Available online at http://www.journalcra.com

International Journal of Current Research
Vol. 7, Issue, 09, pp.19847-19854, September, 2015

INTERNATIONAL JOURNAL OF CURRENT RESEARCH

ISSN: 0975-833X

RESEARCH ARTICLE

MORPHOLOGICAL ATTRIBUTES SPECIES IDENTIFICATION OF OLEIFEROUS BRASSICA SPECIES AND BETTER PARENTS SELECTION CRITERIA FOR BRASSICA JUNCEA

*Md. Harun-Ur- Rashid, Shahanaz Parveen and Md. Shahidur Rashid Bhuiyan

Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

ARTICLE INFO

Article History:
Received 08th June, 2015
Received in revised form
11th July, 2015
Accepted 28th August, 2015
Published online 16th September, 2015

Key words:
Morphological,
Species,
Oleiferous,
Heritability.

ABSTRACT

An experiment was carried out with 40 oleiferous *Brassica* species to categorize them under different species considering the morphological attributes and to find out the best genotypes of *B. juncea* for the future hybridization program. The genotypes showed wide variation for morphological characteristics and thus were categorized under three cultivated species- *B. rapa*, *B. napus* and *B. juncea*. In *B. juncea*, number of primary branches/plant, length of siliqua, number of seeds/siliqua, number of siliquae/plant, 1000 seed weight and days to maturity showed low genotypic and phenotypic coefficient of variation. High heritability coupled with high genetic advance and genetic advance in the percentage of mean was recorded for the character of number of secondary branches/plant. Correlation coefficient revealed that yield/plant had significant positive association with number of primary branches/plant, number of secondary branches/plant, days to 50% flowering, days to maturity and number of siliquae/plant. Path analysis revealed that number of primary branches/plant, number of secondary branches/plant, days to 50% flowering, days to maturity and number of siliquae/plant demonstrated positive direct effect and plant height, length of siliqua, number of seeds/siliqua and 1000 seed weight showed negative direct effect on yield/plant. Considering the genetic status and other agronomic performances 02 materials viz. BD-9069 and BD-9088 could be used as superior parents for mustard and rape improvement programme in future.

Copyright © 2015 Md. Harun-Ur- Rashid et al. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Citation: Md. Harun-Ur-Rashid, Shahanaz Parveen and Md. Shahidur Rashid Bhuiyan, 2015. "Morphological attributes species identification of oleiferous Brassica species and better parents selection criteria for Brassica Juncea", *International Journal of Current Research*, 7, (9), 19847-19854.

INTRODUCTION

Brassica is an important genus of plant kingdom consisting of over 3200 species with highly diverse morphology. It has great economic and commercial value and play a major role in feeding the world population. They ranged from nutritious vegetables, oils, condiments and animal feeds. Vegetable oils and fats (lipids) constitute an important component of human diet, ranking third after cereals and animal products and in addition, oils of plant origin are nutritionally superior to that of animal origin (Singh, 2000). Vegetable oils are used mostly for edible purposes and a part finds industrial applications. Oil cakes are used as manures and good source of protein in animal feed. Bangladesh is now self-sufficient in rice (USAID, 2006) and for this the dominant cropping pattern Transplanted Aman (wet season rice)–fallow-Boro (dry season rice) plays an important role which covers about 1.8 million hectare (about 22% of the total land) of land (Elahi *et al*., 1999). The late harvest of medium duration T. Aman rice and increased cultivation of Boro rice under this cropping pattern causes the decline of mustard area. In the year of 2006-07, it covered 5,20,045 acres land and the production was 1,88,880 metric ton, where in the year of 2010-11 it covered 6,23,294 acres land and the production was 2,46,494 metric tons (Yearbook 2011 of Agricultural Statistics of Bangladesh). A very brief comparison between of mustard in 2006-07 to 2010-2011 indicates an increase of land 19.85%, when the production is increased by more than 30.5% (Yearbook 2011 of Agricultural Statistics of Bangladesh). The demand of edible oil is increasing day by day with the increasing population. The present per capita oil consumption is only 10 g per day as compared to the total need of 22 g per day (Anonymous, 2000). To fulfill the shortage of edible oil, Bangladesh has to import a large quantity of edible oil every year. Development of improved varieties of oilseeds with short durational, better quality, higher yields are the most important issues with high priority (Current & Future challenges as reported by MoA for SYFP 2011 to 2015). The Bangladesh Rice Research Institute (BRRI) has recommended the T. Aman-Mustard-Boro cropping pattern for the irrigated ecosystem (BARC, 2001; Khan *et al.* 2004) with the inclusion of 65-70 days mustard variety, Tori-7 in the transition period between T. Aman and Boro to address the issue. But the farmers harvest poor yield

Corresponding author: Md. Harun-Ur- Rashid,
Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh

from Tori-7 that can be increased manifold by introducing high yielding varieties (Alam and Rahman. 2006; Bask *et al*., 2007). There is no HYV to replace this short durational low yielding local variety.

