*Journal of Applied and Natural Science* 9 (2): 805 - 811 (2017)

JANS

# Characterization and categorization of Indian mustard genotypes for agro-morphological traits

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*Received: October 9, 2016; Revised received: January 28, 2017; Accepted: April 24, 2017*

**Abstract:** A total of sixty genotypes and germplasm lines were evaluated and characterized for 14 quantitative and 8 qualitative traits in *Brassica juncea*. Observations were recorded on the basis of scores given in the DUS descriptor. Majority of accessions were very late in maturity and medium in flowering. No variability was observed for leaf length and leaf width. On the basis of branches, most of the genotypes were classified under intermediate category. Long main shoot length (31), medium number of siliquae on main shoot (46), medium density on main shoot (52), short siliqua length (51), very tall plant height (38), few numbers of seeds per siliqua (33), medium 1000-seed weight (38), medium seed yield per plant (32) and low oil content (40) were observed in most of the genotypes. For qualitative traits, most of the genotype showed dark green leaf color, sparse hairs, dentation of leaf margin lyrate type, open leaf growth habit, yellow petal color, semi-appressed siliqua angle with main shoot and intermediate siliqua surface texture. Wide (Yellow, Dull grey, Reddish brown, Brown and Black) diversity has been observed for seed color.

**Keywords:** Categorization, Characterization, Genotype, Indian mustard, Morphological traits

## INTRODUCTION

Indian mustard (*Brassica juncea* L. Czern and Coss) is an annual species belonging to family Brassicaceae and amongst the most important species of seven cultivated oilseeds of India. Rapeseed and mustard (Brassica sp.) group of crops constitute the largest group of edible oil producing crops in India. In 2012-13, these crops accounted for 22 % of the total acreage and 24.2 % to the total oilseed production (Thakur *et al.* 2015).

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. The oil of rapeseed and mustard is used as the main medium for cooking throughout eastern India and parts of northern India. The oil is used as condiments in preparation of pickles and for flavoring curriest vegetables. It is also used for preparation of hair oils and medicines. Oilseed cake is used for cattle feed and manure. The demand for oils and fats is increasing in India due to growing population and increasing rate of consumption (Gupta, 2009).

Plant genetic resources or germplasm are the key point of any agriculture production system. Genetic resource provides basic raw materials to crop improvement programmes. The success as well as pace of varietal development programmes depends upon available genetic variability for utilization. Characterization and evaluation are important activities under plant genetic resources programmes. Germplasm should preferably be evaluated for important morpho-agronomic traits under different agro-climatic conditions and the systematic evaluation for various morpho-agronomic, quality traits, biotic and abiotic stresses, resulted in the identification of donors for use in the varietal improvement programme (Misra, 2008). Characterization for the classification of germplasm 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 (Avtar *et al.,* 2016). Therefore, keeping in view the above points, present investigation was undertaken to characterize the genotypes of Indian mustard on the basis of qualitative and quantitative morphological characters.

## MATERIALS AND METHODS

The experimental material comprised of 60 genotypes (Table 1) of Indian mustard [*Brassica juncea* (L.) Czern and Coss)] being maintained in the Oilseeds Section Department of Genetics and Plant Breeding, CCS HAU, Hisar. The material was planted in

ISSN : 0974-9411 (Print), 2231-5209 (Online)  

