flowering, DM: Days to maturity, SPPL: Seed yield/plot (g), TSW: Thousand seed weight (g), BMYP: Biomass yield/plot (kg), 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 (%) and EOC: Essential oil content (%) (v/w dry based), rp: Phenotypic correlation its minimum positive direct effect and its correlation magnitude is restored from the counter balance of its indirect effects on seed yield per plant via other traits. The highest negative indirect effect on seed yield per plant were exerted by leaf number per plant via fatty oil content (-0.16) followed by harvest index via biomass yield per plant (-0.11), biomass yield per plant via harvest index per plant (-0.079) and plant height at flowering via thousand seed weight (-0.075), days to maturity via thousand seed weight (-0.073). Mengesha (2008) reported high positive direct effect on seed yield per plant by days to end flowering, longest basal leaf length and plant height, while high negative direct effect by number of umbelletes per umbel, days to start 50% flowering and thousand seed weight. Similarly, high positive indirect effect on seed yield per plant was exerted by days to maturity via days to end flowering, plant height via days to end flowering, high negative indirect effect was exerted by plant height via days to start 50% flowering and days to maturity via number of umbelletes number per umbel in Ethiopian coriander genotypes.

Estimates of direct and indirect effects of various characters on fatty oil content at phenotypic level: The highest favorable positive direct effect on fatty oil content at phenotypic level was exerted by seed yield per plant (0.42) followed by thousand seed weight (0.29), number of primary branches (0.25) and number of secondary branches (0.14). The correlation between fatty oil content and seed yield per plant was strong (rp = 0.30) which is exerted from direct effect of seed yield per plant on fatty oil content. While, the highest negative direct effect on fatty oil content at phenotypic level was exerted by biomass yield per plant (-0.46) followed by harvest index per plant (-0.27), plant height at flowering (-0.24) and days to 50% flowering (-0.21) (Table 3). The highest positive indirect effect on fatty oil content was exerted by biomass yield per plant via seed yield per plant (0.32) followed by number of seed per plant via seed yield per plant and biomass yield per plant (0.3) and harvest index per plant via seed yield per plant.

On the other hand, the highest negative indirect effect on fatty oil content was exerted by days to start of flowering via days to 50% flowering (-0.18) followed by plant height at flowering via days to 50% flowering (-0.18) and plant height at maturity via plant height at flowering (-0.17) (Table 4). In findings of Golparvar and Karimi (2011), plant height and days to physiological maturity exerts positive and high direct effect on oil yield in canola cultivars which is not in agreement with the current findings. Similarly, indirect effect of plant height via days to physiological maturity and days to physiological maturity via plant height on oil yield was positive. Tadesse *et al*. (2009) reported that thousand seed weight, seed yield per plot, days to maturity and harvest index exerts high positive direct effect on fatty oil content at phenotypic level in Ethiopian linseed germplasms.

Genotypic path coefficient

Estimation of direct and indirect effects of various characters on seed yield per plant at genotypic level: The highest favorable positive direct effect on seed yield per plant was exerted by biomass yield per plant (0.68) followed by harvest index per plant (0.5), number of seed per plant (0.16) and thousand seed weight (0.11) (Table 4). The highest positive genotypic correlation between seed yield per plant and biomass yield per plant (rg = 0.75) were directly contributed from the direct effect of biomass yield per plant (0.68). On the other hand, the highest negative direct effects on seed yield per plant was exerted by days to start of flowering and plant height at flowering (-0.08), longest basal leaf length (-0.03) and umbel number per plant (-0.02). In contrast,

Table 4: Estimates of direct (*diagonal) and indirect effects (off diagonal) at genotypic level of 19 traits on seed yield per plant in 81 coriander genotypes tested at adami tulu agricultural research center, 2011/12

