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Heritability and Genetic Advance in Ethiopian Mustard (*Brassica carinata* A. Brun)

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ABSTRACT

Evaluation of locally adapted genotypes is helpful in endeavor of improvement of oilseed of Ethiopian mustard (*Brassica carinata* A. Brun). The present investigation was undertaken to evaluate the performance of different genotypes of Ethiopian mustard, and to estimate the heritability and genetic advance of agronomic traits of these genotypes. The experiment was laid out in simple lattice design at Holetta Research Center, Ethiopia. Wide ranges of mean values were observed for traits such as days to flowering (61-101), days to maturity (155-182), plant height (177-235 m), number of secondary branches per plant (5-25), number of pods per plant (123-279), number of seeds per pod (6-14), number of seeds per plant (3-11), seed yield per plot (334-1300 g), oil yield per plot (141-584 g) and 1000-seed weight (2.4-4.6 g). High genotypic and phenotypic coefficients of variation were shown in traits such as seed yield per plot and oil yield per plot. Low to high heritability values were recorded for the traits studied. High heritability values were recorded for traits such as days to flowering (79.3%), plant height (62.8%), 1000-seed weight (57.9%) and days to maturity (57.5%). Number of seeds per pod, seed yield per plot and oil yield per plot were found to have high genetic advance along with moderate heritability. Thirteen genotypes had days to maturity less than the grand mean as well as the standard checks which may be used for developing early maturing varieties. Traits which showed wide range of variations may serve for further breeding and selection. Employing breeding procedure such as pedigree method may be helpful for improvement of those traits which showed high genetic advance along with moderate heritability.

Keywords: agronomic traits, genotypic coefficient of variation, mean, phenotypic coefficient of variation

INTRODUCTION

Ethiopian mustard (*Brassica carinata* A. Brun) is one of the oilseeds crops which is commonly grown in Ethiopia and it has been cultivated since ancient times (Alemayehu and Becker 2002). It is well adapted to cool, long growing season and high rainfall areas (Getinet and Nigussie 1997). Its area and production are estimated to 33,223 ha and 386,637 quintals with an average productivity of 11.64 quintals/ha (CSA 2009). Nevertheless, lack of early maturing and high yielding varieties are the bottlenecks for its production (EARO 2000).

Obviously, genetic variation is the principal raw material for any breeding and/or improvement program. The effectiveness of breeding for trait desired is depends on the extent of this genetic variation. Variation in locally adapted population of the species is helpful for identifying important traits (Cooper *et al*. 2001), and to develop agronomically viable varieties (Alemayehu and Becker 2002). The extent of genetic variation has been determined by estimation of the heritability in the broad sense in canola (Marwede *et al*. 2004) and tomato (Dar and Sharma 2011). In improvement endeavor, however, heritability accompanied with genetic advance makes selection more effective (Sheikh *et al*. 1999; Ghosh and Gulati 2001; Sharma *et al*. 2003; Singh *et al*. 2003). The present investigation was undertaken to evaluate the performance of different genotypes of Ethiopian mustard, and to estimate heritability in the broad sense and genetic advance of agronomic traits of these genotypes.

MATERIALS AND METHODS

The material for the present investigation consisted of 33 genotypes and 3 standard checks (**Table 1**). The experiment was carried out at Holetta research center using a 6 × 6 simple lattice design in the 2010 cropping season. Each genotype was grown in six rows of 3 m long with spacing of 30 cm between rows. The recommended management practices (Alemyehu and Abebe 1994) were followed for good establishment of the crop.

Description of data collected on plot basis

Days to flowering (DF): The number of days from the date of sowing to the date at which about 50% of the plants in a plot showed blooming on about 50% of their flower buds.

Days to maturity (DM): The number of days from the date of sowing to a stage when 90% of plants reached their physiological maturity.

1000-seed weight (TSW): The weight in g of 1000 seeds sampled from each plot.

Seed yield/plot (SYP): Seed yield per plot was measured in g after moisture of the seed is adjusted to 7%.

Oil content (OC): The proportion of oil in the seed to the total oven dried seed weight as measured by nuclear magnetic resonance spectroscope (NMRS) (Newport Instruments Ltd., Milton Keynes, UK).

