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Multivariate Analysis of Genetic Divergent of Ethiopian Mustard (Brasica carinata A. Braun) Land races in Seed Yield and Its Related Component Traits

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The study was executed to assess the extent and pattern of genetic variability of Ethiopian mustard genotypes with respect to seed yield and its related traits in 49 Ethiopian mustard land races at Holetta Agricultural Research Center, Ethiopia. The experiment was carried out in a simple lattice design. Univariate analysis has shown that there was significant different variation among genotypes in all traits compared. The significant difference indicates that the existence of genetic variability among the accessions that is important for selection program and breeding. Multivariate analyses resulted in the formation of four clusters and have shown the presence of substantial genetic diversity among the genotypes. The present study also showed that geographical diversity could not necessarily be an index of variation and the factors other than geographic diversity such as genetic drift, selection pressure, closeness in pedigree and environment may be responsible for differential grouping of genotypes. The present study revealed the presence of considerable variability among genotypes for all traits. The presences of substantial genetic diversity among genotypes tested indicate that there is good opportunity to improve seed yield and its related component traits using the tested genotypes.

Keywords: Ethiopian mustard, Genetic diversity, univariate and multivariate analysis, seed yield related traits

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INTRODUCTION

The genus *Brassica* of *Brassicaceae* family as a whole is believed to have originated around the Mediterranean, Eastern Afghanistan and the adjoining portion of Pakistan and North-Eastern Africa (Hemigway, 1976). The genus includes six economically important species, namely, *Brassica rapa*, *B. oleracea*, *B. nigra*, *B. juncea*, *B. napus*, and *B. carinata* (Doweny and Röbbelen, 1989). Ethiopian mustard is believed to be originated in the highlands of the Ethiopian plateau and the adjoining portion of East Africa and the Mediterranean coast (Gomez-Campo and Prakash, 1999). It evolved as a natural cross between *B. nigra* (BB) (n=8) and *B. oleracea* (CC) (n=9) and underwent further chromosomal doubling (2n=34; UN, 1935). It is partially amphidiploids. In Ethiopia, among the highland oilseeds, Ethiopian mustard stands third next to niger seed and linseed in total production and areas coverage (CSA, 2013/2014). Its area and production are estimated to 44041.34 hectares and 62450.266 tons, respectively, at private peasants holdings level, with an average productivity of

1.418 tons/ha (CSA, 2013/14). Ethiopian mustard is well adapted to cool, long growing season and high rainfall areas at elevation between 2200 and 2800 meters. In these areas, the temperature and rainfall range from 12 to 18°C and 500 to 1200 mm, respectively during the growing season.

The crop is traditionally used for many purposes, such as greasing traditional bread-baking clay pan, curing certain diseases and as a source of vegetable relish (Nigussie, 2001). Major production constraints of the Ethiopian mustard are: lack of high yielding, early maturing varieties, high erucic acid (C22: 1) content in seed oil and high glucosinolate content in the meal (EARO, 2000). Crop improvement through plant breeding, thus, occurs through selection operating on genetic variability. Selection by plant breeders or by farmers can be powerful and has resulted in major improvements. However, continued success in plant breeding can only be realized in so far as new variability is available for selection (Copper *et al.,* 2001). Such variability provides adaptability, which is the capacity for genetic change in response to selection (Sigmmonds, 1962). Genetic variability is therefore essential for crop improvement. Hence, research efforts to improve seed yield of Ethiopian mustard using suitable selection criteria is indispensable. Therefore the present study was, executed with the objective of assessing genetic variability of Ethiopian mustard land races in seed yield and its related components traits.

MATERIALS AND METHODS

The experiment was conducted at Holetta Agricultural Research Center (HARC) in 2013/2014 cropping season from June to December 2013. Holetta (West Shewa Zone of Oromia Region) is located at latitude 9° N and longitude 38° E, altitude of 2400 m a.s.l situated 30km West of Addis Ababa. It is one of the representatives of oil seed *Brassica* growing areas in the central highlands of Ethiopia (Nigussie and Mesfin, 1994). The area has mean annual rainfall of 1059 mm and temperatures of 23°C (maximum) and 8°C (minimum). The soil type is Nitisols with soil ph in the range of 6.0 -7.5(Nigussie and Mesfin, 1994).

