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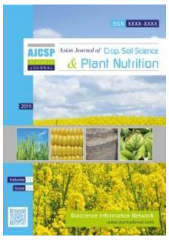

Phenotyping of Mustard (*Brassica juncea)* under the agro ecological condition of Chattogram region

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ABSTRACT

Twelve genotypes of Brassica juncea were evaluated at Regional Agricultural Research Station (RARS), Bangladesh Agricultural Research Institute (BARI), Hathazari, Chattogram to find out the superior lines for using in the breeding program to develop a high yielding variety. The first six principal components (PCs) denoted about 92 % of the total variation among genotypes. The number of branches per plant is closely related with no. of siliqua per plant and 1000 seed weight (g) but it had been not strongly related to other traits. Thousand seed weight (g) is closely related with days to 50% flowering and days to maturity but it had been not strongly related to other traits. The no. of seeds per siliqua was positively correlated with length of siliqua and plant height but negatively correlated with other traits. The short vector of seed yield per plot (kg) denotes that it was not strongly correlated with any other traits. The maturity duration among the tested entries ranged from 93-95 days. The entry BJ-11536(12)-3 created the highest siliqua per plant recorded as 198. In contrast, minimum number of siliqua was gained from BJ-11536(9)-6 which was noted as 104. The highest seed per siliqua noted as 16 was observed in BJ-11536(12)-3 followed by 15 seeds per siliqua in BJ-11536(7)-2 and the lowest seed per siliqua documented as 12 was obtained from the entries BJ-10-10104(y), BJ-11536(9)-2 and BARI Sarisha 11. The entry BJ-11536(12)-3 provided the highest yield of 1.79 t/ha followed by 1.42 t/ha in BJ-2014-y02 and BJ-2104-y05. Three genotypes namely BJ-11536(12)-3, BJ-2014-y02 and BJ-2104-y05 can be selected to be used as parental materials in the breeding program.

Key words: *Mustard, plant growth, seed yield and climatic condition*

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I. Introduction

Brassica Juncea, popularly known as rai or raya is considered as important oilseed crops in Bangladesh. It is universally identified as Indian mustard that is worldwide familiar not only as oilseed but also as vegetable and condiments (Saleem et al., 2017 and Kumar et al., 2018). *Brassica juncea* is capable of high output, strong plantlet development, faster earth layering ability, better tolerance to high temperature and drought with enhanced resistance to insects and disease (Wright et al., 1995 and Burton et al., 2004). It is thought to be an essential resource of catering oil in Bangladesh fulfilling one-third of the edible oil requisite of the state (Ahmed, 1988). It is also known as a carrier of vitamin A, vitamin D, vitamin E and vitamin K which are fat soluble in the body. In the last several decades' severe deficiency of cooking oil has been faced by Bangladesh. Our domestic production is capable to meet up with only about 21% of our expenditure. The remaining 79 % is imported from abroad (Begum et al., 2012). We have to expend enormous money to import oil and oilseeds to meet up shortfall of oil every year. Therefore, the improvement of high yield producing cultivars of oilseed is required to decrease the importation of edible oil. *Brassica* (rapeseed and mustard) is considered as one of the vital oilseed crops in Bangladesh but its countrywide standard yield is 902 kg ha^{-1} only (BBS, 2010). In contrast, the productivity of mustard is 4.3 t/ha in Germany, 3.8 t/ha in France and 3.4 t/ ha in the UK (Yadava et al., 2012). So, in Bangladesh, there is a huge gap in production compared to other developed countries. Though there are many factors related to lower yield, lack of superior varieties with yielding capability is one of the most important factors for the lower yield. Therefore, high yielding varieties can be attained if superior lines are efficiently used as parental resources in breeding program. So, the experiment was executed to seek out the best *Brassica juncea* lines for breeding program to provide superior varieties.

