International Journal of Research Studies in Agricultural Sciences (IJRSAS)
Volume 3, Issue 7, 2017, PP 6-14
ISSN 2454-6224
http://dx.doi.org/10.20431/2454-6224.0307002
www.arcjournals.org

Multivariate Analysis of Genetic Divergent of Ethiopian Mustard (*Brasica carinata* A. Braun) Landraces in Relation to Leafy Vegetative Agro morphological Traits

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Abstract: *The experiment was carried out to assess the extent and patterns of genetic variability of Ethiopian mustard land races in relation to topped plant seed yield and its related leafy vegetative traits at Holetta Agricultural research Center, Ethiopia. Information on the leaves of morphological traits of Ethiopian mustards as a leaf vegetable crop is lacking specifically that of time of defoliation to get dual purpose of the crop (leaf and seed). Therefore forty nine genotypes of Ethiopian mustard land races collected from different agro ecologies were evaluated for agro morphological traits in order to assess the genetic diversity that exists among these materials. The experiment was carried out in a simple lattice design. Univariate analysis of variance showed that there were significant differences among genotypes for leaf length, Length of Petiole, leaf width and leaf area traits but seed yield per plant leaf topped at 40th, 50th and 60th growth stages of days of topping, leaf weight per plant topped to these similar days of topping and number of intact leaves at flowering showed non-significant differences. The significant difference indicates the existence of genetic variability among the accessions which is important for improvement of these traits. Average weight of 2.7g of seed yield per plant of defoliated could be attained by utilization of leaves in the 50th day of growth stage of topping. Multivariate analyses resulted in the formation of four clusters and have shown the presence of substantial genetic diversity among the genotypes. The present study revealed the presence of considerable variability among genotypes for leaf length, Length of Petiole, leaf width and leaf area traits except seed yield per plant, leaf biomass per plant topped at 40th , 50th and 60th growth stage days of topping and number of intact leaves at flowering. The significant difference of results indicates that the presence of good opportunity to improve these characters using the tested genotypes.*

Keywords: *Ethiopian mustard, Genetic diversity, leaf morphological traits univariate analysis, multivariate analysis.*

1. 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 (Hemingway, 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.

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). It is the only highland oil seed vegetable crop able to consume by defoliating its leaves or sold to generate income after month of sowing in most near big city parts of the country. Crop improvement through plant breeding, thus, occurs through selection operating on genetic variability. Genetic variability is therefore essential for crop improvement. In characterization of Ethiopian mustard for vegetative agro-morphological traits Jane Muthoni, (2010) reported as great variation was seen in leaf number per plant, leaf bloom and leaf blade blistering. Information on the leaves morphological traits of Ethiopian mustard as a leaf vegetable crop is lacking specifically that of time of defoliation to get dual purpose of the crop (leaf and seed). Therefore the present study was, executed with the objective of assessing the extent and

patterns of genetic variability of Ethiopian mustard land races in relation to topped plant seed yield and its related leafy vegetative agro morphological traits.

2. MATERIALS AND METHODS

2.1. Experimental Site

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).

2.2. Description of Test Materials

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 Holetta agricultural research Center. 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 Table1

Table1. *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/Woger/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	WestShewa/Jibatena mecha	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
28	" 21068	Bale/Adaba	2500	07-01-00N	39-25-00E
29	" 21157	SNNP /South omo	2830	06-19-00N	38-52-00E
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	" 243756	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	Bale/Dodolla	2500	06-.59-00N	39-12-00E
48	(ZemXYelldDodolla)	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*

2.3. Experimental Design, Management and Season

The experiment was executed from June 2013 to December 2013. The experiment was laid out in simple lattice design seven by seven 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. All other recommended agronomic and cultural practices were carried out following practices described by Adefris (2005). Data was collected for Leaf petiole length (cm), Leaf length (cm), Leaf width (cm), Number of leaves per plant, Leaf area index, Leaf Biomass and Seeds yield of leaf defoliated of five plants on days of growth stage of 40^{th}, 50^{th} and 60^{th}.

2.4. Analysis of Variance

The data collected for leafy vegetative traits 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 version 9.2, (SAS Institute, 2008). Analysis of variance (Table 2) for the considered traits was done using the model for lattice design as follows:

$Yil(j) = u + ti + rj + (b/r)l(j) + eil(j)$ Where, $Yil(j)$ is the observation of the treatment $i(i = 1,....V, k^2)$, in the block $l(l = 1,...k)$ of the replication $j(j = 1,..., m)$; μ is a constant common to all observations; t_i is the effect of the treatment i; r j is the effect of the replication j; $(b|r)_{l(j)}$ is the effect of the block l of the replication j; $e_{il(j)}$ is the error associated to the observation $Y_{il(j)}$, where $e_{il(j)} \sim N(0,s)$ independent.