A total of forty-nine mustard land races that include one local check and one standard check were used in this study. The majority of the accessions represent the national collection from different major mustard growing regions of the country and that are maintained at HARC. The accessions were obtained kindly from Holetta agricultural research center of highland oil crops improvement project. The details of the accessions used in the experiment are given in Table 1.

The experiment was executed from June 2013 to December 2013. The experiment was laid out in simple lattice 7X7 design with two replications. A plot of four central rows each three-meter long and 30Cm spacing between rows were used for data collection. Each replication had seven blocks and each block was represented by seven plots. The path between blocks was 2 m and the spacing between plots with in sub-blocks was also 0.6 m. Each entry was manually drilled, a rate of 10 kg/ha and urea and phosphorous fertilizers were applied at the rates of 46/69 kg/ha N/P_2O_5 respectively following the national recommendations. All other recommended agronomic and cultural practices were carried out following practices described by Adefris(2005).

Data was collected on plot basis for Days to flowering (Df),Days to maturity (Dm),Seed yield per plot (SYPP),Oil content (Oc),Thousand seed weight (Tsw), Oil yield (Oy) and Stand percent (SP): On other hand data was also collected on plant basis for Number of Primary branches per plant (PB), Number of Secondary branches per plant (SB), Plant height (PHT) and Seeds yield per plant (SYPPL).

Clustering of genotypes was performed by canonical roots method using procedures of SAS (SAS Institute, 2008) version 9.20 Software to group sets of genotypes into possible homogenous classes. The genetic distances between clusters was estimated by Mahalanobis's (1936) D^2 statistics using the same software as clustering as:

$$D^2ij = \left(\overline{X}_i - \overline{X}_j\right)^1 COV^{-1}\left(\overline{X}_i - \overline{X}_j\right) \text{W}$$

here, D^2ij = Total generalized distance between class i and j

$\left(\overline{X}_i - \overline{X}_j\right)$ =The difference between the mean vectors of $_i^{th}$ and $j^{th;}$ and COV^{-1} = the pooled variance-covariance matrix within groups.

The significance of D^2ij values for pairs of clusters were tested using the calculated values of chi-square(x^2) at, 0.01%, and 5% probability level. The test was done against the tabulated values of x^2 for 'P' degrees of freedom, where P is the number of quantitative characters considered (Singh and Chaundhary, 1985)

RESULTS AND DISCUSSION

The analysis of variance for the 11 traits studied is given in Table 2.The analysis of variance showed that there were significant differences among genotypes for all traits compared. The significant difference indicates the existence of genetic variability among the accessions that

Table 1. List of 49 Ethiopian mustard genotypes used in the study and their origin

