



Evaluation, classification and characterization of Toria germplasm for different agro-morphological traits

Ram Avtar*, Nisha Kumari, Babita Rani, Amrita Narula, NK Thakral and Dhiraj Singh**

*Oilseeds Section, Department of Genetics and Plant Breeding,
CCS Haryana Agricultural University, Hisar 125 004 (Haryana) India*

***ICAR-Directorate of Rapeseed-Mustard Research, Bharatpur 321303 (Raj) India*

**Corresponding author: ramavtarola@yahoo.in*

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Abstract

Ninety two germplasm accessions of Toria [*Brassica rapa* (L.) var. Toria] were evaluated and characterized for 22 agro-morphological traits as per DUS descriptor of rapeseed-mustard at Oilseeds Section, CCS Haryana Agricultural University, Hisar and established distinctness among different accessions for the traits under study. Majority of the accessions were early in flowering, medium in maturity and had narrow leaves with medium number of lobes on them. Among all the accessions, four lines were observed with short height, while majority of them were grouped under intermediate category of primary and secondary branches/plant with many siliquae on the main shoot. Similarly, intermediate number of seeds/silique, medium seed size, medium seed yield/plant and medium oil content were most dominant among all the accessions studied. Characterization and classification on the basis of qualitative traits revealed that hairs were absent on the leaves of 19 accessions, leaf colour of more than 40% lines was dark and purple green, whereas majority of the cases were characterized with lyrate type of leaf dentation. Yellow and light yellow colour of petals was pre-dominant and more than half of the lines were grouped under intermediate silique surface texture category with high silique density on the main shoots. Moreover, semi-appressed silique angle with main shoot along with reddish-brown seed coat colour was also most common in the germplasm. Maximum genetic distance was observed between the accessions, TC-11 and TC-68, and utilization of these accessions has been advocated in crossing programme to get better transgressive segregants. The results of present study can be used for formation of data base and reference lines, varietal/genotype identification and will also be helpful in augmentation of future Toria improvement programmes.

Keywords: Characterization, classification, evaluation, germplasm, Toria

Introduction

Toria [*Brassica rapa* (L.) var. Toria] holds promise amongst all the *Brassicaceae* due to its significance as a valuable donor source for high temperature stress at seedling stage. This crop is gaining importance globally due to its advantages over other oilseeds, viz., higher yield potential, low moisture requirement, higher returns at low cost of production, wider adaptability for various farming conditions, etc., which is important for the next yellow revolution. Narrow genetic base of the crop for component traits is the main constraint for the cultivation of this crop. Agronomic characterization continues to be a

useful tool for the classification of germplasm as it allows plant breeders to select valuable genetic resources to be utilized later in different breeding programmes. Further, characterization could be utilized for varietal identification in seed production programmes, maintaining the genetic purity of a genotype and also DUS testing becomes easy in a well characterized genotype. Germplasm of a specific crop collected from the diverse sources offers greater genetic diversity and may furnish useful traits to widen the genetic base of crop species. Knowing of duplicates, organization of core collection of a particular population and the selection of parents for the development of new cultivars are directly

related to the genetic diversity. Moreover, evaluation of phenotypic diversity usually reveals key traits of interest to the plant breeder. Therefore, 92 germplasm accessions of Toria collected from different sources were grown and evaluated for 14 quantitative variables and eight qualitative traits by giving scores in accordance with the standard DUS descriptor of rapeseed-mustard.

Materials and Methods

Ninety two germplasm accessions of Toria collected from different sources were grown during *rabi* seasons of 2010-11 and 2011-12 in paired rows of 4 m length each at Oilseeds Research Area, Department of Genetics and Plant Breeding, CCS Haryana Agricultural University, Hisar. Recommended package of practices to raise a good crop was followed. Observations during both the seasons were recorded on five randomly selected plants in each accession on 14 quantitative variables by giving scores to the data observed in accordance with the DUS descriptor of rapeseed-mustard as given in the parentheses *viz.*, number of lobes/leaf (3-few i.e. 1-2, 5-medium i.e. 3-5, 7-many i.e. >5), leaf width (3-narrow i.e. <7 cm, 5-medium i.e. 7-8 cm, 7-broad i.e. >8 cm), days to flowering (1-very early i.e. <31 days, 3-early i.e. 31-40 days, 5-medium i.e. 41-50 days, 7-late i.e. 51-60 days, 9-very late i.e. > 60 days), days to maturity (3-early i.e. < 81 days, 5-medium i.e. 81-100 days, 7-late i.e. 100-120 days), plant height (3-short i.e. <51 cm, 5- medium i.e. 51-75 cm, 7- tall i.e. 76-100 cm, 9- very tall i.e. >100 cm), number of primary branches/plant (3-few i.e. 1-4, 5-intermediate i.e. 5-10, 7-many i.e. >10), number of secondary branches/plant (3-few i.e. 1-7, 5-intermediate i.e. 8-14, 7-many i.e. >14), main shoot length (3-short i.e. <41 cm, 5- medium i.e. 41-60 cm, 7-long i.e. >60 cm), number of siliquae on main shoot (3-few i.e. <30, 5-medium i.e. 30-50, 7- many i.e. >50), silique length (3-short i.e. < 4.5 cm, 5-medium i.e. 4.5-5.5 cm, 7-long i.e. >5.5 cm), number of seeds/silique (3-few- < 11, 5-intermediate- 11-20, 7-many- > 20), seed yield/plant (1-low i.e. > 10.0 g, 2-medium i.e. 10-20 g, 3-high i.e. > 20 g), 1000-seed weight (3-low i.e. < 3.0 g, 5-medium i.e. 3.0-4.0 g, 7-high i.e. > 4.0 g) and oil content (3-low i.e. < 38%, 5-medium i.e. 38-42%, 7-high i.e. 43-46%, 9-very high i.e. > 46%). In addition to these,

