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Selection of rapeseed mutants for higher yield and yield contributing traits

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Abstract

Seven mutants along with the mother variety were evaluated following randomized complete block design with four replicates at four rapeseed growing areas of Bangladesh during 2013-2014 to observe their performances regarding seed yield and yield attributes, and to select promising mutants having higher seed yield with short maturity period. Analysis of variance showed highly significant variations among the mutants and the check for most of the characters studied in individual location and combined over locations. The mutant RM-01-07 required the shortest maturity period except Rangpur and the mother variety Binasarisha-4 required the longest. At Mymensingh and Rangpur, mutant RM-02-07 produced the tallest plant. Both at Mymensingh and Magura, RM-01-07 produced the highest number of siliquae plant^{-1} and the mother variety produced the lowest siliquae plant^{-1}. At Ishurdi, RM-10-07 produced the highest number siliquae followed by RM-03-07. Combined means over locations showed that the six mutants matured earlier except the mutant RM-03-07 and most of the mutants produced higher number of branches plant^{-1} compared to the mother variety. Results over different locations also showed that the three mutants RM-01-07, RM-10-07 and RM-04-07 produced significantly higher seed yield (1912, 1846 and 1862 kg/ha, respectively) which was 15.1, 12.1 and 11.1% higher than the mother variety, Binasarisha-4 with seed yield of 1661 kg/ha. These three mutants had also the higher number of siliquae than the mother variety. This suggests that gamma rays irradiation can be fruitfully applied to develop mutants with higher seed yield and other improved agronomic traits in oleiferous *Brassica*.

Keywords*:* *Brassica napus* L., Rapeseed, Mutants

Introduction

The oleriferous *Brassica* plays an important role in vegetable oil production of the world. Rapeseed-mustard is the third most important oil source in the world after soybean and oil plam. In Bangladesh, rapeseed-mustard is an important leading oil crop and according to BBS (2013) national average seed yield of this crop is only 998 kg/ha. Therefore, only 15% demand of edible oil is fulfilled from domestic production. As a result substantial amount of foreign exchange is spent for its import. To fulfill the requirement of edible oil from native production, attempts should be taken to increase the rapeseed yield as there is little scope of horizontal expansion of the rapeseed cultivation in the country.

For any plant breeding programme, creation of genetic variation followed by selection plays an important role in developing improved crop varieties. Therefore, genetic variations in useful traits are prerequisites for any crop improvement programme. Mutation breeding has been successfully applied in several crops to generate new sources of genetic variations and this technique has greatly enhanced the development of new crop varieties (Shu and Lagoda, 2007; Szarejko and Forster, 2007; Velasco *et al*., 2008). Utilizing mutation breeding, genetic improvement of both qualitative and quantitative yield traits has been successfully achieved in rapeseed *Brassicsa* (Das *et al*., 2004; Seyis *et al*., 2006; Spasibionek, 2006; Zhao *et al*., 2009; Malek *et al*., 2012a). Nearly 3000 mutant induced and mutant-derived crop varieties for commercial utilization proves that among the different methods, induced mutation is an effective breeding method for generating new germplasm in crop improvement (Ishige, 2009). Kharkwal *et al*. (2004) reported that using physical mutagens, 89% of the mutant varieties have been developed worldwide and gamma rays alone contributed 60%.

In this research, we evaluated the performances of those mutants along with mother variety during October 2013 to February 2014 at four rapeseed growing areas of Bangladesh regarding morphological parameters, yield traits and seed yield to select the promising one.

Materials and Methods

Seeds of rapeseed variety Binasarisha-4 were irradiated with 600, 700 and 800 Gy doses of gamma rays using Co^{60} gamma cell to create genetic variations. Irradiated seeds were sown to grow M_1 generation at BINA, Mymensingh in 2009 for selecting desirable mutants in subsequent generations. Selection was made in each of M_2, M_3 and M_4 generation based on desired agronomic traits. From M_4 generation, three M_5 mutants namely RM-01-07, RM-02-07 and RM-03-07 from 700 Gy, and four mutants namely RM-04-07, RM-05-07, RM-10-07 and RM-11-07 from 800 Gy were selected for further evaluation. These seven true breeding (homozygous) mutants along with the mother variety Binasarisha-4 were evaluated at four rapeseed growing areas of Bangladesh during 2013-2014 following randomized complete block design with four replicates. Seeds were sown on 24 October at Magura, 28 October at Ishurdi, 25 October at Rangpur and 3 November at BINA Headquarters farm, Mymensingh in 2013 maintaining unit plot size of 20 m^2 (5.0 m × 4.0 m) with a line spacing of 25 cm and 6-8 cm for plant to plant within rows. Recommended production packages like weeding, thinning and application of fertilizers, irrigation, pesticide etc. were done uniformly to ensure normal growth and development of the plants in each plot as and when necessitated.