Variables	DE	DSF	DF	DM	TSW	PHF	PHM	NPB	NSB	UNP	UNU	NSU	NSP	SYP	LBLL	LN	BYPt	HI	EOC	Rg.
DE	0.050*	-0.044	-0.049	-0.042	0.041	-0.042	-0.029	0.029	-0.029	0.002	0.029	0.027	-0.015	0.009	-0.044	0.001	0.011	-0.021	0.037	-0.08ns
DSF	0.028	-0.080*	0.046	0.038	-0.037	0.043	0.033	-0.019	0.034	-0.016	-0.006	-0.016	-0.002	0.015	0.036	-0.003	-0.026	-0.004	-0.027	-0.41**
DF	0.030	-0.074	0.050*	-0.017	0.015	-0.018	-0.014	0.007	-0.014	0.006	0.002	0.007	-0.001	-0.007	-0.015	-0.001	0.010	0.001	0.011	-0.32**
DM	0.026	-0.060	0.043	-0.020*	-0.072	0.084	0.092	-0.025	0.074	-0.017	-0.011	-0.036	0.019	0.040	0.074	0.019	-0.050	-0.004	-0.040	-0.15ns
TSW	-0.026	0.060	-0.038	0.013	0.110*	0.053	0.045	-0.036	0.036	-0.032	-0.016	-0.028	-0.012	0.017	0.049	-0.019	-0.050	-0.002	-0.043	0.62**
PHF	0.026	-0.068	0.044	-0.015	-0.073	-0.080*	0.030	-0.007	0.029	-0.009	0.001	-0.013	0.001	0.020	0.035	0.001	-0.018	-0.003	-0.019	-0.28**
PHM	0.018	-0.053	0.036	-0.017	-0.061	-0.060	0.040*	-0.002	0.018	-0.002	0.0001	-0.010	0.005	0.017	0.020	0.007	-0.014	-0.001	-0.008	-0.10ns
NPB	-0.018	0.031	-0.018	0.004	0.049	0.015	-0.003	0.030*	0.001	-0.004	-0.003	-0.002	-0.003	-0.003	0.002	-0.004	-0.002	0.001	-0.004	0.50**
NSB	0.018	-0.054	0.035	-0.014	-0.049	-0.057	0.024	-0.001	-0.010*	0.004	-0.002	0.003	-0.001	-0.008	-0.013	-0.003	0.006	0.003	0.004	-0.09ns
UNP	-0.002	0.026	-0.014	0.003	0.043	0.018	-0.003	0.012	0.002	-0.020*	0.004	0.005	0.054	-0.006	-0.011	0.048	0.018	0.012	0.009	0.78**
UNU	-0.018	0.009	-0.005	0.002	0.022	-0.003	0.001	0.009	-0.001	-0.001	0.070*	-0.007	-0.003	-0.008	0.001	-0.003	0.0001	0.003	-0.004	0.20ns
NSU	-0.017	0.026	-0.018	0.006	0.039	0.026	-0.013	0.006	0.002	-0.001	0.026	-0.020*	0.013	-0.001	-0.062	0.009	0.042	0.0001	0.038	0.20ns
NSP	0.009	0.004	0.001	-0.004	0.016	-0.002	0.007	0.010	-0.001	-0.015	0.010	-0.002	0.160*	-0.002	-0.002	-0.023	-0.004	-0.005	-0.002	0.78**
LBLL	-0.005	-0.024	0.018	-0.007	-0.023	-0.040	0.022	0.009	-0.004	0.002	0.027	0.0001	0.009	-0.030*	0.058	0.029	-0.048	-0.022	-0.006	-0.03ns
LN	0.027	-0.057	0.038	-0.013	-0.067	-0.069	0.027	-0.005	-0.006	0.003	-0.003	0.008	0.011	-0.016	0.110*	0.043	-0.226	-0.032	-0.259	-0.15ns
BYPt	0.001	0.004	0.001	-0.003	0.026	-0.001	0.009	0.012	-0.001	-0.014	0.012	-0.001	0.121	-0.008	0.007	0.680*	-0.097	0.044	0.019	0.75**
HI	-0.007	0.041	-0.025	0.009	0.069	0.035	-0.019	0.006	0.003	-0.005	0.001	-0.005	0.019	0.013	-0.037	-0.132	0.500*	-0.001	-0.004	0.48**
EOC	0.013	0.006	-0.002	0.001	0.003	0.005	-0.001	-0.004	0.001	-0.003	-0.011	0.001	0.028	0.006	-0.005	0.059	0.055	-0.010*	0.001	0.15ns
FOC	-0.023	0.043	-0.028	0.007	0.059	0.038	-0.011	0.013	0.002	-0.003	0.015	-0.005	0.010	0.002	-0.042	0.026	0.204	0.001	0.003*	0.32**

Residual = 0.23, DE: Days to emergence, DSF: Days to start of flowering, DF: Days to 50% flowering, DM: Days to maturity, 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), rg: Genotypic correlation

Singh *et al.* (2006) reported high positive direct effect on seed yield per plant by umbel number per plant and branch number plant while, they report highest negative direct effect on seed yield per plant by days to 50% flowering and umbellete number per umbel.

The highest positive indirect effect on seed yield per plant was exerted by fatty oil content via harvest index (0.20) followed by days to maturity via plant height at flowering and plant height at maturity (0.08 and 0.09, respectively) and days to maturity via number of secondary branch (0.07). Similarly fatty oil content have moderate correlation (rg = 0.32) with seed yield per plant with its low direct effect (0.003) in which it restores the moderate correlation from its high positive indirect effect via harvest index per plant (0.20). On the other hand, the highest negative indirect effect was exerted on seed yield per plant by leaf number per plant via harvest index per plant (-0.22) followed by harvest index per plant via biomass yield per plant (-0.13), days to 50% flowering via days to start of flowering (-0.07) and plant height at flowering via thousand seed weight (-0.07) (Table 4). Kahrizi *et al.* (2011) reported that, biological yield and harvest index per plant, essential oil content exerts high positive direct effect on seed yield per plant and number of umbel per plant and number of seed per plant had negative direct effect on seed yield per plant in cumin.