No.	Accession number	Area of collection	Altitude(m)	Latitude	Longitude
1	PGRC/E20001	West Wollega/Arjo	2420	08-44-00N	36-40.00E
2	" 20002	Bale Zone/Kitu	2500	06-.59.00N	39-12-00E
3	" 20004	South Gonder/Liba	1980	12-.05-00N	37-44-00E
4	" 20005	SouthGonder/Debretabor	1830	11-57-00N	37-37-00E
5	" 20006	South Gonder/Debretabor	1980	11-50-00N	37-37_00E
6	" 20007	North Gonder/Wogera/Dabat	2500	*	*
7	" 20017	West Gojiam /Awi /Dangila	1980	11-.20-00N	36-58-00E
8	" 20056	West Shewa/Jibatenamecha	2200	09-01-00N	38.-20-00E
9	" 20065	West Shewa/Jibatenamecha	2200	08-58-00N	37-30.00E
10	" 20066	West Shewa/Ambo	1950	08-.59.00N	37-48-00E
11	" 20067	West Shewa/Ambo	2010	08-.58-00N	37-52-00E
12	" 20076	SNNP/Wenago	1853	06-23-00N	38-20-00E
13	" 20077	South East Tigray/Inderta	2000	13-29-00N	39-30.00E
14	" 20112	West Gojam/JabiTehnan	1980	10-.39.00N	37-24-00E
15	" 20117	West Shewa/Jibatnamecha	2050	08-.58-00N	38-01-00E
16	" 20127	West Shewa/chelia	1700	09-03-00N	37-10-00E
17	" 20133	West Shewa/Menagesha	2600	09-11-00N	39-09.00E
18	" 20134	West Shewa/Jibat	2200	08-.58.00N	37-30-00E
19	" 20146	West Gojam/Bahirdarzuria	1980	11-.25-00N	37-12-00E
20	" 20165	West Gojiam/Awi/Dangila	1980	11-20-00N	36-58-00E
21	" 20166	West Gojiam/Awi/Dangila	1980	11-20-00N	36-58.00E
22	" 21008	Arsi/Gedeb	2380	07-.12.00N	38-09-00E
23	" 21012	West shewa/Dendi	2900	09-.14-00N	38-53-00E
24	" 21017	West Shewa/Gendbert	2470	09-43-00N	37-46-00E
25	" 21026	West Gojiam Awi/Dangila	2000	11-18-00N	36-58.00E
26	" 21035	West Gojam/Sekela	2540	10-.50-00N	37-04-00E
27	" 21037	West Gojiam/Awi/Dangila	2165	11-.14-00N	36-51-00E
No	Accession number	Area of collection	Altitude(m)	Latitude	Longitude
30	" 21225	East Gojam/Enemay	2000	10-.32-00N	38-09-00E
31	" 208411	West Gonder/Debretabor	2150	11-.50-00N	37-35-00E
32	" 229665	West Gojam/Burie	2050	10-33-00N	37-34-00E
33	" 237048	Arsie-Robe	2350	07-08-00N	40-00.00E
34	" 241907	South Gonder/Fogera	1825	12-.01-00N	37-43-00E
35	" 241910	South Gonder/Farta	2289	11-.49-00N	38-00-00E
36	" 242856	Arsi zone /Sherka	2360	07-32-64N	39-37-87E
37	" 242858	Arsi zone /Sherka	2360	07-34-27N	39-31-24E
38	" 243738	South Wollo/Desiezuria	2928	11-08-00N	39-13-00E
39	" 243739	South Wollo/Tenta	2950	11-.14-00N	39-15-00E
40	" 21256	West Gojam/Bahirdarzuria	1940	11-16-00N	36-59-00E
41	" 243750	Wollo/kalu	2020	11-45-00N	39-47.00E
42	" 2243756	South Gonder/ Debark	3115	11-.08.00N	37-56-00E
43	" 243761	Gonder Zuria	2050	12-.19-00N	37-33-00E
44	" 243763	South Gonder/Kemkem	2070	11-57-00N	37-37-00E
45	" 208556	West Shewa/Adis Alem	2200	*	*
46	" 208585	East Shewa/yerer	1600	*	*
47	Yellow dodolla(YD)	Bale/Dodolla	2500	06-.59-00N	39-12-00E
48	(ZemX Yellow Dodolla	Cross	2400	09-00-00N	38-00-00E
49	Local check	Holetta area	2400	09-00-00N	38-00-00E

Source: Holetta highland oil crops research program,*=information not found

Table 2. Mean squares for different sources of variations for 11 agronomic traits of 49 Ethiopian mustard

