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Variability Study in F_2 Progenies of Inter-varietal Crosses of Rapeseed (*Brassica campestris* x *Brassica napus*)

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ABSTRACT

This research work was carried out to estimate the magnitude of variations in characters, inter-genotypic variability, heritability, genetic advance, character associations, direct and indirect effect of different characters in seeds yielded of F_2 population. In this experiment, F_2 population of some inter-varietal crosses of the species BARI Sarisha-14 and BINA Sarisha-4 were used. Significant variation was observed among all eight genotypes for all the characters studied except thousand seed weight. Based on the variability study, some F_2's genotypes (G2, G3, G4 & G6) showed high heritability for yield and yield contributing characters. Thus, the genotypes G2, G3, G4 & G6 might be selected as superior genotypes for future hybridization program because these genotypes could produce transgressive segregants in advanced or later generations.

Keywords: Heritability, Hybridization, Inter-varietal, Transgressive segregants, Variability

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1. INTRODUCTION

Mustard belongs to *Brassica* genus. *B. rapa* (2n = 20) belongs to Brassicaceae family and it has been proposed to originate from two independent centers in Asia and Europe (Zhao et al., 2005). The oil of mustard is a good source of essential fatty acids (linoleic, linolenic, oleic and palmitic acid), and fat-soluble vitamins A, D, E and K (Khobragade et al., 2008). The erucic acid content in mustard samples (n=15) varied from 14% to 33% in the lipids. Foodstuff with a high content of erucic acid is considered undesirable for human consumption because it has been linked to myocardial lipidosis and heart lesions in laboratory rats. Brassica oil is of variable quality with had to good for health probably due to high to zero contents of erucic acid and high to low contents of glucosinolates (Li et al., 1989).

Brassica oil crop supplies substantial quality of edible oil in Bangladesh. Soybean and palm oil are imported and mustard is produced locally. In the recent days Bangladesh's consumers is facing historic high cost of soybean oil. To meet up with country's strong dependence on imports it is time to boost the cultivation of mustard. Even until the 1970s, mustard oil used to be in every kitchen as the major cooking oil of general people. Since the late 1970s, soybean and palm oil slowly started to take the position of mustard oil because of its affordable price. But because of the price hike it seems like the golden days of mustard are coming back. The production of mustard can be more popular as it can be farmed between the gaps of paddy cultivation seasons, particularly after Aman. Mustard is now cultivated as an additional crop between Ropa, Aman and Boro by cultivating short-lived rice in the new crop pattern. The climatic and edaphic factors of Bangladesh are quite

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favorable for the cultivation of rape seed and mustard (Haque et al., 1987). BARI sarisha- 14 & BINA sarisha- 4 are two developed varieties which are short duration, high yielding and disease resistant. They can be cultivated during the gaps of rice cultivation. BARI sarisha- 14 is a short duration variety and BINA sarisha- 4 can be cultivated in diverse types of soil. If a variety could develop which is high yielding and short duration there is a potentiality to fill the gap between Aman and Boro rice cultivation. Theoretically if the harvesting of Aman can be made early by 10 days and the transplanting of Boro rice can be delayed up to 10-15 days it will be possible to cultivate the developed variety. In the meantime if the content of erucic acid can be reduced the quality of the oil will be improved. In this case, interspecific hybridization may be required to incorporate the desired traits into commercial varieties/lines. In this purpose, the present study was carried out in order to generate mustard genotypes with a short duration and high yield crossing between BARI Sarisha- 14 and BINA Sarisha- 4. The objectives include studying variability in the F_2 segregating generation and selecting best yield and yield contributing characters.