randomized block design with three replications at Research Farm, CCS HAU, Hisar. Each genotype was grown in a plot size of 1.5 x 3 m with a spacing 30 and 10 cm row to row and plant to plant respectively. All the recommended package of practices was followed to raise a good crop. Observations were recorded on 14 quantitative traits 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 per leaf [Few (1-2), Medium (3-5), Many (> 5)] leaf length (cm) [Short (< 15 cm), Medium (15-20 cm), Long (> 20 cm)], leaf width (cm) [Narrow (< 7 cm), Medium (7-8 cm), Broad (> 8 cm)], days to 50 % flowering [Very early (< 31 days), Early (31-40 days), Medium (41-50 days), Late (51-60 days), Very late (> 60 days)], days to maturity [Early (< 111 days ), Medium (111-130 days), Late (131-150 days), Very late (> 150 days)], plant height (cm) [Short (< 51 cm), Medium (51-75 cm), Tall (151-200 cm) Very tall (> 200 cm)], primary branches per plant [Few (1-4), Intermediate (5-10), Many (> 10)], secondary branches per plant [Few (1-7), Intermediate (8-14), Many (> 14)], main shoot length (cm) [Short (< 41 cm), Medium (41-60 cm), Long (> 60 cm)], number of siliquae on main shoot [Few (< 30), Medium (30-50), Many (> 50)], siliqua density on main shoot [Low (<0.7), Medium (0.7-0.8), high (>0.8)], Siliqua length (cm) [Short (< 4.5 cm), Medium (4.5-5.5), Long (> 5.5 cm)], number of seeds per siliqua [Few (< 11), Intermediate (11-20), Many (> 20)], 1000-seed weight (g) [Low (< 3.0 g), Medium (3.0-5.0 g), High (> 5.0 g)], seed yield per plant (g) [Low (< 10 g), Medium (10-20 g), High (> 20 g)], oil content (%) [ Low (<38%), Medium (38-42%), High (43-46%), Very high (> 46%)] and 8 qualitative traits *viz.* leaf hairiness [1-absent, 3-sparse, 7-dense], leaf color [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], leaf growth habit (angle b/w stem & petiole) [1-erect (>85$^0$), 3-semi-erect (66-85$^0$), 5-open (46-65$^0$), 7-semi-prostrate (31-45$^0$), 9-prostrate (<31$^0$)], petal color [1-white, 2-cream, 3-light yellow, 4-yellow, 5-orange], siliqua surface texture [1-smooth, 2-intermediate, 3-constricted], siliqua angle with main shoot [3-appressed (<0.8cm), 5-semi-appressed (0.8-1.2cm), 7-open (>1.2cm)] and seed color [1-yellow, 2-dull grey, 3-reddish brown, 4-brown, 5-black]. The oil content of seeds was determined by the method of AOAC (1995). All the 60 accessions were categorized into different distinct classes according to scores given in the DUS descriptor and dendrogram was prepared to form dif-

