International Journal of Research Studies in Agricultural Sciences (IJRSAS)
Volume 6, Issue 4, 2020, PP 17-24
ISSN No. (Online) 2454–6224
DOI: http://dx.doi.org/10.20431/2454-6224.0604003
www.arcjournals.org

Estimates of Heritabiliy, Genetic and Principlal Componente Analysis for Yield and its Traits in Ethiopian Mustard (*Brasica Carinata* A. Braun) Landraces

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Abstract: *The experiment was executed to estimate heritability genetic advance and principal component analysis for yield and its traits in Ethiopian mustard land races at Holetta agricultural research center, Ethiopia. Forty nine genotypes collected from different agro ecologies were analyzed using seed and agronomic traits in order to estimate heritability genetic advance and major principal component traits that exists in these materials. The experiment was carried out in a simple lattice design. The analysis of variance showed that there were significant differences among genotypes for all traits compared. The significant difference indicates the existence of high heritability, genetic advance among the accessions that is important for selection and breeding. The highest heritability in broad sense was recorded for thousand seed weight (68.80%), followed by days to flowering (65.91%), stand percent (63.14%), days to maturity (60.43%), plant height (59.63%) and seed yield per plot (42.99%) and primary branches (34.20%). This suggests that large proportion of the total variance was due to the high genotypic and less environmental variance. Hence, a good progress can be made if some of these traits are considered as selection criteria for the improvement of yield and yield component traits. Principal component analysis showed that 88.18% of the variation was contributed by the first five principal components for agronomic traits. Days to flowering, days to maturity, plant height, primary branches and stand percent of plant were the major seed yield positive contributors of the variation in the first principal component in which 39.5% of the variation revealed. The present study revealed the presence of considerable high principal component contributor traits among genotypes for Leaf area, leaf length, leaf width, petiole length days to flowering and days to maturity traits analyzed. Therefore these traits can serve as selection indices in genetic improvement of mustard yield and its component traits.*

Keywords: *Ethiopian mustard, Genetic advance, heritability, Principal component analysis*

1. Introduction

The genus *Brassica* of *Brassicaceae* family as a whole is believed to have originated around the Mediterranean, Eastern Afghanistan and the adjoing 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 amphidiploid.

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). It is often grown on well-drained and organic matter rich soils close to homesteads but the trend of growing far from their home is started by using inorganic fertilizer. 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 (i.e., June to December). It grows well in either a heavy sandy loam or light clay soils with a good drainage system (Getinet and Nigussie, 1997).

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). For the small-scale farmers, it is a security crop, because it is a source of food and income at the time of acute food and income shortage that mostly occurs at the middle of the main rainy season.

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 successful selection program largely depends on the nature and magnitude of genetic variability present in the germplasm, Goyal and Kumar, (1991). The plant breeder needs to know the estimate of gene effects in order to plan for an effective breeding method for the improvement of the desired traits. Moreover, the type of breeding method to employ for the genetic improvement of yield and its components depends upon the type of gene action controlling the inheritance of the traits. Knowledge on the nature of the combining ability effects and their resulting variances, is the opening line in the preparation for breeding towards improvement of crop species. Therefore the present study was executed to estimate broad sense heritability genetic advance and principal component analysis for seed yield and its attributing traits in forty nine Ethiopian mustard land races

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^o N and longitude 38^o 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^{o}C (maximum) and 8^{o}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 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 aare given in Table 1.

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/E 20001	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	West Shewa/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	" 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	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*

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 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).

2.4. Data Collected

1. Days to flowering (Df): The numbers of days from date of sowing to a stage at which 50% of the plants in a plot open flowers.

2. Days to maturity (Dm): The number of days from date of sowing to a stage at which 50% of the plants have reached physiological maturity. It is the time when 50% of the capsules change their color into brown.

3. Seed yield per plot (SYPP): Seed yield per plot measured in grams after moisture of the seed was adjusted to 7 percent.

4. **Oil content (Oc)**: The proportion of oil in the seed to total oven dried seed weight measured by nuclear magnetic resonance spectroscope as described by Oregon State University seed laboratory.

