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AGRO-MORPHOLOGICAL CHARACTERIZATION OF *Brassica rapa* L. GERMPLASM FROM AZAD JAMMU AND KASHMIR

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ABSTRACT

Brassica rapa is an important crop of Azad Jammu and Kashmir which is a major source of vegetable and oil. The study was carried out to evaluate the genetic diversity among *Brassica rapa* germplasm grown in Azad Jammu and Kashmir based on their morphological characters and yield. The present study was carried out in the field of National Institute of Genomics and Advanced Biotechnology (NIGAB), NARC Islamabad from October 2017 to March 2018. The study showed great diversity among the germplasm for days to germination, primary branches, secondary branches, maturity, plant height, number of silique, seeds per silique, yield per plant and 1000 seed weight. The genotypes 026509, 026514 and 026548 showed maximum yield and other better morphological responses, so these genotypes should be used in future to enhance the production of this crop.

Key words: *Brassica rapa*, Kashmir, agro-morphological, characterization

INTRODUCTION

Brassica species belongs to the family *Brassicaceae*, are considered as important oilseed crop and hold third position in the oil seed crops of the world. Family *Brassiceae* includes mustard and rapeseed. This family consists of 51 genera and 37 species. *B. campestris* now renamed as *B. rapa* is local to Himalayan regions and was introduced to Asia [Jan et al. 2017]. Species of *Brassica* are characterized by diverse range of morphological and genetic varieties, suitable for cultivation under wide range of climatic conditions [Thakur et al. 2017]. India share 20.23% land area under cultivation of mustard crops and occupies first position among the mustard growing countries as food crops. In Pakistan, *Brassica* species are being grown on 305,000 ha land area with 251,000 ton oil production [PARC 2006].

Wide range of genetic and morphological diversity has been observed in *Brassica rapa* germplasm. *B. rapa* includes, early developing subspecies such as brown sarsoon, yellow sarsoon and toria [Prakash and Hinata 1980]. Genetic diversity of the *Brassica* species help in the food security and to meet agronomic production trials [Pervaiz et al. 2010]. Morphological traits, cytogenetic characterization and studies of molecular estimation are used to evaluate the variability and inconsistency in cultivars. Identification of morphological characters is the significant phase for the description of germplasm [Smýkal et al. 2008].

Morpho-molecular techniques also help in the selection of best existing varieties and also for the formation of new suitable variety in the varying agro-cli-

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matic conditions [Zhang et al. 2008]. Genetic diversity can be determined by using phenotypic qualities, but these can be affected by ecological factors such as altitudinal gradient, field moisture content, temperature and species association [Zhao et al. 2005]. *Brassica* species are being used as vegetables, fodder and for oil extraction in Azad Jammu and Kashmir. For quantitative characters the genetic diversity among locally collected *B. rapa* genotypes was carried out by Iqbal et al. [2015] and maximum variation were recorded. The traits likes' 1000-seed weight, seed yield/plant, plant height, main raceme length etc. showed maximum polymorphism.

Yet no significant studies have been carried out on Morphological characterization and genetic evaluation of mustard in Kashmir. The aim of the current research work was to identify different germplasm of *Brassica rapa* based upon morphological characteristics for the enhancement of production of mustard in AJ&K.

MATERIALS AND METHODS

Plant material. The plant material which contains 30 genotypes of *Brassica rapa* L. of Azad Jammu and Kashmir (AJ&K) was collected from the Plant Genetic Research Institute, NARC, Islamabad. The information about collected genotypes is in Table 1.

Morphological characterization. In order to determine the morphological diversity among *Brassica rapa* germplasm the seeds were sown with three replications. Proper irrigation was done when required, weeds were removed. Manure and fertilizer along with pesticide was applied. Data on selected morphological characters such as days to germination, number of primary branches/plant, secondary branches/plant, number of silique/plant, plant height, seeds/pod, length of silique, yield/plant and weight of 1000 seeds was recorded. The data was statistically analysed by using the software MSTATC [Steel et al. 1997] done by using cluster analysis.

RESULTS

A significant variation was present among the germplasm of *Brassica rapa* collected from different regions of Azad Jammu and Kashmir for all the agro-morphological characters.