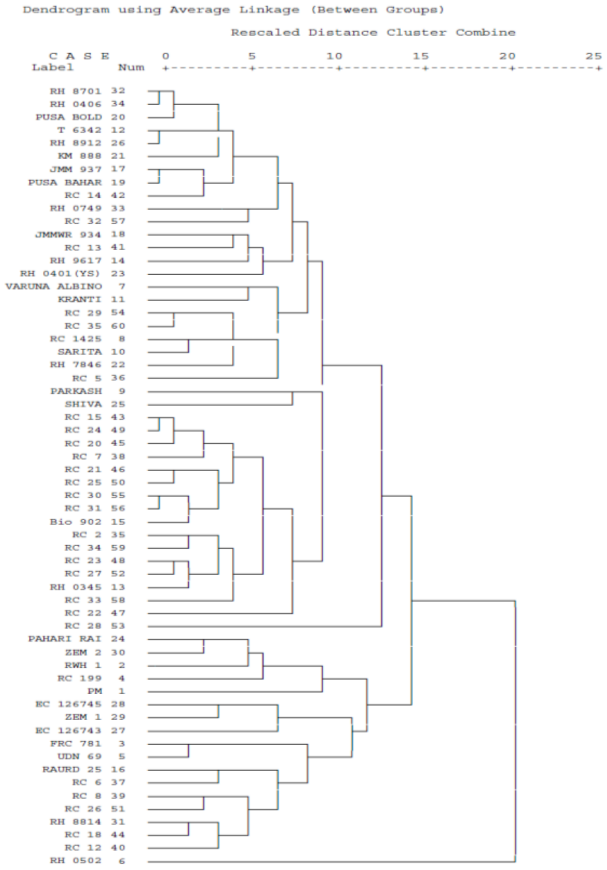


**Fig. 1.** *Dendrogram showing the clustering pattern of different Indian mustard genotypes.*

**Table 1.** List of 60 genotypes of Indian mustard.

| S. No. | Genotypes | S. No. | Genotypes | S. No. | Genotypes | S. No. | Genotypes |
|---|---|---|---|---|---|---|---|
| 1 | Purple mutant | 16 | RAURD-25 | 31 | RH-8814 | 46 | RC-21 |
| 2 | RWH-11 | 17 | JMM-937 | 32 | RH-8701 | 47 | RC-22 |
| 3 | RC-781 | 18 | JMMWR-9348 | 33 | RH-0749 | 48 | RC-23 |
| 4 | RC-199 | 19 | Pusa bahar | 34 | RH-0406 | 49 | RC-24 |
| 5 | UDN-69 | 20 | Pusa bold | 35 | RC-2 | 50 | RC-25 |
| 6 | RH-0502 | 21 | KM-888 | 36 | RC-5 | 51 | RC-26 |
| 7 | Varuna albino | 22 | RH-7846 | 37 | RC-6 | 52 | RC-27 |
| 8 | RC-1425 | 23 | RH-0401 (YS) | 38 | RC-7 | 53 | RC-28 |
| 9 | Parkash | 24 | Pahari rai | 39 | RC-8 | 54 | RC-29 |
| 10 | Sarita | 25 | Shiva | 40 | RC-12 | 55 | RC-30 |
| 11 | Kranti | 26 | RH-8912 | 41 | RC-13 | 56 | RC-31 |
| 12 | T-6342 | 27 | EC-126743 | 42 | RC-14 | 57 | RC-32 |
| 13 | RH-0345 | 28 | EC-126745 | 43 | RC-15 | 58 | RC-33 |
| 14 | RH-9617 | 29 | ZEM-1 | 44 | RC-18 | 59 | RC-34 |
| 15 | BIO-902 | 30 | ZEM-2 | 45 | RC-20 | 60 | RC-35 |

**Table 2.** Characterization and categorization of different Indian mustard genotypes based on 16 quantitative traits.

| S.N | Traits | Categories | No. of genotypes | Name of genotypes |
|---|---|---|---|---|
| 1 | No. of lobe/plant | Few (1-2) | - | |
| | | Medium (3-5) | 8 | ZEM-1, RC-12, RC-15, RC-18, RC-20, RC-22, RC-23, RC-35. |
| | | Many (> 5) | 52 | Purple mutant, RWH-1, RC-781, RC-199, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, T-6342, RH-0345, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusa bahar, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Paharirai, Shiva, RH-8912, EC-126743, EC-126745, ZEM -2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-8, RC-13, RC-14, RC-21, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-34. |
| 2 | Leaf length (cm) | Short (< 15 cm) | - | |
| | | Medium (15-20 cm) | - | |
| | | Long (> 20 cm) | 60 | Purple mutant, RWH-1, RC-781, RC-199, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, T-6342, RH-0345, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Paharirai, Shiva, RH-8912, EC-126743, EC-126745, ZEM -1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-8, RC-12, RC-13, RC-14, RC-15, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-34, RC-35. |
| 3 | Leaf width (cm) | Narrow (< 7 cm) | - | |
| | | Medium (7-8 cm) | - | |