2. MATERIALS AND METHODS

The proposed experiment was conducted at the roof top of EXIM Bank Agricultural University Bangladesh Chapainawabganj, north-western part of Bangladesh. 24° 35' 48"N 88° 16' 13"E Chapainawabganj's climate is characterized by monsoons, high temperatures, high humidity, and moderate precipitation. The hot season starts in March and lasts until July, with April, May, June, and July having the highest average temperatures. In the district, there was approximately 1,448 millimeters of yearly rainfall (57.0 in).This research study examined the variability among eight genotypes from inter-varietal crosses between BARI Sarisha-14 and BINA Sarisha-4, as detailed in Table 1. The experiment involved 24 plastic pots filled with prepared soil, carefully removed gravels and pebbles, and sanitized with natural sunlight. The pots were labeled G1-G8, with each section having 3 pots. Seedlings were grown in various pots and transplanted after 2 weeks of sowing to 24 pots, completed on 14 November 2022. Intercultural operations like weeding, thinning, and irrigation were uniformly performed in plots, with daily water cane irrigation after seedling transplanting. A drainage system was maintained, and weeding and stalking were done at 10 days intervals. Appropriate fertilizers and insecticides are gives in need basis. Harvesting began on February 26, 2023, and ended on March 21, 2023, with 80% of plants showing straw, leaves, stem, and desirable seed colors, and data collected. The data collection process involves measuring plant height, days to 50% flowering, days to maturity, number of primary and secondary branches per plant, siliqua length, number of siliqua per plant, number of grains per siliqua, thousand seed weight, and seed yield per plant. These parameters were taken after harvesting and were used to analyze the growth and development of the plant. The data collected helps in understanding the plant's growth and development. Data on eight genotypes were analyzed using Minitab software, ANOVA, and RStudio software, calculating maximum, minimum, mean, standard deviation, coefficient of variance, heritability, genetic advance, and phenotypic and genotypic variance.

Table1 Selection of plant materials

Genotypes	Inter-varietal Crosses
G1	BARI Sarisha-14 (*Brassica campestris*) × BINA Sarisha-4 (*Brassica napus*)
G2	
G3	
G4	
G5	
G6	
G7	
G8	

3. RESULTS AND DISCUSSION

3.1. Mean, Standard Deviation and Coefficient of Variance Performance of Eight F_2's Genotypes

Several morphological traits were used to evaluate the performance of eight F_2 genotypes that were derived from BARI Sarisha-14 × BINA Sarisha-4 (Fig. 1 and 2).

Plant Height (cm)

With a height of 96.80 cm, genotype G3 plants were the tallest, while genotype G8 plants were the smallest, standing at 57.00 cm. The coefficient of variation was 13.35 with a standard deviation of 11.25 and an average height of 84.25 cm.

Days to 50% Flowering

G2 took the longest (73 days) to flower, while G4 flowered early (63 days). The coefficient of variance and standard deviation were 2.65 and 3.91, respectively, and the mean flowering time was 67.91 days.

Days to Maturity

G8 showed the highest maturity days (115.00), while G2 had the lowest (98.00). With a standard deviation of 4.52 and a coefficient of variance of 4.29, the mean maturity period was 105.46 days.

Number of Primary Branches per Plant

With an average of roughly ten primary branches, G1 produced the most, whereas G7 produced the fewest. There were 4.79 branches on average per plant, with a 1.41 standard deviation.

Number of Secondary Branches per Plant

The most secondary branches were found in G4, which was followed by G8 and G3. For secondary branches, the corresponding coefficient of variance and standard deviation were 32.19 and 3.13, respectively.