observations were also recorded on 8 qualitative traits as per scores mentioned in the DUS descriptor of rapeseed-mustard. These traits were leaf hairiness (1-absent, 3-sparse 7-dense), leaf colour (1-light green, 2-medium green, 3-dark green, 4-purple green, 5-purple), dentation of leaf margin (1-entire, 3- auriculate, 5-lyrate, 7-pointed), petal colour (1-white, 2- cream, 3-light yellow, 4-yellow, 5-orange), silique density on main shoot (3- low, 5- medium, 7- high), silique angle with main shoot (3- appressed i.e. <21°, 5- semi-appressed i.e. 21-30°, 7- open i.e. > 30°), silique surface texture (1- smooth, 2- intermediate, 3- constricted) and seed colour (1- yellow, 2- dull grey, 3- reddish brown, 4- brown, 5- black). Data were pooled over for both the years after subjecting it to Bartlett's test and means were estimated. All the 92 accessions were categorized into different distinct classes according to scores given in the DUS descriptor and dendrogram was prepared to form different clusters of accessions and to estimate genetic similarities among these by using the rescaled distances as per the method suggested by Romesburg (1990).

Results and Discussion

Classification and characterization of all the 92 Toria accessions into different categories for quantitative traits is presented in Table 1. The perusal of data in the table revealed that among all the accessions, 76 lines were observed to have medium number of lobes/leaf (3-5) and remaining 16 lines were having many lobes/leaf (>5). Majority of the germplasm (79 lines) had narrow leaves (<7.0 cm) except 13 lines in which medium leaf breadth (7-8 cm) was observed. A total of 52 lines were early in flowering (31-40 days) whereas, all the accessions showed medium maturity (81-100 days). Plant height divided all the accessions into four categories with four lines having short height (<51 cm) and remaining lines were either medium or tall except 11 lines which were very tall (>100 cm). On the basis of primary and secondary branches/plant, most of the lines (89) were classified under intermediate category (8-14 branches). Half of the accessions were having medium main shoot length (41-60 cm) and number of siliquae on main shoot were also observed medium (30-50) in 13 lines whereas, 40 accessions were characterized with many siliquae on main shoot

Table 1. Characterization and categorization of toria accessions on the basis of quantitative traits

Traits	Categories	No. of genotypes	Name of genotypes
No. of lobes/leaf	Few (1-2)	-	-
	Medium (3-5)	76	TC-1, TC-2, TC-3, TC-4, TC-6, TC-8, TC-9, TC-10, TC-11, TC-12, TC-14, TC-15, TC-16, TC-18, TC-19, TC-22, TC-23, TC-24, TC-25, TC-26, TC-27, TC-29, TC-30, TC-31, TC-32, TC-34, TC-36, TC-37, TC-39, TC-40, TC-41, TC-42, TC-44, TC-45, TC-46, TC-47, TC-48, TC-49, TC-51, TC-52, TC-53, TC-54, TC-55, TC-56, TC-57, TC-60, TC-61, TC-63, TC-64, TC-65, TC-66, TC-67, TC-68, TC-69, TC-70, TC-71, TC-72, TC-74, TC-75, TC-77, TC-78, TC-79, TC-80, TC-81, TC-82, TC-83, TC-84, TC-85, TC-87, TC-88, TC-89, TC-91, TC-92, TC-95, TC-96 and TC-97
	Many (>5)	16	TC-5, TC-7, TC-17, TC-21, TC-33, TC-38, TC-50, TC-58, TC-59, TC-62, TC-73, TC-86, TC-90, TC-93, TC-94 and TC-98
Leaf width (cm)	Narrow(<7cm)	78	TC-1, TC-2, TC-4, TC-5, TC-6, TC-7, TC-8, TC-9, TC-10, TC-11, TC-14, TC-15, TC-16, TC-18, TC-21, TC-22, TC-23, TC-24, TC-29, TC-30, TC-31, TC-32, TC-34, TC-37, TC-38, TC-39, TC-40, TC-41, TC-42, TC-44, TC-45, TC-46, TC-47, TC-48, TC-49, TC-50, TC-51, TC-53, TC-54, TC-55, TC-56, TC-57, TC-58, TC-59, TC-60, TC-61, TC-62, TC-63, TC-64, TC-65, TC-66, TC-67, TC-68, TC-69, TC-70, TC-71, TC-72, TC-73, TC-74, TC-75, TC-77, TC-78, TC-79, TC-80, TC-81, TC-82, TC-83, TC-84, TC-85, TC-86, TC-87, TC-88, TC-90, TC-91, TC-93, TC-95, TC-96, TC-97 and TC-98
	Medium(7-8 cm)	13	TC-3, TC-12, TC-17, TC-19, TC-25, TC-26, TC-27, TC-33, TC-36, TC-52, TC-89, TC-92 and TC-94
	Broad (> 8cm)	-	-
Days to 50% flowering	Very early (<31 days)	52	TC-1, TC-2, TC-3, TC-4, TC-5, TC-6, TC-7, TC-8, TC-9, TC-10, TC-11, TC-12, TC-14, TC-15, TC-16, TC-17, TC-18, TC-19, TC-21, TC-22, TC-23, TC-24, TC-25, TC-26, TC-27, TC-29, TC-30, TC-31, TC-32, TC-34, TC-36, TC-37, TC-38, TC-39, TC-40, TC-41, TC-42, TC-44, TC-45, TC-46, TC-47, TC-48, TC-49, TC-50, TC-51, TC-52, TC-53, TC-54, TC-55, TC-56, TC-57 and TC-59
	Early (31-40 days)	38	TC-33, TC-58, TC-60, TC-61, TC-62, TC-63, TC-64, TC-65, TC-66, TC-67, TC-68, TC-69, TC-70, TC-71, TC-72, TC-73, TC-74, TC-75, TC-77, TC-78, TC-79, TC-80, TC-81, TC-82, TC-83, TC-85, TC-86, TC-88, TC-89, TC-90, TC-91, TC-92, TC-93, TC-94, TC-95, TC-96, TC-97 and TC-98
	Medium (41-50 days)	2	TC-84 and TC-87
	Late (51-60 days)	-	-
	Very late (> 60 days)	-	-