2.5. Cluster Analysis for Quantitative Traits

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.

2.6. Genetic Divergence Analysis

The genetic distances between clusters was estimated by Mahalanobis's (1936) D^2statistics using the same software as clustering as:

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

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

$\left(\overline{\overline{X}}_i - \overline{\overline{X}}_j\right)$ =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)

3. RESULTS AND DISCUSSION

3.1. Analysis of Variance

The analysis of variance for the 11 leaves morphological traits studied is given in Table 2. The analysis of variance showed that there were significant differences among genotypes for Leaf length, petiole length .leaf width and leaf area traits compared but seed yield per plant, leaf biomass per plant topped at 40, 50 and 60 days of topping and number of intact leaves at flowering showed non-significant differences. The significant difference indicates the existence of genetic variability among the accessions that is important for selection and breeding. In characterization of Ethiopian mustard lines for vegetative agro-morphological traits Jane Muthoni, (2010) reported as great variation was seen in leaf number per plant, leaf bloom and leaf blade blistering. At similar manner assessment of genetic variation in this crop was reported by Muhamad *et al*., (2013 for 33 agro-morphological characters.

Table 2. *Mean squares for different sources of variations for 11 leave traits of 49 Ethiopian mustard land races*

Characters	Genotype (48)	Block (12)	Replication(1)	Intera-block error (36)
Seed yield at 40 date of topping	0.2544ns	0.1951	3.530	0.17997
Seed yield at 50 date of topping	0.245ns	0.2628	1.9715	0.1314
Seed yield at 60 date of topping	0.3633ns	0.1902	5.7315	0.3056
Petiole length	11.6242**	2.7005	32.229	2.6565
Leaf length	6.1553**	2.072	22.6368	2.4629
Leaf width	5.8638**	1.8471	22.5408	2.1336
Leaf area	7.3403**	2.0052	25.0026	2.1764
Number of leaf intact at flowering	354.12ns	185.86	969.26	179.31
Leaf biomass at 40 date of topping	2092.69ns	32923.9	9601.02	1120.07
Leaf biomass at 50 date of topping	4322.45ns	3934.41	5683.46	1957.18
Leaf biomass at 60 date of topping	3599.61ns	7416.95	29440	3129.77

**, ** significant at p = 0.05 and 0.01 significance level, respectively; ns= non-significant*

3.2. Mean and Range Values of Different Traits

The mean performance of the studied genotypes for 11vegetative traits are presented in Table 3. The range of seed yield per plants whose leaves were topped at 40 days of growing was from 2.3 to 3.6 g of seeds. Among the tested genotypes for leaf topped at 40 days of growing stage 27 genotypes had shown greater seed yield per plants than the grand mean value of topping stage while 19 genotypes showed least mean value and the rest 3 genotypes had shown equal seed yield per plant. The range of seed yield per plants of the leaf topped at 50 days of growing stage was recorded from 1.7 to 3.5 g of seeds as that of first stage of topping. Among the tested genotypes for leaf topping at 50 days of growing stage 33 genotypes had shown greater or equal seed yield per plants to the grand mean value of its topping stage while 16 genotypes showed less mean value than the grand mean for its topping stage. On the other hand the range of seed yield per plant in plants whose leaves were topped 60 days of growing stage was from 1.6 to 3.4 g. Among the tested genotypes in this category 27 genotypes had showed greater or equal seed yield per plant to the grand mean value while 22 genotypes showed least mean value to the grand mean. The grand mean value showed decrease seed yield per plant when plants were topped at 50 days growth indicating that average seed yield per plant of topped or defoliated plants could be attained by utilization of leafs in this stage of topping. Similarly the mean of petiole length, leaf length, leaf width, leaf area and number of leafs per plant are presented in Table 3. The mean petiole length of the tested genotypes ranged from 2.8cm to 11.8cm. The longest petiole (11.8cm) was recorded for the genotype PGRC/E 243756 while the shortest petiole length (2.8 cm) was recorded for the genotype PGRC/E21068. Similarly mean value leaf length of the tested genotypes ranged from 4.6 cm to 11.2 cm. The longest leaf length (11.8 cm) was recorded for the genotype PGRC/E243756 while the shortest leaf length (4.6 cm) was recorded for the genotype PGRC/E 21068.The mean value for Leaf width ranges from 2.1 cm for genotype PGRC/E 21068 and 8.8 cm for the genotype PGRC/E 2243756.The mean value of leaf area for the tested genotypes also

