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Full Length Research Paper

Morphological Analysis of Ethiopian Mustard Varieties (Brassica carinata A. Braun) in Arusha, Tanzania: A Focus on Vegetative Traits

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This study was conducted at Asian Vegetable Research and Development Center, Regional Center for Africa ((AVRDC - RCA), Madiira Experimental Research Station in Arusha, Tanzania in 2005. The objective of the study was to document vegetative agromophological traits in the Ethiopian mustard lines held at AVRDC – RCA in order to identify lines with useful traits that can be used as genitors for active breeding; and to rationalize the conservation of this species. Forty-seven lines of Ethiopian mustard were characterized for vegetative agromophological traits. Significant differences (P 0.05) were observed in most quantitative traits with eighty eight percent of the accessions flowering after 84 days from sowing. Among the qualitative traits, great variation was seen in leaf number/plant, leaf bloom and leaf blade blistering. There was a strongly negative significant correlation between days to 50% flowering and plant height with tall plants flowering early. There was a positive non-significant correlation between days to 50% flowering and leaf dimensions. There was a significant negative correlation between days to 50% flowering and leaves per plant with plants with many leaves flowering early. There was a positive non-significant correlation between leaf dimensions and leaves per plant. Results from diversity dendrogram showed two main clusters with three sub-clusters showing intra-species diversity. These preliminary results indicate that there is a wide variation in Ethiopian mustard collection held at AVRDC-RCA based on vegetative agromorphological traits. Further work should consider agromorphological characterization at reproductive phase or molecular characterization in order to get a clearer picture of this diversity.

Key words: Ethiopian mustard, *Brassica carinata*, agromorphological characterization

INTRODUCTION

Ethiopian mustard (*Brassica carinata* A Braun) is a traditional African vegetable, previously gathered from the wild for human consumption (Schippers, 2002). It is believed to have originated from the Ethiopian highlands and its cultivation is thought to have started about 4000 years B.C. (Alemayehu and Becker, 2002; Schippers, 2002). It is cultivated as an oil and leafy vegetable crop in the Ethiopian highlands at altitudes between 1500 and 2600 m. As a leafy vegetable, it is often grown in East and Southern Africa as accompaniment for ugali (a stiff porridge made form maize or millet flour) (Mnzava, 1986; Schippers, 2002).

Normally, flowering starts 12 weeks after sowing depending on cultivar and growing conditions. Flowering is delayed by regular harvesting of leaves and young shoots. When grown with adequate moisture it produces seeds in 5-6 months (Mnzava and Schippers, 2004; Schippers, 2002).

A large degree of variability has been observed in Ethiopian mustard for agromorphological characters such as flowering time, plant height, seed colour, seed weight and seed yield and in main seed storage components such as oil, protein, fiber, fatty acids and glucosinolate levels (De Haro et al., 2002). Genetic analysis using microsatellite markers have shown a high degree of hete-

Abbreviations: **AVRDC;** Asian vegetable research and development center, **RCA;** regional center for Africa.

Table 1. Analysis of variance table for some quantitative traits using Student Newman Keul's Test.

Character	F cal	$LSD_{0.0.5}$	Mean	%CV
Leaf length	3.0472^{exp} 14*	2.75	28.39	3.15
Leaf width	11.906 ^{exp} 14*	2.80	12.96	7.13
Plant Height	2.6015^{exp} 14*	2.05	22.00	3.02
Plant diameter	8.3248^{exp} 14*	1.30	58.57	7.22
Petiole length	1.4187^{exp}14*	9.24	11.77	2.55
Petiole width	4.9672^{exp} 14*	5.06	1.13	1.46
Days to 50% flowering	9.0278^{exp}14*	1.75	100	5.68

*= Significant at 5% level.

What is exp and 14 under the F-test column (exponential to power 14)

rogeneity within Ethiopian mustard lines, and only a few lines appear to be uniform at >1 microsatellite locus (Chinoy et al., 2002).