Variation among germplasm on the base of days to germination. The days from sowing up to the germination were recorded for the different genotypes of *Brassica rapa.* It was observed that genotype 026532 took only 2 days for germination which was followed by the genotypes 026517, 026502, 026496, 026503 (3 days), while the two genotypes 026509 and 026557 showed very late germination (14 days). As the histogram shows that maximum number of genotypes (16) germinate in less than four days.

Days to flower initiation. The days for the initiation of flowers showed maximum diversity. The genotypes 026529 and 026499 showed early flower initiation and took (44 days), they were followed by the genotypes 026532 and 026496 (49 days). These genotypes were comparable with genotypes 026514 and 026563 which showed late flowering (96 days). Frequency dispersal data showed that maximum number of genotypes (26) acquired 46 to 65 days for the initiation of flower.

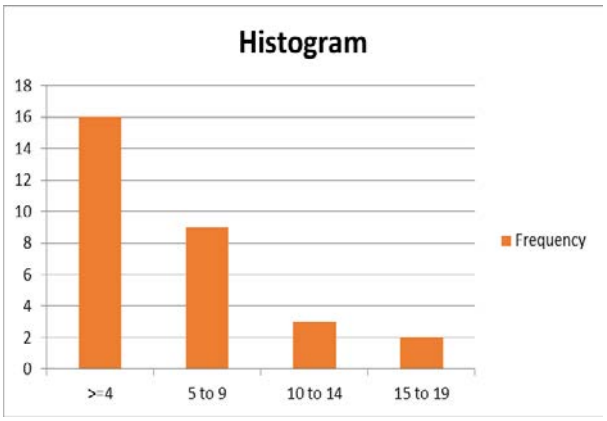
Variation based on days to maturity. The days to maturity are linked with DFI. The genotypes with early flower initiation showed early maturity. Variation was observed among genotypes based on the maturity, genotype 026532, 026564 showed early maturity (85 days) while the genotypes 026514, 026509 and 001321 showed late maturity and took (119 days). Results were further confirmed by frequency histogram which showed that maximum genotypes (26) took 92 to 99 days for their maturity.

Plant height. Based on the height of plant maximum variation was seen among the *Brassica rapa* germplasm. Maximum genotypes showed moderate height, genotype 026548 was with maximum height (175 cm) and was followed by the genotypes 026563 and 026532 (166 cm). Two genotypes 026512 and 026515 showed minimum height (26 cm). From frequency histogram it was observed that maximum number of genotypes (19) out of 30 genotypes showed height ranging 81 to 130 cm.

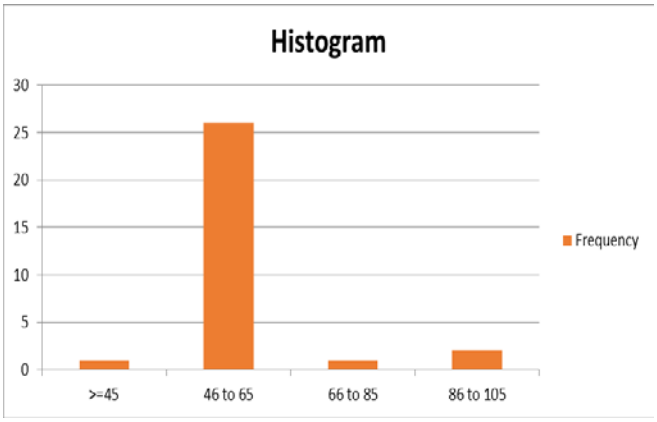
Primary branches/plant (PB/P). The number of primary branches was different among the germplasm of *Brassica rapa*. Genotype 026503 was with maximum number of primary branches/plant (8), followed by 026548 (7). The genotype 026517 was with minimum PB/P (2) and was followed by genotypes, 10, 7 and 16 with number of primary branches (3). The fre-