ranges 3.1 cm for the genotype PGRC/E21068 to 10.6 cm for the genotype PGRC/E243756. Among the tested genotypes for petiole length, leaf length, leaf width and leaf area the mean value of all these characters indicated that genotype PGRC/E 243756 was the first. The mean value of leaf biomass at 40 days topping ranged 34g for the genotype PGRC/E20133 and 191g for the genotype PGRC/E20166. Mean value of leaf biomass weight at 50 days of growing period topping ranges 43 g for the genotype PGRC/E21008 and 243 g for the genotype PGRC/E20017. The mean value of leaf biomass for 60 days of growing period was recorded with the range value of 57g for genotype PGRC/E20133 to 226g for genotype PGRC/E20001.The mean value of leaf biomass topped or defoliated shows trend of increasing by indicating that seed yield of defoliated plants after 50 days of topping shows in yield declining. The last leaf vegetative parameter studied was number of intact leaves at vegetative stage of life cycle growth of the mustard genotypes. The mean value for number leaves intact at vegetative growth stage was recorded from the mean range of 45 for the genotype PGRC/E20127 to 108 for genotype PGRC/E 208585.

Table 3. *Mean and range values of the studied 49 genotypes for 11 leaves vegetative and its related trait tested at Holetta, 2013*

No	Genotype by Code	SY 40DT	SY 50DT	SY 60DT	PL	LL	LW	LA	LB 40DT	LB 50DT	LB 60DT	NOL
1	PGRC/E20001	3.6	2.9	2.9	8.2	10.5	6.0	8.2	94	168	226	69
2	" 20002	3.2	2.7	3.0	4.0	5.5	3.3	4.2	76	130	127	54
3	" 20004	3.3	2.9	2.9	5.3	8.2	4.6	6.1	65	168	97	81
4	" 20005	3.0	2.9	2.5	5.8	6.8	4.6	5.7	69	223	169	90
5	" 20006	3.6	2.3	2.8	8.2	8.9	6.5	7.8	93	148	208	74
6	" 20007	3.0	2.5	2.4	5.7	8.1	5.0	6.3	109	156	147	69
7	" 20017	3.6	3.4	2.3	7.1	9.6	6.2	7.6	107	243	150	69
8	" 20056	3.3	2.7	3.0	8.1	7.4	6.0	7.2	50	74	189	53
9	" 20065	3.5	2.5	1.7	11.1	10.3	6.8	9.4	73	113	196	62
10	" 20066	3.5	3.0	2.8	10.4	10.5	8.0	9.7	121	84	201	76
11	" 20067	3.5	2.8	2.3	5.8	7.6	4.7	6.1	125	97	104	83
12	" 20076	3.4	2.9	2.8	7.5	9.4	5.6	7.5	124	160	139	61
13	" 20077	3.6	2.9	3.0	5.7	7.7	4.1	5.8	91	173	134	64
14	" 20112	3.2	2.6	2.3	6.6	8.8	6.9	7.5	138	163	152	57
15	" 20117	3.2	2.7	2.5	8.8	9.6	7.0	8.5	53	136	156	78
16	" 20127	3.3	2.5	2.0	10.2	10.6	7.4	9.4	60	105	102	45
17	" 20133	2.7	2.7	1.4	3.7	5.8	3.2	4.2	34	96	57	67
18	" 20134	3.4	2.8	2.0	11.2	11.1	8.1	10.1	128	118	153	68
19	" 20146	3.0	2.7	2.6	5.8	8.8	5.8	6.9	67	141	120	52
20	" 20165	3.5	3.5	2.4	8.1	10.3	7.2	8.5	118	126	136	64
21	" 20166	3.5	3.3	2.6	6.8	8.7	5.8	7.1	191	197	185	68
22	" 21008	2.8	2.2	2.7	4.2	5.9	3.3	4.4	74	43	122	89
23	" 21012	2.9	2.7	2.8	7.9	8.4	6.3	7.5	106	109	168	80
24	" 21017	2.6	2.2	2.4	9.4	9.4	7.0	8.6	154	106	158	71
25	" 21026	3.1	3	2.8	7.0	9.0	6.7	7.5	148	90	134	61
26	" 21035	2.3	2.9	1.6	11.7	10.9	8.4	10.3	122	93	97	72
27	" 21037	3.0	3.1	2.8	9.0	9.9	7.1	8.7	114	120	137	71
28	" 21068	2.9	2.9	1.9	2.8	4.6	2.1	3.1	111	82	139	60
29	" 21157	2.8	2.3	2.0	10.1	10.4	7.6	9.4	100	151	145	70
30	" 21225	3.3	2.8	2.4	3.0	6.0	2.6	3.8	108	105	111	66
31	" 208411	3.4	3.3	2.2	6.7	8.0	5.3	6.7	76	152	109	89
32	" 229665	2.6	2.7	2.4	8.5	11.0	8.2	9.2	70	86	187	90
33	" 237048	2.3	2.8	2.5	10.5	10.9	8.1	9.8	94	84	125	67
34	" 241907	2.8	3.3	2.4	6.4	8.1	5.7	6.8	136	132	154	89
35	" 241910	2.7	3.0	2.7	6.9	8.0	5.5	6.8	88	139	181	84
36	" 242856	3.3	3.0	2.8	6.2	7.7	4.5	6.1	82	160	184	56
37	" 242858	3.1	2.9	2.7	10.0	9.5	6.3	8.6	89	240	196	75
38	" 243738	2.8	2.8	2.6	4.4	6.8	3.7	4.9	87	174	126	80
39	" 243739	3.6	2.3	2.6	4.5	5.7	3.4	4.5	82	128	164	67
40	" 21256	2.9	2.2	2.8	10.0	11.1	8.1	9.8	81	202	167	76
41	" 243750	3.1	2.6	2.1	5.1	7.4	4.4	5.6	122	132	155	74
42	" 243756	3.2	2.1	1.6	11.8	11.2	8.8	10.6	94	120	222	48