For use as leafy vegetables, the following traits are preferred: large leaf size, late flowering, many leaves per plant and tolerance to major diseases and pests. Popular cultivars are: White Figiri, Purple Figiri, Lushoo, Mbeya Green and Lambo (from Tanzania); RRS-V (from Zimbabwe); Chibanga and NIRS-2 (from Zambia) (Mnzava and Schippers, 2004). At AVRDC-RCA, Arusha, Tanzania, work has been going on to purify and charac-terize B. carinata lines especially from local populations. This study was part of the purification and characterization efforts

The objective of the study was to document vegetative agromophological traits inherent in the B. carinata lines held at the AVRDC-RCA. This was to assist to identify lines with useful traits that can be used as genitors for active breeding; and to rationalize the conservation of this species.

MATERIALS AND METHODS

The study was carried out at AVRDC-The World Vegetable Center, Regional Center for Africa, Madiira Experimental Research Station in Arusha, Tanzania from July 2005 to December 2005. The area is located at 4° Latitude South, 37° Longitude East and an altitude of 1290 m above sea level. Mean annual rainfall is 1085mm and the prevalent soil type is clay-loam with a pH of 6.0 - 6.7 (Mlahagwa, 2000).

Forty-seven Ethiopian mustard lines were sown in a nursery on 28/6/2005 and transplanted 23 days later into plots laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot consisted of three rows, six meters long with plant spacing of 60 cm between rows and 40 cm within rows giving a total of 45 plants per plot. One day after transplanting, the seedlings were sprayed with a fungicide [Ridomil MZ 68WP (Syngenta Crop Protection, AG basele, Switzerland)] at 30 gm/15 liters of water to prevent against damping-off and an insecticide [Selecron (Syngenta Crop Protection, AG basele, Switzerland)] at a rate of 20 mls/15liters of water to prevent against cutworms. Twenty- seven days later, the plants were sprayed with another insecticide [Actellic (Syngenta Crop Protection, AG basele, Switzerland)] at a rate of 30 cc/15 liters of water for further prevention against insect pests. Fifty-five days after transplanting, they were sprayed again with Selecron (Syngenta Crop Protection, AG basele, Switzerland) at a rate of 20 mls/15 liters of water against aphids.

The plants were fertilized with 150 kg/ha of NPK (20-10-10) (equivalent of 75, 37.5 and 37.5 kg/ha of N, P2O5 and K2O) and Urea (46% N) at a rate of 100 kgN/ha in split form half with the first application carried out together with all NPK one week after transplanting and the second application three weeks thereafter.

All other cultural practices such as irrigation and weeding were carried out whenever needed following previous recommendations.

Data collection

Traits were scored using the descriptor list for Crucifers (AVRDC, 2001). The descriptor list was adopted for Ethiopian mustard since it is well detailed. Ten plants from the middle row of each plot were evaluated for agromorphological traits. The following traits were recorded: leaf blade colour (based on Royal Horticultural Society Colour Chart, 2007); leaf blade margin; plant growth habit; plant height at 50% flowering; plant diameter at 50% flowering; leaf number per plant at 50% flowering; leaf length at 50% flowering (largest leaf including petiole); leaf blade width at 50% flowering (widest point of the largest leaf); leaf blade blistering; leaf angle (angle of petiole and horizontal); leaf bloom; leaf lamina attitude, petiole length at 50% flowering (petiole of the largest leaf); petiole width at 50% flowering (petiole of the largest leaf) and days from sowing to 50% flowering.

Data management and analysis

Data were entered into Microsoft Excel spreadsheet immediately after collection from the field. Data was subjected to analysis of variance for the randomized complete block design as per the procedures outlined by Steel and Torrie (1980) using CoStat statistical package (CoHort, 2003). Mean separation was done using Student Newman Keuls Test at 5 % significance level (Steel and Torrie, 1980). The Pearson Product Moment Correlation Coefficient ('r') was calcu-lated for most quantitative traits using CoStat statistical package (CoHort, 2003). All characterization data was transformed into Dendrograms using R software (R: Console, 2004).

RESULTS AND DISCUSSION

Significant differences (P 0.05) were observed in most quantitative traits with majority of accessions (Table 1). Among the qualitative traits, great variation was seen in leaf number/plant, leaf bloom and leaf blade blistering (Table 2). Fifty three percent of the accessions had an

Table 2. Details of qualitative traits.