| | | Broad (> 8 cm) | 60 | Purple mutant, RWH-1, RC-781, RC-199, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, T-6342, RH-0345, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Paharirai, Shiva, RH-8912, EC-126743, EC-126745, ZEM -1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-8, RC-12, RC-13, RC-14, RC-15, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-34, RC-35. |
| 4 | Days to 50% flow-ering | Very early (< 31 days) | - | |
| | | Early (31-40 days) | - | |
| | | Medium (41-50 days) | 36 | Kranti, T-6342, RH-0345, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, RH-0401 (YS), RH-8814, RH-8814, RH-8701, RH-0749, RH-0406, RC-6, RC-7, RC-8, RC-12, RC-13, RC-14, RC-15, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-26, RC-27, RC-29, RC-30, RC-32, RC-33, RC-34. |
| | | Late (51-60 days) | 12 | RH-0502, Varuna albino, RC-1425, Sarita, KM-888, RH-7846, Shiva, RH-8912, RC-2, RC-28, RC-31, RC-35. |
| | | Very late (> 61 days) | 12 | Purple mutant, RWH-1, RC-781, RC-199, UDN-69, Parkash, Pahari rai, EC-126743, EC-126745, ZEM-1, ZEM-2, RC-5. |
| 5 | Days to maturity | Early (< 111 days) | - | |
| | | Medium (111-130 days) | - | |
| | | Late ( 131-150 days) | 3 | RC-32, RC-33, RC-34 |
| | | Very late (> 150 days) | 57 | Purple mutant, RWH-1, RC-781, RC-199, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, T-6342, RH-0345, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Pahari rai, Shiva, RH-8912, EC-126743, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-8, RC-12, RC-13, RC-14, RC-15, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31, RC-35. |
| 6 | Plant height | Short (< 51 cm) | - | |
| | | Medium (51-75 cm) | - | |
| | | Tall (151-200 cm) | 22 | RH-0502, Parkash, RH-0345, BIO-902, JMM-937, Pusabahar, Shiva, RH-8701, RC-7, RC-14, RC-15, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-27, RC-30, RC-31, RC-33, RC-34 |
| | | Very tall (> 200cm) | 38 | Purple mutant, RWH-1, RC-781, RC-199, UDN-69, Varuna albino, RC-1425, Sarita, Kranti, T-6342, RH-9617, RAURD-25, JMMWR-9348, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Pahari rai, RH-8912, EC-126743, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-8, RC-12, RC-13, RC-18, RC-26, RC-28, RC-29, RC-32, RC-35. |
| 7 | Primary branches/ plant | Few (1-4) | 3 | RH-8701, RH-0749, RC-22. |
| | | Intermediate (5-10) | 53 | Purple mutant, RWH-1, RC-781, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, T-6342, RH-0345, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Pahari rai, Shiva, RH-8912, EC-126743, EC-126745, ZEM-1, ZEM-2, RH -8814, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-8, RC-15, RC-18, RC-20, RC-21, RC-23, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-34, RC-35. |
| | | Many (> 10) | 4 | RC-199, RC-12, RC-13, RC-14. |