Days to maturity	Early (< 81days)	-	-
	Medium (81-100 days)	92	TC-1, TC-2, TC-3, TC-4, TC-5, TC-6, TC-7, TC-8, TC-9, TC-10, TC-11, TC-12, TC-14, TC-15, TC-16, TC-17, TC-18, TC-19, TC-21, TC-22, TC-23, TC-24, TC-25, TC-26, TC-27, TC-29, TC-30, TC-31, TC-32, TC-33, TC-34, TC-36, TC-37, TC-38, TC-39, TC-40, TC-41, TC-42, TC-44, TC-45, TC-46, TC-47, TC-48, TC-49, TC-50, TC-51, TC-52, TC-53, TC-54, TC-55, TC-56, TC-57, TC-58, TC-59, TC-60, TC-61, TC-62, TC-63, TC-64, TC-65, TC-66, TC-67, TC-68, TC-69, TC-70, TC-71, TC-72, TC-73, TC-74, TC-75, TC-77, TC-78, TC-79, TC-80, TC-81, TC-82, TC-83, TC-84, TC-85, TC-86, TC-87, TC-88, TC-89, TC-90, TC-91, TC-92, TC-93, TC-94, TC-95, TC-96, TC-97 and TC-98
Plant height (cm)	Late (100-120 days)	-	-
	Short (< 51cm)	4	TC-85, TC-87, TC-88 and TC-96
	Medium (51-75cm)	40	TC-2, TC-6, TC-7, TC-12, TC-15, TC-18, TC-21, TC-22, TC-24, TC-25, TC-34, TC-41, TC-42, TC-44, TC-47, TC-48, TC-50, TC-51, TC-58, TC-59, TC-61, TC-62, TC-63, TC-65, TC-67, TC-68, TC-70, TC-71, TC-74, TC-79, TC-80, TC-81, TC-84, TC-86, TC-89, TC-90, TC-92, TC-94, TC-95 and TC-97
	Tall (76-100cm)	37	TC-1, TC-3, TC-4, TC-5, TC-8, TC-9, TC-10, TC-16, TC-17, TC-19, TC-23, TC-27, TC-29, TC-30, TC-33, TC-36, TC-37, TC-40, TC-45, TC-46, TC-53, TC-54, TC-55, TC-60, TC-64, TC-66, TC-69, TC-72, TC-73, TC-75, TC-77, TC-78, TC-82, TC-83, TC-91, TC-93and TC-98
Primary branches/plant	Very tall (>100cm)	11	TC-11, TC-14, TC-26, TC-31, TC-32, TC-38, TC-39, TC-49, TC-52, TC-56 and TC-57
	Few (1-4)	3	TC-54, TC-60 and TC-94
	Intermediate (5-10)	89	TC-1, TC-2, TC-3, TC-4, TC-5, TC-6, TC-7, TC-8, TC-9, TC-10, TC-11, TC-12, TC-14, TC-15, TC-16, TC-17, TC-18, TC-19, TC-21, TC-22, TC-23, TC-24, TC-25, TC-26, TC-27, TC-29, TC-30, TC-31, TC-32, TC-33, TC-34, TC-36, TC-37, TC-38, TC-39, TC-40, TC-41, TC-42, TC-44, TC-45, TC-46, TC-47, TC-48, TC-49, TC-50, TC-51, TC-52, TC-53, TC-55, TC-56, TC-57, TC-58, TC-59, TC-61, TC-62, TC-63, TC-64, TC-65, TC-66, TC-67, TC-68, TC-69, TC-70, TC-71, TC-72, TC-73, TC-74, TC-75, TC-77, TC-78, TC-79, TC-80, TC-81, TC-82, TC-83, TC-84, TC-85, TC-86, TC-87, TC-88, TC-89, TC-90, TC-91, TC-92, TC-93, TC-95, TC-96, TC-97 and TC-98
Secondary branches/plant	Many (>10)	-	-
	Few (1-7)	2	TC-60 and TC-65
	Intermediate (8-14)	37	TC-2, TC-3, TC-12, TC-15, TC-21, TC-30, TC-38, TC-45, TC-49, TC-50, TC-54, TC-55, TC-56, TC-57, TC-61, TC-63, TC-66, TC-67, TC-70, TC-71, TC-72, TC-73, TC-75, TC-77, TC-79, TC-82, TC-83, TC-85, TC-88, TC-89, TC-90, TC-91, TC-92, TC-94, TC-95, TC-97 and TC -98