Ethiopian mustard Line	Leaf angle	Plant growth habit	Leaf blade colour	Leaf blade margin	Leave/ plant	Leaf blade bloom	Leaf blade blistering	Leaf lamina attitude
Mbeya green	Open (~67°)	Prostrate	Green	Dentate	40<	High glaucous	Low	Straight
Mbeya purple	Semi prostrate (~45°)	Upright	Green	Serrate	40<	Low	Intermediate	Straight
Site 15 Site 3	Open (~67°)	Upright	Green	Dentate	40<	Intermediate	Intermediate	Convex
(c-1)	Open (~67°)	Prostrate	Green	Undulate	20-40	Absent	High	Straight
Site 3 (c- 2)	Prostrate(<30°)	Prostrate	Light green	Undulate	20-40	Absent	High	Straight
Site 3 (c- 3)	Semi prostrate (~45°)	Prostrate	Light green	Undulate	20>	Absent	High	Mixture
Site 3(c- 4)	Semi prostrate (~45°)	Prostrate	Light green	Undulate	20>	Absent	High	Mixture
Site 14 c-2	Open (~67°)	Upright	Green	Dentate	40<	Intermediate	Intermediate	Straight
Site 14 c-3	Semi prostrate(~45°)	Upright	Light green	Dentate	20-40	Intermediate	Intermediate	Straight
Site 14 c-4	Open (~67°)	Upright	Green	Doubly dentate	40<	Intermediate	Intermediate	Mixture
Site 30B	Open (~67°)	Prostrate	Green	Doubly dentate	40<	Intermediate	Intermediate	Mixture
Site 29	Open (~67^0)	Prostrate	Green	Serrate	20>	High glaucous	Intermediate	Straight
Site 41	Open (~67^0)	Prostrate	Green	Serrate	40<	High glaucous	Intermediate	Straight
Site 26	Open (~67^0)	Upright	Green	Serrate	40<	Intermediate	Intermediate	Straight
Site 67B (s- 5)	Semi prostrate (~45°)	Prostrate	Green	Dentate	20-40	Intermediate	Intermediate	Straight
Site 45	Semi prostrate(~45°)	Prostrate	Green	Dentate	40<	Intermediate	Intermediate	Straight
Site 67B (s – 10)	Prostrate(<30°)	Prostrate	Green	Undulate	40<	Intermediate	High	Concave Drooping
Site 57 (s – 5)	Open (~67°)	Prostrate	Light green	Dentate	40<	Absent	Intermediate	Straight
Site 151	Open (~67°)	Prostrate	Light green	Dentate	40<	Absent	Intermediate	Straight
Site 50	Prostrate(<30°)	Prostrate	Green	Undulate	40<	Absent	Intermediate	Straight
Site 57 (s – 8)	Semi prostrate (~45^0)	Prostrate	Green	Serrate	20-40	Intermediate	High	Mixture
Site 43	Open (~67°)	Prostrate	Green	Dentate	20-40	Intermediate	High	Straight
Site 22A	Open (~67°)	Upright	Green	Dentate	40<	Intermediate	High	Straight
Site 18	Semi prostrate(~45°)	Prostrate	Green	Serrate	40<	High glaucous	Low	Concave/Drooping
Site 10B	Open (~67°)	Prostrate	Purple green	Dentate	20-40	Intermediate	High	Concave/Drooping
Site 3	Open (~67°)	Prostrate	Green	Undulate	20-40	Intermediate	7	Straight
Site 4 (c-1)	Prostrate(<30°)	Prostrate	Green	Undulate	20-40	Intermediate	Intermediate	Straight
Site 4(c – 2)	Prostrate(<30°)	Prostrate	Light green	Undulate	20>	Intermediate	Intermediate	Straight
Site 4 (c – 3)	Semi prostrate(~45°)	Prostrate	Light green	Dentate	20>	High glaucous	High	Straight
Site 4 (c – 4)	Semi prostrate (~45°)	Prostrate	Green	Dentate	20-40	High glaucous	High	Straight
Site 6	Open (~67°)	Prostrate	Green	Serrate	40<	Mixture	Intermediate	Straight
Site 14 c – 1	Open (~67°)	Upright	Light green	Serrate	40<	Mixture	Intermediate	Straight
Site 27B	Open (~67°)	Prostrate	Dark green	Dentate	20-40	Low	Intermediate	Convex
Site 47	Open (~67°)	Intermediate	Green	Serrate	40<	Absent	Intermediate	Straight

Table 2. Contd.