5. **Thousand seed weight (Tsw)**: The weight (g) of 1000 seeds from randomly sampled grains.

6. Oil yield (Oy): The amount of oil in grams obtained by multiplying seed yield per plot by corresponding oil percent.

7. Stand percent (SP): The proportion of plants at vegetative stage and at harvest as visually assessed in percentage.

8. Number of Primary branches per plant (PB): The average number of primary branches per plant was counted from five randomly selected plants.

9. Number of Secondary branches per plant (SB): The average number of secondary branches per plant was counted from five randomly selected plants.

10. Plant height (PHT): The average height of five randomly selected plants was measured in centimeters from the ground surface to the top of the main stem at maturity.

11. Seeds yield per plant (SYPPL): The weight of the seeds of the five randomly selected plants measured in grams that are divided by five.

12. **Leaf petiole length (cm)**: average measurements of the leaf petiole length from bottom, middle and top of five plants. From each leaf starting from base to the apex of the leaf blade excluding leaf part was measured at full vegetative stage.

13. **Leaf length (cm)**: average measurements of the leaf length from bottom, middle and top of five plants. From each leaf starting from the base to the apex of leaf blade excluding petiole was measured at full vegetative stage.

14. **Leaf width (cm)**: An actual measurement across the widest portion/section of the same leaf was at full vegetative stage.

15. **Leaf area** was measured using leaf area meter from bottom, middle and top of five plants for three leaf blade.

3. Results and Discussion

The analysis of variance for the 15 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 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, number of seed per plant, thousand seed weight, number of primary branches, number of secondary branches, plant height of traits found the same result. Besides, 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 Erana(2001).

Table2. *Mean squares for different sources of variations for 15 genetic and morphological traits of 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**	1.3825ns	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 secondary branches	0.3389*	4.0816	4.0816	0.2421
Plant height	1004.12**	1102.13	2812.5	169.46
Leaf 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

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

3.1. Heritability in the Broad Sense

Breeders can make rapid progress where heritability is high by using selection methods that are dependant solely on phenotypic characteristics (e.g. mass selection). However, where heritability is low methods of selection based on families and progeny testing are more effective and efficient. Heritability estimated using the total genetic variance is called broad sense heritability. Heritability in the broad sense of the traits is presented in Table 4. In this study, heritability values were found to be sufficiently high for most important yield component characters. Dabholkar (1992) generally classified heritability estimates as low (5-10%), medium (10-30%) and high (30-60%). Based on this classification, thousand seed weight (68.80%), days to flowering (65.91%), stand percent (63.14%), days to maturity (60.43%), plant height (59.63%), seed yield per plot(42.99%) and number of primary branches per plants (34.20%) exhibited high heritability estimates. Thousand seed weight was found to be the most heritable trait in the genotype, with heritability of 68.80%, followed by days to maturity (65.91%) and stand percent (63.14%). This indicates that selection for these traits in the genotype would be most effective for the expression of these traits in the succeeding generations. Therefore, good improvement can be made if some of these traits are considered as selection criteria in future breeding program. Similar findings had been reported by Yared (2010) for thousand seed weight, date of flowering, date of maturity and plant height. High heritability value for thousand seed weight, date to flowering, days to maturity plant height recorded in the current study was also recorded by Yared (2010) and Abebe (2006). According to Singh (1993), if the heritability of a character is high, selection for such character is fairly easy as selected character will be transmitted to its progeny. This is because there would be a close correspondence between the genotype and phenotype due to a relatively similar contribution of the environment to the genotype. At the same time secondary branches per plant (28.86%), exhibit medium heritability estimates.

3.2. Genetic Advance

Concerning the genetic advance at 5% intensity the highest genetic gain was predicted for seed yield per plot (806.89kg/ha) followed by oil yield (378.38kg/ha) and while the lowest genetic advance was predicted for thousand seed weight (0.43). Genetic advance as a percent mean ranged from 4.12 % for leaf area to 57.18.% for petiole length (Table 3). Within this range, a relatively high genetic advance as a percent mean was observed for petiole length (57.18%) and seed yield per plant (56.65%) and followed by leaf width (48.63%). On the other side high genetic advance with high heritability was shown for seed yield per plot and plant height in cm which may be because of the presence of both additive and non-additive gene action (Liang *et al.*, 1972).Those traits having medium heritability along with high genetic advance could be improved using breeding procedure such as pedigree method. On the other hand, the lowest genetic gain as percent of means was observed for leaf area 4.12% followed by oilcontent5.08%. Low genetic advance as percent means observations in this study indicates that characters probably were under environmental influence than the genotypic expression and that selection based on these traits would be ineffective.

