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Collection, Evaluation and Utilization of Oilseed Mustard (*Brassica juncea* L.) in Pakistan

Rabbani, M. A., A. Iwabuchi, Y. Murakami, T. Suzuki and K. Takayanagi
Institute of Agriculture & Forestry, University of Tsukuba, Tsukuba, Ibaraki 305, Japan

Abstract

in order to assess the potential of oilseed mustard in the breeding programs, 52 accessions were grown in the field and characterized for different morphological characteristics. The germplasm was collected from Punjab and N. W. F. Province of Pakistan in 1994 and evaluated for morpho-physiological traits under field conditions at Tsukuba. Japan during 1995 and 1996. Thirty-five phenotypic traits were recorded for all accessions from seedling emergence till crop harvest. A considerable level of genetic variation was observed among all tested accessions for various traits. However, most of the germplasm collections from Pakistan shared similar morphology with one another when compared with the leafy vegetable cultivars from Japan. Seedling characteristics showed less variation, while the largest variation was found for flowering and maturity stage characters. Generally, low correlation was observed among different traits, however, some of the related characters were significantly correlated with each other. The results indicated that oilseed mustard in Pakistan has narrow genetic base and experiencing high level of genetic erosion perhaps due to selection for similar traits, replacement by new uniform varieties and socio-economic changes in agriculture. Therefore, future germplasm collections should be focused to the unexplored, unique peripheral and more isolated areas of the country. Introduction of germplasm from abroad and hybridization in the available material will also be helpful to broaden the gene-pool of oilseed mustard in Pakistan.

Introduction

Plant germplasrn is a vital resource in generating new types having desired traits that help in increasing the food production and thus improve the level of human nutrition. Plant germplasm of a particular crop collected from the local sources provides greater genetic variability and can furnish useful traits to broaden the genetic base of crop species. Wild relatives of crops are also useful gene sources for breeding aimed at pest and disease resistance and tolerance to environmental stresses. However, the native plant genetic resources are now gradually disappearing due to the introduction of improved varieties, socio-economic changes in agriculture and rapid urbanization (Frankel *et al*., 1995; Okuno, 1996). Germplasm collections exist to conserve the genetic diversity of these crop species and their wild relatives (Williams, 1991). The genetic potential of the collected and preserved germplasm can only be fully exploited by the breeders if systematic evaluation is undertaken for various important traits (Pecetti *et al*., 1992). The conserved germplasm supplied to plant breeders for use in the development of improved varieties for farmers ultimately produces the economic return on investment made in germplasm collection, evaluation and preservation (Vaughan and Jackson, 1995).

Rapeseed and mustard are the second contributors to the local production of vegetable oil after cotton seed in Pakistan. These crops have been grown all over the country since ancient times under irrigated as well as rain-fed conditions. They are cultivated as sole crops or grown mixed with wheat and chickpea for seed as well as fodder production. However, because of the rapid development of brassica improvement in the last decades, as in other crops, local land races have been replaced by modern cultivars, which have led to a great erosion of genetic diversity. Average per hectare yield of rapeseed and mustard is very low in Pakistan as compared to the agriculturally advanced countries. The main reasons for the low yield are losses due to disease and insect attack, shattering, lodging and non-availability of improved varieties and marketing system. More over, unlike other more profitable crops, oilseed brassicas have been grown under marginal lands having low levels of moisture and soil fertility.

Of the five oilseed brassica species grown in Pakistan, brown or Indian mustard (*B. juncea* L.) is the most extensively cultivated and well adapted species in the country. It has a great seed yield potential for semi-arid conditions and is known to be more drought tolerant and shattering resistant than rapeseed species (Woods *et al*., 1991; Getinet *et al*., 1996). It matures earlier than *B. napus* and thus escapes the attack of aphids and hairy caterpillars. It is also more lodging resistant as compared to rapeseed. With both canola quality characteristics now available in *B. juncea* (Woods *et al*., 1991), there is a much scope to develop new mustard varieties, containing low levels of erucic acid in oil and glucosinolates in the oil-free meal and consequently it is expected to be grown commercially as an edible oil crop in the drier and semi-arid regions of the world including Pakistan. Therefore, an attempt has been made to evaluate mustard germplasm recently collected from various regions of Pakistan for various morpho-physiological traits under field conditions for further utilization in future breeding programs.