Contd.....

| | | | | |
|---|---|---|---|---|
| 8 | Secondary branches/ plant | Few (1-7) | - | |
| | | Intermediate (8-14) | 49 | Purple mutant, RC-781, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, T-6342, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Shiva, RH-8912, EC-126743, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-6, RC-8, RC-12, RC-13, RC-14, RC-15, RC-18, RC-20, RC-21, RC-23, RC-25, RC-26, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-34, RC-35. |
| | | Many (> 14) | 11 | RWH-1, RC-199, Kranti, RH-0345, Pusabahar, Pahari rai, RC-5, RC-7, RC-22, RC-24, RC-27. |
| 9 | Main shoot length (cm) | Short (< 41 cm) | - | |
| | | Medium (41-60 cm) | 29 | Purple mutant, RWH-1, RC-781, RH-0502, Varuna albino, RC-1425, Kranti, BIO-902, JMMWR-9348, KM-888, RH-7846, RH-0401 (YS), Pahari rai, RC-2, RC-5, RC-7, RC-12, RC-20, RC-21, RC-22, RC-23, RC-24, RC-28, RC-29, RC-30, RC-31, RC-33, RC-34, RC-35. |
| | | Long (> 60 cm) | 31 | RC-199, UDN-69, Parkash, Sarita, T-6342, RH-0345, RH-9617, RAURD-25, JMM-937, Pusabahar, Pusa bold, Shiva, RH-8912, EC-126743, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-6, RC-8, RC-13, RC-14, RC-15, RC-18, RC-25, RC-26, RC-27, RC-32. |
| 10 | No. of siliquae on main shoot | Few (< 30) | 6 | RH-0401 (YS), Shiva, EC-126745, RC-15, RC-20, RC-34. |
| | | Medium (30-50) | 46 | Purple mutant, RWH-1, Varuna albino, RC-1425, Parkash, Sarita, Kranti, T-6342, RH -0345, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-7846, Pahari rai, RH-8912, EC-126743, ZEM-1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-13, RC-14, RC-21, RC-22, RC-23, RC-24, RC-25, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC -33, RC-35. |
| | | Many (> 50 cm) | 8 | RC-781, RC-199, UDN-69, RH-0502, RC-8, RC-12, RC-18, RC-26. |
| 11 | Siliquae density on main shoot | Low (<0.7) | 2 | UDN-69, RH-0502. |
| | | Medium (0.7-0.8) | 52 | Purple mutant, RWH-1, RC-781, RC-199, Varuna albino, RC-1425, Sarita, Kranti, T-6342, RH-0345, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-7846, Pahari rai, RH-8912, EC-126743, ZEM-1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-8, RC-12, RC-13, RC-14, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-34, RC-35. |
| | | High (>0.8) | 6 | Parkash, RH-9617, RH-0401 (YS), Shiva, EC-126745, RC-15. |
| 12 | Siliqua length (cm) | Short (< 4.5 cm) | 51 | Purple mutant, RWH-1, RC-781, RC-199, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, BIO-902, RAURD-25, JMMWR-9348, Pusabahar, RH-0401 (YS), Pahari rai, RH-8912, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-8, RC-12, RC-13, RC-14, RC-15, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-34, RC-35. |
| | | Medium (4.5-5.5 cm) | 9 | T-6342, RH-0345, RH-9617, JMM-937, Pusa bold, KM-888, RH-7846, Shiva, EC-126743. |
| | | Long (> 5.5 cm) | - | |
| 13 | No. of seeds/ siliqua | Few (< 11) | 33 | RWH-1, RH-0502, RC-1425, Parkash, Sarita, Kranti, BIO-902, RAURD-25, JMM-937, JMMWR-9348, RH-7846, RH-0401 (YS), Pahari rai, Shiva, RH-8912, EC-126743, EC-126745, ZEM-2, RH-8701, RC-6, RC-7, RC-14, RC-15, RC-20, RC-22, RC-23, RC-24, RC-25, RC-26, RC-28, RC-29, RC-31, RC-35. |
| | | Intermediate (11-20) | 27 | Purple mutant, RC-781, RC-199, UDN-69, Varuna albino, T-6342, RH-0345, RH-9617, Pusabahar, Pusa bold, KM-888, ZEM-1, RH-8814, RH-0749, RH-0406, RC-2, RC-5, RC-8, RC-12, RC-13, RC-18, RC-21, RC-27, RC-30, RC-32, RC-33, RC-34. |
| | | Many (> 20) | - | |
| 14 | 1000-seed weight | Low (< 3.0 g) | 12 | RC-199, EC-126743, RC-2, RC-12, RC-20, RC-21, RC-22, RC-24, RC-25, RC-27, RC-32, RC-33. |
| | | Medium (3.0-5.0 g) | 38 | Purple mutant, RWH-1, RC-781, UDN-69, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, T-6342, BIO-902, RAURD-25, JMM-937, JMMWR-9348, RH-7846, Pahari rai, RH-8912, EC-126745, ZEM-1, ZEM-2, RH-8701, RC-5, RC-6, RC-7, RC-8, RC-13, RC-14, RC-15, RC-18, RC-23, RC-26, RC-28, RC-29, RC-30, RC-31, RC-34, RC-35. |
| | | High (> 5.0 g) | 10 | RH-0345, RH-9617, Pusabahar, Pusa bold, KM-888, RH-0401 (YS), Shiva, RH-8814, RH-0749, RH-0406. |
| 15 | Seed yield/plant (g) | Low (> 10 g) | 7 | Parkash, RH-7846, RH-0749, RC-7, RC-20, RC-28, RC-32. |
| | | Medium (10-20 g) | 32 | Purple mutant, RC-1425, Sarita, RH-0345, BIO-902, RAURD-25, Pahari rai, Shiva, EC-126743, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-8701, RH-0406, RC-2, RC-5, RC-6, RC-8, RC-15, RC-21, RC-22, RC-23, RC-24, RC-26, RC-27, RC-29, RC-30, RC-31, RC-33, RC-34, RC-35. |
| | | High (> 20 g) | 21 | RWH-1, RC-781, RC-199, UDN-69, RH-0502, Varuna albino, Kranti, T-6342, RH-9617, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-0401 (YS), RH-8912, RC-12, RC-13, RC-14, RC-18, RC-25. |
| 16 | Oil content (%) | Low (< 38) | 40 | Purple mutant, RWH-1, RC-781, UDN-69, Varuna albino, RC-1425, Parkash, Sarita, RH-0345, RH-9617, RAURD-25, JMMWR-9348, RH-7846, Pahari rai, RH-8912, EC-126743, EC-126745, ZEM-1, RH-8814, RC-6, RC-7, RC-8, RC-12, RC-13, RC-14, RC-15, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-26, RC-27, RC-28, RC-29, RC-32, RC-33, RC-34, |
| | | Medium (38-42) | 20 | RC-199, RH-0502, Kranti, T-6342, BIO-902, JMM-937, Pusabahar, Pusa bold, KM-888, RH-0401 (YS), Shiva, ZEM-2, RH-8701, RH-0749, RH-0406, RC-2, RC-5, RC-30, RC-31, RC-35. |
| | | High (43-46) | - | |
| | | Very high (> 46) | - | |