	Many (>14)	53	TC-1, TC-4, TC-5, TC-6, TC-7, TC-8, TC-9, TC-10, TC-11, TC-14, TC-16, TC-17, TC-18, TC-19, TC-22, TC-23, TC-24, TC-25, TC-26, TC-27, TC-29, TC-31, TC-32, TC-33, TC-34, TC-36, TC-37, TC-39, TC-40, TC-41, TC-42, TC-44, TC-46, TC-47, TC-48, TC-51, TC-52, TC-53, TC-58, TC-59, TC-62, TC-64, TC-68, TC-69, TC-74, TC-78, TC-80, TC-81, TC-84, TC-86, TC-87, TC-93 and TC-96
Main shoot length (cm)	Short (< 41cm)	29	TC-11, TC-16, TC-19, TC-38, TC-44, TC-45, TC-46, TC-47, TC-51, TC-53, TC-60, TC-63, TC-65, TC-68, TC-69, TC-71, TC-72, TC-75, TC-78, TC-80, TC-82, TC-84, TC-86, TC-87, TC-88, TC-92, TC-94, TC-95 and TC-97
	Medium (41-60 cm)	46	TC-1, TC-2, TC-3, TC-4, TC-6, TC-8, TC-9, TC-15, TC-17, TC-21, TC-24, TC-29, TC-31, TC-33, TC-34, TC-36, TC-37, TC-39, TC-40, TC-42, TC-48, TC-50, TC-52, TC-54, TC-55, TC-58, TC-59, TC-61, TC-62, TC-64, TC-66, TC-67, TC-70, TC-73, TC-74, TC-77, TC-79, TC-81, TC-83, TC-85, TC-89, TC-90, TC-91, TC-93, TC-96 and TC-98
	Long (> 60cm)	17	TC-5, TC-7, TC-10, TC-12, TC-14, TC-18, TC-22, TC-23, TC-25, TC-26, TC-27, TC-30, TC-32, TC-41, TC-49, TC-56 and TC-57
No. of siliquae on main shoot	Few (< 30)	39	TC-2, TC-3, TC-6, TC-8, TC-9, TC-10, TC-12, TC-15, TC-17, TC-18, TC-22, TC-23, TC-31, TC-38, TC-39, TC-41, TC-44, TC-48, TC-50, TC-51, TC-53, TC-56, TC-59, TC-62, TC-66, TC-67, TC-70, TC-71, TC-74, TC-77, TC-78, TC-81, TC-82, TC-89, TC-90, TC-91, TC-94, TC-96 and TC-97
	Medium (30-50)	13	TC-1, TC-4, TC-14, TC-16, TC-25, TC-26, TC-29, TC-30, TC-32, TC-34, TC-36, TC-55 and TC-88
	Many (> 50)	40	TC-5, TC-7, TC-11, TC-19, TC-21, TC-24, TC-27, TC-33, TC-37, TC-40, TC-42, TC-45, TC-46, TC-47, TC-49, TC-52, TC-54, TC-57, TC-58, TC-60, TC-61, TC-63, TC-64, TC-65, TC-68, TC-69, TC-72, TC-73, TC-75, TC-79, TC-80, TC-83, TC-84, TC-85, TC-86, TC-87, TC-92, TC-93, TC-95 and TC-98
Siliqua length (cm)	Short (< 4.5cm)	32	TC-31, TC-32, TC-34, TC-37, TC-39, TC-40, TC-49, TC-55, TC-57, TC-58, TC-59, TC-61, TC-62, TC-64, TC-65, TC-67, TC-68, TC-69, TC-70, TC-73, TC-74, TC-77, TC-78, TC-79, TC-81, TC-82, TC-84, TC-85, TC-87, TC-88, TC-92 and TC-95
	Medium (4.5-5.5cm)	37	TC-2, TC-4, TC-8, TC-10, TC-11, TC-15, TC-16, TC-17, TC-19, TC-22, TC-23, TC-26, TC-27, TC-33, TC-36, TC-38, TC-41, TC-42, TC-46, TC-50, TC-53, TC-54, TC-56, TC-60, TC-63, TC-66, TC-71, TC-72, TC-75, TC-80, TC-83, TC-86, TC-91, TC-93, TC-94, TC-96 and TC-98
	Long (> 5.5cm)	23	TC-1, TC-3, TC-5, TC-6, TC-7, TC-9, TC-12, TC-14, TC-18, TC-21, TC-24, TC-25, TC-29, TC-30, TC-44, TC-45, TC-47, TC-48, TC-51, TC-52, TC-89, TC-90 and TC-97
No. of seeds/siliqua	Few (< 11)	12	TC-9, TC-14, TC-25, TC-27, TC-33, TC-59, TC-71, TC-74, TC-78, TC-91, TC-93 and TC-96
	Intermediate (11-20)	62	TC-1, TC-4, TC-5, TC-6, TC-7, TC-10, TC-12, TC-15, TC-16, TC-17, TC-18, TC-21, TC-22, TC-23, TC-24, TC-26, TC-30,