Characters	Genotype (48)	Block (12)	Replication(1)	Intera-block error (36)
Date of flowering	141.98**	6.39	0.91	9.96
Date of maturity	284.69**	45.67	84.5	44.36
Seed yield per plot	503441*	925530	7543862	231667
Oil content	3.4446**	1.3825	217.51	1.1283
Oil yield	108661*	167934	2098030	46331
Seed yield per plant	18.2377*	15.9527	88.2551	9.6692
Thousand seed weight	0.1939**	0.06957	0.1111	0.06942
Stand percent	208.34**	721.28	4676.83	23.4813
Number of primary branches	9.8346*	6.07095	24.7004	6.1063
Number of primary branches	0.3389*	4.0816	4.0816	0.2421
Plant height	1004.12**	1102.13	2812.5	169.46

*, ** significant at p = 0.05 and 0.01 significance level, respectively

is important for selection and breeding. Similarly Yared,(2010) studied thirty six genotypes of mustard for date of flowering, date of maturity, seed yield per plot, oil content, oil yield, number of seed per plant, thousand seed weight, number of primary branches, number of secondary branches, plant height of traits found the same result. Genetic variability of Ethiopian mustard for days to flowering and plant height has been reported by Getahun (1988) and Erena (2001) as well as days to maturity by Erena (2001).

The mean and range values for 11 agronomic traits are presented in Table 3. Wide ranges were observed for traits such as days to flowering, days to maturity, seed yield per plot, oil content percent, oil yield, seed yield per plant, stand percent, plant height and thousand seed weight . This result was similar with results of Yared, (2010) that noted wide range of variation in days to flowering, days to maturity, seed yield per plot, oil yield and thousand seed weight in Ethiopian mustard genotypes. Maximum days to flowering (113 days) were recorded by genotype PGRC/E 20065, while the minimum was recorded by genotype PGRC/E 21068 and genotype PGRC/E 21225 (79 days). Similarly, maximum days to maturity (202 days) were recorded by genotypes such as PGRC/E 20065, while the minimum (157 days) was recorded by the genotype PGRC/E 21068.Twenty genotypes had days to maturity less than the total grand mean as well nine genotypes less than the grand mean of compared with the standard checks, which indicates possibility of improving these genotypes for earliness for at least a minimum of five to fifteen days or there is an opportunity to find genotypes, among the tested entries, that perform better than the existing varieties in moisture stressed areas and/or to use them as parents for hybridization programs. Maximum seed yield obtained among the genotypes was (3297kg/ha) for the standard check Yellow Dodolla, while the minimum was recorded for the genotype PGRC/E 20065.

The oil content of genotypes ranged between 39.1percent to 46.0 percent while oil yield ranges from 370.4kg/ha to 1478kg/ha. The maximum oil content was recorded even better than standard check by genotype PGRC/E 208585 and the minimum was also recorded for the genotype PGRC/E20133. Mean values for the genotypes of PGRC/E20112, PGRC/E 20165, PGRC/E21026 and PGRC/E 21256, PGRC/E 208585 shows 45.4%, 44.7%, 45.5% and 46.0% the highest oil content than the standard check Yellow Dodolla (44.4%) respectively. The maximum oil yield was recorded for the standard check Yellow Dodolla genotype and the minimum oil yield was recorded for genotype PGRC/E20065. The mean value of the 25(51%) genotypes tested for this study had shown greater oil content percent than the grand mean of the tested genotypes. Similarly, 23 genotypes showed greater oil yield than the grand mean of oil yield. The highest seed yield per plant was 20.5g for the genotype PGRC/E208585 while the lowest was 3.3g for the PGRC/E20002. Seventy percent stand count was recorded for PGRC/E20065 and PGRC/E 20133 that of genotypes PGRC/E20166 was found to be 100%. Number of primary branches per plant ranged between seven to eighteen with a mean value of eleven and that of secondary branches ranged from 2 to 4 with a mean value of 3.3. The highest number of primary branches per plant was recorded by the genotypes PGRC/E 208556 and while the lowest was recorded by genotype PGRC/E21157. On the other hand the highest plant height (224 cm) for the genotype PGRC/E21037 was recorded while the lowest (115 cm) was recorded to the genotype PGRC/E 20065. The highest value for 1000-seed weight (4.0g) was recorded by genotype PGRC/E