**Table 3.** Characterization and categorization of different Indian mustard genotypes based on qualitative traits.

| S.N | Categories | Categories | No. of geno-types | Name of genotypes |
|---|---|---|---|---|
| 1 | Leaf hairiness | Absent | 10 | RH-0502, Kranti, T-6342, RAURD-25, Pusa bold, EC-126745, RC-8, RC-12, RC-15, RC-22. |
| | | Sparse | 30 | RWH-1, RC-199, Varuna albino, RC-1425, Parkash, Sarita, RH-0345, RH-9617, BIO-902, JMM-937, Pusabahar, KM-888, RH-7846, RH-0401 (YS), Pahari rai, Shiva, RH-8912, EC-126743, ZEM-1, ZEM-2, RH-8814, RC-5, RC-20, RC-21, RC-24, RC-25, RC-26, RC-29, RC-30, RC-35. |
| | | Dense | 20 | Purple mutant, RC-781, UDN-69, JMMWR-9348, RH-8701, RH-0749, RH-0406, RC-2, RC-6, RC-7, RC-13, RC-14, RC-18, RC-23, RC-27, RC-28, RC-31, RC-32, RC-33, RC-34. |
| 2 | Leaf color | Light green | 21 | RC-781, T-6342, BIO-902, Pusabahar, RH-8912, EC-126743, RC -8, RC-14, RC-15, RC-21, RC-23, RC-24, RC-25, RC-27, RC-28, RC-29, RC-30, RC-31, RC-32, RC-33, RC-35. |
| | | Medium green | 1 | UDN-69, |
| | | Dark green | 37 | Purple mutant, RWH-1, RC-199, RH-0502, Varuna albino, RC-1425, Parkash, Sarita, Kranti, RH-0345, RH-9617, RAURD-25, JMM-937, JMMWR-9348, Pusa bold, KM-888, RH-7846, RH-0401 (YS), Pahari rai, Shiva, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-0749, RH-0406, RC-2, RC-5, RC-6, RC-7, RC-12, RC-13, RC-18, RC-20, RC-22, RC-26, RC-34. |
| | | Purple green | 1 | RH-8701, |
| | | Purple | - | |
| 3 | Dentation of leaf margin | Entire | - | |
| | | Auriculate | 18 | Purple mutant, RH-0502, RC-1425, Sarita, RH-0345, RH-9617, JMMWR-9348, Pusabahar, KM-888, RH-7846, ZEM-2, RH-8814, RC-6, RC-12, RC-13, RC-18, RC-23, RC-30. |
| | | Lyrate | 25 | RWH-1, RC-199, Varuna albino, RH-0401 (YS), EC-126743, ZEM-1, RH-0749, RH-0406, RC-2, RC-5, RC-7, RC-8, RC-14, RC-15, RC-20, RC-21, RC-22, RC-24, RC-25, RC-26, RC-28, RC-29, RC-31, RC-32, RC-34. |
| | | Pointed | 17 | RC-781, UDN-69, Parkash, Kranti, T-6342, BIO-902, RAURD-25, JMM-937, Pusa bold, Pahari rai, Shiva, RH-8912, EC-126745, RH-8701, RC-27, RC-33, RC-35. |
| 4 | Leaf growth habit (angle b/w stem and petiole) | Erect | - | |
| | | Semi-erect | 27 | UDN-69, RH-0502, Kranti, T-6342, RH-0345, RH-9617, RAURD-25, JMM-937, RH-7846, RH-0401 (YS), Pahari rai, Shiva, EC-126743, EC-126745, RH-8814, RH-8701, RC-5, RC-7, RC-8, RC-12, RC-14, RC-15, RC-18, RC-24, RC-25, RC-26, RC-29. |
| | | Open | 29 | Purple mutant, RC-781, Varuna albino, RC-1425, BIO-902, JMMWR-9348, Pusabahar, Pusa bold, KM-888, RH-8912, ZEM-1, ZEM-2, RH-0749, RH-0406, RC-2, RC-6, RC-13, RC-20, RC-21, RC-22, RC-23, RC-27, RC-28, RC-30, RC-31, RC-32, RC-33, RC-34, RC-35. |
| | | Semi-prostrate | 4 | RWH-1, RC-199, Parkash, Sarita. |
| | | Prostrate | - | |
| 5 | Petal color | White | 2 | Purple mutant, Varuna albino. |
| | | Cream | - | |
| | | Light yellow | 24 | RC-199, UDN-69, RH-0502, T-6342, RH-0345, RH-7846, RH-0401 (YS), Pahari rai, RH-8912, ZEM-1, ZEM-2, RH-8701, RC-2, RC-7, RC-8, RC-12, RC-13, RC-14, RC-26, RC-27, RC-28, RC-29, RC-30, RC-31. |
| | | Yellow | 34 | RWH-1, RC-781, RC-1425, Parkash, Sarita, Kranti, RH-9617, BIO-902, RAURD-25, JMM-937, JMMWR-9348, Pusabahar, Pusa bold, KM-888, Shiva, EC-126743, EC-126745, RH-8814, RH-0749, RH-0406, RC-5, RC-6, RC-15, RC-18, RC-20, RC-21, RC-22, RC-23, RC-24, RC-25, RC-32, RC-33, RC-34, RC-35. |
| | | Orange | - | |
| 6 | Siliqua surface texture | Smooth | 2 | RC-29, RC-30. |
| | | Intermediate | 30 | RC-199, RH-0502, RC-1425, Parkash, T-6342, BIO-902, RAURD-25, JMM-937, KM-888, RH-7846, RH-0401 (YS), EC-126743, EC-126745, ZEM-1, RH-0406, RC-2, RC-6, RC-7, RC-13, RC-15, RC-18, RC-20, RC-21, RC-22, RC-26, RC-27, RC-31, RC-32, RC-33, RC-34. |
| | | Constricted | 28 | Purple mutant, RWH-1, RC-781, UDN-69, Varuna albino, Sarita, Kranti, RH-0345, RH-9617, JMMWR-9348, Pusabahar, Pusa bold, Pahari rai, Shiva, RH-8912, ZEM-2, RH-8814, RH-8701, RH-0749, RC-5, RC-8, RC-12, RC-14, RC-23, RC-24, RC-25, RC-28, RC-35. |