Data were taken on different morphological traits and yield attributes like plant height, number of branches/plant, number of siliquae $plant^{-1}$ and number of seeds $siliqua^{-1}$ from 10 randomly selected representative plants from each plot at maturity. List of all the traits under study and their description of measurement have been presented in Table 1. The collected data were analyzed statistically according to the design followed using the analysis of variance (ANOVA) technique following Gomez and Gomez (1984). The mean values were compared by DMRT at 5% level of significance.

Table 1. List of seven different traits and their description of measurement

Serial No.	Traits	Methods of measurement
1	Days to maturity	The number of days from sowing to 70% siliquae turned into brownish colour
2	Plant height (cm)	The height from the base to the tip of the main rachis
3	Branches $plant^{-1}$ (no.)	Total number of primary branches per plant
4	Siliqua $plant^{-1}$ (no.)	Total number of siliqua with seeds in a plant
5	Seeds $siliqua^{-1}$ (no.)	Total number of seeds in a siliqua
6	1000-seed wt. (g)	One thousand seeds counted randomly and weighed
7	Seed yield (kg/ha)	Weighing the seeds produced in a plot and then converted into kg/ha

Results and Discussion

Analysis of variance indicated highly significant variations ($p \leq 0.01$) among the mutants and check for most of the studied characters in different locations indicating the presence of sufficient amount of genetic variability among the mutants. In rapeseed genotypes, significant variations have also been reported by others for various characters (Ali *et al*., 2002; Hasan *et al*., 2006; Mahmud *et al*., 2008).

Results of mean values of four individual locations and combined over four locations for all the characters have been presented in Table 2. Maturity period is the most important and frequent character which can be modified in oilseed *Brassica* using induced mutation. Significant differences were observed for days to maturity in different locations. At Mymensingh, two mutants RM-01-07 and RM-02-07 required shortest maturity period (87 days) having non-significant difference with other five mutants while Binasarisha-4 had the longest maturity period of 94 days. RM-01-07 required the shortest period of 80 days to mature while the mother variety Binasarisha-4 took the highest maturity period of 87 days at Magura. Mutant RM-01-07 required the shortest maturity period of 91 days having non-significant difference with five other mutants while Binasarisha-4 required the longest duration 98 days at Ishurdi. At Rangpur, Binasarisha-4 also required the longest duration of 88 days to mature. In combined over locations, days to maturity varied from 86 days in RM-01-07 to 92 days in Binasarisha-4 having non-significant difference only with the mutant RM-03-07. So, most of the mutants matured earlier than the mother variety. This result revealed that through induced mutation maturity period can be shorten. Induction of early maturity in the mutants of oilseed *Brassica* has been reported by Spasibionek (2006), Shah and Rahman (2009), Malek *et al*. (2012a) which confirm the present result.