			TC-31, TC-34, TC-36, TC-37, TC-38, TC-39, TC-40, TC-42, TC-44, TC-45, TC-46, TC-47, TC-48, TC-49, TC-50, TC-51, TC-53, TC-55, TC-57, TC-58, TC-60, TC-61, TC-62, TC-63, TC-64, TC-72, TC-73, TC-75, TC-77, TC-79, TC-80, TC-81, TC-82, TC-83, TC-84, TC-85, TC-86, TC-87, TC-88, TC-89, TC-90, TC-92, TC-94, TC-95 and TC-97.
	Many (> 20)	18	TC-2, TC-3, TC-8, TC-11, TC-19, TC-29, TC-32, TC-41, TC-52, TC-54, TC-56, TC-65, TC-66, TC-67, TC-68, TC-69, TC-70 and TC-98
1000-seed weight (g)	Low (< 3.0 g)	35	TC-3, TC-4, TC-5, TC-8, TC-9, TC-15, TC-18, TC-26, TC-29, TC-30, TC-41, TC-50, TC-60, TC-65, TC-68, TC-70, TC-72, TC-73, TC-75, TC-77, TC-78, TC-80, TC-81, TC-82, TC-85, TC-87, TC-88, TC-89, TC-91, TC-93, TC-94, TC-95, TC-96, TC-97 and TC-98
	Medium (3.0-4.0 g)	52	TC-2, TC-6, TC-7, TC-10, TC-11, TC-14, TC-17, TC-19, TC-21, TC-23, TC-24, TC-25, TC-27, TC-31, TC-33, TC-34, TC-36, TC-37, TC-38, TC-39, TC-40, TC-42, TC-44, TC-45, TC-46, TC-47, TC-48, TC-49, TC-51, TC-52, TC-53, TC-54, TC-55, TC-56, TC-57, TC-58, TC-59, TC-61, TC-62, TC-63, TC-64, TC-66, TC-67, TC-69, TC-71, TC-74, TC-79, TC-83, TC-84, TC-86, TC-90 and TC-92
	High (> 4.0 g)	5	TC-1, TC-12, TC-16, TC-22 and TC-32
Seed yield/ plant (g)	Low (< 10.0 g)	32	TC-6, TC-33, TC-38, TC-41, TC-44, TC-48, TC-52, TC-55, TC-56, TC-58, TC-59, TC-60, TC-65, TC-70, TC-72, TC-73, TC-74, TC-75, TC-78, TC-79, TC-80, TC-82, TC-84, TC-87, TC-88, TC-91, TC-92, TC-93, TC-94, TC-95, TC-96 and TC-97.
	Medium (10-20 g)	60	TC-1, TC-2, TC-3, TC-4, TC-5, TC-7, TC-8, TC-9, TC-10, TC-11, TC-12, TC-14, TC-15, TC-16, TC-17, TC-18, TC-19, TC-21, TC-22, TC-23, TC-24, TC-25, TC-26, TC-27, TC-29, TC-30, TC-31, TC-32, TC-34, TC-36, TC-37, TC-39, TC-40, TC-42, TC-45, TC-46, TC-47, TC-49, TC-50, TC-51, TC-53, TC-54, TC-57, TC-61, TC-62, TC-63, TC-64, TC-66, TC-67, TC-68, TC-69, TC-71, TC-77, TC-81, TC-83, TC-85, TC-86, TC-89, TC-90 and TC-98
	High (> 20 g)	-	-
Oil content (%)	Low (< 38%)	-	-
	Medium (38-42%)	65	TC-1, TC-3, TC-5, TC-7, TC-10, TC-14, TC-15, TC-17, TC-18, TC-21, TC-22, TC-24, TC-25, TC-26, TC-27, TC-29, TC-30, TC-31, TC-32, TC-33, TC-36, TC-37, TC-38, TC-39, TC-40, TC-41, TC-45, TC-46, TC-48, TC-49, TC-50, TC-52, TC-55, TC-57, TC-58, TC-59, TC-60, TC-61, TC-62, TC-68, TC-69, TC-70, TC-71, TC-72, TC-73, TC-77, TC-78, TC-79, TC-80, TC-81, TC-82, TC-83, TC-84, TC-85, TC-86, TC-87, TC-88, TC-90, TC-92, TC-93, TC-95, TC-96, TC-97 and TC-98
	High (43-46%)	27	TC-2, TC-4, TC-6, TC-8, TC-9, TC-11, TC-12, TC-16, TC-19, TC-23, TC-34, TC-42, TC-44, TC-47, TC-51, TC-53, TC-54, TC-56, TC-63, TC-64, TC-65, TC-66, TC-67, TC-74, TC-75, TC-91 and TC-94
	Very high (> 46%)	-	-

Table 2. Characterization and categorization of toria accessions on the basis of qualitative traits