43	" 243761	2.5	2.2	2.3	9.1	8.9	6.6	8.2	133	146	210	55
44	" 243763	3.0	1.7	2.3	6.9	7.5	5.4	6.6	140	109	111	58
45	" 208556	3.5	2.6	2.3	6.1	7.5	5.1	6.2	63	117	98	77
46	PGRC/E	3.5	2.8	3.0	9.6	10.0	7.8	9.1	158	202	108	108
47	Yellow dodolla	3.5	2.8	3.4	5.2	6.9	4.4	5.5	82	216	213	60
48	(ZemXYellow Dodolla)	3.3	2.7	3.1	5.0	7.2	4.2	5.4	123	126	122	100
49	Local check	3.3	2.3	2.5	3.9	6.0	3.4	4.4	85	96	98	81
Range		2.3-3.6	1.7-3.5	1.6-3.4	2.8-11.8	4.6-11.2	2.1-8.8	3.1-10.6	34-191	43-243	57-226	45-108
Mean		3.1	2.7	2.5	7.2	8.5	5.7	7.2	100	137	149	71
CV (%)		13.59	12.68	22.4	22.5	18.4	20.6	36.8	33.4	32.46	37.61	36.75
LSD(0.05)		0.853	0.741	1.111	3.77	3.155	2.966	57.37	73.26	95.19	0.529	57.37

YD, Yellow Dodolla, Sy40DT, SY50DT, SY 60DT=Seed yield of (40, 50, 60) days of toping, PL, LL, LW = Petiole, leaf, width length respectively, LA= leaf area and LB40, LB50, LB60=Leaf biomass at (40, 50. 60)days of topping per plants: NOL=number of leaf intact at vegetative stage/ flowering stag

3.3. Multivariate Analyses

3.3.1. Clustering of Genotypes using Leaf Vegetative Traits

Clustering based on leaf vegetative traits made on 49 genotypes is presented in Table 4. Cluster1 consists the largest of all included 33 (67.34 %) genotypes that comprised nine genotypes of West Shewa, eight genotypes from West and East Gojam, six genotypes of South and North Gonder, two genotypes each from Arsie zone and Southern Nation's Nationalities People, three genotypes from South Wollo, one each from South Tigray, Bale zone, and cross. The second cluster comprises nine (18.36%) genotypes three of each from South Gonder and Shewa, one each from East Gojam, Arsiezone and West Wollega. Cluster3 comprised 5(10.20%) genotypes. Two Genotypes were from West Gojam, one genotype each from South Gonder, Arsiezone and standard check. Cluster 4 comprised genotypes that were origins of one from East Shewa and West Gojam. The produced a clear grouping of the 49 genotypes into four clusters, where by the individuals within any one cluster are more closely related than other individuals in different clusters. In leafy vegetative traits clustering the highest 67.34% of the genotypes were grouped in C1 followed by 18.36 % in C2, 10.20 % in C3 and 4.08% 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 C3, which indicates that these varieties may have 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 area.