Site 68A	Semi prostrate (~45°)	Prostrate	Green	Undulate	40<	Absent	High	Convex
Site 38	Semi prostrate (~45°)	Prostrate	Light green	Serrate	40<	Absent	High	Convex
Site 46	Open (~67°)	Upright	Light green	Dentate	40<	Absent	High	Concave/Drooping
Site 44	Open (~67°)	Upright	Dark green	Serrate	40<	Low	Intermediate	Straight
Site 52B	Open (~67°)	Prostrate	Dark green	Dentate	40<	Absent	Intermediate	Concave/Drooping
Site 42	Open (~67°)	Upright	Green	Dentate	40<	Absent	Intermediate	Straight
Site 38(s – 2)	Open (~67°)	Upright	Green	Crenate	40<	Absent	Intermediate	Concave/Drooping
Site 53B	Open (~67°)	Upright	Green	Crenate	40<	Absent	Intermediate	Concave/Drooping
Site 67B (s – 6)	Semi prostrate (~45°)	Prostrate	Dark green	Undulate	20-40	Intermediate	Intermediate	Concave/Drooping
Site 38 (s –6)	Semi prostrate (~45°)	Upright	Green	Undulate	40<	Mixture	High	Convex
Site 57b(s – 6)	Semi prostrate (~45°)	Prostrate	Green	Undulate	20-40	Mixture	High	Convex
Site 37	Semi prostrate (~45°)	Prostrate	Green	Serrate	40<	Intermediate	High	Straight
Site 49	Erect(>87°)	Prostrate	Purple green	Dentate	20>	High glaucous	Intermediate	Concave/ Drooping

Table 3. Summary of some traits

Leaf angle	% of accessions	Leaf bloom	% of accessions	Leaves per plant	% of accessions	Days to 50 % flowering	% of accessions
Open	53	Absent	31	20< do you mean less than 20	10	64	7
Semi-prostrate	34	Low	15	20-40	26	73	5
Prostrate	11	Intermediate	36	40<?	64	84	8
Erect	2	High glaucous	11			91	8
		Mixture	7			96	18

open leaf angle (~67°) while 64% had more than 40 leaves per plant (Table 3). Eighty eight percent of the accessions flowered after 84 days from sowing (Table 3). There was a strongly negative significant correlation between days to 50% flowering and plant height with tall plants flowering early (Table 4). There was a positive non-significant correlation between days to 50% flowering and leaf dimensions. There was a signi-

Table. 4. The Pearson Product Moment Correlation Coefficient (r) for various characters.

	Days to 50% flowering	Plant height	Plant diameter	Leaves/plant	Leaf length	Leaf blade width	Petiole length	Petiole width	Leaf angle
Days to 50% flowering	1.0000	-0.6086***	0.3100*	-0.3101*	0.0010ns	0.09911ns	0.5989***	0.4768***	-0.21873ns
Plant height		1.0000	-0.07441ns	0.4010**	0.1585ns	-0.0651160ns	-03126*	-0.3135*	0.050606ns
Plant diameter			1.0000	0.02403ns	0.3751**	0.3650**	0.6775***	0.5882***	0.121076ns
Leaves/plant				1.0000	0.16721ns	0.1570ns	-0.2062ns	-0.1245ns	-0.02112ns
Leaf length					1.0000	0.8496***	0.2670*	0.1874ns	-0.04484ns
Leaf blade width						1.0000	0.2797*	0.23104ns	0.083381ns
Petiole length							1.0000	0.8034***	-0.24452ns
Petiole width								1.0000	0.084962ns
Leaf angle									1.0000

*= Significant at 0.05, ** = Significant at 0.01, *** = Significant at 0.001

ficant negative correlation between days to 50% flowering and leaves per plant with plants with many leaves flowering early. There was a positive non- significant correlation between leaf dimensions and leaves per plant (Table 4).