Materials and Methods

Plant Material: Plant material consisted of a total of 52 genotypes. Among them, 41 accessions were collected from Pakistan, three oilseed cultivars from Pakistan and India, three improved lines from China and Australia and four leafy vegetable cultivars from Japan. In addition to the mustard entries, one commercial cultivar of *Brassica campestris* from Japan was also included as an out group for comparison (for details of accessions see Rabbani *et al*., 1998).

Germplasm Collection: Local germplasm/land races are valuable sources for agricultural prosperity due to high adaptability, better quality and resistant for biotic and abiotic stresses. The efforts for collection of cruciferous genetic diversity were initiated during 1976, when more than 300 seed samples of four oilseed species including *B. campestris*, *B. napus*, *B. juncea* and *Eruca sativa* were collected from diverse habitats throughout Pakistan (Knowles and Rana, 1976). In most of the cases, the seed was obtained from small seed stores in towns and cities as well as grain markets that were accessible along the roads. A second joint venture was undertaken by Pakistan Agricultural Research Council and Japan International Cooperation Agency (JICA) in March-April, 1994 to collect the genetic resources of these crops from Punjab and N. W. F. Province of Pakistan. In all 177 accessions were collected from either farmer's fields or threshing floor including *Eruca sativa* (52), *B. juncea* (42), *Raphanus sativus* (31), *B. campestris* (24), *B. napus* (12), *B. oleracea* (12) and *Sinapis alba* (2) for preservation and future utilization (Arif *et al*., 1994). Among seven collected species, oilseed mustard was picked for present study on the basis of its wider adaptation and better performance. Collected germplasm represents a wide eco-geographic variation from dry mountain areas to irrigated plains and sandy arid regions of Pakistan (Fig. 1). The altitude of collection sites varied from less than 100 m to 600 m above sea level.

Field Evaluation: The field experiments were conducted at the Agriculture and Forestry Research Center, University of Tsukuba, Japan (36°, 6.2' N and 140°, 5.7' E). Seed sowing was performed under glasshouse in the third-week of February, 1995 and first week of March, 1996. Seedlings were transplanted into the field at 3-4 leaf stage. The experimental design was randomized complete block design with two replications. Experimental plot consisted of two rows of 2 m length with 80 cm spacing between rows and 20 cm between plants within a row. Consequently, each experimental unit comprised of 20 plants/replication, while ten individuals were used for data recording. All the accessions were characterized for 35 quantitative and qualitative traits from seedling stage till crop maturity as per descriptors for cruciferous crops (IBPGR, 1990; Gupta *et al*., 1991). Seedling characteristics were recorded at 3-4 leaf stage before transplanting into the field, flowering traits were observed from bolting initiation till last flowering, while maturity characters were scored at crop harvest stage (Rabbani *et al*., 1998).

Data Analysis: The simple statistics including mean, range, standard deviation in different traits, Individual analysis of variance were performed for each of the 25 quantitative characters. Anthocyanin coloration of hypocotyl, leaf shape, lobation of leaf margins, number of leaflets, number of serrates and seed color were excluded from analysis of variance, as these were qualitative characters. Accession means were used to calculate the coefficient of variation, variance among accessions and frequency distribution of 52 accessions for various traits. Also, simple correlation coefficients between all pairs of characters were calculated according to Steel and Torrie (1981) using plot mean values.