S.No.	Traits	Categories	No. of genotypes	Name of genotypes
1.	Leaf hairiness	Absent	19	TC-2, TC-5, TC-7, TC-10, TC-21, TC-39, TC-46, TC-48, TC-50, TC-54, TC-61, TC-81, TC-83, TC-84, TC-85, TC-86, TC-88, TC-92 and TC-95
		Sparse	41	TC-1, TC-3, TC-4, TC-8, TC-9, TC-15, TC-17, TC-19, TC-22, TC-25, TC-30, TC-31, TC-32, TC-38, TC-40, TC-42, TC-44, TC-45, TC-47, TC-49, TC-53, TC-55, TC-56, TC-62, TC-63, TC-65, TC-67, TC-71, TC-72, TC-74, TC-75, TC-77, TC-80, TC-82, TC-87, TC-89, TC-90, TC-91, TC-93, TC-94 and TC-98
		Dense	32	TC-6, TC-11, TC-12, TC-14, TC-16, TC-18, TC -23, TC-24, TC-26, TC-27, TC-29, TC-33, TC-34, TC-36, TC-37, TC-41, TC-51, TC-52, TC-57, TC-58, TC-59, TC-60, TC-64, TC-66, TC-68, TC-69, TC-70, TC-73, TC-78, TC-79, TC-96 and TC-97
2.	Leaf colour	Light green	18	TC-1, TC-46, TC-47, TC-48, TC-49, TC-51, TC-54, TC-61, TC-62, TC-74, TC-75, TC-77, TC-84, TC-90, TC-92, TC-93, TC-95 and TC-98
		Medium green	9	TC-2, TC-4, TC-33, TC-42, TC-57, TC-79, TC-81, TC-89 and TC-91
		Dark green	24	TC-3, TC-9, TC-15, TC-22, TC-24, TC-26, TC-27, TC-32, TC-40, TC-56, TC-63, TC-64, TC-65, TC-66, TC-67, TC-68, TC-71, TC-72, TC-78, TC-82, TC-83, TC-85, TC-86 and TC-94
		Purple green	23	TC-5, TC-7, TC-10, TC-12, TC-14, TC-16, TC-19, TC-21, TC-23, TC-25, TC-30, TC-31, TC-34, TC-37, TC-41, TC-44, TC-45, TC-55, TC-69, TC-70, TC-73, TC-80, TC-87 and TC-96.
		Purple	17	TC-6, TC-8, TC-11, TC-17, TC-18, TC-29, TC-36, TC-38, TC-39, TC-50, TC-52, TC-53, TC-58, TC-59, TC-60, TC-88 and TC-97
3.	Dentation of leaf margin	Entire	15	TC-31, TC-33, TC-37, TC-41, TC-42, TC-44, TC-45, TC-48, TC-49, TC-51, TC-55, TC-57, TC-60, TC-87 and TC-92
		Auriculate	29	TC-1, TC-2, TC-5, TC-11, TC-16, TC-18, TC-29, TC-32, TC-34, TC-36, TC-38, TC-40, TC-46, TC-47, TC-52, TC-59, TC-62, TC-66, TC-67, TC-68, TC-70, TC-71, TC-74, TC-80, TC-82, TC-85, TC-88, TC-94 and TC-95
		Lyrate	35	TC-3, TC-4, TC-7, TC-9, TC-10, TC-12, TC-14, TC-17, TC-21, TC-22, TC-24, TC-26, TC-30, TC-50, TC-53, TC-54, TC-56, TC-58, TC-61, TC-63, TC-65, TC-69, TC-72, TC-73, TC-75, TC-77, TC-79, TC-81, TC-84, TC-86, TC-89, TC-91, TC-93, TC-96 and TC-97
		Pointed	13	TC-6, TC-8, TC-15, TC-19, TC-23, TC-25, TC-27, TC-39, TC-64, TC-78, TC-83, TC-90 and TC-98

4.	Petal colour	White	4	TC-2, TC-24, TC-33 and TC-50
		Cream	4	TC-42, TC-44, TC-59 and TC-78
		Light yellow	37	TC-6, TC-7, TC-9, TC-11, TC-12, TC-18, TC-21, TC-23, TC-25, TC-29, TC-30, TC-32, TC-34, TC-36, TC-37, TC-40, TC-45, TC-46, TC-49, TC-51, TC-55, TC-58, TC-60, TC-63, TC-65, TC-68, TC-71, TC-72, TC-79, TC-81, v-82, TC-86, TC-87, TC-88, TC-91, TC-93 and TC-98
		Yellow	42	TC-1, TC-3, TC-4, TC-5, TC-8, TC-10, TC-14, TC-15, TC-16, TC-17, TC-19, TC-22, TC-27, TC-31, TC-38, TC-39, TC-41, TC-47, TC-48, TC-52, TC-53, -54, TC-56, TC-57, TC-61, TC-62, TC-64, TC-66, TC-67, TC-69, TC-70, TC-73, TC-74, TC-75, TC-80, TC-83, TC-85, TC-89, TC-90, TC-92, TC-95 and TC-96
5.	Siliqua surface texture	Orange	5	TC-26, TC-77, TC-84, TC-94 and TC-97
		Smooth	11	TC-2, TC-7, TC-16, TC-18, TC-22, TC-33, TC-52, TC-62, TC-68, TC-91 and TC-93
		Intermediate	53	TC-1, TC-3, TC-4, TC-5, TC-6, TC-8, TC-9, TC-10, TC-11, TC-12, TC-19, TC-21, TC-24, TC-30, TC-36, TC-38, TC-39, TC-41, TC-42, TC-44, TC-46, TC-48, TC-49, TC-50, TC-51, TC-53, TC-54, TC-56, TC-57, TC-60, TC-61, TC-63, TC-64, TC-66, TC-67, TC-71, TC-72, TC-74, TC-75, TC-77, TC-80, TC-82, TC-83, TC-85, TC-86, TC-89, TC-90, TC-92, TC-94, TC-95, TC-96, TC-97 and TC-98
		Constricted	28	TC-14, TC-15, TC-17, TC-23, TC-25, TC-26, TC-27, TC-29, TC-31, TC-32, TC-34, TC-37, TC-40, TC-45, TC-47, TC-55, TC-58, TC-59, TC-65, TC-69, TC-70, TC-73, TC-78, TC-79, TC-81, TC-84, TC-87 and TC-88
6.	Siliqua density on main shoot	Low	12	TC-1, TC-4, TC-5, TC-10, TC-15, TC-19, TC-36, TC-59, TC-86, TC-87, TC-88 and TC-93
		Medium	32	TC-2, TC-3, TC-6, TC-7, TC-8, TC-9, TC-14, TC-16, TC-17, TC-18, TC-22, TC-25, TC-27, TC-29, TC-31, TC-32, TC-33, TC-38, TC-45, TC-46, TC-49, TC-51, TC-56, TC-60, TC-65, TC-71, TC-74, TC-81, TC-82, TC-89, TC-96 and TC-97
		High	48	TC-11, TC-12, TC-21, TC-23, TC-24, TC-26, TC-30, TC-34, TC-37, TC-39, TC-40, TC-41, TC-42, TC-44, TC-47, TC-48, TC-50, TC-52, TC-53, TC-54, TC-55, TC-57, TC-58, TC-61, TC-62, TC-63, TC-64, TC-66, TC-67, TC-68, TC-69, TC-70, TC-72, TC-73, TC-75, TC-77, TC-78, TC-79, TC-80, TC-83, TC-84, TC-85, TC-90, TC-91, TC-92, TC-94, TC-95 and TC-98
7.	Siliqua angle with main shoot	Appressed	18	TC-3, TC-4, TC-6, TC-8, TC-15, TC-24, TC-31, TC-37, TC-38, TC-44, TC-45, TC-46, TC-52, TC-53, TC-56, TC-58, TC-70 and TC-90
		Semi appressed	44	TC-1, TC-2, TC-5, TC-9, TC-11, TC-12, TC-14, TC-16, TC-18, TC-21, TC-23, TC-25, TC-26, TC-27, TC-29, TC-30, TC-33, TC-34, TC-40, TC-41, TC-47, TC-49,