Table 2. Mean of M_7 mutants and check of rapeseed for different characters

Locations	Mutants/ Check	Days to maturity	Plant height (cm)	Branches /plant (no.)	Siliquae /plant (no.)	Seeds/ siliqua (no.)	1000-seed weight (g)	Seed yield (kg/ha)	Seed yield increased over mother variety (%)
Mymensingh	RM-01-07	87b	97ab	2.7a	90a	27b	4.23a	1812a	11.0%
	RM-02-07	87b	100a	2.3ab	78ab	26b	4.26a	1717a-d	5.1%
	RM-03-07	89b	96ab	2.2b	71bc	26b	4.24a	1783ab	9.2%
	RM-04-07	88b	95ab	2.5ab	78ab	26b	4.28a	1690d	3.5%
	RM-05-07	88b	99a	2.5ab	79ab	28b	4.11ab	1600cd	–2.0%
	RM-10-07	89b	97ab	2.3ab	68bc	28b	4.27a	1817a	11.3%
	RM-11-07	89b	91c	2.2b	68bc	31a	4.13ab	1617bcd	–1.0%
	Binasarisha-4	94a	97ab	2.1b	61c	28b	4.01b	1633abc	-
Magura	RM-01-07	80b	113	3.1a	96a	27	4.19a	2070b	17.2%
	RM-02-07	82b	111	2.8abc	86bcd	27	4.20a	1930bcd	9.3%
	RM-03-07	84a	105	2.6bcd	83bcd	26	4.13a	1833cd	3.8%
	RM-04-07	82b	110	2.5cd	81cd	27	4.17a	2305a	30.5%
	RM-05-07	84a	112	3.0ab	78d	27	4.12ab	1944bc	10.1%
	RM-10-07	85a	113	3.2a	92ab	26	4.07ab	2055b	16.4%
	RM-11-07	85a	106	2.6bcd	85bcd	25	4.06ab	2041b	15.6%
	Binasarisha-4	87a	104	2.3d	68e	28	3.97b	1766d	-
Ishurdi	RM-01-07	91b	115	2.2	75a	28	4.33ab	2121a	24.0%
	RM-02-07	94ab	104	2.5	73a	31	4.30ab	1889bc	10.4%
	RM-03-07	96a	110	2.3	77a	34	4.28ab	1800bc	5.2%
	RM-04-07	92b	102	2.2	71ab	29	4.27ab	1966ab	14.9%
	RM-05-07	94ab	106	2.9	64b	29	4.19ab	1911b	11.7%
	RM-10-07	92b	109	2.7	80a	30	4.38a	1922b	12.3%
	RM-11-07	92b	107	2.2	68b	30	4.18ab	1847bc	7.9%
	Binasarisha-4	98a	108	2.5	73ab	30	4.10b	1711c	-
Rangpur	RM-01-07	85ab	115a	3.7	52	29	3.97a	1644	7.2%
	RM-02-07	85ab	116a	3.9	46	28	3.94ab	1599	4.3%
	RM-03-07	87a	108b	3.3	46	30	3.87ab	1622	5.8%
	RM-04-07	84b	107b	3.5	49	27	3.92ab	1422	–7.2%
	RM-05-07	84b	110ab	3.9	50	30	3.81b	1489	–2.9%
	RM-10-07	83b	115a	3.7	48	26	4.01a	1655	8.0%
	RM-11-07	83b	104b	4.0	49	26	3.83b	1666	8.7%
	Binasarisha-4	88a	115a	2.8	46	27	3.80b	1533	-
Combined over four locations	RM-01-07	86b	110a	2.9ab	78a	28	4.18a	1912a	15.1%
	RM-02-07	87b	108abc	2.9ab	71b	28	4.18a	1784abc	7.4%
	RM-03-07	89ab	105cde	2.6bc	69bc	29	4.13a	1760abc	6.0%
	RM-04-07	87b	104de	2.7bc	70bc	27	4.16a	1846ab	11.1%
	RM-05-07	88b	107a-d	3.1a	68bc	29	4.06ab	1736bc	4.5%
	RM-10-07	87b	109ab	3.0ab	72b	28	4.18a	1862ab	12.1%
	RM-11-07	87b	102e	2.8bc	68bc	28	4.05ab	1793abc	7.9%
	Binasarisha-4	92a	106bcd	2.4c	62d	28	3.97b	1661c	-
Location Means	Mymensingh	89b	97c	2.4c	74b	28bc	4.19a	1695bc	
	Magura	84c	109ab	2.8b	84a	27c	4.11a	1979a	
	Ishurdi	94a	108b	2.4c	71b	30a	4.25a	1896ab	
	Rangpur	85c	111a	3.6a	48c	28bc	3.89b	1579c	

Note: Same letter(s) in a column for individual location/combined means/location means do not differ significantly 4at 5% level of significance

A significant variation was observed in plant height. At Mymensingh, mutant RM-02-07 produced the highest plant height (100 cm) closely followed by RM-05-07 (99 cm) while RM-11-07 produced the shortest plant of 91 cm. At Rangpur, RM-02-07 also produced the tallest plant (116 cm) which was closely followed by RM-01-07, RM-10-07 and Binasarisha-4 which was 115 cm, whereas RM-11-07 produced the shortest plant with 104 cm height. In combined over locations, mutant RM-01-07 produced the highest plant height of 110 cm followed by RM-10-07 (109 cm) while the mutant line RM-11-07 produced the shortest plant height of 102 cm. In case of number of branches/plant, mutant RM-01-07 produced the highest number of 2.7 branches/plant followed by the mutants RM-04-07 and RM-05-07 (2.5 branches/plant) while Binasarisha-4 produced the lowest number at Mymensingh. Mutant RM-10-07 produced the highest number of 3.2 branches/plant closely followed by RM-01-07 and RM-05-07 (3.1 and 3.0, respectively) while the mother variety Binasarisha-4 produced the lowest number of 2.3 branches at Magura. Binasarisha-4 produced the lowest number of 2.4 branches. Plant heights may vary due to the genetic effects present among the genotypes as well as the proper agronomic management. Development of shorter mutants in oilseed *Brassica* has been reported by Shah *et al*. (1990) and Malek *et al*. (2012a). These results also conform that using induced mutation plant stature can be altered in rapeseed-mustard. In case of number of branches plant^{-1}, all the mutants produced higher number of branches than the mother variety. The present results having more number of branched in the rapeseed mutants than the mother confirm the findings of Khatri *et al*. (2005) and Shah and Rahman (2009).