Table4. *Distribution of 49 Ethiopian mustard genotypes in different clusters based on their leafy vegetative traits.*

Cluster		Genotypes included by code and origin
Cluster I	No. of genotypes 33	20(Gojam),27(Gojam),6(Gonder),29(Sidamo),11(Shewa),26((Gojam)),2(Bale), 19((Gojam)),13(Tigray),38(wollo),18(Shewa),41(Wollo),12(Sidamo),14(Gojam), 3(Gonder),31(Gonder),28(Bale),33(Arsie),30((Gojam)),35(Gonder),39(Wollo), 34(Gonder),45(Shewa),49(Shewa),25((Gojam)),44(Gonder),23(Shewa),48(cross), 16(Shewa),15(Shewa),24(Shewa), 17(Shewa),22(Arsie),
Cluster II	9	1(Wolega),5(Gonder),9(Shewa),42(Gonder),36(Arsie),8(Shewa),32(Gojam), 43(Gonder), 10(Shewa).
Cluster III	5	4(Gonder), 40(Gojam), 37(Arsie), 47(Bale), 7(Gojam).
Cluster IV	2	21 (Gojam), 46(Shewa).

3.3.2. Cluster Mean for Leafy Traits, Distance and Component Analysis

Cluster Means for leafy Vegetative Traits

Intra-class genetic divergence of Ethiopian mustard land races for leafy vegetative traits is shown in Table 5. Genotypes in Cluster 4 showed high seed yield per plants of leaf toped at 40, 50 and 60 days of growth stage of genotypes than other clusters. The least seed yield per plants of leaf toped at 40, 50 and 60 days of growth stage of genotypes were found in Cluster 1 of SY60DT (2.4gm) than other topping stages of the study. On the other hand Cluster 2 showed much lengthier in petiole length (9.1), leaf length (9.6), leaf width (6.8) and leaf area (8.5cm^3) than other clusters. But leaf width of Cluster 2 and Cluster 4 was found similar (6.8cm^3). Genotypes in Cluster 3 showed more leaf biomass weight per plants of leaf topped at 50 days of growth stage of genotypes than others. Similarly high intact number of leafs per plant during vegetative stage of growth/flowering stage was observed from Cluster 4 (88) following Cluster 3(74) and Cluster 1(71) genotypes.

Table 5. *Clusters mean for leaf vegetative traits of the Ethiopian Mustard genotypes*.

	Cluster			
Traits	Cluster 1	Cluster2	Cluster3	Cluster4
	Mean	Mean	Mean	Mean
Seed yield at 40 date of topping	3.1	3.2	3.2	3.5
Seed yield at 50 date of topping	2.7	2.6	2.8	3.1
Seed yield at 60 date of topping	2.4	2.5	2.7	2.8
Petiole length	6.7	9.1	7.6	8.2
Leaf length	8.2	9.6	8.8	9.4
Leaf width	5.4	6.8	5.9	6.8
Leaf area	6.7	8.5	7.4	8.1
Leaf biomass at 40 date of topping	101	90	86	175
Leaf biomass at 50 date of topping	123	122	225	200
Leaf biomass at 60 date of topping	130	203	179	147
Number of leaf intact at flowering	71	65	74	88

3.4. Distance Analysis among Genotypes using Leaf Vegetative Traits

The pair wise generalized squared distance (D2) among the clusters based on leaf vegetative traits are presented in Table 6. Genetic distances were highly significant between Cluster 2 and Cluster 4. The highest genetic distance was recorded between Cluster 2 and

Cluster 4 (46.26) followed by Cluster 1 and Cluster 4 (22.92), and Cluster 3 and Cluster 4 (22.08). The genetic divergence between Cluster 1 and Cluster 2, Cluster 1 and Cluster 3, Cluster 1 and Cluster 4 were also significant. Genetic distances of genotypes based on leaf vegetative traits between Cluster2 and Cluster 3 were non significant, indicating close relationship among the genotypes.

