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Evaluation of some rapeseed mutants based on growth attributes

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Abstract: An experiment was conducted at the field laboratory of Bangladesh Institute of Nuclear Agriculture, Mymensingh to investigate morpho-physiological characters in seven advanced mustard mutants *viz.,* RM 01, RM 02, RM 03, RM 04, RM 05, RM 10 and RM11 along with a cultivar BINA sarisa-4.The experiment was laid out in a Randomized Complete Block Design with three replications. Results revealed that plant height, leaf area index (LAI), total dry mass (TDM), absolute growth rate (AGR) and relative growth rate (RGR) differed significantly at all growth stages. LAI and AGR increased till 60 days after sowing (DAS) followed by a decline due to leaf shedding at later growth stages whereas RGR increased till 50 DAS. The mutant RM 05 showed superiority in respect of branch number, TDM, LAI and growth parameters like AGR and RGR at most of the growth stages and also produced the highest seed yield whilst RM 01 and RM 10 showed the inferiority in case of plant height, branch number, LAI, AGR and RGR. Among the mutants/cultivars, RM 05 produced the highest seed yield due to morpho-physiological superiority than the others.
Key words: Mustard, mutants, evaluation, growth attributes.

Introduction

Mustard (*Brassica sp.)* is one of the most important oil crops of the world. Oil of plant origin constitute important component of human diet, ranking third after cereals and animal products and are nutritionally superior to animal oil (Singh, 2000). The genus *Brassica* belongs to the family Brassicaceae (formally Cruciferae).The seed contains 40-45% oil and 20-25% protein. About 13.2% of the annual world edible oil supply comes from this crop (FAO, 2007). In Bangladesh, about ten oil seed crops are grown in the country. Among them, *Brassica* oil crop is the most important that supplies major edible oil in Bangladesh (BBS.2009). It covers about 80% of the total oilseed acreage and about 71% of the total production (BBS, 2009). In Bangladesh, the seed yield of mustard is about 760 kg ha^{-1} which is very low in comparison to other developed countries (2400 kg ha^{-1}) (FAO, 2007). The low yield is due to lack of high yielding varieties and improper agronomic practices. An understanding of some morpho-physiological characters in mustard is necessary to make progress in genotypic improvement and for the management of the crop either to increase yield and quality or to reduce the cost of production (Mendham and Salisbury, 1985). Important physiological attributes such as leaf area index (LAI), crop growth rate (CGR), relative growth rate (RGR), net assimilation rate (NAR) and specific leaf weight (SLW) can address various constraints of a variety for increasing its productivity (Tandale and Ubale, 2007). A plant with optimum LAI, NAR may produce higher biological yield. The capability of efficient partitioning between the vegetative and reproductive parts may produce high economic yield (Maola, 2005). For optimum yield in mustard, the LAI should be ranged from 3.5 to 4.5 (Bhat *et al.*, 2006). Any reduction of leaf area or the amount/intensity of light may have an adverse effect on yield (Dutta and Mondal, 1998). The dry matter accumulation may be the highest if the LAI attains its maximum value within the shortest possible time (Tandale and Ubale, 2007). In Bangladesh, several research Institutes like BARI, BINA and BAU have developed a couple of varieties of mustard which are high yielding compared to local landrace. Recently, BINA has developed several promising mustard genotypes of high yield potentials. These genotypes need to be assessed for their physiological growth and morphological maneuvering that takes place compared to the existing mustard cultivars. The present research work has been designed to study different growth parameters and other morpho-physiological characteristics responsible for higher biological yield as well as their interrelation to the grain yield. Overall objectives of the research work were as follows: to evaluate the growth and development of seven elite mustard genotypes compared to the existing variety, BINA sarisa-4; and to select better genotype in respect to growth components.