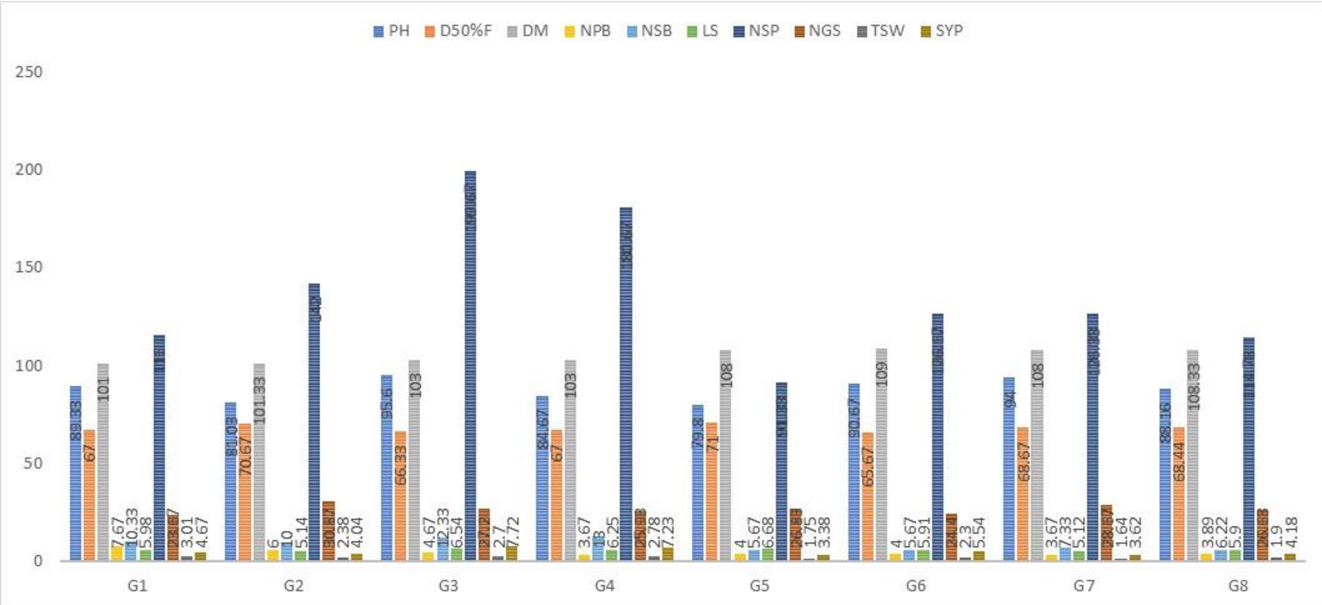

Fig. 1 Mean performance of ten characters of 8 F2’s genotypes derived from BARI sarisha-14 × BINA sarisha-4.