	Open	30	TC-50, TC-51, TC-54, TC-55, TC-57, TC-60, TC-61, TC-64, TC-67, TC-68, TC-72, TC-75, TC-77, TC-78, TC-79, TC-81, TC-84, TC-87, TC-92, TC-96, TC-97 and TC-98 TC-7, TC-10, TC-17, TC-19, TC-22, TC-32, TC-36, TC-39, TC-42, TC-48, TC-59, TC-62, TC-63, TC-65, TC-66, TC-69, TC-71, TC-73, TC-74, TC-80, TC-82, TC-83, TC-85, TC-86, TC-88, TC-89, TC-91, TC-93, TC-94 and TC-95	
8.	Seed colour	Yellow	2	TC-6 and TC-54
		Dull grey	16	TC-7, TC-11, TC-16, TC-18, TC-22, TC-26, TC-29, TC-32, TC-40, TC-44, TC-59, TC-60, TC-61, TC-67, TC-95 and TC-96
		Reddish-brown	37	TC-1, TC-2, TC-5, TC-8, TC-10, TC-23, TC-24, TC-31, TC-33, TC-36, TC-37, TC-38, TC-39, TC-41, TC-45, TC-47, TC-48, TC-49, TC-50, TC-51, TC-53, TC-58, TC-63, TC-64, TC-68, TC -73, TC-75, TC-77, TC-78, TC-79, TC-80, TC-81, TC-83, TC-88, TC-93, TC-97 and TC-98
		Brown	28	TC-4, TC-9, TC-12, TC-15, TC-17, TC-21, TC-25, TC-27, TC-30, TC-34, TC-52, TC-55, TC-56, TC-57, TC-62, TC-66, TC-69, TC-70, TC-71, TC-74, TC-82, TC-84, TC-86, TC-87, TC-89, TC-90, TC-92 and TC-94
		Black	9	TC-3, TC-14, TC-19, TC-42, TC-46, TC-65, TC-72, TC-85 and TC-91

(>50) and remaining 39 lines had few siliqua on the main shoot (<30). Moreover, most of the accessions possessed short siliqua length (<4.5 cm). A large number of rapeseed-mustard germplasm were also evaluated and characterized for various agro-morphological traits and biotic stresses by Misra and Kumar (2009). In the present study, 12 lines were having few number of seeds/siliqua (<11), 62 lines recorded intermediate number of seeds/siliqua (11-20) and 18 lines exhibited many seeds/siliqua (>20). Medium seed size (3.0-4.0 g) was most common and observed in 52 lines. Seed yield/plant grouped all the germplasm into 2 categories viz., low (<10.0 g) and medium (10.0-20.0 g) of which 32 lines were grouped into low and remaining 60 in medium. Singh (2004), Usman *et al.* (2007), Iqbal *et al.* (2008) and Neeru (2013) also reported adequate variability for days to flowering, days to maturity, plant height, primary branches/plant, secondary branches/plant, siliquae number/plant, seeds/siliqua, 1000-seed weight and seed yield/plant in Indian mustard. Similarly, Zada *et al.* (2013) reported sufficient genetic variation in 134 germplasm collections of Ethiopian mustard on the

basis of characterization for 33 agro-morphological characters ranging from seedling emergence to crop maturity. In the present study on the basis of oil content, majority of the lines (65 lines) were characterized with medium oil content (38-42%) while, remaining 27 lines were having high oil content (43-46 %). Similarly, Misra and Kumar (2009) also evaluated and characterized a large number of rapeseed and mustard germplasm and revealed least variability for oil content.

Qualitative traits like leaf hairiness, leaf colour, dentation of leaf margin and petal colour were examined 45-50 days after sowing. Similarly, traits like siliqua surface texture, siliqua density on main shoot, siliqua angle with stem and seed colour were recorded at the time of maturity. Characterization and classification of all the toria accessions on the basis of qualitative traits has been given in Table 2. The differences for leaf hairiness grouped all the accessions into 3 categories (dense, sparse and absent) and revealed that hairs were absent on the leaves of 19 accessions, whereas 41 and 32 accessions were having sparse and dense leaf hairs,

