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CORRELATION AND PATH ANALYSIS FOR YIELD AND YIELD COMPONENT IN BLACK CUMIN (*NIGELLA SATIVA* L.)

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ABSTRACT

Thirty-three accessions and three released varieties of black cumin genotypes were field evaluated at Debre Zeit Agricultural Research Center during 2015 main season using 6x6 simple lattice Design. The objectives were to assess the genetic variability, correlation coefficients of yield and its component traits into direct and indirect effects through path analysis. Analysis of variance showed significant differences among accessions for most of the traits, Partitioning the total variation revealed that, the genotypic coefficients of variation (GCV) was high for seed yield per plot. On the other hand, phenotypic coefficients of variation (PCV) was high for seed yield per plot and seed yield per plant. High broad sense heritability was not associated with high genetic advance for all characters under consideration. Although, moderate heritability and high genetic advance was obtained for flower duration and seed yield per plot. The phenotypic correlation was positive and significant for seed yield per plant with plant height, biomass per plot, seed yield per plot, days to maturity and harvest index. The genotypic correlation was positive and significant for yield per plant with days to maturity, plant height, biomass per plot, thousand seeds weight, and harvest index. Path coefficient analysis indicated that biomass per plot, days to 50% flowering, days to maturity, plant height, number of locules, harvest index, and seed yield per plant revealed positive direct effect on seed yield. In contrast, days to first flowering, flower duration and thousand seeds weight had negative direct effects on seed yield. Thus, there is enormous opportunity to use the existing accessions for direct selection as well as using distant parents for crossing purposes to improve specific traits.

KEYWORDS: Variability, correlation, and path analysis.

INTRODUCTION

Black cumin *(Nigella sativa* L.) or black seeds, a member of *Rananculaceae* (diploid, 2n=12) is a minor cultivated crop from Morocco to Northern India; in sub-Saharan Africa particularly Niger, and eastern Africa, especially Ethiopia (Iqbal *et al.*, 2010).

Black cumin is grown under a wide range of environments, but flourishes in cooler and dry regions (Weiss, 2002). Black cumin can grow on all kinds of soils (Jansen, 1981) but, it prefers loamy sand soils (Datta *et al.*, 2001). It can be grown from sea level to 2500 m of altitude with a reduction in yield with increasing altitude. Many medical properties have been attributed to the black cumin seeds and its oil, including carminatives, diuretics, antineoplastic (antitumour), antifungal, anti-helminthic, while their oil has protective action against histamine induced bronchospasm, cough and bronchal asthma (Worthen *et al.*, 1998), antidiabetics (Fararh *et al.*, 2002), spasmolytic and bronchodilator (Boskabady *et al.*, 2004), anti-inflammatory (Hajhashemi *et al.*, 2004), antibacterial (Mashhadian and Rakhshandeh, 2005), galactogogue, antioxidant (Brutis and Bucar, 2000) and insect repellent effects (Fisher, 2002).

Beside its medicinal uses, black cumin has a long history of uses for food flavor either as whole grain, in powdered form or as an oleoresin extract for preparation of curries, bread, katikala (Jansen, 1981).

In Ethiopia black cumin is cultivated as rain fed crop in the highlands from 1500 to 2500 meter above sea level. Cultivation as a crop is reported from the provinces of Begemdir (Dembia, Gondar), Shoa (Alem-Gena), Bale (Dinsho), Hararge (Chercher Highlands) and Kefa (Jimma Region) (Jansen, 1981).

In spite of the overwhelming importance of seed spice and the steadily growing research in Ethiopia, the research efforts that have been undertaken were very limited, and not systemized. Up to now information on the extent and pattern of genetic variability, inter variables association and variables effect on seed yield of

Ethiopian black cumin genotypes has not been fully exploited (Adam, 2006).