Oil yield/plot (OYPP): The amount of oil in g obtained by multiplying seed yield per plot by corresponding oil percentage.

Description of data collected on plant basis

Primary branches per plant (NPB): The average number of primary branches per plant.

Secondary branches per plant (NSB): The average number of secondary branches formed on primary branches per plant.

Number of seeds per pod (SPPD): Number of seeds per pod was obtained by dividing the seeds obtained from 10 randomly taken plants to their total number of pods.

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Table 1 List of genotypes considered in the study and their origin.

Code	Acc. No	Area of collection	Altitude (m)	Code	Acc. No	Area of collection	Altitude (m)
1	PGRC/E 20052	West Shoa	2540	19	PGRC/E 208596	East Harargae	-
2	PGRC/E 20059	West shoa	1630	20	PGRC/E 208865	North Omo	1300
3	PGRC/E 20068	West shoa	2010	21	PGRC/E 208961	East Wolega	2700
4	PGRC/E 20163	East Tigrai	2300	22	PGRC/E 21057	East Gojam	-
5	PGRC/E 20168	East Tigrai	-	23	PGRC/E 21068	Bale	2500
6	PGRC/E 208419	West Gojam	2050	24	PGRC/E 21069		-
7	PGRC/E 208507	*	-	25	PGRC/E 21163	East Wolega	2340
8	PGRC/E 208513	*	-	26	PGRC/E 21266	South Wolo	2550
9	PGRC/E 208523	*	-	27	PGRC/E 21278	South Wolo	-
10	PGRC/E 208530	*	-	28	PGRC/E 213168	-	-
11	PGRC/E 208545	*	-	29	PGRC/E 21369	Jimma	1720
12	PGRC/E 208558	*	-	30	PGRC/E 214620	North Omo	-
13	PGRC/E 208560	*	-	31	PGRC/E 215284	East Gojam	-
14	PGRC/E 208571	*	-	32	PGRC/E 215562	Gedeo	1820
15	PGRC/E 208575	*	-	33	PGRC/E 215790	West Wolega	1950
16	PGRC/E 208584	*	-	34	YD	Check	2400
17	PGRC/E 208585	East shoa	1600	35	S-67	Check	2400
18	PGRC/E 208594	East Hararrgae	1750	36	H-1	Check	2400

*: Donation by Foundation for Agricultural Plant Breeding S.V.P P.O.Box 117 Wageningen, The Netherlands
- :Information not available
Acc. No : Genotype accession number

Number of pods per plant (NPP): The average number of pods counted from the same sample plants.

Plant height (PH): The height of plants in each plot measured in cm from the ground surface to the top of the main stem at maturity.

Number of seeds per plant (SPP): The average seed yield in g obtained from 10 randomly taken plants in each plot.

Length of pod: The length of pod measured in cm.

Data analysis

Data were subjected to analysis of variance using the procedures outlined by Gomez and Gomez (1984). Phenotypic and genotypic variance, as well as phenotypic and genotypic coefficients of variation were estimated following Burton and De Vane (1953). Heritability in the broad sense of the traits studied was computed as per the suggestion of Allard (1960), and the expected genetic advance under selection assuming selection intensity of 5% (2.063) was calculated following Johnson *et al*. (1955). All statistics were done using SAS software version 9.00 (SAS 2002).

Table 2 Mean squares of genotypes for 11 agronomic traits.

Traits	Error Mean Squares	Genotypes Mean Squares	Block Mean Squares
DF	16.04	138.92**	45.13
DM	24.83	91.99**	26.89
PH	108.12	472.57**	2.94
NPB	0.94	2.59**	0.85
NSB	21.53	33.14^{ns}	8.11
SPP	2001.71	2095.56^{ns}	119.61
LP	0.199	0.496**	0.188
SPPD	5.02	10.58*	1.28
SPP	5.65	6.16^{ns}	0.03
SYPP	36715.24	88376.65**	20570.68
OYPP	7698.19	18577.94**	3799.01
TSW	0.082	0.294**	0.133