Table 3. Mean and range values of the studied 49 genotypes for 11 agronomic traits tested at Holetta, 2013/14

Genotypes		DF	DM	SYPP	OC	OY	SYP PL	SP	PB	SB	PHT	TSW
1	PGRC/E 20001	95	187	2045	43.8	904	8.7	77	11	3	158	3.7
2	" 20002	81	179	1334	41.9	472	3.3	78	9	2	153	3.6
3	" 20004	90	174	1390	42.5	609	8.7	81	9	3	172	3.0
4	" 20005	86	168	1805	42.9	773	14.0	78	13	4	178	3.3
5	" 20006	99	188	1733	42.7	748	7.3	87	10	3	197	3.5
6	" 20007	90	172	1975	43.2	881	7.2	88	9	4	203	3.5
7	" 20017	94	179	1866	43.5	817	5.8	93	10	3	190	3.5
8	" 20056	102	191	1226	41.8	515	5.8	77	13	4	159	2.9
9	" 20065	113	202	904	41.0	370	6.4	70	10	2	115	3.7
10	" 20066	91	183	1375	42.2	583	10.2	78	13	4	184	3.4
11	" 20067	89	169	2534	44.0	1106	10.9	91	12	4	198	3.3
12	" 20076	94	180	2580	43.0	1101	13.5	89	10	4	173	3.6
13	" 20077	85	165	1883	42.1	805	9.6	91	12	4	174	3.5
14	" 20112	98	191	2406	45.4	1084	7.7	97	8	3	199	3.7
15	" 20117	104	189	2080	43.0	901	11.9	84	14	5	170	3.4
16	" 20127	107	193	1846	42.4	789	6.6	82	13	4	173	3.6
17	" 20133	85	178	999	39.1	398	5.8	70	9	3	154	2.8
18	" 20134	102	190	2473	42.4	1044	11.5	85	13	3	209	3.6
19	" 20146	92	180	2360	43.7	1031	6.6	89	9	2	181	3.3
20	" 20165	97	181	2465	44.7	1111	6.4	98	10	3	219	3.7
21	" 20166	94	182	2362	43.5	1026	6.5	100	10	3	210	3.3
22	" 21008	82	166	1637	43.5	713	10.9	77	11	4	159	3.4
23	" 21012	102	191	2162	43.2	945	6.1	86	11	2	147	3.3
24	" 21017	105	190	2240	42.6	980	7.3	88	11	3	179	3.6
25	" 21026	99	191	3054	45.5	1364	6.2	91	10	2	193	3.5
26	" 21035	106	192	1643	43.3	700	7.0	90	13	4	194	3.4
27	" 21037	94	183	2639	43.1	1217	10.0	94	11	3	224	3.2
28	" 21068	79	157	1804	41.3	739	7.4	83	8	3	167	2.7
29	" 21157	90	197	1342	41.1	585	4.6	82	7	2	144	4.0
30	" 21225	79	163	1928	41.5	809	6.6	82	11	4	160	3.6
31	" 208411	100	189	1586	43.9	704	6.1	85	13	3	179	2.8
32	" 229665	100	192	1904	43.7	817	7.9	84	17	3	194	3.2
33	" 237048	109	192	1688	41.5	713	7.3	90	11	4	201	3.5
34	" 241907	93	184	1988	41.6	848	9.9	94	14	3	195	3.3
35	" 241910	93	180	2566	43.1	1100	9.0	83	9	3	187	2.7
36	" 242856	90	173	2135	41.5	892	8.2	82	12	3	174	3.0
37	" 242858	97	183	2019	41.3	832	8.4	87	14	2	204	2.8
38	" 243738	88	160	2022	41.3	862	9.5	85	11	4	188	3.2
39	" 243739	86	158	2231	44.2	982	7.6	89	12	3	178	3.4
40	" 21256	98	189	2291	44.5	1021	9.9	86	15	3	221	3.3
41	" 243750	85	164	2142	42.5	934	9.6	91	12	4	193	3.1
42	" 243756	108	193	1859	42.7	797	5.8	86	11	4	186	3.2
43	" 243761	88	192	1931	43.5	846	4.6	84	9	2	163	3.3
44	" 243763	95	191	1348	42.1	563	4.0	84	13	3	165	3.5
45	" 208556	86	164	1879	44.2	846	12.6	88	18	4	172	3.6
46	" 208585	94	168	2142	46.0	973	20.5	89	10	4	208	3.7
47	Yellow dodolla(YD)	85	167	3297	44.4	1478	7.3	88	11	4	177	3.8
48	(ZemXYD)	80	162	2603	43.8	1157	12.6	85	8	4	203	3.9
49	Local check	85	165	2212	42.4	934	9	86	11	4	155	2.9