The objectives of this research, therefore, were to:

1. Assess the genetic variability, heritability and genetic advance of genotypes with respect to various morpho-agronomic traits;
2. Partition the correlation coefficients of yield and its component traits into direct and indirect effects through path analysis;

MATERIALS AND METHODS

Experimental site and materials

The morphological diversity assessment of thirty-three accessions and three released varieties was conducted at Debre Zeit Agricultural Research Center (DZARC) which is located at about 47 Km East of Addis Ababa, in East Shoa zone Ada district, $08^{o}44'$N latitude and $38^{0}58'$E longitude at an altitude of 1860 masl. The area has two growing seasons, main seasons which is rain fed and off-season which is irrigation based. The area has minimum and maximum temperature of 19.03 and 26.91^{o}c respectively, annually, and it receives average annual rainfall of 851mm. The soil type of the center is classified as black soil (Vertisol that has high water holding capacity) and light soil. Black soil (vertisol) was used for this experiment. The experiment included 33 genotypes of Ethiopian black cumin collected from various parts of Ethiopia by Ethiopian Biodiversity Institute. In addition to these accessions, three released varieties were included, thus 36 genotypes were used. The genotypes were received from Kulumsa Agricultural Research Center. For this experiment, 6x6 simple lattice design was used and seeding was done in five rows of each genotype. Seeds were drilled in two-meter bed length, 15 cm plant to plant distance and 30 cm row distance were kept by thinning at the true leaf stage. Distance between two genotypes within the same block was 50 cm, between two adjacent blocks was 1 m and between replications was 2 m. The layout and randomization were done as per the standard procedure set by Cochran and Cox (1957). Recommended weeding and other cultural practices for the crop were done throughout the growing season.

Data Collection and Analysis

The following data were collected either from whole plot or from ten randomly selected samples of plants from the middle parts of the three central rows of each plot. For individual plant traits, the mean values of the 10 samples of plants from each plot were used. Plot based parameters were Days to first flower (D1F), Days to 50% flowering (DF), Days to maturity (DM), Flowering duration (FD), Seed yield per plot (SYPPLOT)(g) and Biomass (BM). whereas, plant-based parameters were Plant height (PH), Seed yield per plant (SYPP) (g), Number of locules (NL), 1000 Seed weight (1000 SW), and Harvest index (HI).

The data collected for each trait were subjected to analysis of variance (ANOVA) for simple lattice design. Analysis of variance was done using Proc lattice and Proc GLM procedures of SAS software. The phenotypic ($\mathbf{v}_p$) and genotypic ($\mathbf{v}_g$) variances and the corresponding phenotypic (PCV) and genotypic (GCV) coefficients of variation for each trait were estimated following the method described by Burton and Dorane (1953). The estimation of heritability was made following the method of Allard (1960) and Falconer (1990). Estimation of the phenotypic and genotypic correlation coefficients were computed following the procedures suggested by Miller *et al.* (1958). The significance of phenotypic correlation coefficients was tested by the formula of Singh and Chaudhary (1977). The coefficient of variation at genotypic level was tested for significance using the formula proposed by Robertson (1959). The direct and indirect effects of the independent characters on seed yield were estimated by simultaneous equation using the formula as applied by Dewey and Lu (1959).

RESULTS AND DISCUSSIONS

Analysis of Variance

The analysis of variance showed highly significant ($P < 0.01$) differences among the test black cumin genotypes in days to first flower, days to 50% flowering, flowering durations, days to maturity, plant height, thousand seeds weight, seed yield per plot and per plant, and biomass per plot (Table 1).

Similar results were found in seed yield for tested ten black cumin ecotypes by Golparvar *et. al*, (2014). According to Iqbal *et. al.*, (2013) high diversity was observed for grain yield in tested thirty-two black cumin germplasms, and highly significant difference was found in thirty black cumin accessions tested by Adam, (2006) for days to flower, days to mature, and plant height. Likewise, Arameshwarappa *et al.,* (2009) and Narayanan and Murugan (2013) reported significant differences among sesame accessions for days to 50% flowering, days to maturity, plant height, and seed yield per plant.

The significant variation between the black cumin materials tested for the measured agro- morphological traits indicated the presence of high degree of phenotypic variability, and it implies the availability of great potential for future improvement of black cumin.