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

	Cluster			
Cluster	Cluster 1	Cluster 2	Cluster 3	Cluster4
Cluster 1	0	13.81**	17.73*	22.92**
Cluster 2		0	20.83ns	46.26**
Cluster 3			0	22.08**
Cluster 4				0

3.5. Principal Component Analyses

In order to assess the patterns of variations of principal component analysis (PCA) was done by considering 11 traits for leaf vegetative traits. Principal component analyses are presented in Tables 7. Principal component analysis showed that 88.18% of the variation was contributed by the first five principal components for leaf vegetative traits. Leaf area, leaf width, leaf length and petiole length, were the major seed yield positive contributors of the variation in the first principal component in which 39.53%of the variation revealed. Leaf area and leaf width had relatively high positive weight. In Component 1 there was no negative weight record. Additional 24.10% variation in the second principal component was mainly observed through trait such as leaf width and leaf length. The third

principal component accounted for another additional 12.20%of the variation in which petiole length and leaf area was the major contributor. Principal component 4 and 5 contributed 7.94% and 4.41% additional variations respectively. Leaf length in principal component 4 was among the major contributors. Leaf length and leaf area in principal component 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 (± 0.419-0.09) to the total variation and, therefore, differential grouping of genotypes was mainly attributed by the cumulative effect of the individual traits.

Table7. *Component scores of the first five principal components of 49 genotypes of Ethiopian mustard based on their leaves vegetative traits*

	Component scores				
Traits	Principal component 1	Principal component 2	Principal component 3	Principal component 4	Principal component 5
Petiole length	0.407	-0.050	0.086	0.052	-0.085
Leaf length	0.408	0.043	0.031	0.078	-0.102
Leaf width	0.417	0.032	0.030	0.019	-0.085
Leaf area	0.419	0.002	0.053	0.047	-0.09
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

4. 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 objective of estimating leafy vegetative agro-morphological traits, topped plants of seed yield and its related characters, to assess genetic diversity through morphological traits .The analysis of variance showed the presence of highly significant differences among the tested genotypes for Leaf area, leaf width, leaf length and petiole length of characters considered, indicating the existence of variability among the tested genotypes for these characters. The grand mean value shows a decrease mean value for seed yield per plant from growth stage of 50^{th} days of topping of leafs to 60^{th} day of growth stage of topping indicating that average seed yield per plant of topped or defoliated could be attained by utilization of leaves in this stage of topping. Petiole length has shown significant positive correlation with leaf length, leaf width, and leaf area and leaf biomass of topped at 60^{th} days of growth stage. Similarly leaf length shown significant positive correlation for leaf width, leaf area and leaf biomass of topped at 60^{th} days of growth stage. Multivariate Analyses of genetic divergence of Ethiopian mustard genotypes for leafy vegetative traits have resulted in the formation of four clusters and have shown genetic variability for further selection and breeding improvement work. Genotypes in C4 showed high seed yield per plants of leaf toped at 40^{th}, 50^{th} and 60^{th} days of growth stage of genotypes than other clusters. The least seed yield per plants of leaf toped at 40^{th}, 50th and 60th days of growth stage of genotypes was found in C1 of SY60DT (2.4g) than other topping stages of the study. On the other hand C2 showed much lengthier in petiole length (9.1), leaf length (9.6), leaf width (6.8) and leaf area ($8.5cm^3$) than other clusters. Genotypes in C3 showed more leaf biomass weight per plants of leaf topped at 50 days of growth stage of genotypes than others. Similarly high intact number of leafs per plant during vegetative stage of growth stage was observed from C4 (88) following C3 (74) and C1 (71) genotypes. 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 Leaf area, leaf width, leaf length and petiole length traits compared but none significant for seed yield per plant, leaf biomass per plant topped at 40,50 and 60 days of topping and number of intact leaves at flowering. These conditions indicate that there is good opportunity to improve these characters using the tested genotypes.

ACKNOWLEDGMENT

The first author acknowledges Jimma University of College of agriculture and Veterinary Medicine and Embassy of Netherland in Ethiopia for their sponsoring fund to conduct field experiment.

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Citation: *F. Amsalu, et al. "Multivariate Analysis of Genetic Divergent of Ethiopian Mustard (Brasica carinata A. Braun) Landraces in Relation to Leafy Vegetative Agro morphological Traits", International Journal of Research Studies in Agricultural Sciences (IJRSAS), vol. 3, no. 7, p. 9, 2017. http: //dx.doi.org /10.20431/2454-6224.0307002*