Table 3. Continuation

Range		79-113	157-202	904-3297	39-46	370-1478	3-20	70-100	7-18	2-4	115-224	2.7-4.0
Mean		93	180	1999	42.9	866	8	86	11	3.3	181	3.3
CV (%)		3.38	3.70	24.08	2.477	24.86	37.11	5.64	22.19	25.2	7.185	7.89
LSD (0.05)		6.34	13.39	1063.71	2.13	474.4	8.86	10.59	4.96	1.31	29.05	0.52

DF= days to flowering, DM= days to maturity, SYPP=seed yield per plot, OC=oil content, OY= Oil yield, SYPPL= seed yield per plant, SP= stand percent, PB= primary branches per plant, NB= secondary branches per plant, PHT= plant height, TSW =thousand -seed weight

Table 4. Distribution of 49 Ethiopian mustard genotypes in different clusters based on their agronomic traits

Cluster	No. of genotypes	Genotypes included by code and origin
Cluster I	28	16(West Shewa),42(South Gonder),7(West Gojam),13(South east Tigray),34(South Gonder),37(Arsie zone),24(West Shewa),39(South wollo),1(West Wolega),15(West Shewa),4(SouthGonder), 28(Bale),45(West Shewa),38(South Wollo),41(Wollo),46(East Shewa),26(West Gojam),33(Arsie Robie),32(West Gojam),30(East Gojam),43(Gonder Zuria),6(North Gonder),23(West Shewa),49(West Shewa),22(Arsie -Gedeb),31(West Gonder),36(Arsie Zone)and 5(North Gonder).
Cluster II	11	12(SNNP,Wenago),35(South Gonder),19(West Gojam),21(West Gojam),11(West Shewa),14(West Gojam),20(West Gojam), 18(West Shewa),48 (West Shewa),40(West Gojam),27(West Gojam).
Cluster III	8	29(SNNP/South omo),44(South Gonder),3(GSouth onder),10(West Shewa),9(West Shew),17(ShewaWest),2(Bale Zone)and 8(West Shewa).
Cluster IV	2	25 (West Gojam), 47(Bale Dodolla).

*SNNP; Southern Nations and Nationalities

21157 and the lowest (2.7g) was recorded by genotype PGRC/E 241910.

Multivariate Analyses

Clustering of genotypes using agronomic traits

Clustering based on agronomic traits made for 49 genotypes is presented in Table 4. The 49 genotypes of Ethiopian mustard that were collected from 12 different Ethiopian agro ecological zones of the country sources were grouped in to four clusters. Cluster 1 the largest of all included 28 (57.14 %) of the genotypes that comprised seven genotypes each from either South or West Shewa and Gonder, four genotypes each from either West or East Gojam and Arsi zone, three genotypes from South Wollo, one each from South Tigray, West Wollega, and Bale zone, respectively. The local check was also included in cluster 1.The second cluster comprises 11(22.44%) genotypes six from west Gojam, two from West Shewa and one genotype each from South Gonder, Southern nation's nationalities people and the standard check. Cluster3 comprised 8(16.32%) genotypes. Four Genotypes were from South Shewa, two genotypes from South Gonder and one genotype each from Southern nation's nationalities People and Bale Zone. Cluster 4 comprised two (4.08%) genotypes that were origins of one from West Gojam and standard check. The produced a clear grouping of the 49 genotypes into four clusters, whereby the individuals within any one cluster are more closely related than other individuals in different clusters. The highest (57.14%) of the genotypes were grouped in C1 followed by 22.44 % in C2, 16.32 % in C3 and 4.1 % in C4.