Contd.….

| | | | | |
|---|---|---|---|---|
| 7 | Siliqua angle with main shoot | Appressed | 11 | RH-0502, Kranti, RH-0345, RAURD-25, JMM-937, RH-0749, RC-2, RC-5, RC-23, RC-30, RC-34. |
| | | Semi-appressed | 33 | RWH-1, RC-781, RC-199, Varuna albino, RC-1425, Parkash, Sarita, T-6342, RH-9617, JMMWR-9348, Pusabahar, RH-0401 (YS), EC-126743, EC-126745, ZEM-1, ZEM-2, RH-8814, RH-0406, RC-6, RC-7, RC-12, RC-13, RC-15, RC-18, RC-20, RC-21, RC-22, RC-24, RC-26, RC-29, RC-31, RC-32, RC-35. |
| | | Open | 16 | Purple mutant, UDN-69, BIO-902, Pusa bold, KM-888, RH-7846, Pahari rai, Shiva, RH-8912, RH-8701, RC-8, RC-14, RC-25, RC-27, RC-28, RC-33. |
| 8 | Seed color | Yellow | 6 | JMM-937, RH-0401 (YS), EC-126743, EC-126745, ZEM-1, ZEM-2, |
| | | Dull grey | 11 | RH-0502, RH-0345, JMMWR-9348, Pusabahar, KM-888, Pahari rai, RH-0749, RH-0406, RC-21, RC-24, RC-25. |
| | | Reddish brown | 19 | RC-781, RC-199, Varuna albino, Parkash, Sarita, BIO-902, Pusa bold, RH-7846, RH-8814, RH-8701, RC-8, RC-13, RC-14, RC-18, RC-26, RC-27, RC-28, RC-30, RC-34. |
| | | Brown | 12 | Purple mutant, UDN-69, RC-1425, Kranti, RC-5, RC-12, RC-15, RC-23, RC-29, RC-31, RC-32, RC-35. |
| | | Black | 12 | RWH-1, T-6342, RH-9617, RAURD-25, Shiva, RH-8912, RC-2, RC-6, RC-7, RC-20, RC-22, RC-33. |