II. Materials and Methods

The experiment was directed at RARS, BARI, Hathazari, Chattogram during 2017-2018 & 2018-2019 in Rabi season to evaluate the 12 genotypes of *Brassica juncea*. BARI Sarisha 11 and BARI Sarisha 16 were used as check varieties in this experiment. The experiment was executed following Randomized Completely Block Design by 3 replications where plot size was 3 m × 2 m. Seeds were treated with provex @ 2g/kg to avoid seed borne contamination. Treated seeds were sown in a continuous line and row was 30 cm aside from each. Thinning operation was done maintaining 5 cm distance from one another after a couple of days of germination. The doses of fertilizer were applied @ 260:180:90:120:0.5 and 1.10 kg/ha of Urea:TSP:MP:Gypsum: Boric acid and Zinc oxide respectively. The half of urea and a full dose of all other fertilizers were applied during final land preparation. Half of the remaining part of urea was given after thinning. After 20-25 days of germination, the remaining parts of the urea were applied before flowering. After each time of urea application, irrigation was given to the field. Weed in the field was removed by hand weeding after 20-22 days of germination. Malathion 57 EC @ 2ml/L of water was sprayed after 20-35-60 days of germination to control aphid. The plant development and yield related traits were calculated from five plants which are nominated randomly from all plots. Data were documented on days to fifty percent (50%) flowering, days to maturity, plant height, no. of branches/plant, siliqua/plant, length of siliqua (cm), seeds/siliqua, 1000 seed wt. (g) and yield/plot. The plot yield was transformed into ton/hectare. Recorded data were analyzed statistically by R package (R core team, 2014). Box plot, multivariate analysis and biplot analysis were accomplished using Statistical Tool for Agricultural Research (STAR 2.0.1) developed by IRRI.

III. Results and Discussion

Analysis of variance and frequency distribution of traits

Analysis of variance (ANOVA) provided high significant variation among treatments for all the considered traits. The trait study in this experiment has influenced by genotypes. In descriptive statistics, a box plot is a suitable technique of graphically presenting sets of numerical data with the help of their quartiles. Box plot might also have lines expanding perpendicularly from the boxes (whiskers) representing variability outside the upper and lower quartiles. In the box plot, box edges demonstrate upper and lower quartiles and the median as presented in the middle of the box. The circles indicated the individuals which were falling outside of the rank of whiskers. All the traits of this experiment fitted with normal distribution except some traits skewed left and some are right (Figure 01).