Based on this clustering, genotypes with the same geographic origin were grouped in the same cluster. This phenomenon might have resulted from their similar genetic background. On the other hand, there are also genotypes with same geographical origin but grouped in different clusters which might be due to difference in their genetic background. All checks were grouped in different clusters, i.e. Local check under C1 and standard check under C4, which indicates that these varieties may have

Table 5. Cluster means for agronomic traits of Ethiopian mustard genotypes

Traiats	Cluster			
	Cluster 1	Cluster2	Cluster3	Cluster4
	Mean	Mean	Mean	Mean
Date of flowering	94	94	93	92
Date of maturity	178	181	187	179
Seed yield per plot	1942	2480	1240	1176
Oil content	42.9	43.6	41.5	45.0
Oil yield	839	1091	512	1421
Seed yield per plant	9	10	6	7
Stand percent	86	91	78	90
Number of primary branches	12	10	10	11
Number of secondary branches	3	3	3	3
Plant height	180	202	156	185
Thousand seed weight	3.3	3.4	3.4	3.7

Table 6. Pair wise generalized squared distance (D2) among 49 genotypes of Ethiopian mustard in four clusters based on their agronomic traits

Cluster	Cluster			
	Cluster 1	Cluster 2	Cluster 3	Cluster4
Cluster 1	0	15.05ns	21.22*	70.53**
Cluster 2		0	64.81**	28.29**
Cluster 3			0	155.10**
Cluster 4				0

different relationship with the genotypes in their respective clusters. Besides, genotypes with different geographical origin were grouped in same cluster which might have been as a result of the difference in selection pressure applied on different components of various geographical areas which might coincide resulting in clustering together of genotypes which have been collected at different areas. In general, the present investigation indicated that geographic diversity, though important, it may not be the only factor in determining genetic divergence. Similarly, these situations have been reported by various authors (Adefris *et al*., 2000; Nigussie and Becker, 2002; Jeena and Sheikh, 2003; Gemechu *et al*., 2005; Adefris, 2005), Yared(2010).

Cluster means for agronomic traits

Intra-class average genetic divergence of Ethiopian mustard for agronomic traits is shown in Table 5. Genotypes in Cluster 4 showed earliness in days to flowering and genotypes in Cluster1 showed early maturity than other clusters. Genotypes in Custer 3 showed late maturity than other clusters. Similarly genotypes in Cluster 2 showed high seeds yield per plot (2480Kg)and seed yield per plant (10g) stand percent (91%) and plant height (202Cm) than other clusters. The highest seed yield per plants was found in Cluster 2 followed by Cluster 1. Genotypes in Cluster 4 showed high oil content (45%) and oil yield per plot (1421) than other clusters and high thousand seed weight were identified in Cluster 4 (3.7g).

Distance analysis among genotypes using agronomic traits

The pair wise generalized squared distance (D^2) among the clusters based on agronomic traits are presented in Table 6. Genetic distances were highly significant among most of clusters. The genetic distance between Cluster 1 and Cluster 3 were significant. The highest genetic distance, based on agronomic morphological traits, was recorded between Cluster 3 and Cluster 4 (155.10) followed by the cluster 1 and Cluster 4 (70.53), and cluster 2 and Cluster 3 (64.81). Considering distance analysis using agronomic traits of the study traits only the genetic divergence between Cluster 1 and Cluster 2were none significant. Parents may be selected from those clusters which had significant genetic distance for crossing in order to obtain the genetic recombination and transgressivesegregants in the subsequent generations. However, it is also worth considering genotypes within a cluster with respect to a trait of interest as suggested by