Table 1. List of *Brassica rapa* germplasm from Azad Jammu and Kashmir

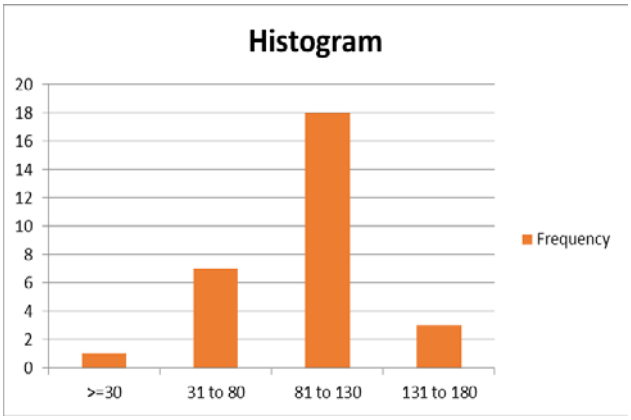
Sr. Nu	Acc. Nu	Genus	Species	Local name	Origin	Province	Location
1	026502	*Brassica*	*Rapa*	Sarsoon	Pakistan	Azad Jammu Kashmir (AJK)	Bhimber
2	026503	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bhimber
3	026508	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
4	026509	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
5	026510	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
6	026512	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
7	026513	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
8	026514	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
9	026515	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
10	026517	*Brassica*	*Rapa*	Ghobi Sarsoon	Pakistan	AJK	Kotli
11	026518	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Kotli
12	026527	*Brassica*	*Rapa*	Ghobi Sarsoon	Pakistan	AJK	Rawalakot
13	026529	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Rawalakot
14	026532	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Rawalakot
15	026533	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Rawalakot
16	026538	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bagh
17	026539	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bagh
18	026540	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bagh
19	026542	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bagh
20	026545	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bagh
21	026548	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Muzaffarabad
22	026551	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Muzaffarabad
23	026557	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Muzaffarabad
24	026562	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Muzaffarabad
25	026563	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Muzaffarabad
26	026564	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Muzaffarabad
27	001321	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Muzaffarabad
28	026498	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bhimber
29	026499	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bhimber
30	026496	*Brassica*	*Rapa*	Sarsoon	Pakistan	AJK	Bhimber