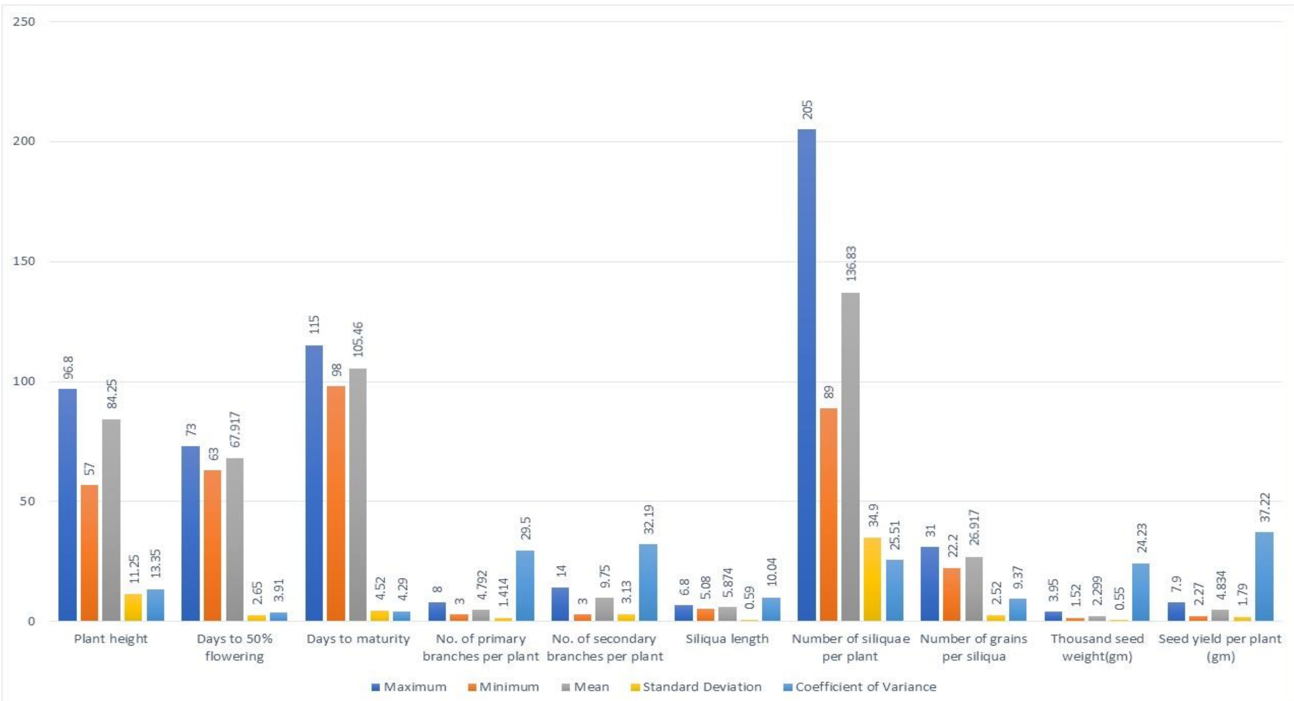

Fig. 2 Maximum, minimum, mean, standard deviation and coefficient of variance value of yield and yield contributing ten characters of 8 F2’s genotypes derived from BARI sarisha-14 × BINA sarisha-4.

Siliqua Length (cm)

The length of silica varied from 6.80 cm to 5.08 cm. The longest was produced by G5, and the shortest by G2. 10.04 and 0.59 were the coefficient of variance and standard deviation, respectively.

Number of Siliquae per Plant

G5 had the lowest average (89.90), and G3 had the highest average (205). This trait's mean was 136.83.

Number of Grains per Siliqua

The grains per siliqua ranged from 31.0 to 22.0. G7 was the most productive, G6 the least. The standard deviation and coefficient of variance were 2.52 and 9.37, respectively.

Thousand Seed Weight (gm)

The weight of the thousand seeds varied, averaging 2.29 gm and ranging from 3.95 gm to 1.52 gm. G1 produced the heaviest seeds, with a coefficient of variance and standard deviation of 24.23 and 0.55, respectively.

Seed Yield per Plant (gm)

The average seed weight per plant was 4.83 gm, with G3 having the highest seed weight (7.90 gm) and G8 yielding the lowest (2.27 gm). The coefficient of variance was 38.54 with a standard deviation of 1.79.