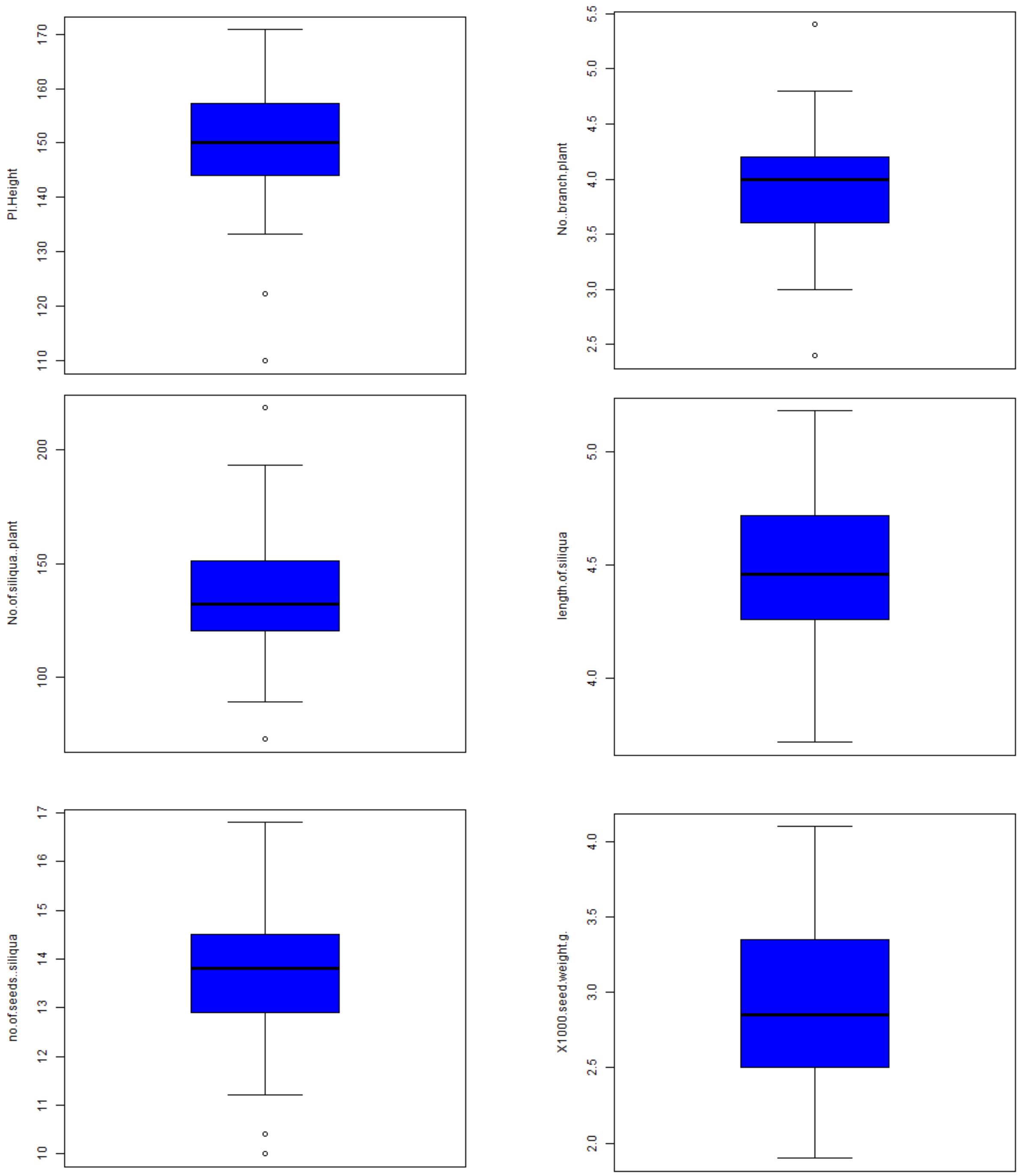

Figure 01. Boxplot showing the frequency distribution of data of studied traits.

Plant growth, yield and yield related features of studied genotypes

Ten genotypes of *Brassica juncea* along with BARI Sarisha 11 and BARI Sarisha 16 as check varieties were evaluated for yield and yield related characters. A significant statistical difference was obtained in all characters apart from the plant height (Table 01). Fifty percent of flowers of studied genotypes bloomed at the ranges of 36-40 days. BARI Sarisha 16 required 40 days for 50% flowering while the entries BJ-10-10104 (y), BJ-10-10411 (y) and BJ-2014-y01 required minimum days for 50% flowering recorded as 36 days. The days to maturity ranges from 93-95 days. The final plant height revealed the expansion behavior of a crop (Sana et al. 2003). The plant height ranges from 138 cm-155 cm. The highest plant height was obtained from BJ-11536(9)-2 followed by BJ-11536(9)-6 which are 158 cm and 155 cm respectively. On the contrary, the minimum plant height was recorded as 138 cm attained from BARI Sarisha 11. The number of branches/plant ranges from 3-6. The hereditary makeup of the crop and environmental circumstances cause a higher number of branches/plants which play an important part in the ultimate seed yield of the crop (Sana et al. 2003). The yield enhancing character like number of branches/plant is an essential attribute that results in the production of more leaves and pods and eventually contributes to photosynthesis which reveals within the study. The highest seed yield was found from BJ-11536(12)-3 which is 1.79 ton/ha had a higher number of branches noted as 6. While genotype BJ-11536(9)-6 produced the lowest number of branches per plant documented as 3 contributing to lower seed yield recorded as 1.05 ton/ha. The number of siliquae plant-1 is thought to be a main yield contributing traits of oilseed rape. Several studies suggest that a higher number of siliquae plant^{-1} has the greatest contribution to seed production on rape and mustard (Mendham et al., 1981; Thurling, 1974; Rahman et al., 1988).

For confirming high yields in *Brassica juncea*, the plant should contain more number of siliqua/plant (Yadav et al., 1979). A similar result was found in this study. The highest number of siliqua (198) was found from BJ-11536(12)-3 followed by BJ-2014-y05 and BJ- BJ-2014-y05 which is counted as 175 and 172 respectively. Significant differences were found in terms of number of seeds/siliqua among all the tested genotypes of *Brassica juncea* varieties. The maximum number of seeds/siliquae (16) was manufactured by the BJ-11536(12)-3 and it was statistically similar to the line BJ-11536(7)-2 (15). The minimum number of seeds/siliqua (12) was obtained from the genotypes BJ-10-10104(y), BJ-11536(9)-2 and BARI Sarisha 11 and it was similar to the variety BJ-11536(9)-6 (13) statistically. In case of 1000 seed weight, significant differences were obtained among all the varieties. Identically, the highest 1000 seed weight (4.00g) was documented in the variety BARI Sarisha-11 while moderate seed weight found in BJ-2014-y05 and BJ-11536(12)-3 (3.48g). The lowest 1000 seed weight (2.35g) was recorded from the genotype BJ-11536(9)-6. Thousand seeds weight was 3.20 g in BARI Sarisha-15 when there were 10 plant populations/m2 of land (Mamun et al., 2014). The weight of 1000 seeds is usually varied among the varieties and species. Some researchers found the thousand seed weight of improved Tori was 2.50-2.65g (*B. campestris)* (Mondal et al., 1992). The highest length of siliqua was acquired from BJ-11536(12)-3 which is 4.93 cm while the lowest length of siliqua recorded from entry BJ-11536(9)-2 which is 4.03 cm. The accumulative positive response of the crop traits viz. number of branches/plant, siliqua/plant and seeds/siliqua contribute to the higher yield for different crop varieties. The seed yield of mustard lines differed significantly (Figure 02). The genotype BJ-11536(12)-3 provided the maximum seed yield (1.79 t/ha) due to the highest number of branches/plant, siliqua/plant, seeds/siliquae and length of siliqua followed by other two lines BJ-2104-y01 and BJ-2014-y05 (1.42 t/ha). On the opposite hand, BJ-11536(9)-6 provided the lowest seed yield (1.05 t/ha). Seed yield is considered as a very complicated feature, contains various components which lastly effect in a greatly plastic yield constitution (Diepenbrock, 2000).