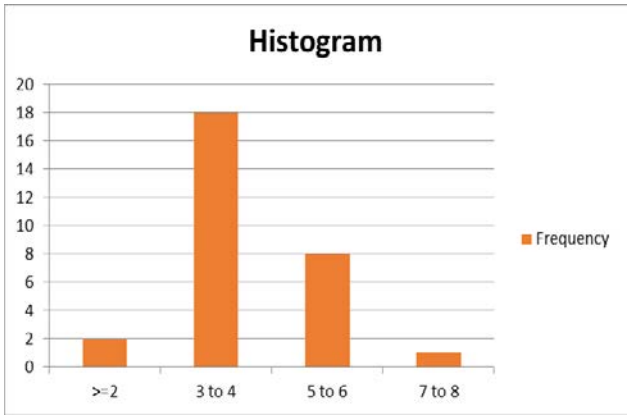
Days to germination of *B. rapa*



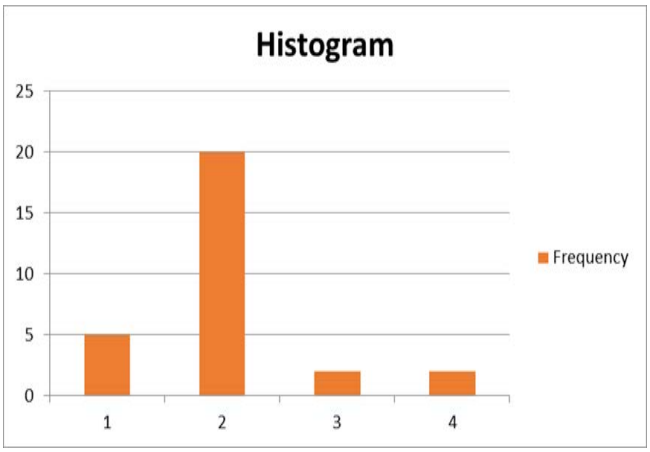
Days to flower initiation of *B. rapa*



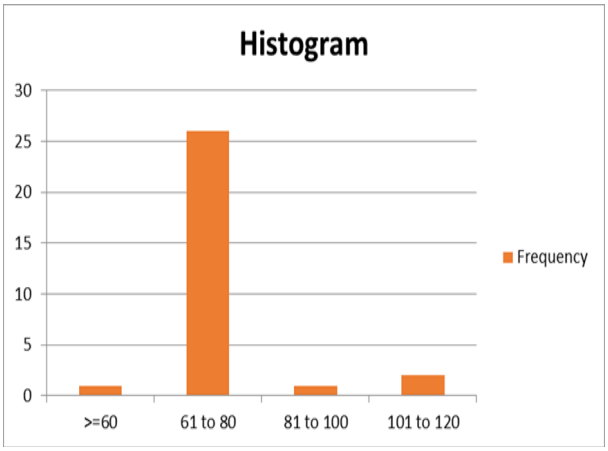
Height of plant of *B. rapa*



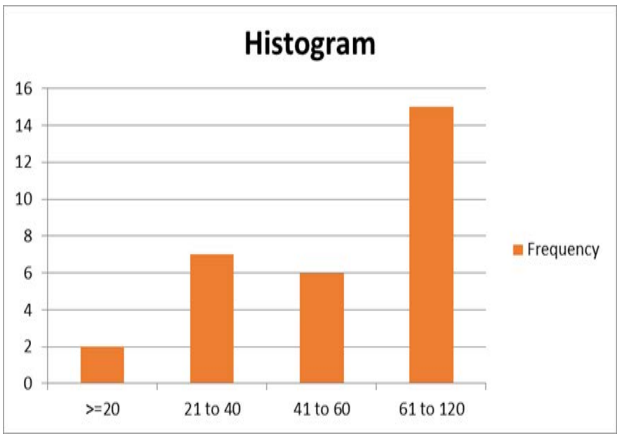
Primary branches/plant of *B. rapa*



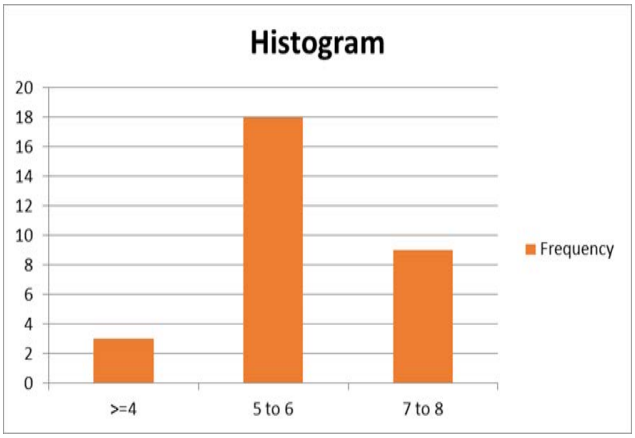
Secondary branches/plant of *B. rapa*



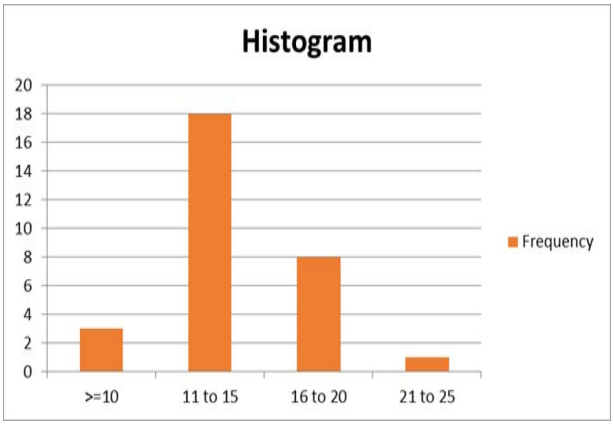
100% maturity of *B. rapa*



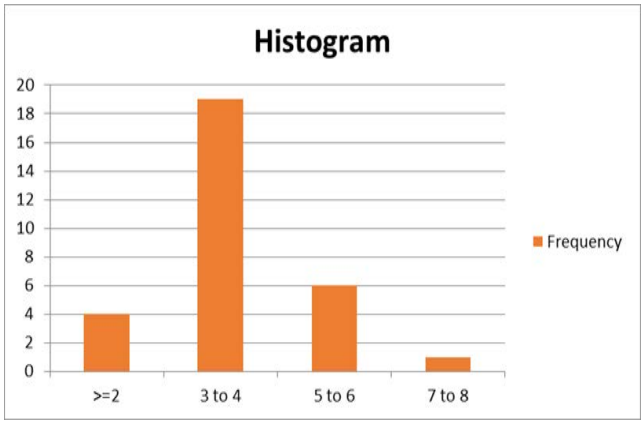
No. of silique/plant of *B. rapa*



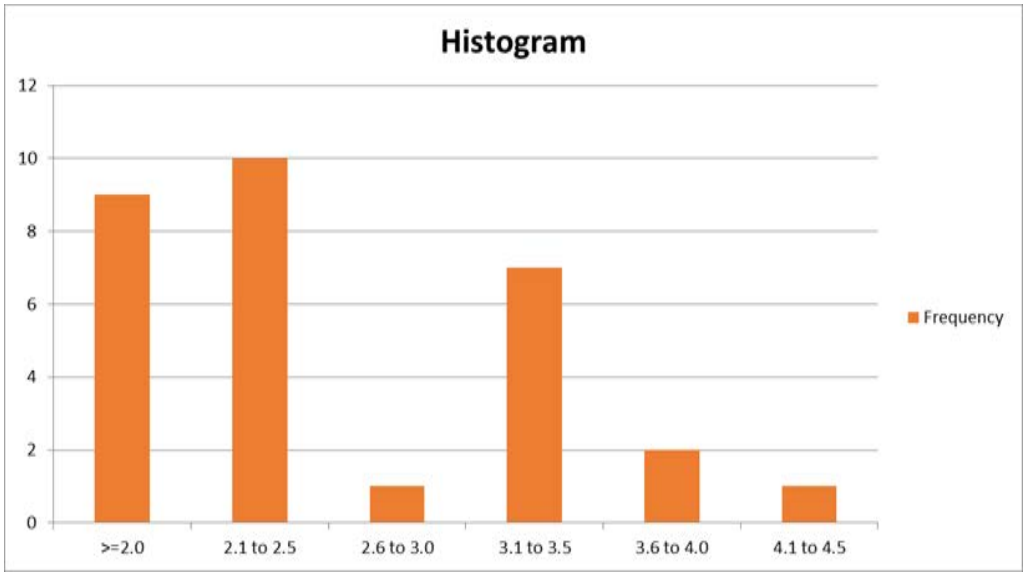
Length of silique of *B. rapa*



Seeds per pod of *B. rapa*



Yield/plant of *B. rapa*



1000 seed weight of *B. rapa*

Fig. 1. Histograms of 30 mustard genotypes based on morphological characters

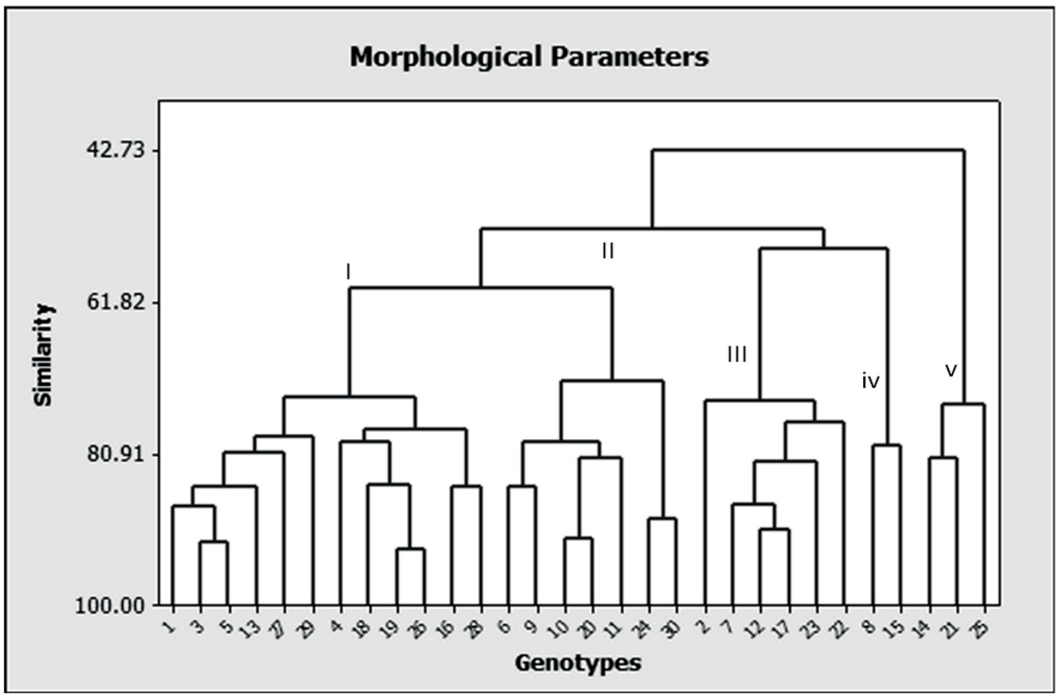


Fig. 2. Dendrogram of *B. rapa* genotypes based on morphological characters

quency histogram showed that maximum genotypes (18) were with 3 to 4 number of PB/P.

Secondary branches/plant. The number of secondary branches was different in different genotypes of *Brassica rapa.* Genotype 026518 showed maximum number of secondary branches (6), as compare to the genotypes 026508, 026512 which showed number of SB/P (2). Frequency histogram showed that maximum genotypes 20 were with 2 to 3 number of secondary branches.

Silique per plant. The number of silique are concerned with the number of seeds and thus with yield of plant. The genotype 026503 showed maximum number of silique (120), followed by 026545 with 112 S/P, while genotypes 026562 and 026498 were with minimum number of silique (21). From frequency histogram it was observed that 15 genotypes showed the number of silique ranging from 61 to 120.