The genus *Brassica* has generally been divided into three groups, namely rapeseed, mustard and cole. Out of the oil bearing plants *Brassica* rape includes the diploid *B. rapa*, turnip rape (AA, 2n=20) and amphidiploids *B. napus* L., rape (AACC, 2n=38) while the mustard component includes the amphidiploids *B. juncea* Czern and Coss as Indian mustard (AABB, 2n=36) and *B. carinata* brown as Abyssinian mustard (BBCC, 2n=34), respectively (Yarnell, 1956). The genomic constitutions of the three elemental species are *B. rapa* (AA, 2n=20), *B. oleracea* (CC, 2n=18) and *B. nigra* (BB, 2n=16). The amphidiploids species of *B. napus* (AACC, 2n=38), *B. juncea* (AABB, 2n=36) and *B. carinata* (BBCC, 2n=34) has been derived by genomic recombination of the diploid elemental species. U (1935) diagrammatically illustrated the interrelationships between the three diploids and their allotetraploids by the so called U-triangle. In the oleiferous *Brassica* group, a considerable variation of genetic nature exists among different species and varieties within each species in respect of different morpho-physiological characters (Malik *et al*., 1995; Nanda *et al.,* 1995; Kakroo and Kumar, 1991; Singh *et al.*, 1991).

Among different *Brassica* species, the diploid species *Brassica rapa* L. var. toria and sarson (brown/yellow) and *B. juncea* L. are widely cultivated in Bangladesh. Besides, several non pungent allotetraploid varieties of rapeseed *B. napus* L. have been developed by Bangladesh Agricultural Research Institute (BARI) and Bangladesh Institute of Nuclear Agriculture (BINA). These varieties are physiologically more productive with higher oil content (42-44%) and tolerant to stresses like Alternaria blight disease and water-logged conditions. The country is facing increasing deficiency in oilseed production and consequently, import cost is increasing. The causes for the low yield are also due to low yield potential of the varieties, insufficient precipitation when the crops are cultivated under rainfed conditions and the primitive crop management practices. Moreover, area of oilseed crops including mustard and rapeseed is also decreasing. On the other hand, high population growth rate is also increasing pressure on per capita consumption rate of oils.

Thus to nourish the people of our country adequately, we should develop varieties with higher seed yield with more oil percentage in seed and tolerant to biotic and abiotic stresses. According to Burton (1952), for the improvement of any character through breeding, it is essential to know the extent of variability present in that species, nature of association among the characters and the contribution of different characters towards seed yield. The efficiency of a plant breeding programmed depends on the amount of genetic variability exist in nature or how much a plant breeder can create variability in the target population so as to perform effective selection. So, in case of *B. juncea*, it contains some remarkable characteristics like biotic and abiotic stresses resistance. So, this species could be a good choice for breeding biotic and abiotic stress resistance oleiferous *Brassica* species. The germplasms were received from the gene bank of Bangladesh Agricultural Research Institute (BARI), Gazipur without having the information about the species. So, it is an opportunity to categorize the germplasm morphologically under different species for future utilization in the development for high yielding genotypes of oleiferous *Brassica*.

MATERIALS AND METHODS

Experimental Site

The present research work was carried out in the experimental farm, Sher-e-Bangla Agricultural University (SAU), Dhaka. The location of the site is 23° 74′ N latitude and 90° 35′ E longitude with an elevation of 8.2 meter above sea level. The experimental site was situated in the subtropical zone. The soil of the experimental site lies in Agroecological region of “Madhupur Tract” (AEZ No. 28). Its top soil is clay loam in texture and olive gray with common fine to medium distinct dark yellowish brown mottles. The pH is 6.1 and organic carbon content is 0.82%.

Plant materials

40 oleiferous *Brassica* genotypes were used in these experiments (Table 1) for species identification on morphological attributes and 6 germplasms *B. juncea* were used for variability as well as character association study.

Field experiment

The experimental plot was prepared by ploughing with proper tiller. The weeds and other unwanted plant materials were removed from the field during the land preparation. Proper laddering was done to bring the soil at proper tilth condition.