Materials and Methods

In this chapter the details with different materials used and methodology followed during the experimental period under the following heads:

Experimental site

The experiment was carried out the Field Laboratory, Bangladesh Institute of Nuclear Agriculture (BINA), Mymensingh. The experimental field was medium high land belonging to the Sonatola Soil Series of Grey Floodplain soil under the agro-ecological zone of Old Bahmaputra Flood plain (AEZ-9). The soil was silty loam.

Materials and treatment of the experiment

Seven advanced mutant lines along with one mustard variety (BINA sarisa-4) were collected from Plant Breeding Division, BINA, Mymensingh and used as treatment in the present study. The characters of advanced mutant lines are still unknown. The variety, BINA sarisa-4 was released in 1998 for country wide cultivation. It requires 90-95 days to mature. The average yield potential of BINA sarisa-4 is about 2.0 t ha^{-1}.The land of the experimental site was first opened with power tiller. After ploughing and laddering, all the stubbles and uprooted weeds were removed and the land was made ready.

Experimental design and lay-out

The experiment was laid out in a Randomized Complete Block Design with 3 replications. The size of the unit plot was 4.0 m × 2.5 m. Distances between block to block and plot to plot were 1.0 and 0.5 meter, respectively. Plant to plant and row to row distances were maintained as 5-8 cm and 30 cm, respectively. Urea, TSP, MP, gypsum and borax were used. The seeds of mustard were hand sown in rows and placed at about 3-4 cm depth from the soil surface. Plants were thinned at 5-8 cm distance from one another at 20 days after sowing (DAS). Weeding was done once at 20 DAS only. Two irrigations were applied. The first irrigation was applied at 21 DAS and second one at 45 DAS. At flowering, few plants were affected by aphid. To control aphid, Malathion 57 EC was sprayed @ 25 L ha^{-1} in the afternoon by using a sprayer.

Crop sampling and data collection

Growth parameters

To study ontogenetic growth characteristics, a total of five harvests were made. At final harvest, data were collected on some morpho-physiological parameters. The first crop sampling was done at 30 DAS and continued at an interval of 10 days up to 70 DAS. From each sampling, five plants were randomly selected from each plot and uprooted for collecting necessary data. The plants were separated into leaves, stems and roots and corresponding dry weight were recorded after oven drying at 80 ± 2°C for 72 hours. The leaf area of each sample was measured by LICOR automatic leaf area meter (Model: LICOR 2000).The growth analyses like AGR and RGR were carried out following the formulae Hunt (1978).

Absolute growth rate (AGR): Rate of dry matter production per unit of time per plant = $\{(W_2 - W_1) \div (T_2 - T_1)\}$ g $plant^{-1}day^{-1}$. Where, W_2 and W_1 are the DM at time T_2 and T_1, respectively.

Relative growth rate (RGR): Rate of dry matter production per unit if dry matter per unit of time = $\{(\ln W_2 - \ln W_1) \div (T_2 - T_1)\}$ g $g^{-1}day^{-1}$. Where, W_2 and W_1 are the DM at time T_2 and T_1 , respectively.

Leaf area index (LAI): It is the ratio of leaf area subtended by land area = {(Leaf area) ÷ (Land area)}.

Plant height (cm): Plant height was taken to be the length between the base of the plant to the tip of the main stem.

Total dry matter $plant^{-1}$ (g): The total dry matter was recorded by drying (80 °C± 2) for 72 hours and calculated from summation of leaves, stem, roots and pods dry weights taken in an electronic balance.

Harvesting: The date of harvest was determined when 85-90% of the siliqua became brown colour. The Maturity dates were different among the varieties. Before harvesting the plots, 10 plants were randomly selected from each plot for necessary morphological characters. The plots were harvested separately and tagged and brought to the threshing floor and dried in the sun. The seeds were threshed by mild pounding with stick.

Statistical analysis

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the mean differences were adjusted with Duncans Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986).

Results and Discussion

The results of the study on the mutant's effect on growth characters of mustard have been presented and possible interpretations have been made in this chapter.