Results

Agro-Morphological Traits: Mean value, range, coefficient of variation and variance between accessions for each of quantitative characters are prevented in Table 1. The analysis of variance showed significant differences among the accessions for most of the characters studied. Most of the vegetative characteristics showed less variation such as cotyledon size, hypocotyl length, leaf shape, etc. The largest variation was found for days to bolting initiation and first flowering, leaf size, plant height, length of main inflorescence and siliques/main inflorescence, indicating a considerable scope of improvement for these characters in the present material. Among 52 accessions, the number of days from sowing to first flowering ranged from 45.5 for Varuna to 77 days for Negarashina with a mean flowering of 58.3 ± 7.52 days, while it ranged from 49.5 to 69.5 days among oilseed collections. Pakistani commercial cultivars, S-9 and BARD-1 flowered at 50.5 and 55 days of sowing, respectively. Leaf size at flowering stage of the crop showed a great deal of variability as length varied from 17.8 to 70.7 cm with a mean length of 29.7 ± 11.69 cm, whereas among oilseed collections it varied between 17.8 and 38.9 cm only. Selection for this economic trait is effective in developing bigger leaved varieties of mustard for fodder and vegetable purposes. The maturity period among all accessions ranged from 101 days (PAK-85838) to 129.3 days (Sendai-bashouna). Compared to vegetable cultivars, oilseed collections matured within 101 to 122 days. Generally, vegetable cultivars were late maturing as compared to oilseed collections as well as cultivars. Mustard accessions also varied widely for plant height which ranged from 79.7 cm for PAK-85839 to 175.7 cm for Kikarashina with a mean height of 129.9 ± 18.02 cm. In contrast to leafy cultivars, oilseed collections exhibited 79.9 to 155.1 cm plant height among themselves, Of 41 collections, PAK-85859 attained the maximum plant height of 155.1 cm followed by PAK-8591 1 and PAK-85897 with 148.9 cm and 146.4 cm, respectively. Oilseed collections, PAK-85835 and PAK-85839 were with the minimum plant height of 91.6 and 79.7 cm, respectively which could be a good source to be utilized in breeding of short-statured varieties.

Overall, a low level of variation was observed among mustard germplasm for primary branches/plant. Inflorescence length is one of the most important yield contributing traits in mustard. The length of inflorescence on main shoot was between 26.8 and 82.8 cm with a mean of 47.0±10.76 cm. Mustard inflorescences of oilseed collections were shorter in length ranging from 26.8 (PAK-85839) to 60.5 cm (PAK-85870) only. Generally, a low level of variability was observed in silique size, as all collections/cultivars had 40 to 55 mm silique length except PAK-85835, PAK-85910 and PAK-85955 which gave comparatively longer siliques with 73.9, 80.8 and 60.5 mm, respectively. Low genetic variability for branches/plant and silique size in oilseed mustard seemed to restrict the scope of selection for these traits in the present germplasm collections. The weight of 1000-grains varied from 1.26 to 3.98 g, the average being 2.13 g. Among oilseed group, commercial cultivars BARD-1, Varuna and XA-303 produced heavier grains with 3.53, 3.64 and 3.98 g/1000 seeds, respectively, while leafy vegetable cultivars showed lighter seeds. Among oilseed collections, only PAK-85835 and PAK-85910 produced bold seeds with 3.20 and 3.44 g/1000 seeds, respectively. None of the evaluated collections could exceed commercial cultivar, BARD-1 for seed weight, hence new sources of genes for high seed weight could be identified and utilized for the manipulation of this trait in developing bold seeded cultivars as high seed weight in any seed crop in preferred by the consumers. A considerable diversity for seed yield per plant was recorded among 52 genotypes. Seed yield ranged from 6.26 to 23.63 g with a mean yield of 13.61 g/plant. On average, Hakarashina (23.63 g), PAK-85897 (23.55 g) and PAK-85855 (22.80 g) produced the highest seed yield, while the lowest yield was recorded in PAK-85839.

Distribution of Plant Characters: Different types of phenotypic distributions were observed for morphological traits measured in all genotypes. The accessions were normally or near normally distributed for days to first flower, days to maturity, plant height, silique width and seed yield/plant. Leaf length, leaf width, siliques/main inflorescence and silique length had similar type of distributions in which discrete groups were observed. The growth period from seed sowing to bolting initiation of 62 percent of accessions was between 40 to 50 days. The length of main inflorescence of 58 percent of the genotypes was in between 1.50 to 2.50 g. Generally, germplasm collections had higher seed weight as compared to leafy vegetable cultivars, while lower than oilseed commercial cultivars. The frequency distribution of some of the qualitative traits is depicted in Table 2. Phenotypic distribution of different leaf shapes showed the predominance of spatulate leaf shape (84.6%) followed by obovate (9.6%) and ovate shape (5.8%). The predominant leaf incision was lobed (92.3%), while only 5.8 and 1.9 percent of accessions were of cleft and entire types, respectively. About 53.9 percent of the mustard entries had medium number of leaf serrates. Of the total accessions/cultivars, 57.7 percent were found to be brown seeded followed by dark brown (25%) and red brown (11.5%) seed color, while only 3.9 percent were yellow seeded.