Table 1. List of 40 oleiferous *Brassica* species used in the experiment

SL No.	Genotype	SL No.	Genotype	SL No.	Genotype	SL No.	Genotype
01	BD-6948	11	BD-9063	21	BD-9074	31	BD-9085
02	BD-6949	12	BD-9064	22	BD-9075	32	BD-9086
03	BD-6956	13	BD-9065	23	BD-9076	33	BD-9087
04	BD-7108	14	BD-9066	24	BD-9077	34	BD-9088
05	BD-7810	15	BD-9067	25	BD-9078	35	BD-9099
06	BD-7811	16	BD-9068	26	BD-9079	36	BD-9100
07	BD-7812	17	BD-9069	27	BD-9081	37	BD-9104
08	BD-7813	18	BD-9070	28	BD-9082	38	BD-9106
09	BD-7814	19	BD-9071	29	BD-9083	39	BD-9080
10	BD-9062	20	BD-9073	30	BD-9084	40	SAUYC

A Randomized Complete Block Design (RCBD) was used in the experiment with three replications. The field was divided into three blocks; the blocks were subdivided into 40 plots. Genotypes were randomly assigned into 40 plots in each block. The plot size was 21 m × 55 m. Block to block and plot to plot distance were 1.5 m and 0.5 m respectively. Intra and inter row distance were maintained @ 10 cm and 35 cm respectively. Seeds were sown in lines in the experimental plots and were placed at about 1.5 cm depth in the soil. Urea, Triple Super Phosphate, Muriate of Potash, Gypsum and Borax @ 250, 170, 85, 150, 5 kg/ha respectively were used in the experiment. Urea was applied by two installments. Total amount of TSP, MP, gypsum and borax along with half of the urea were applied at the time of final land preparation as a basal dose.

The second half of the urea was top-dressed at the time of flower initiation. One post sowing irrigation was given by sprinkler after sowing of seeds to bring proper moisture condition of the soil to ensure uniform germination of the seeds. A good drainage system was maintained for immediate release of rainwater from the experimental plot during the growing period. The first weeding was done after 15 days of sowing. During the same time, thinning was done for maintaining the proper distance of plant growth. Second weeding was done after 35 days of sowing. The crop was protected from the attack of aphids by spraying Malathion-57 EC (organophosphates) @ 2 ml/litre of water. The insecticide was applied for the first time approximately before one week of flower initiation and it was applied for another two times at an interval of 15 days. To protect the crop from the Alternaria leaf spot, Rovral-50 WP (iprodione) was sprayed @ 2g/l water at 50% flowering stage for the first time and it was again applied for two times at an interval of 15 days. Harvesting was started when 80% of the plant population of each plot reached maturity. Data were recorded on individual plant basis from 10 randomly selected plants. Observations were recorded on various plant traits i.e. plant height, number of primary branches/plant, number of secondary branches/plant, length of siliqua, number of seeds/siliqua, number of siliquae/plant, days to 50% flowering, days to maturity, 1000 seed weight and yield/plant.

advance were measured using the formula given by Singh and Chaudhary (1985) and Allard (1960). Genotypic and phenotypic coefficient of variation was calculated by the formula of Burton (1952). Simple correlation coefficient was obtained using the formula suggested by Singh and Chaudhary (1985) and path co-efficient analysis was done following the method outlined by Dewey and Lu (1959).

RESULTS AND DISCUSSION

Species identification

In this experiment, all of the genotypes were categorized on the basis of the morphological characteristics of the species *Brassica rapa*, *B. juncea* and *B. napus*. Among the 40 germplasms, 19 germplasms were categorized as *B. rapa*, 15 germplasms *B. napus* and rest 6 germplasms *B. juncea* (Table 2). The inflorescence was the key to distinguish different species of *Brassica*. The shape of the inflorescence can generally be provided indications to distinguish species. *B. oleracea* had the buds at a higher level than the flowers just opened. This character was dominant in the hybrids, *B. napus* and *B. carinata* whereas in *B. rapa* the buds were at a lower level than the flowers just opened. However, there were exceptions to this rule and in *B. napus* with the same bud position as in *B. rapa* might be found. The morphological and other characteristics of *Brassica* differ from the common genotypes between *B. rapa*, *B. juncea* and *B. napus*. *Brassica* was a dicotyledonous herbaceous annual.