Similarly, positive indirect effect were exerted by biological yield via essential oil content and number of seed per umbel, number of seed per plant and thousand seed weight via biological yield. Chitra and Rajamiani (2010) reported that, plant height, number of leaf per plant, days to 50% flowering, number of pod per plant and number of seed per plant exerts high positive direct effect on seed yield, while number of branch per plant, days to flowering and number of flowers per plant exerts negative direct effect on seed yield in glory lily.

Estimates of direct and indirect effects of various characters on fatty oil content at genotypic level: The highest favorable positive direct effect on fatty oil content was exerted by days to maturity (0.38) followed by leaf number per plant (0.27), number of seed per plant (0.23) and thousand seed weight (0.15) (Table 5). Similarly, the highest negative direct effect at genotypic level were exerted by days to 50% flowering (-0.6) followed by plant height at flowering (-0.48), biomass yield per plant (-0.32), umbel number per plant (-0.23) and number of seed per umbellate (-0.16).

The maximum positive indirect effect on fatty oil content was exerted by thousand seed weight via days to 50% flowering (0.45), days to start of flowering via thousand seed weight (0.45), days to 50% flowering via plant height at flowering (0.34) and days to 50% flowering via days to maturity (0.33). The highest negative indirect effect on fatty oil content was exerted by days to start of flowering via days to 50% flowering (-0.56) followed by plant height at flowering via days to 50% flowering (-0.53) and days to maturity via days to 50% flowering (Table 5).

The highest positive direct effect of days to maturity on fatty oil content was masked by its highest negative indirect effect via days to 50% flowering and result in negative correlation with fatty oil content (rg = -0.36) (Table 1). Similarly, the highest negative direct effect of days to 50% flowering (-0.6) directly contributes to its strong negative correlation with fatty oil content (rg = -0.56). Adeyanju *et al.* (2010) reported, days to 50% germination, fruit yield, 100 seed weight and pedicle length had significant positive direct effect on oil content at genotypic level in castor bean and the highest indirect effect was exerted by 100 seed weight via days to 50% flowering at genotypic level. Delesa (2006) reported that, biomass yield per plot, days to flowering, number of primary branches, harvest index per plot and 1000 seed weight exerts high positive direct effect,

Table 5: Estimates of direct (*diagonal) and indirect effects (off diagonal) at genotypic level of 21 traits on fatty oil content in 81 coriander genotypes tested at Adami tulu agricultural research center, 2011/12