Correlation Analysis: Correlation among various morphological characters is presented in Table 3. Of 300 combinations of morphological traits within 52 mustard genotypes, some of the characteristics showed high and significant correlation ($r<0.70$). Measurements of some related traits were significantly correlated with each other. For example, leaf length was positively associated with leaf width at seedling ($r = 0.95$) as well as flowering ($r = 0.89$) stage of the crop. Similarly, days to bolting initiation was highly significant correlated with the component traits, days to first flowering ($r = 0.95$) and days to maturity ($r = 0.75$). At the same time, highly positive correlation was also found between days to bolting initiation and leaf length ($r = 0.84$), leaf width ($r = 0.81$) and siliques/main inflorescence ($r = 0.73$). There was also a high positive association between length of main inflorescence and siliques per main inflorescence ($r = 0.80$). Hypocotyl length showed a strong positive correlation with silique length ($r = 0.80$) and significant negative correlation with plant height ($r = 0.73$). Highly significant correlation was also found between bolting, flowering and maturity time and leaf size and siliques/main inflorescence. Seed weight was positively correlated with silique width ($r = 0.84$) and showed poor correlation with most of the other traits. Similarly, poor correlation was observed between seed yield and most of the other morphological characters.

Discussion

Germplasm evaluation must be considered the first step in plant breeding programme and it is commonly based on a simultaneous examination of a large number of population for several characters of both agronomic and physiologica interest (Revilla and Tracy, 1995). In this preliminary study, mustard germplasm was evaluated for different quantitative and qualitative characters under field conditions. It was observed that oilseed mustard from Pakistan has not developed significant variation for most of the morphological traits, instead the germplasm collections shared similar morphology. Even those accessions that originated from distant places exhibited similarity for most of the features. The pattern of variation among the accessions was different for different traits. Seedling, characteristics such as cotyledon size, hypocotyl length, leaf shape, lobation of leaf margins, etc. showed the lowest variation, hence improvement for these traits seemed to be difficult in the local germplasm used under present study and the genes for these traits should be investigated or exploited from other sources, i.e., inter-specificific hybridization, mutation, etc. Flowering and maturity characters exhibited a considerable level of diversity among

Table 1: Variation among mustard accessions/cultivars for 25 quantitative traits

Characteristics	Mean±SD	Range	CV (%)	Variance*	F-value	LSD#
Cotyledon petiole length (cm)	2.01±0.29	1.35-2.54	14.5	0.09	11.93	0.22
Cotyledon length (cm)	1.61±0.21	1.18-1.99	12.9	0.04	11.93	0.13
Cotyledon width (cm)	2.10±0.26	1.6-2.65	12.2	0.07	20.49	0.15
Hypocotyl length (cm)	1.95±0.79	0.73-4.89	40.4	0.62	69.51	0.28
Leaf petiole length (cm)	3.03±1.07	0.68-6.20	35.4	1.15	28.75	0.55
Leaf length (cm)	9.23±2.21	6.09-16.01	24.0	4.90	18.19	1.13
Leaf width (cm)	2.95±0.67	1.37-4.75	22.6	0.44	17.48	0.35
Days to bolting initiation	47.89±7.92	28.5-77.5	16.5	62.76	52.97	3.67
Days of first flowering	58.31±7.52	45.5-86.0	12.9	56.48	26.82	5.07
Leaf petiole length (cm)	5.02±2.17	0.0-21.3	43.2	4.69	65.76	0.79
Leaf length (cm)	29.73±11.69	17.77-70.7	39.3	136.68	192.33	2.66
Leaf width (cm)	12.31±5.38	6.02-32.8	43.7	28.90	151.61	1.36
Leaf length/width ratio	2.54±0.58	1.78-5.07	22.7	0.33	38.3	0.25
Days to maturity	115.73±6.05	101.0-129.25	5.2	36.62	51.84	2.50
Number of leaves/plant	9.13±1.13	6.75-13.55	12.3	1.27	15.91	0.83
Plant height (cm)	129.88±18.02	79.7-157.7	13.9	324.68	48.36	9.18
Number of primary branches/plant	8.56±1.21	5.58-13.0	14.2	1.47	4.45	1.38
Length of main inflorescence (cm)	46.97±10.76	26.82-82.83	22.9	115.77	11.60	9.73
Siliques/main inflorescence	24.88±8.62	13.67-53.33	34.6	74.30	24.93	6.25
Silique length (mm)	47.10±7.69	38.1-80.77	16.3	59.10	118.88	1.97
Silique width (mm)	3.66±0.56	2.7-5.15	15.2	0.31	57.08	0.18
Silique length/width ratio (mm)	13.25±1.83	10.15-18.31	13.8	3.35	23.16	0.89
Number of seeds/silique	17.88±2.01	13.72-23.48	11.2	4.03	23.59	1.11
1000-seed weight (9)	2.13±0.59	1.26-3.98	27.4	0.34	27.15	0.29
Seed yield/plant (g)	13.61±4.96	6.26-23.63	36.5	24.60	4.94	6.39