It grew to a height of 2-3 ft as soon as the plants became 30 to 90 days old. They bore numerous beautiful yellow flowers. The flowers bloomed gradually from below upwards and bore pods in the same order. In *B. rapa*, the leaves of the inflorescence grasped the stalk completely but in case of *B. napus*, they grasped the stalk partially. In *B. juncea* the lamina of the upper leaves did not reach the stalk. The most reliable characters used for distinguishing the *Brassica* species in the generative phase was the shape of the upper leaves, exceptions in this character were almost never found. In the basic species *B. rapa* the lower part of the blade (lamina) grasped the stalk completely,

Plate 1. Photographs showing the distinguishing characters among *B. rapa*, *B. napus* and *B. juncea* leaves

Statistical analysis

Phenotypic and genotypic variance was estimated by the formula used by Johnson *et al*. (1955). Heritability and genetic

whereas in *B. oleracea* the blade just reached the stalk. The hybrid *B. juncea* had obtained much of these characters but the petiole was rather short (Bengtsson *et al*., 1972). The flowering

Plate 2. Photographs showing the distinguishing characters among *B. rapa*, *B. napus* and *B. juncea* inflorescence

Plate 3. Photograph showing the distinguishing character among *B. rapa*(*campestris*), *B. juncea* and *B. napus* leaves

Plate 4. Photograph showing the distinguishing character among *B. napus*, *B. rapa* and *B. juncea* siliquae

Table 2. Genotypes of 40 *Brassica* categorized in *B. rapa, B. napus* and *B. juncea*

B. rapa	*B. rapa*	*B. napus*
BD-9062	BD-9084	BD-9106
BD-9063	BD-9085	BD-6949
BD-9064	BD-9087	BD-7810
BD-9067	BD-6956	BD-7811
BD-9068	SAUYC	BD-7812
BD-9071	*B. napus*	BD-7813
BD-9073	BD-9065	BD-7814
BD-9074	BD-9070	*B. juncea*
BD-9075	BD-9076	BD-7108
BD-9079	BD-9077	BD-9066
BD-9080	BD-9078	BD-9069
BD-9081	BD-9099	BD-9086
BD-9082	BD-9100	BD-9088
BD-9083	BD-9104	BD-6948

habit of *B. napus* and *B. juncea* was such that the open flowers appeared below the flower buds but the situation was reversed in case of *B. rapa*, i.e. the fresh open flowers appeared above the flower buds.

Brassica juncea

Variability

The analysis of variance indicated the existence of highly significant variability for all the characters studied (Table 3). From the mean value it was found that the tallest plant of 130.93cm in BD-9086 while the shortest plant of 68.33cm was in BD-9069 (Table 4). The minimum number of primary branches/plant (5.60) was recorded in BD-9066 followed by BD-6948 (5.73) and BD-7108 (6.03) and maximum number was found in BD-9069 (8.27). The number of secondary branches/plant 6.43 was recorded highest in BD-9069. On the other hand, BD-7108 and BD-9086 had the minimum number of secondary branches/plant (2.97).

Table 3. Analysis of variances of 10 important characters in respect of *B. juncea*

SV	df	PH	PB	SB	LS	SS	SP	1000SW	YP	DF	DM
Replication	2	207.49	0.11	0.35	0.01	0.17	364.93	0.01	0.03	9.56	18.00
Genotypes	5	1719.70**	3.35**	5.50**	0.48**	12.66**	1233.02*	0.43**	0.58**	482.89**	80.40**
Error	10	491.77	0.13	0.28	0.02	0.36	335.53	0.01	0.06	2.36	3.20

** Significant at 1% level of probability Here, PH = Plant height (cm), PB =Primary branches/plant (no.), SB = Secondary branches/plant (no), LS = Length of siliqua (cm), SS = Seeds/siliqua (no.), SP = Siliqua/plant(no.), SW = Seed weight(g), YP = Yield/plant(g), DF = Days of 50% flowering, DM = Days of 80% maturity, SV= Source of variation, df= Degrees of freedom