* and **: significance level at $p \leq 0.05$ and $p \leq 0.01$, respectively , ns: non significant
DF: days to flowering, DM: days to maturity, PH: plant height, NPB: Number of primary branches per plant, NSB: Number of secondary branches per plant, NPP: Number of pods per plant, LP: length of pod, SPPD: Number of seeds per pod, SPP: Number of seeds per plant, SYPP: Seed yield per plot, OYPP: Oil yield per plot, TSW: 1000-seed weight

RESULTS AND DISCUSSION

Analysis of variance showed that there were significant differences among genotypes for all traits except number of pods per plant, number of secondary branches per plant and number of seeds per plant (**Table 2**). This indicates the existence of considerable genetic variability for further selection and breeding. Similarly, genetic variability were revealed among sixty Ethiopian mustard genotypes (Delesa 2006) and 27 genotypes of rapeseed (Esmaeeli *et al*. 2009) grown under normal condition. Akhtar *et al*. (2007) reported genetic variability among six cultivars of *Brassica* grown in glasshouse under phosphorus-deficient soil. Besides, genetic variability for days to flowering and plant height in Ethiopian mustard genotypes (Mulat 1988) grown under normal condition has also been reported. Khan *et al*. (2008) reported similar finding of highly significant variation for plant height in $F_{3:4}$ population *of Brassica* grown under irrigated condition.

Mean performances of the genotypes for 12 agronomic traits is presented in **Table 3**. Maximum days to flowering (101 days) were recorded by genotype 13, while the minimum was recorded by genotype 23 (61 days). Similarly, maximum days to maturity (182 days) were recorded by genotypes such as 30 and 33, while the minimum (155 days) was recorded by genotype 15.

Thirteen genotypes had days to maturity less than the grand mean as well as the standard checks, which indicate that there is the possibility of improving the genotypes for earliness for at least two weeks. The highest number of primary branches per plant and number of secondary branches per plant was recorded by the genotypes 7 and 12, respectively, whereas the lowest value for both aforementioned traits was recorded by genotype 6. Similarly, the highest number of seeds per pod (14) was recorded by genotype 23 while the lowest (6) was recorded by genotype 28. The highest value for 1000-seed weight (4.6) was recorded by genotype 10 and the lowest (2.4) was recorded by genotype 1. In general, wide ranges were observed for traits such as days to flowering, days to maturity, plant height, number of secondary branches per plant, number of pods per plant, number of seeds per pod, number of seeds per plant, seed yield per plot, oil yield per plot and 1000-seed weight. A wide range of variation recorded for traits such as number of pods per plant, plant height, days to maturity, days to flowering, number of seeds per plant, seed yield and oil yield per plot is in accordance to the result of Delesa (2006) who carried out similar genetic variability study on sixty Ethiopian mustard genotypes which were grown under normal condition. Similarly, in other findings, Oboh (2007) observed wide variability for most of the traits studied in 16 accessions of *Amaranthus* hybrids grown under normal condition. All the five accessions studied showed variability for morphological traits in Tribulus *terrestris* grown under normal condition (Raghu *et al*. 2007). Adebooye *et al* (2006) reported wide variability for qualitative traits in tomato

Table 3 Mean values of the studied 36 genotypes for 11 agronomic traits tested at Holetta, 2010.