Table 01. Plant growth and yield related features of studied genotypes

Genotypes	Days to 50% flowering	Days to Maturity	Plant Height (cm)	No. branch /plant	No of siliqua/ plant	length of siliqua (cm)	No of seeds/ siliqua	1000 seed weight (g)
BJ-10-10104(y)	36	95	152	4	110	4.50	12	3.12
BJ-10-10411(y)	36	93	151	4	139	4.67	14	2.60
BJ-2014-y01	36	94	149	4	134	4.71	14	3.07
BJ-2014-y02	37	93	147	4	172	4.23	14	3.20
BJ-2014-y03	37	94	145	4	126	4.00	14	2.88
BJ-2014-y05	37	94	150	4	175	4.70	14	3.48
BJ-11536(7)-2	37	94	143	4	142	4.55	15	2.72
BJ-11536(9)-2	37	94	158	4	148	4.03	12	2.55
BJ-11536(9)-6	37	95	155	3	104	4.16	13	2.35
BJ-11536(12)-3	38	94	153	6	198	4.93	16	3.48
BARI Sarisha 11	38	94	138	4	167	4.31	12	4.00
BARI Sarisha 16	40	93	146	4	125	4.63	14	2.68
CV (%)	4.12	9.23	8.80	12.56	13.96	5.8	7.73	12.49
lsd	2.59***	1.46***	22.2^{NS}	.82*	32.05***	0.44 **	1.77**	0.61***

* CV= Coefficient of variation, *=5% level of significance, **=1% level of significance and ***=0.1% level of significance, NS=Non significant, lsd=Least Significant differences

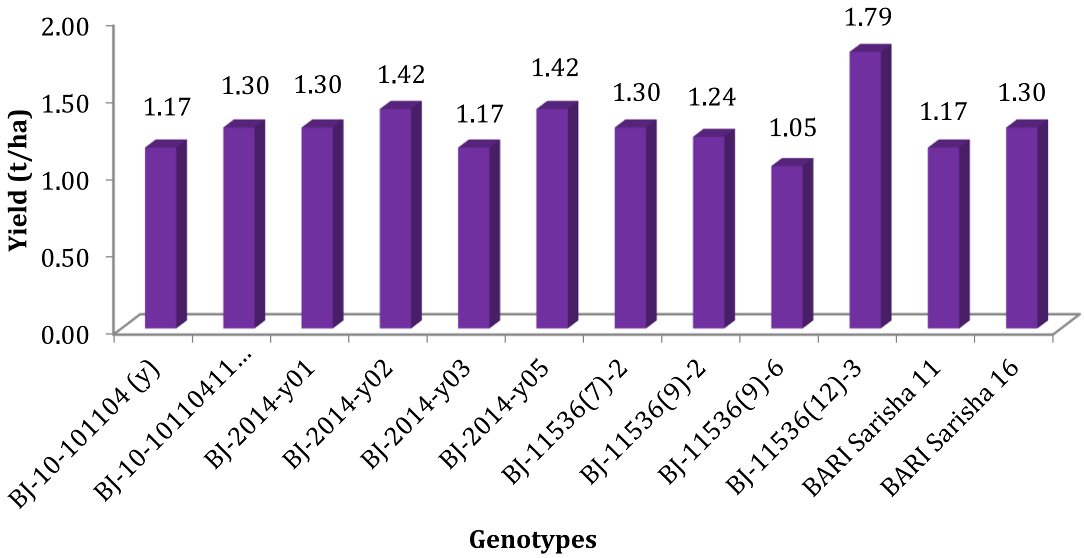

Figure 02. The yield (t/ha) of *Brassica juncea* lines in Chattogram region.