Table 4. Mean performance of 10 important characters in respect of *B. juncea*

Genotypes	PH	PB	SB	LS	SS	SP	1000 SW	YP	DF	DM
BD-7108	88.15abc	6.03c	2.97b	3.47a	14.25a	135.00bc	2.47a	1.44c	35.00c	84.33b
BD-9066	80.57bc	5.60c	3.10b	2.87c	10.83c	120.13c	2.25b	1.60c	32.33c	77.67c
BD-9069	68.33c	8.27a	6.43a	2.71d	12.18b	143.00abc	1.88c	2.64a	60.67a	91.67a
BD-9086	130.93a	7.27b	2.97b	2.48e	8.19d	157.07ab	1.98c	1.81bc	58.00a	88.33a
BD-9088	119.22ab	7.17b	3.23b	2.64d	10.45c	177.80a	1.54d	2.18b	59.67a	90.33a
BD-6948	105.33abc	5.73c	3.50b	3.33b	12.34b	158.80ab	2.53a	1.76bc	49.67b	83.67b
L.SIG	**	**	**	**	**	**	**	**	**	**
Lsd.05	40.34	0.643	0.97	0.081	1.09	0.33	0.13	0.46	2.79	3.25
Sx/sd	12.80	0.204	0.31	0.03	0.35	10.58	0.04	0.15	0.89	1.03
CV (%)	22.46	5.30	14.41	1.57	5.26	12.32	3.24	13.25	3.12	2.08

Here, CV% = Percentage of coefficient of variation, Lsd = Least significant difference,
Sx/sd =Standard deviation In a column means having similar letter(s) or without letter is identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

Table 5. Estimation of some genetic parameters in respect of *B. juncea*

Parameters	PH	PB	SB	LS	SS	SP	1000 SW	YP	DF	DM
GV	409.31	1.07	1.74	0.16	4.10	299.16	0.14	0.17	160.18	25.73
PV	901.08	1.20	2.024	0.16	4.46	634.69	0.15	0.24	162.53	28.93
GCV	20.49	15.49	35.63	13.67	17.81	11.64	17.74	21.73	25.71	5.90
PCV	30.40	16.40	38.43	13.75	18.57	16.95	18.06	25.48	25.90	6.25
h^2b	45.42	89.17	85.96	98.76	91.95	47.13	96.55	72.77	98.55	88.94
GA	28.44	30.13	68.05	27.98	35.17	16.46	1.14	38.19	52.58	11.46
GAPM	28.80	451.2	1839.16	958.7	309.27	11.07	53.85	2006.59	106.83	13.32

Here, GV= Genotypic variance, PV= Phenotypic variance, GCV= Genotypic coefficent of variation,
PCV= Phenotypic coefficent of variation, h^2b= Heritability %, GA= Genetic advance,
GAPM= Genetic advance in percentage of mean

Table 6. Correlation coefficient among different characters of the *B. juncea*

Trait	PH	PB	SB	DF	DM	LS	SS	SP	1000 SW	YP
PH	1.000	-0.065	-0.540*	0.350	0.292	-0.250	-0.509	0.500*	-0.255	-0.215
PB		1.000	0.653**	0.777**	0.766**	-0.632**	-0.280	0.329	-0.693**	0.802**
SB			1.000	0.414	0.400	-0.189	0.212	0.063	-0.256	0.834**
DF				1.000	0.864**	-0.624**	-0.427	0.543*	-0.693**	0.682*
DM					1.000	-0.435	-0.125	0.371	-0.646**	0.583*
LS						1.000	0.833**	-0.235	0.809**	-0.502*
SS							1.000	-0.312	0.518*	-0.122
SP								1.000	-0.427	0.470*
1000 SW									1.000	-0.609**

**, *, Significant at the 0.01 and 0.05 level of probability respectively

Table 7. Partitioning of genotypic correlation with seed yield/plant into direct (underline) and indirect components of *B. juncea*

Trait	PH	PB	SB	DF	DM	LS	SS	SP	1000SW	YP
PH	**-0.157**	3.504	-0.26	4.117	-8.629	0.205	-0.258	0.248	-2.887	-0.215
PB	1.019	**-5.39**	0.315	9.14	-2.264	0.519	-0.142	0.163	-7.847	0.802
SB	8.47	-3.519	**0.482**	4.87	-1.182	0.155	0.108	3.129	-2.899	0.834
DF	-5.489	-4.188	0.199	**0.118**	-2.553	0.513	-0.217	0.269	-7.847	0.682
DM	-4.58	-4.129	0.193	0.101	**-2.955**	0.358	-0.636	0.184	-7.315	0.583
LS	3.921	3.407	-9.113	-7.341	1.286	**-0.822**	0.424	-0.117	9.16	-0.502
SS	7.984	1.509	0.102	-0.05	3.694	-0.685	**0.508**	-0.155	5.865	-0.122
SP	-7.843	-1.773	3.038	6.388	-0.01	0.193	-0.157	**0.497**	-4.835	0.47
1000SW	3.999	3.735	-0.123	-8.153	1.909	-0.665	0.263	-0.212	**0.113**	-0.609
Residual effect: 2.928										