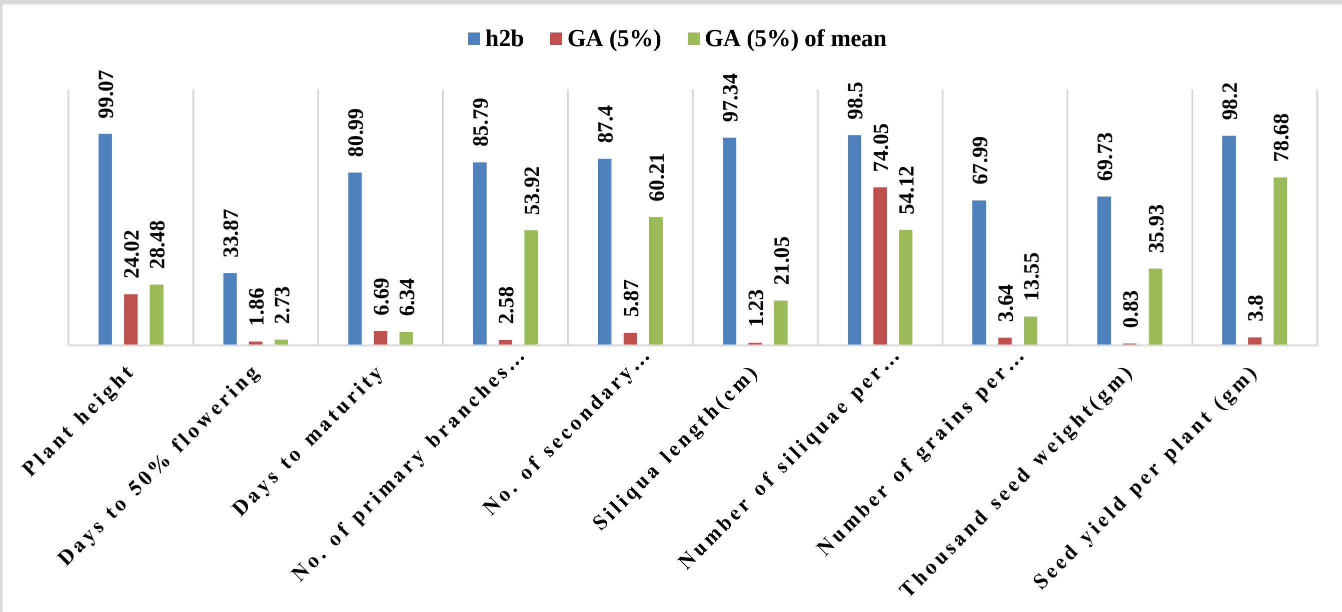

Fig. 3 Heritability, genetic advance and genetic advance as percentage of mean for yield and yield contributing characters of 8 F_2's genotypes derived from BARI sarisha-14 × BINA sarisha-4.

3.2. Heritability, Genetic Advanced and Selection

Various morphological traits were analyzed in eight F_2 genotypes that were derived from BARI Sarisha-14 ×BINA Sarisha-4. (Fig. 3).

Plant Height (cm)

G8 was the shortest genotype at 57.00 cm, and G3 was the tallest at 96.80 cm. 84.25 cm was the average height overall (SD=11.25, CV=13.35). Plant height revealed high heritability in the broad sense of (99.07%) with high genetic advance (24.02%) and high genetic advance in percentage of mean (28.48%) indicated the possibility of additive genes effect for the expression of this character. There for selection would be effective for producing varieties.

Days to 50% Flowering

Days to 50% flowering exhibited moderate heritability (33.87%) in broad sense (h^2_b) coupled with low genetic advance 1.86% and low genetic advance in percentage of mean 2.73% indicated the character were highly influenced by environmental effects and selection for such trait might not be rewarding. Siddikee (2006). Malik et al., (1995), Li et al., (1989) and Singh et al., (1987) obtained similar type result.

Days to Maturity

The magnitude of heritability 80.99% in broad sense (h^2_b) for days to maturity was high with moderate genetic advance 6.69% and low genetic advance in percentage of mean 6.34% indicating this character is governed by non-additive gene.

Number of Primary Branches per Plant

Number of primary branches per plant exhibited high heritability (85.79%) in broad sense (h^2_b) coupled with low genetic advanced 2.58% and high genetic advanced in percentage of mean 53.92%, indicated the character were highly influenced by environmental effects i.e. there was some scope of isolating some good genotypes but selection is less effective. Similar results were also reported by Praveen (2007) and Siddikee (2006).

Number of Secondary Branches per Plant

This character exhibited high heritability (87.40%) in broad sense (h^2_b) coupled with mode rate genetic advance 5.87% and high genetic advanced in percentage of mean60.21% Indicating that selection may be successful and that this attribute was controlled by additive gene. Siddikee (2006) discovered high heritability in the broad sense (86.68) with moderate genetic progress (6.75) and medium genetic progress (38.23) in terms of percentage of mean.

Siliqua Length (cm)

Length of siliqua exhibited high heritability (97.34%) in broad sense (h^2_b) with low (1.23%) genetic advance and high (21.05%) genetic advance in percentage of mean. In that case the high values of heritability are not always an indication of high genetic advance i.e. this character is governed by non-additive gene. The high heritability was due to the favorable influence of environment rather than genotype and selection for such trait might not be rewarding. It differs with the findings of Rashid (2007) but similar with the findings of Siddikee (2006), Singh et al., (1987).