Phenotypic and Genotypic Coefficients of Variability

According to Deshmukh *et. al.*, (1986), PCV and GCV values roughly more than 20% are regarded as high, whereas values less than 10% are considered to be low and values between 10 and 20% to be medium. Generally, in this study the PCV values were higher than their corresponding GCV values for all the characters considered which reflect the influence of environment on the expression of characters (Table 1). Similarly, Alemayheu *et. al.*, (2013) stated that the phenotypic coefficient of variation (PCV) was much higher than genotypic coefficient of variation (GCV) for all characters of lentil accessions tested.

High estimates of phenotypic coefficients of variation (PCV) were observed for seed yield/plot (25.78) and seed yield/plant (24.11) (Table 1). Similarly, Sarada *et. al.,* (2008) reported high PCV value for seed yield for fenugreek genotypes, and also Adam *et. al.*, (2006) obtained high PCV value for seed yield per plant in black cumin. while low estimates were obtained for days to first flower (3.72), days to 50% flowering (5.12), days to maturity (2.65), plant height (4.47), and thousand seeds weight (4.86). On the contrary, moderate PCV were noted for flower duration (14.05) and biomass per plot (14.06).

The estimates of GCV were high for seed yield per plot (20.43) (Table 1). Likewise, Adam *et. al.*, (2006) reported high GCV value for yield per plot in black cumin accessions tested. The high GCV values of these characters suggest the possibility of improving these traits through selection. Moderate GCV estimates were found for seed yield per plant (18.10) and flower duration (11.91). In contrast, the GCV estimates were low for biomass per plot (8.29), days to 50% flowering (4.87), days to first flowering (3.47), thousand seeds weight (3.64), plant height (3.08), and days to maturity (1.49). Similarly, Andualem *et. al.,* (2013) found that plant height and days to maturity had low GCV values in finger millet germplasms. As Burton (1952) suggested, the GCV together with high heritability and genetic advance would give the best picture on the extent of advance expected from selection.

In present study, estimates of broad sense heritability ranged from 30.17% for seed yield per plant to 90.31% for days to 50% flowering (Table 1). According to Singh (2001), if heritability of a character is very high, say 80% or more, selection for such characters could be fairly easy. This is because there would be a close correspondence between the genotype and the phenotype due to the relatively small contribution of the environment to the phenotype. For characters with low heritability, say 40% or less, selection may be considerably difficult or virtually impractical due to the masking effect of environment.

Considering these bench-marks, the tested black cumin genotypes in the present study showed high heritability values for days to 50% flowering (90.31%) and days to first flowering (87.34). Moderate estimates for flower duration (71.82%), thousand seeds weight (55.85), plant height (47.48%), and seed yield per plot (46.46%) (Table 1). On the other hand, low heritability was recorded for biomass per plot (34.75%), days to maturity (31.75%), and seed yield per plant (30.17%). Similar to the present findings, Adam *et. al.,* (2006) found moderate heritability results for plant height, days to maturity, seed yield per plant, and grain yield per plot of black cumin. Also, Aditya *et. al.,* (2011) found moderate heritability estimates for plant height and high heritability for days to 50% flowering in soybean genotypes. In agreement with the present study, Andualem (2013) reported moderate heritability in grain yield, days to maturity, and plant height of finger millet genotypes. Heritability alone is not enough to make efficient selection unless accompanied by genetic advance. Genetic advance has added advantage over heritability as a guiding factor in a selection program.

Phenotypic correlations

Phenotypic correlation tells us the relationship between two or more characters. Assessment of the pair-wise associations among different characters revealed that some of the characters are positively correlated while others are negatively correlated indicating that improving or increasing specific character will have positive or negative influence on the other characters in such degree apparent from the correlation coefficients (Table 2).

Seed yield per plant had positive significant correlation with plant height (0.63), biomass per plot (0.49), seed yield per plot (0.49), days to maturity (0.40) and harvest index (0.34) (Table 2). Experiment done on fenugreek by Jain *et. al.,* (2013) showed positive correlation of plant height and number of pods per plant with seed yield. Positive and significant correlation of seed yield with days to maturity and plant height on black cumin were reported by Adam (2006).