Table 7. Component scores of the first five principal components of 49 genotypes of Ethiopian mustard based on their agronomic traits

Traits	Component scores				
	Principal component 1	Principal component 2	Principal component 3	Principal component 4	Principal component 5
Date of flowering	0.373	-0.086	0.0226	-0.123	0.093
Date of maturity	0.356	-0.211	-0.177	-0.067	0.127
Seed yield per plot	0.005	0.483	-0.216	-0.134	0.254
Oil yield	0.017	0.488	-0.209	0.001	0.239
Seed yield per plant	-0.021	0.288	0.478	0.238	-0.288
Stand percent	0.084	0.413	-0.215	-0.182	-0.025
Number of primary branches	0.102	0.041	0.506	-0.362	0.692
Number of secondary branches	-0.067	0.181	0.568	0.172	-0.056
Plant height	0.128	0.413	0.026	-0.281	-0.389
Thousand seed weight	0.117	0.104	-0.102	0.799	0.319
Eigen value	5.53	3.37	1.71	1.11	0.62
Variance (%)	39.53	24.10	12.20	7.94	4.41
Cumulative (%)	39.53	63.63	75.83	83.77	88.18

Adefris *et al*., (2000); Chahal and Gosal, (2002) and Gemechu *et al*., (2005).

Principal component analyses

In order to assess the patterns of variations, principal component analysis (PCA) was done by considering ten traits for an agronomic traits. Principal component analyses are presented in the Tables 7. Principal component analysis showed that 88.18% of the variation was contributed by the first five principal components for agronomic traits. Days to flowering and days to maturity were the major seed yield positive contributors of the variation in the first principal component in which 39.53% of the variation revealed. Plant height, thousand seed weight, primary branches and stand percent had relatively high positive weight. Seed yield per plants and secondary branches had negative weight. Additional 24.10% variation in the second principal component was mainly observed through trait such as oil yield per plot, seed yield per plot stand percent and plant height. The third principal component accounted for another additional 12.20% of the variation in which secondary branches was the major contributor. Thousand seed weight had the highest negative weight. Principal component 4 and 5 contributed 7.94% and 4.41% additional variations respectively. Thousand seed weight in principal component 4 and number of primary branches per plant in principal component 5 were among the major contributors. Primary branches per plant in principal component 4 and plant height in principal component 5 had the most negative weight. In general, it is assumed that traits with larger absolute values closer to unity within the first principal component influence the clustering more than those with lower absolute values closer to zero (Chahal and Gosal, 2002). In this study, most of the traits individually contributed small effects (± 0.389-0.799) to the total variation and, therefore, differential grouping of genotypes was mainly attributed by the cumulative effect of the individual traits.

CONCLUSION

In this study, 49 Ethiopian mustard genotypes acquired from diverse zones/regions of Ethiopia were evaluated in simple lattice design with two replications at Holetta Agricultural Research Center, West Shewa zone, with the objectives of assessing genetic diversity among land races through seed yield and its related components traits.

Multivariate analyses of genetic divergence among genotypes have resulted in the formation of four clusters, and have shown the presence of genetic variability for further selection and breeding. Genetic distances among most clusters were significant from which selection of parents may be made for crossing in order to obtain the genetic recombination and the trans-gressive segregants. Genotypes for maturity earliness may be obtained from C1. Likewise, genotypes in C2, C3 and C4 may used for improvement of seed yield, oil yield and oil content respectively. Genotypes formed in C1 could also be used for their high oil content. From the present investigation, we could also found that geographical diversity could not necessarily be an index of genetic variability, and the factors other than geographic diversity such as genetic drift, selection pressure and environment may be responsible for differential grouping of genotypes. The present study revealed the presence of considerable variability among genotypes for all traits compared. These conditions indicate that there is good opportunity to improve seed yield and yield component traits using the tested genotypes. Further similar study on variability of metric characters using biotechnological tools would also help in sustaining the result

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