Table3. *Broad sense heritability and genetic advance and Genetic advance as percent of mean of studied traits*

Character	h2b	GA k = 5%	GA/Grand mean *100 k 5%
Date of flowering	65.91	14.36	15.39
Date of maturity	60.43	20.24	11.26
Seed yield per plot	42.99	806.89	40.37
Seed yield per plant	39.18	4.75	56.65
Thousand seed weight	68.80	0.43	14.36
Stand percent	63.14	17.36	20.23
Number of primary branch	34.20	3.35	30.10
Number of secondary branch	28.86	0.59	17.81
Plant height	59.63	37.97	20.96
Oil yield	44.84	378.38	43.71
Petiole length	56.03	4.06	57.18
Leaf length	46.28	2.87	33.72
Leaf width	48.29	2.82	48.63
Leaf area	52.09	3.20	4.12
Oil content	50.33	2.18	5.08

h2b = Broad sense heritability, GA = Genetic advance and K = Selection intensity

3.3. Principal Component Analyses

In order to assess the patterns of variations, principal component analysis (PCA) was done by considering thirteen traits for seed yield and agronomic traits. Principal component analyses are presented in Tables 4. Principal component analysis showed that 88.18% of the variation was contributed by the first five principal components for agronomic traits. Leaf area, leaf length, leaf width, petiole length, days to flowering and days to maturity were the major seed yield positive contributors of the variation in the first principal component in which 39.5% 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 24.1% variation in the second principal component was mainly observed through trait such as oil yield per plot, seed yield per plot and plant height. The third principal component was accounted for another additional 12.2% 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 7.9% and 4.4% 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 (± 0.288-0.389) to the total variation and, therefore, differential grouping of genotypes was mainly attributed by the cumulative effect of the individual traits. However, traits which had relatively greater weight in the first principal component largely contributed to the total variation and they were accountable for differential grouping of genotypes.

Table4. *Component scores of the first five principal components of 49 genotypes of Ethiopian mustard based on their agronomic traits*

	Component scores				
Traits	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
Petiol 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 broad sense heritability, genetic advance and principal component analysis for seed yield and its attributing traits in forty nine Ethiopian mustard land races. The analysis of variance showed the presence of highly significant differences among the tested genotypes for the all of characters considered, indicating the existence of genetic variability among the tested genotypes for these characters.

Heritability in broad sense estimates were high for thousand seed weight, days to flowering, stand percent, days to maturity, plant height, seed yield per plot and number of primary branches per plants exhibited high heritability estimates.

Similarly, only the heritability values of secondary branches per plant exhibited medium estimates. Genetic advance as percent of the mean (GAM) was high for petiole length, seed yield per plants, followed by leaf width and where as the rest shows low GAM below almost 45%. 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 39.5% of the variation revealed. Additional 24.1% variation in the second principal component was mainly observed through trait such as seed yield per plot and plant height. The third principal component was accounted for another additional 12.2% of the variation in which secondary branches was the major contributor.. Principal component 4 and 5 contributed 7.9% and 4.4% 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. However, traits which had relatively greater weight in the first principal component largely contributed to the total variation and they were accountable for differential grouping of genotype. Therefore these traits can serve as selection indices in genetic improvement of mustard yield and its component traits.

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Citation: *Fekadu Amsalu, "Estimates of Heritabiliy, Genetic and Principlal Componente Analysis for Yield and its Traits in Ethiopian Mustard (Brasica Carinata A. Braun) Landraces" International Journal of Research Studies in Agricultural Sciences (IJRSAS), 2020; 6(4), pp. 17-24,http://dx.doi.org/10.20431/2454-6224.0604003*