Table 2 Genetic parameters for yield and yield contributing characters of 8 F2's genotypes derived from BARI Sarisha-14 X BINA Sarisha-4

Characters	Mean sum of square	σ^2_g	σ^2_e	σ^2_p	GCV (%)	PCV (%)
Plant height	412.35**	137.02	1.28	138.30	13.89	13.95
Days to 50% flowering	11.88**	2.40	4.68	7.08	2.28	3.92
Days to maturity	42.09**	13.01	3.05	16.06	3.42	3.80
No. of primary branches per plant	5.80**	1.83	0.30	2.13	28.25	30.50
No. of secondary branches per plant	29.21**	9.29	1.33	10.63	31.26	33.44
Siliqua length(cm)	1.12**	0.30	0.01	0.38	10.35	10.49
No. of siliqua per plant	3956.0**	1312.0	19.98	1331.99	26.47	26.67
No. of grains per Siliqua	15.99**	4.60	2.16	6.77	7.97	9.67
Thousand seed weight(gm)	0.79	0.23	0.10	0.33	20.88	25.01
Seed yield per plant (gm)	10.48**	3.47	0.06	3.53	38.54	38.89

** Significant at 1% level of probability

Number of Siliqua per Plant

The magnitude of heritability (98.50%) in broad sense (h^2_b) for number of siliqua per plant was high with considerably high genetic advance 74.05% and high genetic advance in percentage of mean 54.12% indicated that the character was governed by additive gene and selection might be effective. Similar result was also reported by Siddikee (2006).

Number of Grains per Siliqua

The number of grains per siliqua showed high heritability (67.99%) in the broad sense, low genetic advance (3.64%), and medium genetic advance in percentage of mean (13.2623%). Indicating that selection may be successful and that this attribute was controlled by additive gene. Siddikee (2006) discovered high heritability in the broad sense (86.68) with moderate genetic progress (6.75) and medium genetic progress (38.23) in terms of percentage of mean.

Thousand Seed Weight (g)

The magnitude of high heritability (69.73%) in broad sense with low (0.83%) genetic advance and high (35.93%) genetic advance in percentage of mean revealed the possibility of predominance of additive gene effect and selection might be effective for producing varieties. Akanda et al., (1997) opined that the characters with high heritability accompanied by high genetic advance in percentage of mean indication that they might transmit to their hybrid progenies.

Seed Yield per Plant (g)

Seed yield per plant exhibited high heritability (98.20%) in broad sense (h^2_b) with low (3.80%) genetic advance and high (78.687%) genetic advance in percentage of mean revealed the possibility of predominance of additive gene effect and selection might be effective for producing varieties. Akanda et al., (1997) opined that the characters with high heritability accompanied by high genetic advance in percentage of mean indication that they might transmit to their hybrid progenies.

3.3. Variability and other biometrical studies of parental lines

Several morphological traits of the eight F_2genotypes generated by crossing BINA Sarisha-4 with BARI Sarisha-14 were found to differ significantly. Biometric analyses included genotypic and phenotypic variances in addition to plant height, days to 50% flowering, days to maturity, number of primary and secondary branches per plant, length of the siliqua, number of siliqua per plant, number of grains per siliqua, thousand seed weight, and seed yield per plant. (Table 2).

Plant Height (cm)

Significant differences was observed among all genotypes (412.35) studied for this character. Plant height showed genotypic (137.02) and phenotypic (138.30) variance with relatively low differences between them indicating moderate environmental influences on these character as well as GCV (13.89%) and PCV (13.95%) indicating presence of considerable variability among the genotypes. Tyagi et al.

(2001) observed highest variation in plant height among parent and their hybrid.

Days to 50% Flowering

The phenotypic and genotypic variances for this trait were (7.08) and (2.40) respectively with minimum differences between them. The phenotypic variances appeared to be higher than the genotypic variance, suggested considerable influence of environment on the expression of the genes controlling this trait. The difference between phenotypic co-efficient of variation (3.92%) and genotypic co-efficient of variation (2.28%) was minimum. Lekh et al., (1998) recorded highest GCV and PCV for days to 50% flowering. Singh et al., (1987), found significant genetic variability in days to 50% flowering in *Brassica napus* and in *Brassica rapa*.

Days to Maturity

Genotypic and phenotypic variance for days to maturity was observed 13.01 and 16.06 respectively with moderate differences between them, suggested considerable influence of environment on the expression of the genes controlling this trait. The phenotypic coefficient of variation (3.80) was higher than the genotypic coefficient of variation (3.42). Which suggested that environment has a significant role on the expression of this trait. Higher genotypic variances indicate the better transmissibility of a character from parent to the offspring (Ushakumari et al., 1991).