Variables	DE	DSF	DF	DM	TSW	PHF	PHM	NPB	NSB	UNP	UNU	NSU	NSP	SYP	LBLL	LN	BYPt	HI	EOC	Rg.
DE	-0.190*	0.022	0.024	0.021	-0.020	0.021	0.015	-0.014	0.014	-0.001	-0.015	-0.014	0.007	-0.003	-0.004	0.022	0.0001	-0.006	0.011	-0.46**
DSF	-0.105	0.040*	-0.555	-0.453	0.447	-0.513	-0.400	0.234	-0.404	0.196	0.067	0.198	0.029	0.245	-0.181	-0.427	0.031	0.311	0.043	-0.54**
DF	-0.115	0.037	-0.600*	0.325	-0.286	0.335	0.271	-0.137	0.264	-0.107	-0.038	-0.137	0.011	-0.120	0.136	0.292	0.011	-0.192	-0.017	-0.56**
DM	-0.100	0.030	-0.514	0.380*	0.144	-0.168	-0.184	0.049	-0.149	0.034	0.021	0.071	-0.039	0.034	-0.081	-0.148	-0.037	0.100	0.009	-0.36**
TSW	0.097	-0.030	0.452	-0.248	0.150*	-0.233	-0.195	0.156	-0.156	0.138	0.071	0.124	0.052	0.218	-0.073	-0.214	0.084	0.221	0.010	0.53**
PHF	-0.099	0.034	-0.528	0.289	-0.100	-0.480*	0.007	-0.002	0.006	-0.002	0.0001	-0.003	0.0001	-0.002	0.005	0.008	0.0001	-0.004	-0.001	-0.47**
PHM	-0.069	0.027	-0.428	0.318	-0.084	-0.360	0.009*	-0.008	0.072	-0.010	-0.001	-0.039	0.021	-0.012	0.067	0.080	0.028	-0.057	-0.004	-0.27**
NPB	0.068	-0.016	0.216	-0.085	0.067	0.088	-0.001	0.120*	-0.002	0.049	0.035	0.024	0.041	0.060	0.035	-0.020	0.047	0.024	-0.016	0.43**
NSB	-0.068	0.027	-0.418	0.257	-0.067	-0.344	0.005	-0.002	0.120*	0.045	-0.029	0.037	-0.013	0.022	-0.091	-0.145	-0.033	0.069	0.031	-0.19
UNP	0.006	-0.013	0.169	-0.059	0.059	0.110	-0.001	0.049	-0.023	-0.230*	0.003	0.003	0.039	0.039	-0.004	-0.008	0.034	0.013	0.008	0.13
UNU	0.070	-0.004	0.060	-0.036	0.030	-0.016	0.0001	0.035	0.015	-0.014	0.050*	-0.022	-0.009	-0.012	-0.023	0.003	-0.010	0.0001	0.009	0.22*
NSU	0.065	-0.013	0.217	-0.123	0.053	0.156	-0.003	0.024	-0.019	-0.015	0.019	-0.060*	0.019	0.047	-0.001	-0.088	0.013	0.061	-0.001	0.24*
NSP	-0.036	-0.002	-0.018	0.067	0.022	-0.013	0.002	0.041	0.007	-0.178	0.007	-0.005	0.230*	0.094	0.007	0.008	0.090	0.014	0.021	0.07
SYP	0.015	-0.016	0.190	-0.058	0.093	0.133	-0.001	0.060	-0.011	-0.180	0.010	-0.012	0.180	0.120*	-0.001	-0.003	0.015	0.010	0.003	0.32**
LBLL	0.020	0.012	-0.215	0.139	-0.031	-0.242	0.005	0.035	0.047	0.019	0.019	0.0001	0.013	-0.004	0.020*	0.142	0.071	-0.117	-0.054	-0.06
LN	-0.103	0.028	-0.462	0.256	-0.092	-0.416	0.006	-0.020	0.076	0.037	-0.002	0.023	0.016	-0.017	0.011	0.270*	-0.020	0.106	0.015	-0.38**
BYPt	0.001	-0.002	-0.017	0.065	0.036	-0.008	0.002	0.047	0.017	-0.158	0.008	-0.003	0.173	0.090	0.005	0.017	-0.320*	-0.014	0.006	0.04
HI	0.026	-0.021	0.302	-0.172	0.095	0.213	-0.004	0.024	-0.036	-0.058	0.0001	-0.016	0.027	0.058	-0.009	-0.090	0.062	0.070*	-0.001	0.41**
EOC	-0.050	-0.003	0.026	-0.015	0.004	0.032	0.0001	-0.016	-0.016	-0.038	-0.008	0.0001	0.040	0.017	-0.004	-0.013	-0.028	0.008	-0.010*	-0.11

Residual = 0.82, DE: Days to emergence, DSF: Days to start of flowering, DF: Days to 50% flowering, DM: Days to maturity, SPPL: Seed yield/plot (g), TSW: Thousand seed weight (g), BMYP: Biomass yield/plot (kg), 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 (%) and EOC: Essential oil content (%) (v/w dry based), rg: Genotypic correlation while seed yield per plant, number of secondary branches, plant height and days to maturity exerts high negative direct effect on oil content in 64 Ethiopian mustard genotypes. Haghi *et al.* (2012) also reported high positive direct effect exerted on oil content by seed diameter, 100 seed weight and number of pod per plant in soybean. Similarly, negative direct effect was exerted on oil content by seed yield per plant.

CONCLUSION

Coriander is an important seed spice crop in Ethiopia. However, there is lack of information on genetic divergence among yield and yield related traits in Ethiopian genotypes and there is a need to study correlation among seed yield, yield related and oil content to design effective breeding programmes. From the current finding seed yield per plant and oil is significantly correlated with biomass yield per plant, thousand seed weight and harvest index per plant and focusing on genotypes with thousand seed weight, harvest index per plant and biomass yield per plant can improve seed yield per plant and oil content in Ethiopian coriander. The path coefficient analysis result suggested that biomass yield per plant, harvest index per plant and number of seed per plant is the major positive direct effect contributors while, days to start of flowering, plant height at flowering and longest basal leaf length is the major negative direct effect contributors.

In conclusion, the present investigation indicated that there is wide range of genetic variability and diversity in Ethiopian coriander germplasm. There is large scope of simultaneous improvement in seed yield as well as oil content through selection. The traits having positive direct effects on seed yield and oil yield are considered to be suitable selection criteria for evolving high yielding genotypes in Ethiopian coriander land races.

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