*Between accessions and #LSD (0.05)

Table 2: Phenotypic diversity for some of qualitative traits of mustard accessions/cultivars

Leaf blade shape	Frequency (%)	Lobation of leaf margin	Frequency (%)	No. of serrates	Frequency (%)	Seed color	Frequency (%)
Spathulate	84.6	Entire	1.9	Absent	1.9	Yellow	3.9
Ovate	5.8	Lobed	92.3	Few	36.5	Light brown	1.9
Obovate	9.6	Cleft	5.8	Medium	53.9	Brown	57.7
				Many	7.7	Dark brown	25.0
						Red brown	11.5

Table 3: Correlation coefficients between 25 quantitative traits of mustard accessions/cultivars

Characteristics	CPL	CL	CW	HL	LALs	LLs	LWs	DBI	DFF
Cotyledon petiole lenght (CPL)	1.00								
Cotyledon length (CL)	0.85	1.00							
Cotyledon width (CW)	0.77	0.86	1.00						
Hypocotyl length (HL)	0.40	0.31	0.21	1.00					
Leaf petiole length (LPLs)	-0.03	0.01	-0.01	0.40	1.00				
Leaf length (LLs)	-0.28	-0.15	-0.18	0.00	0.76	1.00			
Leaf width (LWs)	-0.25	-0.07	-0.05	-0.13	0.64	0.95	1.00		
Days to bolting initiation (DBI)	-0.45	-0.33	-0.44	-0.35	-0.22	0.15	0.19	1.00	
Days to first flowering (DFF)	-0.45	-0.31	-0.41	-0.40	-0.25	0.15	0.21	0.95	1.00
Days from DBI-DFF	0.14	0.13	0.16.	0.05	0.08	0.05	0.05	-0.31	-0.02
Days from DFF-DLF	-0.36	-0.30	-0.19	-0.55	-0.30	-0.12	-0.02	0.24	0.21
Leaf petiole length (LPLf)	-0.49	-0.54	-0.50	-0.39	-0.03	0.17	0.17	0.35	0.35
Leaf length (LLf)	-0.40	-0.32	-0.37	-0.47	-0.31	0.12	0.21	0.84	0.81
Leaf width (LWf)	-0.40	-0.25	-0.27	-0.53	-0.36	0.19	0.31	0.81	0.82
Number of leaves/plant (NL/P)	0.02	0.03	0.02	0.10	0.07	0.25	0.33	0.39	0.33