ferent 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

**Characterization and categorization of different Indian mustard genotypes based upon quantitative characters:** The data on characterization and classification of Indian mustard genotypes for quantitative characters have been presented in Table 2. On the basis of lobes/leaf, all the genotypes were categorized into two distinct classes, 52 genotypes were observed to have many numbers of lobes per leaf and remaining 8 lines were having medium number of lobes per leaf. No variation was observed for leaf length and leaf width and all the genotypes were classified under long and broad leaf category. As far as 50 % flowering is concerned majority of genotypes (36) were grouped into medium category while, remaining 24 genotypes were grouped into late (12) and very late (12) category. In case of days to maturity, only 3 genotypes were late viz. RC 32, RC 33, RC 34 while remaining was very late. Data on plant height revealed that 22 genotypes were tall and 38 genotypes were very tall. On the basis of primary and secondary branches per plant most of the lines were classified under intermediate category. On the basis of main shoot length, all the genotypes were grouped into two categories i.e. 29 genotypes exhibited medium main shoot length and remaining 31 genotypes were having long main shoot. The few number of siliquae on main shoot were recorded in 6 genotypes, medium in 46 and many siliquae (> 50) in 8 genotypes. On the basis of siliqua density on main shoot, 52 genotypes were grouped into medium, 6 in high and 2 in low siliqua density category. The data on siliqua length revealed that 51 genotypes possessed short and 9 medium siliqua length. Thirty three genotypes were having few numbers of seeds (<11) while 27 genotypes were possessing intermediate number of seeds/siliqua. Similarly, on the basis of 1000-seed weight, 12 genotypes had very low, 38 genotypes had medium and remaining 10 genotypes had high 1000-grain weight. For seed yield/plant, 7 genotypes were grouped into low, 32 genotypes in medium and 21 genotypes in high seed yield/plant category. None of the genotypes had high oil content whereas, 40 genotypes were observed under low oil content category and remaining 20 genotypes under medium oil content category.

A large number of Indian -mustard (*Brassica juncea*) germplasm was also evaluated and characterized for various agro-morphological traits and biotic stresses by Misra and Kumar (2009). Singh (2004), Iqbal *et al.* (2008) and Misra *et al.,* 2010 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 and reported that the largest variation was observed for seed yield while a moderate variability was observed for plant height, glucosinolate contents and erucic acid. Yadav *et al.* (2013) characterized 78 genotype of Indian mustard for 34 morphological traits and observed maximum variability for leaf length, leaf width, leaf color and stem color.

**Characterization and categorization of different Indian mustard genotypes based on morphological traits:** The data on characterization and classification of Indian mustard genotypes for qualitative traits has been given in (Table 3). On the basis of leaf hairiness all the 60 genotypes grouped into three categories (absent, sparse and dense). The leaf hairs were absent in 10 genotypes and among the rest of genotypes, 30 were sparse and 20 were having dense leaf hairs. Leaves were light green of 21, medium green and pur-

ple green of one each and dark green of 37 genotypes. Lyrate dentation of leaf margin was the most common followed by auriculate and pointed type. None of the genotypes had erect leaf growth habit whereas, 27 had semi-erect twenty nine genotypes showed open type and 4 showed semi-prostrate type of leaf growth habit. Only 2 genotypes were white, 34 yellow and 24 were light yellow for petal color. On the basis of siliqua surface texture all the genotypes were classified into three categories viz., intermediate (30 lines), constricted (28 lines) while, and only 2 lines had smooth siliqua surface texture. Semi-appressed siliqua angle with main shoot was most common in the germplasm (33 lines) followed by open (16) and appressed type (11 lines). Seed coat color was found reddish brown in 19 genotypes, dull grey in 11 genotypes, yellow in 6 genotypes and brown and black each in 12 genotypes. Similar results were also reported by Yadav *et al.* (2013) and Avtar *et al.* (2016) in Indian mustard. The association among the different genotypes is presented in the form of dendrogram (Fig.1) prepared using rescaled distances. The genotypes which are lying nearer to each other in the dendrogram are more similar to one another than those lying apart. For example, the genotype RC-8701 was found at the farthest place from RC-0502 meaning thereby that they had maximum genetic distance between them. The resemblance coefficient between the two genotypes is the value at which their branches join. The dendrogram also showed the relative magnitude of resemblance among the genotypes in different clusters.

## Conclusion

The characterization helps the breeders to differentiate extent of variability within the available germplasm. The genetic variation identified by morphological characters can be exploited in future breeding programme. Thus, the characterization is an important prerequisite to evaluate phenotypic diversity within germplasm collections. It creates the basis to ensure effective utilization of the crop germplasm by the breeders otherwise unevaluated germplasm remain mere curiosities to the breeding programmes.

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