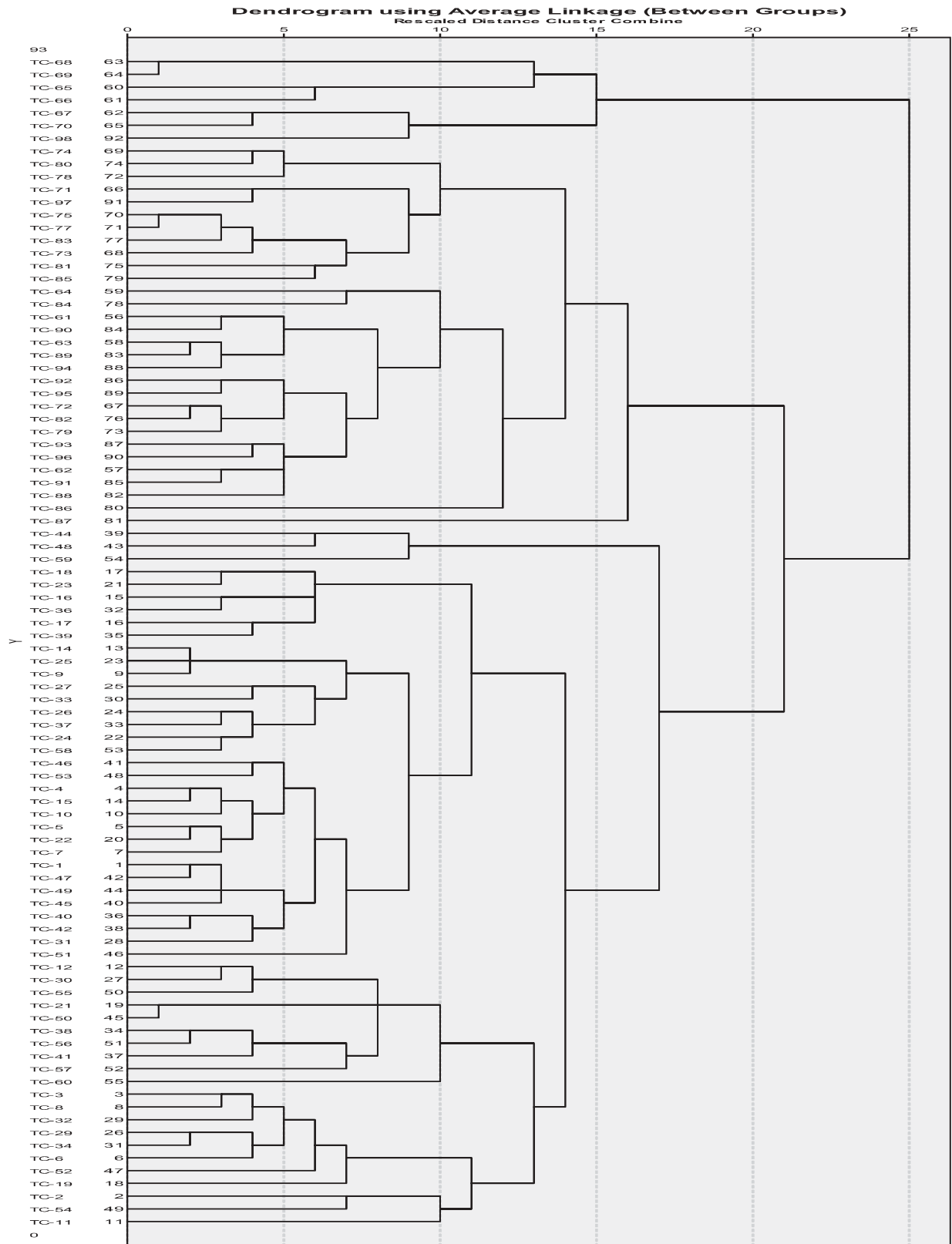


Fig. 1: Dendrogram showing the genetic distances amongst different Toria accessions

respectively. Leaf colour of more than 40% lines was dark and purple green, whereas 17 lines were having purple leaves. Lyrate dentation of leaf margin was the most common followed by auriculate type. Yellow and light yellow colour was pre dominant for petals, whereas 5 lines had white petal colour. On the basis of siliqua surface texture all the accessions were classified into three categories viz., intermediate (53 lines), constricted (28 lines) while, 11 lines had smooth siliqua surface texture. Siliqua density was found high in 48 lines, whereas, 12 lines had low and remaining 32 lines had medium siliqua density on the main shoot. Semi-appressed siliqua angle with main shoot was most common in the germplasm (44 lines) followed by open (30) and appressed type (18 lines). Seed coat colour divided all the accessions into five categories (yellow in 2 lines, dull grey in 16, reddish-brown in 37 lines, brown in 28 lines and black in 9 lines). Similar results were also observed by Yadav *et al.* (2013) in Indian mustard.

The hybridization among diverse parents is likely to produce heterotic hybrids and desirable transgressive segregants in further generations. So it is quite imperative to utilize the most diverse parents in crossing programmes of traits combination breeding in toria. The association among different accessions is presented in the form of dendrogram (Fig.1) prepared using rescaled distances. The accessions which are lying nearer to each other in the dendrogram are more similar to one another than those lying apart. The resemblance co-efficient between the two accessions is the value at which their branches join. The dendrogram also shows the relative magnitude of resemblance among the toria accessions in different clusters. Interestingly, the accession TC-11 found the farthest place from TC-68 meaning thereby that they had maximum genetic distance between them. Likewise the positional distances between all the accessions on X-axis represent the genetic distances between these accessions and use of the accessions with maximum genetic distance is advocated in crossing programmes to develop toria varieties/populations with desirable combination of traits in them.

As the success in the improvement of a crop both qualitatively and quantitatively, and the development

of a species requires the availability and accessibility of genetic diversity, therefore, the characterization of germplasm will provide valuable information for strengthening of future breeding programme on toria. Since the breeding strategies in this crop need to exploit the existing variation in the germplasm, it will also be helpful in formation of data base and reference lines/core collection for further use and maintaining genetic purity of the toria accessions.

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