A significant variation was found among the mutants and mother variety on the number of siliquae plant^{-1} in Mymensingh, Magura and Ishurdi. Both at Mymensingh and Magura, RM-01-07 produced the highest number of siliquae plant^{-1} (90 and 96, respectively) and the mother variety produced the lowest number (61 and 68, respectively). At Ishurdi, RM-10-07 produced the highest number siliquae (80) followed by RM-03-07 with 77 number. Combined means showed that the highest number of siliquae plant^{-1} (78) was produced by RM-01-07 and other three mutants, RM-10-07, RM-02-07 and RM-04-07 produced 72, 71 and 70 number of siliquae plant^{-1}, respectively while the lowest number (62) was found in Binasarisha-4. Significant differences were observed for 1000-seed weight in different locations. On an average, the five mutants RM-01-07, RM-02-07, RM-03-07, RM-04-07 and RM-10-07 produced significantly higher 1000-seed weight than Binasarisha-4. Other two mutants RM-05-07 and RM-11-07 produced statistically equal seed weight with mother variety. In oilseed *Brassica*, as a consequence of mutagenesis, Javed *et al*. (2003), Khatri *et al*. (2005) and Malek *et al*. (2012a) reported higher siliquae number in developed mutants over their mothers. Number of seeds siliqua^{-1} did not differ significantly both in individual locations (except Mymensingh) and combined over locations. In rapeseed-mustard, Javed *et al*. (2003) reported that seed size has direct influence on seed yield. Present result showed that most of the mutants gave higher seed weight than Binasarisha-4. Generation of bold-seeded mutants in rapeseed-mustard has also been reported earlier by Chauhan and Kumar (1986) and Shah *et al*. (990).

The mutants RM-10-07 produced the highest seed yield of 1817 kg/ha followed by RM-01-07 (1812 kg/ha) and RM-03-07 (1783 kg/ha) which was 11.3, 11.0 and 9.2 % higher than the mother variety Binasarisha-4 at Mymensingh. At Magura, the five mutants RM-04-07, RM-01-07, RM-10-07, RM-11-07 and RM-05-07 produced significantly higher seed yield of 2305, 2070, 2055, 2041 and 1944 kg/ha, respectively than Binasarisha-4 (1766 kg/ha). Mutants RM-01-07 produced the highest yield (2121 kg/ha) at Ishurdi. At Rangpur, seed yield and its components showed non-significant differences among the genotypes. Combined means over four locations showed that three mutants namely RM-01-07, RM-04-07 and RM-10-07 produced significantly higher seed yield (1912, 1846 and 1862 kg/ha, respectively) than mother variety Binasarisha-4 (1661 kg/ha) and in percentage, their seed yield were 15.1, 11.1 and 12.1% higher than Binasarisha-4 while other four mutants produced statistically similar seed yield with Binasarisha-4. Results also showed that three high yielding mutants also produced significantly higher number of siliquae/plant than mother variety. In plant breeding, generation of genotypes having improved yield contributing characters is the main objective for achieving higher yield. In oilseed *Brassica*, the most important yield attributes responsible for the increased seed yield are the siliquae number, seed number in siliqua and individual seed weight. Seed yield is a complex quantitative character governed by a large number of genes and is greatly affected by environmental fluctuations. For considering as a promising variety of a particular crop, seed yield is the most important. In rapeseed-mustard, mutants having higher seed yield over mother varieties were also reported earlier by Javed *et al*. (2003), Seyis *et al*. (2006), Zhao *et al*. (2009), Brave *et al*. (2009) and Malek *et al*. (2012a, 2012b).

In seed yield and its attributes and other morphological traits variations were observed among the locations which are due to the variations in environments among the locations.

Conclusion

It was observed that among the mutants and mother variety, three mutants RM-01-05, RM-04-05 and RM-10-05 performed better for seed yield and yield contributing characters which can be selected for further trials to be registered as varieties. Moreover, this suggests that gamma rays irradiation with 700 to 800 Gy can be fruitfully applied to induce mutants in *B. napus* with higher seed yield and other improved agronomic traits.

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