Number of Primary Branches per Plant

Number of primary branches per plant showed high differences between genotypic (1.83) and phenotypic (2.13) variance indicating large environmental influence on these character and relatively low difference between GCV (28.25%) and PCV (30.50%) value indicating the apparent variation not only due to genotypes but also due to the large influence of environment. Chaudhury et al., (1987) found significant differences for number of primary branches per plant.

Number of Secondary Branches per Plant

Number of secondary branches showed moderate difference between genotypic (9.29) and phenotypic (10.63) variance indicating moderate environmental influence on these character. The PCV (33.44%) was much higher than GCV (31.26%) for this trait suggested that environment has a significant role on the expression of this trait. Lekh et al., (1998) reported similar result.

Siliqua Length (cm)

Length of siliqua showed genotypic (0.30) and phenotypic (0.38) variance with minimum difference between them indicating that they were less responsive to environmental factors for their phenotypic expression and relatively low GCV (10.35%) and PCV (10.49%) indicating that the genotype has less variation for this trait. Labowitz (1989) studied *Brassica campestris* population for siliqua length and observed high genetic variation on this trait.

Number of Siliqua per Plant

Highest genotypic and phenotypic variance was observed (1312.00) and (1331.99) respectively for number of siliquae per plant with large environmental influence and difference between the GCV (26.47%) and PCV (26.67%) indicating existence of adequate variation among the genotype. Singh *et* al., (1987) found 25.41% and29.15% of GCV and PCV respectively in *Brassica campestris*. Higher genotypic variances indicate the better transmissibility of a character from parent to the offspring (Ushakumari et al., 1991).

Number of Grains per Siliqua

The differences in magnitudes in between genotypic (4.60) and phenotypic (6.77) variances was relatively high for number of grains per siliqua indicating large environmental influence on these characters. Bhardwaj & Singh (1969) observed 35.85% GCV in *Brassica campestris.*

Thousand Seed Weight (g)

The phenotypic and genotypic variances for this trait were (0.33) and (0.23) respectively. The phenotypic variance appeared to be higher than the genotypic variance suggested considerable influence of environment on the expression of the genes controlling this trait. The difference between phenotypic coefficient of variation (25.01%) and genotypic co-efficient of variation (20.88) was maximum. Bhardwaj &Singh (1969) reported values 11.8% and 18.9% of CCV and PCV for thousand seed weight in *Brassica campestris.*

Seed Yield per Plant (g)

The phenotypic and genotypic variances for this trait were comparatively low (3.53 and 3.47). The phenotypic variance appeared to be much higher than the genotypic variance, suggested large influence of environment on the expression of the genes controlling this trait. The phenotypic co-efficient of variation (38.89%) was higher than the genotypic co-efficient of variation (38.54%), which suggested that environment has a significant role on the expression of this trait. High degree of variation in yield was reported by Yin (1989) in *B. rapa*, Kudla (1993) in *Brassica napus* and Kumar et al., (1988) in *Brassica juncea*. Singh (1987) reported values 44.04% and 46.9% of CCV and PCV respectively for *Brassica juncea*.

All things considered, the results highlight the intricate interactions between environmental and genetic factors that shape the morphological features and yield-related traits of the genotypes under study.

5. CONCLUSION

This research work was carried out to study the inter-varietal crosses between BARI sarisha-14 and BINA sarisha-4 in order to check variability in F_2 segregating generation. To select some potential F_2 hybrids having high yielding and early maturity. The developed variety can be cultivated during the gaps of rice cultivation. Trial of these might be conducted to find out the adaptability of the hybrids. If a variety could develop which is high yielding & short duration there is a potentiality to fill the gap between Aman and Boro rice cultivation. Thus the genotypes G2, G3, G4 & G6 might be selected as superior genotypes for future hybridization program because these genotypes could produce transgressive segregants in advanced or later generations, the predominance of additive gene action for these traits and there is always a good chance of improving those traits by accumulation of favorable genes.

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