Variation based upon pod length. In this study pods of *Brassica rapa* with different sizes were observed. Some pods were small, some with medium height and some were long ranging from 4–8 cm. The maximum pod length was 8 cm observed in the genotype 026545. The least PL values was showed by genotype 026538 and 026518 (4 cm) and it was followed by 026514 (3.7 cm). In most genotypes PL ranges from 5–7 cm. It was further cleared from frequency histogram that maximum genotypes (18) showed the pod length from 5 to 7 cm.

Number of seeds/pod. A great variation was observed among the genotypes depending upon the seeds number present in the pod ranging from 8 to 25. Their maximum number was 25 which was seen in the genotype 026509. Their minimum number was (5) which was noted in genotype 026508. From the frequency histogram it was noted that 11 to 15 genotypes were with 11–18 seeds in their pods.

Yield based variations. The most important character of a plant is its yield, which is the total seed mass of that plant. It was observed in this study that genotypes 026545 and 026509 showed maximum SY/P (7 g). While genotype 026532 showed minimum yield

that was only (2 g). From frequency histogram it was observed that 19 genotypes showed seed yield/plant only 3 to 4 g. Only three genotypes were with excellent yield.

Thousand seed weight. The weight of 1000 seeds showed maximum diversity among germplasm of *Brassica rapa*. In the present study the genotype 026512 showed maximum thousand seeds weight (4.5 gm) which was followed by genotype 026533 with (4.1 g). While minimum value was observed for genotype 026540 which showed (1.8 g) TSW. It is cleared from frequency histogram that maximum number of genotypes were with 2.1–2.5 g TSW.

The Figure 1 shows the frequency distribution of different agro-morphological characters of *Brassica rapa* genotypes which clearly depicts the variations present among the genotypes which were collected from different regions of the Azad Jammu and Kashmir Pakistan.

Cluster analysis. To determine the diversity among the germplasm cluster analysis of the data was done using Minitab. All the 30 genotypes were divided into 5 clusters, each cluster with geographically different genotypes. Cluster 1 was with 12 genotypes from different regions of Azad Jammu and Kashmir, while cluster IV was with only two genotypes both from different regions one from Rawalakot and other from Bagh. While cluster II was with seven genotypes and cluster III with six genotypes along with three genotypes in cluster V. Plants with maximum height were in same cluster as in cluster V genotypes 026548, 026532 and 026563 were present, while plants with initial DFI were grouped in cluster IV. The genotypes with maximum yield, length of silique and 1000 seed weight were grouped in cluster II. From the cluster analysis it was concluded that the same population fall in different clusters based on their morphological characters.