It was found that the highest 1000 seed weight 2.53g was recorded in BD-6948 which was statistically identical with BD-7108 (2.47g) while the lowest was in BD-9088 (1.54g). The highest yield/plant 2.64g was recorded in BD-9069 and the lowest yield/plant was recorded in BD-7108 (1.44g) followed by BD-9066 (1.60g). Early flowering (32.33 days) and early maturity (77.67 days) was observed in BD-9066. Late flowering and late maturity was observed in BD-9069 followed by BD-9088. Number of primary branches/plant, length of siliqua, number of seeds/siliqua, 1000 seed weight and yield/plant showed minimum difference between genotypic and phenotypic variance (Table 4) which indicated low environmental influence on this character which might be due to their genetic control. Plant height, number of secondary branches/plant, number of siliquae/plant, days to 50% flowering and days to maturity showed much difference between genotypic and phenotypic variance indicated large environmental influence on these characters. Number of primary branches/plant, length of siliqua, number of seeds/siliqua, number of siliquae/plant, 1000 seed weight and days to maturity showed low genotypic and phenotypic coefficient of variation in Table 4.

Moderate genotypic and phenotypic coefficient of variation was observed in plant height, number of secondary branches/plant, days to 50% flowering and yield/plant.

Heritability and genetic advance

The heritability estimates, genetic advance and genetic advance in percent of mean for the genotypes under *B. juncea* were presented in Table 5. Plant height, number of siliquae/plant showed low heritability with low genetic advance and low genetic advance in percentage of mean which indicated the characters were highly influenced by environmental effects and selection would be ineffective. Length of siliqua, 1000 seed weight and days to maturity showed high heritability with low genetic advance and low genetic advance in percentag mean which indicated the possibility of non-additive gene action. The high heritability was due to favorable influence of environment rather than genotype and selection for such traits might not be rewarding. Number of primary branches/plant, number of secondary branches/plant, number of seeds/siliqua, days to 50% flowering and yield/plant showed high heritability with high genetic advance and high genetic advance in percentage of mean revealed the possibility of predominance of additive gene effects and selection might be effective.

Correlation matrix

Genotypic and phenotypic correlation coefficients between pairs of characters for *B. juncea* in the presented study were presented in Table 6. Plant height showed highly significant positive association with number of siliquae/plant. The results revealed that the tallest plant initiated with an increase of number of siliquae/plant. On the other hand, plant height had non significant negative association with number of primary branches/plant, length of siliqua, number of seeds/siliqua, 1000 seed weight and yield/plant and non significant positive correlation with days to 50% flowering and days to maturity. Positive correlation of plant height with number of seeds/siliqua, number of siliquae/plant and negative correlation with 1000 seed weight were reported by Chowdhury *et al.* (1987). The present findings are partially agreed with Chowdhury *et al.* (1987). Number of primary branches/plant had highly significant positive correlation with number of secondary branches/plant, days to 50% flowering, days to maturity and yield/plant which indicated that more primary branches producing genotype produced more seed yield. But length of siliqua and thousand seed weight showed significant negative correlation with number of primary branches/plant. Reddy (1991) found the similar findings in his experiment. Number of secondary branches/plant showed highly significant positive correlation with yield/plant. The results revealed that number secondary branches/plant might be considered for the selection of yield/plant.

On the other hand, days to 50% flowering, days to maturity, number of seeds/siliqua and number of siliquae/plant showed non-significant positive correlation with number of secondary branches/plant. Days to 50% flowering showed significant positive association with days to maturity, number of siliquae/plant and yield/plant. Days to maturity showed significant positive correlation with yield/plant and highly significant negative correlation with thousand seed weight (Table 6). Positive association of days to maturity with siliqua length, number of siliquae/plant and thousand seed weight had been reported by Chowdhury *et al.* (1987). Highly significant positive association found length of siliqua with number of seeds/siliqua and 1000 seed weight and significant negative correlation with yield/plant. Chaudhry *et al.* (1993) found that seed yield was positively correlated with siliqua length which is disagreed with this experimental result. Number of seeds/siliqua showed significant positive correlation with thousand seed weight and number of siliquae/plant had significant positive association with yield/plant. 1000 seed weight showed highly significant negative correlation with yield/plant.