Growth parameters

Plant height: The increment of plant height over time in mustard variety is presented in Table 1. The increment of plant height varied significantly among the mutants at all growth stages. Plant height increased rapidly until 50 DAS followed by a slow increasing pattern till physiological maturity (90 DAS).

The variety BINA sarisa-4 showed the tallest plant at later growth stages and the shortest was recorded in RM-01 which was statistically similar to RM-10. These results are in agreement with the result of Rahman (2007) who stated that plant height differed significantly among the studied mustard genotypes. The results of present study were also supported by the results of Khaton (2004) in mustard.

Table 1. Plant height at different growth stages in eight mustard mutants

Variety/mutants	Plant height (cm) at					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	90 DAS
RM 01	15.5 a	24.50 d	67.2 c	77.7 bc	80.7 c	83.9 b
RM 02	15.7 a	28.83 c	74.0 ab	80.0 abc	86.0 abc	90.6 ab
RM 03	14.7 ab	23.50 d	72.5 abc	80.0 abc	84.3 abc	88.6 ab
RM 04	15.7 a	31.00 bc	71.8 abc	79.2 abc	87.8 ab	88.1 ab
RM 05	15.7 a	33.00 ab	77.7 a	82.8 ab	89.0 a	90.1ab
RM 10	15.3 a	34.67 ab	69.0 bc	74.8 c	81.2 c	84.1 b
RM 11	13.7 b	35.17 a	70.3 bc	75.3 c	83.0 bc	85.7 b
BINA sarisa-4	14.3 ab	33.17 ab	74.7 ab	83.3 a	89.0 a	92.9 a
F-test	*	**	*	*	*	*
LSD (0.05)	1.42	3.72	5.46	4.95	5.33	6.1
CV (%)	5.34	6.96	4.32	3.57	3.58	3.96

In a column, means followed by same letter(s) do not differ significantly at 5% level by DMRT; *, ** indicates significant at 5% and 1% levels of probability, respectively.

Leaf area index: Significant difference on leaf area index (LAI) in mustard mutants was observed at all growth stages except 40 DAS (Table 2). The LAI continued to increase till 60 DAS followed by a decline due to leaf shedding. The higher LAI was recorded in RM 03 at most of the growth stages. In contrast, RM 10 showed the lowest LAI over its growth period. The variation in LAI might occur due to the variation in number of leaves and their expansion. The results obtained from the present study are consistent with the result of Wei *et al.* (2007) who stated that the variation in LAI could be attributed to the changes in the number of leaves and rate of leaf expansion and abscission.

Total dry mass production $plant^{-1}$: The total dry mass (TDM) production in mustard mutants is presented in Table 3. Result revealed that TDM production increased with age up to physiological maturity (90 DAS). Result showed that high yielding genotypes produced higher TDM than low yielding ones. The genotype RM 05 maintained the highest TDM.

Table 2. Effect of mutants on leaf area index at different growth stages in mustard

Variety/mutants	Leaf area index at				
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
RM 01	0.82 b	1.49	2.26 d	3.16 abc	1.17 a
RM 02	0.89 a	1.65	2.62 c	3.12 bc	0.98 b
RM 03	0.87 ab	1.66	2.92 ab	3.55 a	0.56 d
RM 04	0.83 b	1.49	2.56 c	3.29 ab	0.70 c
RM 05	0.84 ab	1.68	2.97 ab	3.37 ab	0.54 d
RM 10	0.68 d	1.58	2.51 cd	2.69 d	0.71 c
RM 11	0.76 c	1.46	2.70 bc	2.86 cd	1.07 b
BINA sarisa-4	0.82 b	1.61	3.10 a	3.30 ab	1.21 a
F-test	**	NS	**	**	**
LSD (0.05)	0.055	0.25	0.277	0.367	0.096
CV (%)	4.04	6.98	5.8	6.62	6.08

In a column, means followed by same letter(s) do not differ significantly at 5% level by DMRT; NS=Not significant; ** indicate significant at 1% levels of probability, respectively.