DISCUSSION

The knowledge of the genetic diversity of plant genetic resources is essential for plant breeding. The morphological studies must be performed to gather the knowledge of the genetic diversity. There are many techniques used to quantify and analyze morphological characters which include the use of the morphological parameters. The field experiment is the important way to screen out best genotype in the determination of morphological variations. In order to get the better quality and expansion of any cultivar the genetic diversity of species is used [Jan et al. 2016]. In the past, morphological characters were the only source to determine diversity among crops [Khatun et al. 2010, Sinhamahapatra et al. 2010].

Current study was conducted to evaluate the *Brassica rapa* germplasm collected from the different areas of the Azad Jammu & Kashmir (AJK) by using morphological characters which were not evaluated earlier for these agro-morphological characters. Data on selected morphological characters such as days to germination, number of primary branches/plant, secondary branches/plant, number of silique/plant, plant height, seeds/pod, length of silique, yield/plant and weight of 1000 seeds was recorded. Major differences were perceived for the significant morphological characters. Variations in the characters as plant height, days to maturity, 50% flowering and seed yield among the different genotypes was observed. Similar variation were observed among the Brassica germplasm by Zada et al. [2013] and Jan et al. [2017a]. The plant height, number number of silquae/plant, primary branches/plant have positive effect on total yield, while 1000 seed weight have negative effect on the yield [Islam et al. 2016]. Significant variations were recorded for quantative characters and plant yield. Wide range of variation were observed for traits like days to maturity, days to flower initiation, 1000 seed weight, plant height, primary and secondary branches and seed yield per plot [Worekeneh et al. 2016] A high degree of variation was observed in different phenotypic characters like silique width. The characterization is necessary to improve the economically important characters [Iqbal et al. 2015]. There are many factors such as photoperiod which affect the maturity of the different genotypes. Our finding revealed that genotypes that were in full light showed early maturity as compare the genotypes that were not in the full sun light. Our finding are similar to the [Singh and Sharma 1996] who reported early maturity of the crops with high light intensity. According to our outcomes the genotypes 026513 and 026503 were with maximum number of silique and these genotypes gives maximum yield. Similar results were obtained by Sinhamahapatra et al. [2010], who reported that the plants with high number of silique give maximum yield. It is necessary to investigate agro-morphological characters, genetic diversity and

molecular processes of important food crop species [Jan et al. 2017b]. Padilla et al. [2005] evaluated 134 different landraces for different agro-morphological characters and classified the genotypes into 5 major groups. Considerable variation was recorded both for quantitative and qualitative characters. Sinhamahapatra et al. [2010] noted that higher number of siliquae per plant increases the yield. Genetic diversity study is important to study the agro-morphological, biochemical and molecular processes of important crop plants [Shinwari et al. 2013]. In the present study number of seeds showed high variations but very low variability was observed for the 1000 seeds weight. Results of this study were in agreement with the similar studies carried out in India. Thakur et al. [2017] reported low yield of *Brassica rapa* germplasm because of the low variations among the 1000 seeds weight.

Cluster analysis showed that the genotypes collected from the same geographical regions were divided into different clusters based upon their morphological differences. Our results got support from the earlier work of Ali et al. [2015] and Sarwar et al. [2010] who reported that cluster formation occur due to morphological differences not due to geographical affinity.

CONCLUSION

This research work was conducted to evaluate the *Brassica rapa* germplasm from Azad Jammu and Kashmir Pakistan by using morphological parameters. Variation for all morphological characters were observed among the germplasm. The genotype 026548 showed maximum diversity as it was with maximum height (175 cm), the genotype 026545 from Bagh Azad Kashmir was with maximum number of silique and maximum yield was given by the same genotype. All genotypes showed highest genetic diversity even collected from same geographical regions. Based upon the present studies the genotypes 026509, 026545, 026548, had been recognised as potential genotypes which could be use in future plant breeding program.

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