Path coefficient

Estimation of direct and indirect effect of path coefficient analysis for *B. juncea* was presented in Table 7. Number of primary branches/plant, number of secondary branches/plant, days to 50% flowering,days to maturity and number of siliquae/plant showed positive direct effect and plant height, length of siliqua, number of seeds/siliqua and 1000 seed weight showed negative direct effect on yield/plant. Han (1990) working with *B. napus*, observed negative direct effect of number of siliquae/plant and positive direct effect of number of seeds/siliqua and plant height on seed yield. Plant height had negative indirect effects on secondary branches/plant, days to maturity, number of seeds/siliqua and 1000 seed weight. On the contrary plant height had positive indirect effects on primary branches/plant, days to 50% flowering, length of siliqua and number of siliquae/plant. Path analysis showed that number of primary branches/plant had negative indirect effect on days to maturity, number of seeds/siliqua and thousand seed weight and positive indirect effect on plant height, number of secondary branches/plant, days to 50% flowering, length of siliqua and number of siliquae/plant (Table 7).

Number of secondary branches/plant had positive indirect effects on plant height, days to 50% flowering, length of siliqua, number of seeds/siliqua and number of siliquae/plant. On the other hand, number of secondary branches/plant had negative indirect contribution on number of primary branches/plant, days to maturity and thousand seed weight. Path analysis revealed that days to 50% flowering had positive indirect effects on number of secondary branches/plant, length of siliqua and number of siliquae/plant. Chauhan and Singh (1985) observed high positive direct effect of days to 50% flowering, plant height, primary branching, number of siliquae/plant, number of seeds/siliqua on yield. Days to maturity showed positive indirect contribution on number of secondary branches/plant, days to 50% flowering, length of siliqua and number of siliquae/plant. Length of siliqua had positive indirect contribution on plant height, number of primary branches/plant, days to maturity, number of seeds/siliqua and 1000 seed weight. Kumar *et al.* (1984) and Chen *et al.* (1983) found negative effect in plant height on days to maturity and siliqua length. Path analysis revealed that number of seeds/siliqua had positive indirect effect on plant height, number of primary branches/plant, number of secondary branches/plant, days to maturity and 1000 seed weight (Table 7). Chen *et al.* (1983), Chauhan and Singh (1985) and Han (1990) found substantial direct effect of number of seeds/siliqua on seed yield. Number of siliquae/plant had positive indirect effect on number of secondary branches/plant, days to 50% flowering and length of siliqua. 1000 seed weight had positive indirect effect on plant height, number of primary branches/plant, days to maturity and number of seeds/siliqua. Varshney (1986) working with several strains of *B. rapa* found the negative direct effect of plant height, number of siliquae/plant, number of seeds/siliqua and 1000 seed weight on yield.

Conclusion

BD-9069 was late flowering and late maturing type while BD-9066 was early flowering and BD-9086 was early maturing type. BD-9100 was the tallest type plant, whereas BD-9069 was the shortest type plant and produced highest number of primary and secondary branches/plant. BD-9066 produced lowest number of primary branches/plant while BD-9086 and BD-7108 had lowest number of secondary branches/plant. BD-9088 showed highest number of siliquae/plant and BD-9066 showed lowest in number. BD-7108 produced highest number of seeds/siliqua and BD-9086 produced lowest number. The length of siliqua was highest in BD-7108 and lowest in BD-9086. Highest 1000 seed weight was recorded in BD-6948 while lowest in BD-9088. BD-9069 produced highest yield/plant whereas lowest was produced by BD-7108. Number of primary branches/plant, length of siliqua, number of seeds/siliqua, 1000 seed weight and yield/plant showed minimum difference between genotypic and phenotypic variance. Number of primary branches/plant, length of siliqua, number of seeds/siliqua, number of siliquae/plant, 1000 seed weight and days to maturity showed low genotypic and phenotypic coefficient of variation. High heritability coupled with high genetic advance and genetic advance in percentage of mean was recorded for the character number of secondary branches/plant.

Correlation co-efficient revealed that yield/plant had significant positive association with number of primary branches/plant, number of secondary branches/plant, days to 50% flowering, days to maturity and number of siliquae/plant. Path analysis revealed that number of primary branches/plant, number of secondary branches/plant, days to 50% flowering, days to maturity and number of siliquae/plant showed positive direct effect and plant height, length of siliqua, number of seeds/siliqua and 1000 seed weight showed negative direct effect on yield/plant. Considering genetic status and other agronomic performances 02 materials viz. BD-9069 and BD-9088 could be used as superior parents for mustard and rape improvement programme in future.

REFERENCE

Alam, M. M. and Rahman, M. M. 2006. Effect of row spacing on seed yield of five varieties of Rapeseed. *Bangladesh J. Crop Sci*. 17(1): 163-168.

Allard, R.W. 1960. Principles of Plant Breeding. John Willey and Sons. Inc. New York. p. 36.