Plant height (PH)	-0.41	-0.27	-0.28	-0.73	-0.16	0.17	0.29	0.60	0.62
Days to maturity (DM)	-0.42	-0.37	-0.40	-0.50	-0.23	0.08	0.10	0.75	0.80
Primary branches plant (NPB/P)	0.08	0.09	0.11	0.22	0.18	0.25	0.31	0.16	0.12
Length of main inflorescence (LMI)	-0.65	-0.53	-0.53	-0.49	-0.02	0.28	0.28	0.66	0.67
Siliquesimain inflorescence (S/MI)	-0.61	-0.44	-0.44	-0.49	-0.08	0.33	0.41	0.73	0.71
Silique length (SL)	0.35	0.32	0.30	0.80	0.31	0.08	0.02	-0.08	-0.17
Silique width (SW)	0.13	0.08	0.26	0.53	0.36	0.16	0.11	-0.14	-0.09
Seeds/siligue (S/S)	-0.37	-0.25	-0.31	-0.02	0.15	0.20	0.15	0.45	0.42
1000-seed weight (1000-SW)	0.30	0.24	0.49	0.51	0.34	0.09	0.06	-0.39	-0.36
Seed yield/plant (SY/P)	-0.42	-0.27	-0.30	-0.23	0.25	0.35	0.33	0.19	0.23
	DBI-DFF	DFF-DLF	LPLf	LLf	LWf	NL/P	PH	DM	NPB/P
Days from DBI-DFF	1.00								
Days from DFF-DLF	-0.25	1.00							
Leaf petiole length (LPLf)	-0.10	0.41	1.00						
Leaf length (LLf)	-0.28	0.41	0.57	1.00					
Leaf width (LWf)	-0.19	0.40	0.42	0.89	1.00				
Number of leaves/plant (NL/P)	-0.20	-0.03	-0.04	0.39	0.34	1.00			
Plant height (PH)	-0.08	0.49	0.54	0.62	0.62	0.04	1.00		
Days to maturity (DM)	-0.01	0.47	0.43	0.70	0.65	0.15	0.58	1.00	
Primary branches/plant (NPB/P)	-0.08	-0.1	-0.29	0.09	0.07	0.89	-0.12	-0.01	1.00
Length of main inflorescence (LMI)	-0.26	0.47	0.60	0.84	0.81	0.28	0.67	0.55	0.02
Silique length (SL)	-0.14	-0.41	-0.37	-0.17	-0.22	0.33	-0.53	-0.30	0.41
Silique width (SW)	0.28	-0.33	-0.35	-0.28	-0.23	0.19	-0.44	-0.09	0.37
Seeds/siligue (S/S)	-0.11	0.05	0.10	0.35	0.29	0.23	0.24	0.28	0.20
1000-seed weight (1000 SW)	0.24	-0.27	-0.37	-0.46	-0.38	0.04	-0.55	-0.24	0.22
Seed yield/plant (SY/P)	0.03	0.19	0.44	0.23	0.22	-0.02	0.42	0.33	-0.06
	LMI	S/MI	SL	SW	S/S	10005W	SY/P		
Length of main inflorescence (LMI)	1.0								
Siligues/main inflorescence (S/MI)	0.80	1.00							
Silique length (SL)	-0.28	-0.18	1.00						
Silique width (SW)	-0.15	-0.25	0.61	1.00					
Seeds/siligue (S/S)	0.45	0.46	0.25	0.18	1.00				
1000-seed weight (1000 SW)	-0.34	-0.41	0.56	0.84	-0.16	1.00			
Seed yield/plant (SY/P)	0.42	0.42	-0.20	-0.02	0.37	-0.13	1.00		

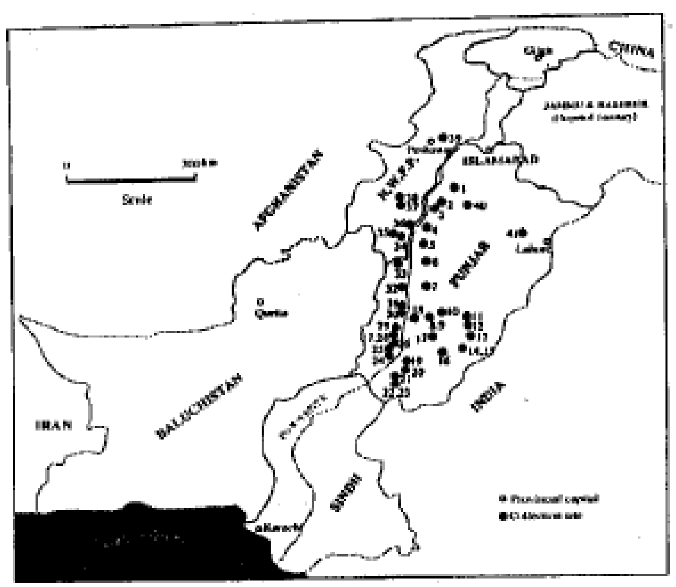

Fig. 1: Map of Pakistan showing the geographical distribution of mustard accessions. Numbers indicate the collection site of each accession

the accessions, which in general revealed that the selection for these traits is effective in developing new mustard varieties. At seedling stage, oilseed forms showed fast vegetative growth, whereas after transplanting, leafy vegetable cultivars exhibited vigorous plant growth and better canopy development as compared to oilseed group. Limited variation was also observed within oilseed collections/cultivars from Pakistan as compared to leafy vegetable cultivars on the basis of morphological traits (Rabbani *et al*., 1998).