Multivariate analysis and genotype by trait interactions

The first six principal components (PCs) denoted about 92 % of the total variation among genotypes studied under this experiment (Table 02). A genotype × traits biplot was created from a two-way matrix of nine traits and 12 genotypes with the help of relative value of the traits (Figure 03). The second two consecutive principal components are plotted. Genotypes are plotted consistent with scores on each principal component, and traits are plotted based on the eigenvectors on each principal component. The plot condenses the information from this matrix into principle components, the two of which comprise 62 % of the entire variation within the dataset. The plot shows the connection between traits. The cosine of the angle between the vectors of two traits determines the coefficient of correlation between them. Thus, an angle smaller than 90^0 indicates a direct correlation, an angle greater than 90^0 indicates an indirect correlation and an angle of 90^0 indicates zero correlation. Based on these principles, the subsequent observations are often made up from Figure 03. The number of branches per plant is closely related with no. of siliqua per plant and 1000 seed weight (g) but it had been not strongly related to other traits. Thousand seed weight (g) is closely related with days to 50% flowering and days to maturity but it had been not strongly related to other traits. The no. of seeds per siliqua was positively correlated with length of siliqua and plant height but negatively correlated with other traits. The short vector of seed yield per plot (kg) denotes that it was not strongly correlated with any other traits.

Table 02. The first six principal components of trait eigenvectors in studied genotypes

Variables	PC1	PC2	PC3	PC4	PC5	PC6
Days to 50% flowering	-0.1401	0.5726	-0.0312	-0.0399	-0.3338	0.0438
Days to maturity	-0.1607	0.5602	-0.2967	0.1061	-0.1117	0.3507
Plant height	0.2728	0.0393	-0.4859	0.4204	-0.0866	-0.6771
No. of branch/ plant	0.265	-0.0811	0.3615	0.2266	-0.5641	0.051
No.ofsiliqua/plant	0.3094	0.1109	0.5441	0.2991	-0.1174	0.0261
Length of siliqua	0.2066	0.0246	-0.1854	-0.5256	-0.5683	-0.1533
No.of seeds/siliqua	0.3912	-0.2882	-0.2176	-0.3985	-0.0405	0.267
1000 seed weight (g)	-0.0068	0.3563	0.4001	-0.4842	0.2475	-0.5249
Yield (Kg/ ha)	0.5091	0.2522	-0.0565	0.0052	0.2746	0.1466
Cumulative proportion	0.29	0.48	0.62	0.75	0.87	0.92

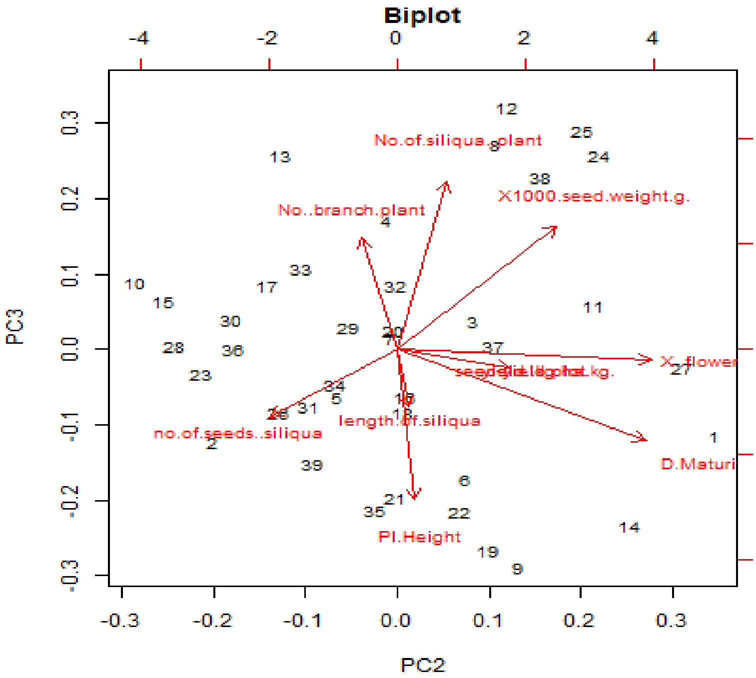

Figure 03. Genotype × trait biplot presenting the relationship among the studied characters.

IV. Conclusion

Genetic variations were assessed within the studied genotypes in the climatic condition of chattogram region. Considering yield performance the entries BJ-11536(12)-3, BJ-2014-y02 and BJ-2104-y05 might be selected as parental materials to be used in the breeding program to find out higher yielding variety. However, the present study will offer guidelines for the plant breeders to develop new varieties.

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