Genotypic correlations

The inherent or heritable association between two variables is known as genotypic correlation. This type correlation may be either due to pleiotropic action of genes or due to linkage or more likely both. The main genetic cause of such correlation is pleitropy, which refers to manifold effects of a gene (Falconer, 1989). Generally, in a genetic breeding program several traits are targeted simultaneously, so that the understanding of the genetic associations helps to refine the Variances at phenotypic (o^2p), genotypic (o^2g) and environmental (a^2e) levels, heritability in broad sense, genetic advance and genetic advance expressed as percentage of mean for 16 traits of tested entries.

Table 1: Variances at phenotypic (o2p), genotypic (o2g) and environmental (a2e) levels, heritability in broad sense, genetic advance and genetic advance expressed as percentage of mean for 16 traits of tested entries.

Characters	Mean	MS	vp	vg	Ve	GCV (%)	PCV (%)	H^2 (%)
D1F	58.806	9 94**	4.78	4.17	0.61	3.47	3.72	87.34
DF	77.458	32.48**	15.74	14.21	1.53	4.87	5.12	90.31
FD	18.65	13.73**	6.87	4.93	1.94	11.91	14.05	71.82
DM	135.25	55.57**	12.80	4.06	8.74	1.49	2.65	31.75
PH	50.515	21.587**	5.11	2.42	2.68	3.08	4.47	47.48

TSW	2.63	0.03731**	0.02	0.01	0.01	3.64	4.86	55.85
BPP	971.6	50331.5*	18648.58	6480.08	12168.50	8.29	14.06	34.75
SYPP	4.783	2.703*	1.33	0.75	0.58	18.10	24.11	30.17
SYPPLOT	222.092	8168.923**	3277.10	2057.88	1219.22	20.43	25.78	46.46

D1F= days to first flowering, DF= days to 50% flowering, FD= flower duration, DM= days to maturity, CL=capsule length, PH= plant height, NPB= number of primary branches, NL= number of locules, NCPPP= number of capsule per plant, Cwt= capsule weight, NSPC= number of seeds per capsule, TSW= thousand seeds weight, BPP= biomass per plot, and SYPP=seed yield per plant, SYPPLOT= seed yield per plot, choice of the most appropriate procedures (Santos and Vencovsky 1986).

Seed yield per plant had significant positive correlations with days to maturity (0.43), plant height (0.69), biomass per plot (0.71), thousand seeds weight (0.34), and harvest index (0.41). This indicates that these characters can be improved simultaneously. Mulusew (2012) also found significant correlation of seed yield per plant with plant height in Ethiopian linseed landrace accessions and exotic cultivars.

Path Coefficient Analysis

Path coefficient analysis is simply a standardized partial regression coefficient which splits the correlation coefficient into the measures of direct and indirect effects. In other words, it measures the direct and indirect contribution of various independent characters on a dependent character.

In this experiment, the results obtained from path analysis of seed yield showed that biomass per plot and harvest index had the highest and positive direct effect on seed yield, while, days to 50% flowering, days to maturity, plant height, number of locules, and seed yield per plant also exerted positive direct effect on seed yield (Table 3). On the other hand, days to first flowering, flowering duration and thousand seeds weight had negative direct effects on seed yield. In agreement to the present findings, experiments with rapeseed genotypes revealed that days to flowering, days to maturity, and plant height had positive direct effect on seed yield, and flower duration had negative direct effect on seed yield (Rameeh, 2014). Majumder *el. al.,* (2008) also found positive direct effects of harvest index on grain yield of spring wheat varieties. Furthermore, Gadisa *et. al.,* (2014) reported that days to maturity, biomass per plot, and harvest index had direct effect on seed yield.

Biomass per plot had positive indirect effect on seed yield through harvest index, thousand seeds weight, plant height, and days to maturity, while it had negative indirect effect through days to first flowering and days to 50%flowering (Table 3). On the other hand, harvest index had positive indirect effect on seed yield through thousand seeds weight and days to maturity, but it had negative indirect effect through days to first flowering, days to 50% flowering, and number of locules. The residual effect was very small (0.012) which indicates that the characters under consideration were appropriate for the study of yield determination in black cumin.

In general, high biomass per plot and the low days to first flowering would be important as the causes for improvement of seed yield in black cumin. Alternatively, harvest index could also be considered for yield improvement.

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Table 2: Estimates of genotypic (above diagonal) and phenotypic (below diagonal) coefficients of correlations among 16 traits in Ethiopian black cumin accessions and released varieties.