Oilseed collections as well as cultivars were characterized by early in bolting and flowering, medium stature, smaller leaf size and comparatively bigger siliques with bold seeds. In contrast to oilseed forms, leafy vegetable cultivars had more height, late in maturity with an extended period of bolting and flowering, bigger leaves, smaller siliques with many small-sized seeds. Seed yield potential of germplasm collections was comparable with both oilseed as well as vegetable cultivars. Most of the entries gave higher yield than that of oilseed cultivars. These lines could be the good sources of yield improvement in mustard breeding. It was also observed that some of the accessions possessed best genes for more than one characters and hence could be utilized directly for varietal improvement program. Accessions, PAK-85835, PAK-85839 and PAK-85910 were distinct from rest of mustard collections in many phenotypic traits. PAK-85839 had dwarf plants with sect leaves, compact short inflorescence and yellow seed color. Similarly, PAK-85835 and PAK-85910 were characterized by longer hypocotyl, comparatively short stature, longer and wider siliques with heavier grains etc. PAK-85839 could be used for the development of yellow seeded cultivars in future breeding programs, whereas PAK-85835 and PAK-85910 may serve a gene source for the improvement of seed characteristics.

Various forms of phenotypic distributions were observed for different traits in 52 accessions of mustard. Distribution of days to bolting, flowering, maturity, plant height, length of main inflorescence, silique width, seeds/silique, seed yield, etc. was normal or near normal; leaf length, width and number, siliques/inflorescence, silique length, etc. showed discrete groups; while most of the qualitative characters were skewed. Song *et al*. (1995) also found discrete groups in leaf characters, skewed distribution for days to bud and auxiliary shoot, while normal distribution for plant height in F2 population of *B. campestris*. Similarly, Kennard *et al*. (1994) reported normal distribution for lamina width, petiole length, etc. in *B. oleracea* population. Both leaf size and flower number were normally distributed, while some other traits were skewed in white clover cultivars (Caradus *et al*., 1989). Likewise, different types of phenotypic distributions were also observed for pod and seed morphology in groundnut by Retamal *et al*. (1982).

The correlation is a measure of the degree to which variables vary together or a measure of intensity of association (Steel and Torrie, 1981). Generally, a low correlation was observed between different characters. However, some of the related traits were significantly correlated with one another. For example, leaf length was positively associated with leaf width. Similarly, days to bolting initiation was highly significant correlated with the component traits, days to first flower and maturity. Highly significant correlations had also been reported between leaf length and width, days to bud and days to flower by Kennard *et al*. (1994) in *B. oleracea*, by Song *et al*. (1995) in *B. campestris* and by Mulder and Mastebroek (1996) in *Crambe hispanica*. In the present study, highly positive correlations were also found between bolting and flowering time and leaf size and plant height of mustard genotypes. Similar tendency of larged leaves and tall height cultivars to be later flowering had also been reported by Caradus *et al*. (1989) in white clover and by Mulder and Mastebroek (1996) in Crambe.

in the light of these observations, it is concluded that morphologically, collected germplasm among themselves and with oilseed cultivars showed comparatively low level of genetic variability. However, a considerable level of genetic variation was observed between oilseed group and Japanese vegetable cultivars. It indicated that oilseed group is phenotypically distinct from vegetable cultivars based solely on breeding objectives and horticultural uses. The smaller number of differences among collected germplasm themselves is likely due to the use of same ancestors in selection of new lines, easy exchange of germplasm between the regions and perhaps replacement of local landraces by new advanced cultivars. Therefore, germplasm collection should be focused on remaining unexplored areas and unique peripheral regions which are more isolated geographically or climatically from major growing areas. Besides, new germplasm from abroad should also be introduced to broaden the gene-pool of mustard crop in Pakistan for conservation and future variety development programs.

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