Anonymous. 2000. Tel Fasaler Utpadan Prajukti (In Bangla), Oil Seed Res. Centre, Bangladesh Agril. Res. Inst., Joydebpur, Gazipur. pp. 1-102.

Bask, N. C., Pandit, J. C. and Khurram, M. H. 2007. On-farm evaluation of three mustard varieties under different fertilizer packages. *Bangladesh J. Sci. Ind. Res*. 42(3): 335-340.

Bengtsson, P.P., Basu, M.S. and Reddi, P.S. 1972. Genetic variability, character association and path coefficient of quantitative traits of groundnut. *Indian J. Agric*. 41(2): 215-284.

Burton, G.W. (1952). Quantitative inheritance in grass pea. Proc. 6 th Grassl. Cong. 1: 277-283.

Chaudhury, P.K., Singh, P. and Kumar, A. 1993. Association and Interdependence of morpho-physiological characters under moisture stress in *Brassica*. *Beitrage Zar Tropichen Landuirtshaft*. 18(1): 43-47.

Chauhan, J. and Singh, P. 1985. Association of some morpho-physiological determinants with seed yield in toria (*B. campestris* L. var. Toria). *Indian J. Agric. Sci*. 55(3): 42-43.

Chen, C., Hwu, K.K., Liu, C.P. and Lin, M.S. 1983. Selection criteria for yield improvement in rape. *J. Agri. Asso. China*. 124: 63-73.

Chowdhury, M.A.Z., Mia, M.F.C., Afjal, M.A. and Ali, M.M. 1987. Comparative study of D^2 and metroglyph analysis in groundnut. *Thailand J. Agric. Sci*. 31(3): 436-443.

Dewey, D.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agron. J*. 51 : 515-518.

Elahi, N. E., Khan, A. H., Siddique, M. R., Saha, A., Nasim, M., Mollah, M. I. U. and Shahidullah, S. M. 1999. Existing cropping patterns of Bangladesh, potential technologies and strategies for improving systems productivity. Proceedings of the workshop of modern rice cultivation in Bangladesh. Feb. 14-16. pp. 107-170.

Han, J.X. 1990. Genetic analysis of oil content in rape *Brassica napus*. Oil crops of China. 2: 1-6.

http://en.wikipedia.org/wiki/Brassica_rapa

http://en.wikipedia.org/wiki/Brassicaceae

http://www.ais.gov.bd/doc/read/7213/

http://www.bbs.gov.bd/Home.aspx

http://www.indexmundi.com/agriculture/?country=bd

Johnson; Herbert, W., Robinson, H.F. and Comstock, R.E. 1955. Estimates of genetic and environmental variability in soyabeans. *Agron. J*. 47: 314-318.

Kakroo, P. and Kumar, S. 1991. Genetic determination of seed yield through it's components in Indian mustard. *Indian J. Genet. Pl. Breed.* 51(2): 82.

Kumar, P., Yadava, T.P. and Yadav, A.K. 1984. Association of seed yield and its component traits in the F_2 generation of Indian mustard. *Indian J. Agric. Sci*. 54(5): 604-607.

Malik, V., Singh, H. and Singh, D. 1995. Gene action of seed yield and other desirable characters in rapeseed. *Analysis Biol. (Ludhiana)*. 11(1/2): 94-97.

Nagaharu U. 1935. Genome analysis in *Brassica* with special reference to the experimental formation of *B. napus* and peculiar mode of fertilization. *Japanese Journal of Botany* 7: 389–452.

Nanda, R., Bhargava, S.C. and Tomar, D.P.S. 1995. Rate and duration of siliqua and seed filling and their rotation to seed yield in *Brassica* species. *Indian J. Agric. Sci.* 64(4): 227-232.

Reddy, V.R.G., Singh, B.N. and Rai, B. 1987. Analysis of genetic divergence in spreading varieties of groundnut. *Crop Improv*. 14(2): 149-152.

Singh, R.K. and Chaudhary, B.D. 1985. Biometrical methods in quantitative genetic analysis. Kalyani Publishers, New Delhi, India. p. 56.

Singh, R.P., Khera, M.K. and Gupta, V.P. 1991. Variability and correlation studies for oil and seed yield in gobhi sarson. *Crop Improv*. 18(2): 99-102.

USAID (United States Agency for International Development) Bangladesh. 2006. Food and Agriculture in Bangladesh: A Success Story, United States Agency for International Development.

Yarnell, S.H. 1956. Cytogenetics of vegetable crops. *Crucifers Bot. Rev*. 22(2): 81-166.

****