	D1F	DF	FD	DM	PH	NL	TSW	HI	BPP	SYPP	SYPPLOT
D1F	1	0.91**	0.55**	0.39*	0.30	0.39	-0.35*	-0.45**	-0.28	-0.13	-0.41*
DF	0.83**	1	0.83**	0.39*	0.37*	0.26	-0.23	-0.37*	-0.34*	-0.03	-0.38*
FD	0.42*	0.85**	1	0.28	0.30	0.12	-0.06	-0.22	-0.32	0.05	-0.29
DM	0.33	0.31	0.21	1	0.52**	-0.41*	0.61	0.65**	0.77**	0.43**	0.67**
PH	0.27	0.30	0.26	0.51**	1	0.10	0.38*	0.44**	0.74**	0.69**	0.59**
NL	0.36*	0.32	0.23	-0.11	0.18	1	-0.76**	-0.74**	-0.49**	-0.17	-0.27
TSW	-0.32	-0.20	-0.03	0.52**	0.32	-0.34*	1	0.82**	0.76**	0.34*	0.74**
HI	-0.36*	-0.36*	-0.26	0.53**	0.37*	-0.27	0.65**	1	0.99**	0.40*	0.98**
BPP	-0.30	-0.27	-0.14	0.54**	0.50**	-0.22	0.63**	0.70**	1	0.71**	0.99**
SYPP	-0.10	-0.03	0.08	0.40*	0.63**	-0.24	0.27	0.34*	0.49**	1	0.54**
SYPPLOT	-0.37*	-0.35*	-0.22	0.56**	0.49**	-0.66**	0.66**	0.91**	0.93**	0.49**	1

D1F= days to first flowering, DF= days to 50% flowering, FD= flower duration, DM= days to maturity, CL=capsule length, PH= plant height, NPB= number of primary branches, NL= number of locules, NCPPP= number of capsule per plant, Cwt= capsule weight, NSPC= number of seeds per capsule, TSW= thousand seeds weight, HI= harvest index, BPP= biomass per plot, and SYPP=seed yield per plant, SYPPLOT= seed yield per plot *, ** significant at $P<0.05$ and $P<0.01$, respectively.

Table 3: Path coefficient analysis showing direct (bold) and indirect effect of component traits in thirty-three accessions and three varieties of black cumin evaluate at DZARC during the 2015/16.

	D1F	DF	FD	DM	PH	NL	TSW	HI	BPP	SYPP	rp
D1F	**-0.062**	0.045	-0.016	0.004	0.011	0.001	0.017	-0.188	-0.164	-0.004	-0.37
DF	-0.052	**0.054**	-0.033	0.004	0.012	0.001	0.010	-0.188	-0.147	-0.001	-0.35
FD	-0.026	0.046	**-0.039**	0.003	0.011	0.001	0.002	-0.135	-0.076	0.003	-0.22
DM	-0.021	0.017	-0.008	**0.012**	0.021	0.000	-0.027	0.276	0.295	0.015	0.56
PH	-0.017	0.016	-0.010	0.006	**0.041**	0.001	-0.017	0.193	0.273	0.024	0.49
NL	-0.062	0.017	-0.09	-0.021	0.007	**0.003**	0.018	-0.171	-0.22	-0.09	-0.66
TSW	0.020	-0.011	0.001	0.006	0.013	-0.001	**-0.052**	0.339	0.344	0.010	0.66
HI	0.022	-0.019	0.010	0.006	0.015	-0.001	-0.034	**0.521**	0.382	0.013	0.91
BPP	0.019	-0.015	0.005	0.007	0.020	-0.001	-0.033	0.365	**0.545**	0.018	0.93
SYPP	0.006	-0.002	-0.003	0.005	0.026	-0.001	-0.014	0.177	0.267	**0.037**	0.49
Residual	**0.012**										

D1F= days to first flowering, DF= days to 50% flowering, FD= flower duration, DM= days to maturity, PH= plant height, NL= number of locules, TSW= thousand seeds weight, HI= harvest index, BPP= biomass per plot, and SYPP=seed yield per plant.

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