Genotypes	DF	DM	PH	NPB	NSB	NPP	LP	SPPD	SPP	SYPP	OYPP	TSW
1	85	174	184	11	17	186	4.71	13	6	749.7	322.34	2.4
2	95	181	225	11	20	200	4.31	11	7	1153.6	492.6	3.1
3	78	165	197.25	10	19	178	4.59	11	6	808.05	350.97	3.15
4	84	170	213.75	9	12	168	4.32	9	6	648.65	293.95	3.5
5	75	171	194	9	10	135	3.93	12	6	812.2	352.19	3.8
6	82	174	235	8	5	123	4.25	10	5	850.2	378.96	3.7
7	79	179	195	12	19	279	3.84	7	6	539.75	220.63	2.8
8	96	181	217.75	11	14	183	5.4	9	5	787	341.35	3.2
9	76	170	177.25	8	10	171	3.89	10	7	840.6	388.01	3.7
10	92	180	221.75	9	15	174	6	7	6	568.65	249	4.6
11	89	179	211.75	9	15	204	4.24	6	5	607.55	256.05	3.65
12	92	181	207	10	25	216	5.03	11	10	911.8	394.1	3.9
13	101	181	216.5	9	14	176	5.2	12	7	490	195.36	3.3
14	77	176	185	9	14	169	4.41	12	7	815.25	346.98	3.4
15	79	155	186	9	17	234	3.95	13	11	875.8	395.1	3.5
16	74	168	196.5	8	15	225	3.46	11	9	668.7	288.1	3.55
17	89	176	215.5	10	15	196	4.46	9	6	785.95	355.81	3.3
18	78	169	196.5	8	15	192	4.03	11	7	967.75	423.4	3.15
19	86	178	219.7	10	20	275	4.64	9	8	920.85	415.99	3.3
20	88	174	210	11	20	196	4.27	14	9	1300.3	584	3.25
21	91	182	192.75	11	11	160	4.22	12	7	608	263.17	3.3
22	88	179	201	8	10	192	5.17	8	6	892.45	385.4	3.8
23	61	160	203.25	9	16	205	4.04	14	10	1086.2	476.56	3.35
24	75	162	192.75	8	13	164	4.3	14	8	1016.55	445.8	3.35
25	77	168	192.75	11	17	200	4.56	10	7	762.8	350.5	3.6
26	79	171	183.25	10	15	185	4.2	12	8	527.35	244.8	3.4
27	79	165	182.23	9	16	181	4.92	12	7	547.45	244.3	3.05
28	95	176	215.75	8	8	188	4.46	6	4	334.4	141.2	3.15
29	77	169	179	8	9	168	4.07	13	7	824.7	377.7	3.45
30	92	182	200.75	11	13	214	4.03	8	6	663.55	307.9	3.2
31	91	180	232.25	9	11	179	4.67	5	3	566.2	246.02	3.45
32	93	179	225.5	10	9	174	4.89	8	5	775.65	331.91	3.6
33	93	182	199.75	9	13	154	4.7	7	4	388.5	161.26	3.5
34	81	174	217.5	11	11	161	4.43	11	7	938.75	447.08	3.85
35	81	175	208	9	11	148	4.77	10	6	920	409.15	3.9
36	80	175	201	10	16	214	4.34	12	10	950.05	432.1	4.1
Range	61-101	155-182	177-235	8-12	5-25	123-279	3.5-6	6-14	3-11	334.4-1300	141.2-584	2.4-4.6
Mean	84	173.8	203.6	9	14	188	4.46	10	7	775.14	341.94	3.45
CV %	4.8	2.87	5.11	10.27	32.76	23.81	9.99	21.91	35.49	24.72	25.66	8.29
LSD(0.05)	8.1	10.12	21.11	1.97	9.42	90.83	0.9	4.55	4.83	388.99	178.12	0.58

CV: coefficient of variation, LSD: least significance difference

DF: Days to flowering, DM: Days to maturity, PH: plant height, NPB: Number of primary branches per plant, NSB: Number of secondary branches per plant, NPP: Number of pods per plant, LP: Length of pod, SPPD: Number of seeds per pod, SPP: Number of seeds per plant, SYPP: Seed yield per plot, OYPP: Oil yield per plot, TSW: 1000-seed weight

Table 4 Component of variance, coefficient of variation, heritability in broad sense, genetic advance and genetic advance as percent of mean.

Traits	Variance			CV		h^2 (%)	GA	GA as % of mean
	PV	GV	EV	GCV	PCV			
DF	77.4	61.4	16	9.4	10.5	79.3	14.34	17.1
DM	58.4	33.6	24.8	3.3	4.4	57.5	9.03	5.2
PH	290.3	182.2	108.1	6.6	8.4	62.8	22	10.8
NPB	1.7	0.8	0.9	9.5	14.2	47.1	1.26	13.4
NSB	27.3	5.8	21.5	17	36.9	21.2	2.28	16.1
NPP	2048.7	46.9	2001.8	3.6	24.1	2.3	2.14	1.1
LP	0.3	0.1	0.2	7.1	14.2	33.3	0.37	8.4
SPPD	7.8	2.8	5	16.4	27.3	35.9	2.06	20.2
SPP	6	0.3	5.7	8.2	36.3	5	0.25	3.8
SYPP	62545.9	25830.7	36715.2	20.7	32.3	41.3	212.36	27.4
OYPP	13137	5440	7697	21.6	33.5	41.4	97.56	28.5
TSW	0.19	0.11	0.08	9.6	13	57.9	0.52	15