Results from diversity dendrogram showed two main clusters with three sub-clusters showing intra-species diversity (Figure 1). For vegetable production, large leaves, high number of leaves per plant and longer harvesting duration (indicated by number of days to flowering) are important selection criteria (Mnzava and Schippers 2004). The above results however did not show a strong positive correlation in these traits. Maybe there was a strong competition for photoassimilates between leaves and flowers forcing the plants with many leaves to flower early.

A large degree of variability within and between Ethiopian mustard accessions has been observed for morpho-agronomic characters such as flowering time, plant height, seed colour, seed weight and seed yield and in main seed storage components such as oil, protein, fiber, fatty acids and glucosinolate levels (De Haro et al., 2002).

The great diversity in agromorphological traits in Ethiopian mustard observed here agrees with observations previously made by other researchers such as Mnzava and Schippers (2004) and it offers opportunities for selection and breeding.

Conclusions and Recommendations

These preliminary results indicate that there is a wide variation in Ethiopian mustard collection held at AVRDC-RCA based on vegetative agromor-phological traits. Further work should consider agromorphological characterization at reproductive phase or molecular characterization in order to get a clearer picture of this diversity. Besides, the study may be repeated in different agro- ecological zones so that the effect of genotype X environment interaction in expression of the phenotypes may the identified.

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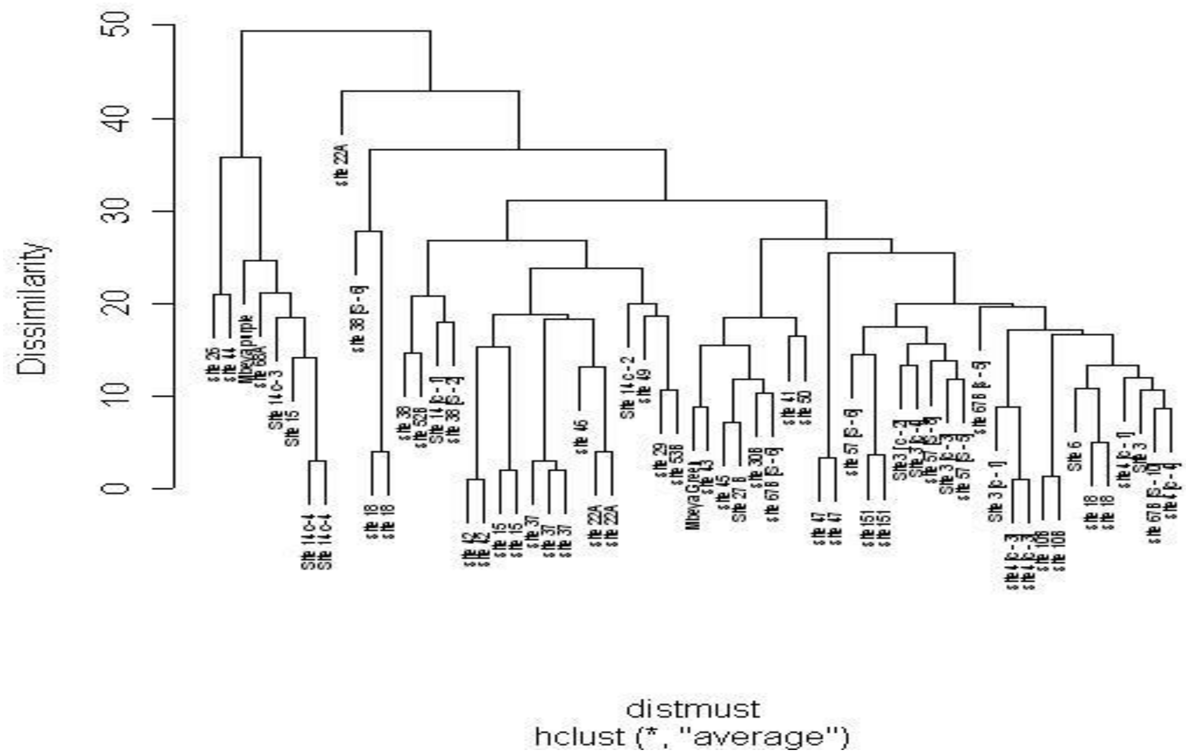

Figure 1. Cluster, dendrogram

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