Table 3. Total dry mass production at different growth stages in eight mustard varieties

Variety/mutants	Total dry mass plant^{-1} (g) at					
	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS	90 DAS
RM 01	0.36 ab	0.89 cd	3.03 d	6.18 d	8.65 e	9.16 e
RM 02	0.38 a	0.97 bc	4.02 a	7.55 ab	9.61 c	11.11 cd
RM 03	0.37 ab	1.04 b	3.84 ab	7.61 ab	10.50 b	12.50 b
RM 04	0.29 c	0.83 d	3.92 a	6.68 cd	10.18 bc	12.00 bc
RM 05	0.30 c	1.14 a	4.10 a	8.02 a	11.48 a	13.92 a
RM 10	0.29 c	0.94 c	3.40 c	6.79 c	9.02 de	10.56 d
RM 11	0.29 c	0.85 d	3.61 bc	6.96 c	9.35 de	11.06 cd
BINA sarisa-4	0.32 bc	1.17 a	4.10 a	7.26 bc	10.35 bc	11.51 bcd
F-test	**	**	**	**	**	**
LSD (0.05)	0.055	0.078	0.241	0.556	0.739	1.121
CV (%)	7.89	4.16	3.64	4.46	4.27	5.58

In a column, means followed by same letter(s) do not differ significantly at 5% level by DMRT; ** indicates significant at 1% levels of probability at most of the growtn stages.

Table 4. Absolute growht rate at different growth stages in eight mustard mutants/variety

Variety/mutants	Absolute growht rate (mg/plant/day) at				
	30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS	70-90 DAS
RM 01	53 d	214 d	315 cd	247 c	51 e
RM 02	59 cd	305 ab	353 abc	206 c	150 c
RM 03	67 b	280 ab	377 ab	289 b	200 b
RM 04	55 d	309 a	350 d	350 a	182 bc
RM 05	84 a	296 ab	392 a	246 a	144 a
RM 10	65 bc	246 c	339 bc	223 c	154 c
RM 11	56 d	276 b	335 bc	239 c	171 bc
BINA sarisa-4	85 a	290 ab	316 cd	309 ab	96 d
F-test	**	**	**	**	**
LSD (0.05)	6.68	26.82	39.53	40.51	30.07
CV (%)	5.82	5.53	6.68	8.38	11.01

In a column, means followed by same letter(s) do not differ significantly at 5% level by DMRT; ** indicates significant at 1% levels of probability.

On the other hand, RM 01 maintained the lowest TDM over its growth period followed by RM 10. Increased TDM in RM 05 and RM 03 was possibly due to greater LAI (Table 2) and AGR (Table 4). The result is supported by the result of MalaKer (2007) in mustard who reported that high yield genotypes produced greater TDM than low yielding ones.

Absolute growth rate: The absolute growth rate (AGR) derived from eight mustard mutants was determined from vegetative stage (30 DAS) to physiological maturity (90 DAS) and the results have been presented in Table 4. Results showed that AGR in all genotypes differed significantly at all growth stages. Result revealed that AGR in increased till 60 DAS in all mutants followed by a decline till physiological maturity.

The mutant RM 05 maintained the highest AGR value at most of the growth stages. In contrast, RM 01 and RM 10 maintained the lower AGR at most of the growth stages. CGR is positively correlated with LAI (Bhardway *et al.*, 1987). The CGR increased along with increased in LAI. The lower value of CGR at initial stages of growth was the result of lower LAI. This result is in agreement with the findings of Prasad *et al.,* (1978). At 50-60 DAS, the AGR value was found to be maximum which mean that plants expanded its assimilate for the growth of leaf area and feeding of pods. The declining of AGR after reaching the maximum in all genotypes might be the result of abscission of leaves. These results are consistent with the results of Begum (2007).