DF: days to flowering, DM: days to maturity, PH: plant height, NPB: Number of primary branches per plant, NSB: Number of secondary branches per plant, NPP: Number of pods per plant, LP: length of pod, SPPD: Number of seeds per pod, SPP: Number of seeds per plant, SYPP: Seed yield per plot, OYPP: oil yield per plot, TSW: 1000-seed weight, PV: phenotypic variance, GV: genotypic variance, EV: environmental variance, CV: coefficient of variation, GCV: genotypic coefficient of variation, PCV: phenotypic coefficient of variation, h^2: heritability, GA: genetic advance

varieties grown under different phosphorus level. Diverse and superior wheat genotypes could also be identified based on mean performance of yield and other traits (Kumar *et al.* 2009).

Days to flowering, days to maturity and plant height showed high phenotypic and genotypic variance indicating that the genotypes could be reflected by the phenotype and the effectiveness of selection based on the phenotypic performance for these traits. In other findings, high genotypic and phenotypic variances were recorded for plant height and pods per plant in mustard (Labana *et al.* 1980; Ali 1985). Sadat *et al.* (2010) reported high genotypic and phenotypic variances for pods per plant and seed yield in advanced generation of three rapeseed varieties grown under normal condition. High genotypic coefficient of variation (GCV) and phenotypic coefficients of variation (PCV) were shown in traits such as seed yield per plot and oil yield per plot, which means selection of these traits based on phenotype may be useful for yield improvement. This result is in agreement with the findings of Delesa (2006), and Aytac and Kinaci (2009) who reported high GCV and PCV for seed yield per plot and oil yield per plot in Ethiopian mustard and winter rapeseed, respectively. A similar study of genetic variability in tomato (Dar *et al*. 2011) revealed higher values of PCV compared to GCV for all traits studied.

The broad sense heritability and genetic advance as percent of mean of the traits are presented in **Table 4**. Heritability estimates were grouped into high (>50%), moderate (20-50%) and low (<20%) as described by Stansfield (1988). Accordingly, we recorded high heritability for days to flowering (79.3%), plant height (62.8%), 1000-seed weight (57.9%) and days to maturity (57.5%). This indicates that the proportion of total variance is largely genotypic in which selection based on phenotypic value of these traits may be effective. Some of these results are in agreement with Delesa (2006) who found high heritability for traits such as days to flowering, days to maturity, plant height and 1000 seed weight in Ethiopian mustard. Similar findings of high heritability for days to flowering, plant height and 1000-seed weight were also observed in other *Brassica* species (Robbelen and Thies 1980; Major and Singh 1996; Becker *et al*. 1999; De *et al*. 2000; Ali *et al*. 2003; Aytac and Kinaci 2009).

Moderate heritability (20-50%) was found for number of primary branches per plant, number of secondary braches per plant, length of pod, number of seeds per pod, seed yield per plot and oil yield per plot. Almost similar finding of moderate value for pod length (37.0%) was reported by Aytac and Kinaci (2009). On the other hand, low heritability (<20%) was shown by number of pods per plant and number of seeds per plant, indicating greater environmental influence than those traits with moderate and high heritability, which indicates selection of these traits based on phenotype may be ineffective.

The highest genetic advance as percent of mean was shown by oil yield per plot (28.5%) followed by seed yield per plot (27.4%) and number of seeds per pod (20.2%) (**Table 4**). In this study, high genetic advance along with moderate heritability was shown by number of seeds per pod, seed yield per plot and oil yield per plot in which both additive and non-additive gene action may be expressed. Contrarily, in other findings, Sadat *et al*. (2010) reported high heritability along with high genetic advance for pods per plant and seed yield in F_2 and F_3 generations of three rapeseed varieties grown under normal condition.

CONCLUSIONS

Breeders should focus on traits which showed wide range of variations which may serve for further improvement of the trait desired. Breeding procedure such as pedigree method may be valuable in improvement of those traits which have shown considerable values for both heritability and genetic advance.

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