Relative growth rate: Relative growth rate (RGR) is the increase of plant dry matter per unit time per unit materials and it represents the efficiency of a plant as producer of new materials. The variation in RGR among the mutants was assessed from 30 DAS until attaining physiological maturity (90 DAS) and the results are plotted in Table 05. It was observed that an inverse relationship between RGR and plant age was existed from 40-50 DAS. Genotypic difference in RGR was found significant.

Table 5. Effect of mutants on relative growth rate at different growht stages in mustard

Variety/mutants	Relative growth rate (mg/g/d) at				
	30-40 DAS	40-50 DAS	50-60 DAS	60-70 DAS	70-90 DAS
RM 01	90.5 e	122.5 b	71.3 a	33.6 bc	5.70 e
RM 02	93.7 de	142.2 ab	63.0 bc	24.1 d	14.5 e
RM 03	100.4 cde	130.6 b	68.3 ab	32.2 bc	17.4 ab
RM 04	105.2 cd	155.2 a	53.3 d	42.1 a	16.4 bc
RM 05	133.5 a	128.0 b	67.1 ab	35.9 b	19.3 a
RM 10	117.6 b	128.6 b	69.2 ab	28.4 cd	15.8 bc
RM 11	107.5 bc	144.6 ab	65.6 ab	29.5 cd	16.8 bc
BINA sarisa-4	129.6 a	125.4 b	57.1 cd	35.7 b	10.6 d
F-test	**	*	**	**	**
LSD (0.05)	11.34	19.92	6.2	5.17	2.22
CV (%)	5.9	8.45	5.5	9.02	8.69

In a column, means followed by same letter(s) do not differ significantly at 5% level by DMRT; *, ** indicates significant at 5% and 1% levels of probability, respectively at all growth stages.

The RGR increased till 50 DAS and thereafter declined in six mutants out of eight and the next two mutant, RM 05 and BINA-4 showed declining trend from vegetative stage (30 DAS) to maturity (90 DAS). Generally, with the advancement of the plant age, the RGR decreased in most of the field crops (Dutta and Mondal, 1998). In the present experiment, the RGR increased till 50 DAS and then declined. The RGR of the genotypes showed the highest value at 40-50 DAS and followed a declining trend with being the lowest at near physiological maturity stage (80-90 DAS). At early growth stage (30-40 DAS), RM 05 and BiNA sarisa-4 showed the higher RGR but at 40-50 DAS, RM 04 showed the highest RGR and the lowest was recorded in RM 01. The results of the present study are in agreement with the results of Begum (2007) in mustard who stated that the maximum RGR was observed during vegetative stage and declined rapidly with the advancement of growth stages.

The ontogenetic variation in plant height, leaf area, leaf area index and total dry mass production of mustard mutants/variety differed significantly at all growth stages. Of the mutants/variety, BINA sarisa-4 was the tallest (92.9 cm) whilst RM 01 and RM 10 was the shortest (83.9 cm). The maximum LAL (3.55) was observed in RM 03 followed by RM 05 whilst the lowest in RM 10 (2.69). The highest TDM Plant $^{-1}$ was observed in RM 05 (13.92g) and the lowest in RM 01 (9.16g). However, the LAL increased till 60 DAS followed by a decline due to leaf shedding at later growth stages. The variation in growth parameters like AGR and RGR of mustard mutants/variety were significant at all growth stages. AGR increased till 60 DAS followed by decline with age. On the other hand, the RGR increased till 50 DAS and then decreased with increasing plant age. The mutant RM 05 showed superiority in AGR and RGR at most of the growth stages compared to others. In contrast, RM 01 showed inferiority in case of AGR and RGR over its growth period. From the results above, it may be concluded that- (i) High yielding mutants have higher number of branches, higher leaf area as well as LAI, TDM, AGR and RGR which resulted higher number of pods plant^{-1} than the low yielders in mustard and among the mutants/variety, RM 05 produced the highest seed yield which might be due to its morpho-physiological superiority than the others.

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