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EVALUATION OF SHORT STATURE MUTANTS OF BASMATI-370 FOR YIELD AND GRAIN QUALITY CHARACTERISTICS*

M.A. Awan, Maqbool Ahmad and Akbar Ali Cheema

Nuclear Institute for Agriculture and Biology, Faisalabad

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Three short stature mutants were induced in an indica rice cultivar by gamma irradiation. The mutants were assessed for their yielding ability and grain quality characteristics. All the mutants out yielded the parent variety, Basmati-370. The increase in yield of the mutants ranged from 19.37% to 29.66%. DM-2 gave the highest yield (3587.96 kg/ha) among the mutants. As regards physical, cooking and eating quality characteristics, there was no significant difference in water absorption, volume expansion ratios and stickiness among the mutants and Basmati-370. However, Basmati-370 was scored best for flavour as this variety had strong aroma as compared to its mutants which were scored for moderately strong aroma.

INTRODUCTION

Rice is an important food grain crop of Pakistan for domestic consumption and export abroad. The climatic conditions of the province of Punjab are particularly suitable for cultivation of Basmati varieties. Basmati - 370 is the predominant variety grown in the rice tract of the Punjab province. It possesses excellent grain and cooking quality and is the most popular variety of rice. However, grain yield of basmati is very low mainly due to its tall growth habit and poor response to fertilizers. Evidence accumulated in the rice growing countries of the world indicates that in order to get maximum yield, it is essential that the rice plant must resist lodging. The ideal situation would, therefore, be to develop varieties with basmati type grain on IRRI type plant. But so far, efforts, to develop such combinations through conventional plant breeding, have not been successful despite the fact that genes for dwarfness do exist in the world germplasm.

The use of induced mutations in recent years has become an important approach to plant breeding for the improvement of crop plants (1). It has now been established that character like short stature can be easily induced and incorporated in commercial cultivars (2–4).

In view of the national interest involved in the cultivation of basmati rice, it seems imperative to identify short stature rice genotypes freed in the basmati background, capable of giving high yield and good quality under the improved production technology. An attempt has, therefore, been made to evaluate a few promising induced mutant lines of Basmati-370 regarding their morphological as well as physico-chemical characteristics.

MATERIALS AND METHODS

Three induced short statured lines namely DM-16-5-1, DM-16-5-2 and DM-2 were isolated from the local cultivar Basmati-370 in M_2 generation after treatment with 25 kR of gamma rays. The breeding behaviour of these mutant lines was tested in M_3. The mutants were grown in a small replicated plot (1.80 m x 4.50 m) in M_4 generation yield trail alongwith the parent variety Basmati-370 at NIAB, Faisalabad. In 1978, mutant lines DM-16-5-1 and Dm-16-5-2 and DM-2 alongwith Basmati-370 were grown in a large plot (2.80 x 6.00 m) yield trial at two locations i.e. NIAB, Faisalabad and Agricultural Farm, Gujranwala. A randomised complete block design with three replications was used in each large plot yield trial. Planting distance was 22 x 22 cm with single seedling per hill. All the normal cultural practices were followed for the crop. Nitrogen was applied at the rate of 67 kg/ha. Data with respect to number of days from seeding to flowering, plant height, internode length, tillers per plant, flag leaf collar to panicle neck node length, panicle length, branches per panicle, fertility percentage, 1000-grain weight, and grain yield per hectare were recorded.

Size and shape classification of milled rice kernels was carried out according to the standards based on the list published by the consultative sub-committee of the FAO and reported by Grist (5). Quality index of raw rice kernel was calculated according to the formula used by Aziz [6]. The volume expansion and water absorption ratios were calculated according to Juliano et al (7). Total solids in the cooking gruel were determined by the method of Batcher et al. [8], and the results expressed

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as total solids in 100 ml residual cooking gruel. Elongation ratio was calculated by the formula used by Aziz and Shafi[9].

Sensory evaluation of all the cooked samples was carried out by 5 judges (scientists from Food Science Division, NIAB) for aroma (5 very strong; 1 = very weak) and co-hesiveness or stickiness (5 = well separated: 1 = pasty) by the scoring method reported by Larmond[10]. All the data were analysed statistically by the analysis of variance technique [11].

RESULTS AND DISCUSSIONS

In the present study, a significant reduction in plant height of the three short statured mutants was observed in the yield trials at NIAB and Gujranwala (Tables 1 and 2). The reduction in height ranged from 15 to 30%. None of the mutants i.e. DM-16-5-1, DM-16-5-2 and DM-2 lodged under field conditions (N at the rate of 67 kg/ha) whereas Basmati did. The mutants thus resist lodging and are relatively more responsive to nitrogenous fertilizers. A significant difference in the peduncle length between the mutants and the parent cultivars was also noticed. Peduncle length constitutes the larger proportion towards final plant height followed by lower internodes accordingly both in tall and dwarf cultivars. A reduction in the internodol length of the mutants as compared to that of Basmati-370 was also noticed (Table 1). The length between the flag leaf collar to panicle neck node in the short statured mutants understudy was significantly less than that of Basmati-370 (Table 1). This length is very important in determining leaf canopy of a cultivar. It is generally believed that lesser the distance between the flag leaf collar to neck node, the more erect is the flag leaf; and an erect flag leaf is economical for interception of sunlight needed for photosynthesis. Previously, two cultivars viz Reimie and Milyang 10 were produced by the use of induced mutations. The principal improved character of these cultivars was that these were about 15 cm shorter than the parent varieties[12]. Rutger et al. [13] also reported an induced dwarf mutant D-7 with reduced internodal length and more erect flag leaf. D-7 out yielded the check variety CS-M3 in several yield trials in California [14].

A significant difference in tillers per plant among the short statured mutants and Basmati-370 was noticed in yield trials at both the locations (Tables 1 and 2). Maximum tillering ability was manifested by DM-16-5-1 and DM-2. Tillering ability is directly related to the yield potential of a cultivar. Our results are in agreement with those of Saini et al. [4] and Gangadharan et al. [15] who also reported short statured mutants of rice with increased number of ears and high yielding ability.

Grain yield of the short statured mutants in the present study was significantly higher than that of Basmati-370 both at NIAB and at Gujranwala (Tables 1 and 2). DM-2 gave maximum yield. The increase in grain yield can be attributed to higher values of tillers per plant and fertility percentage. Although the fertility, percentage of DM-2

Table 1. Performance of short stature mutants of Basmati-370 in a yield trial at NIAB.

Varieties/ mutant	Plant height (cm)	Days from seeding to flowering	Peduncle length (cm)	Flage leaf collar to neck node length (cm)	Intremode length (cm) 1	2	3	4	5	Tillers/ plant	Panicle length (cm)	Fertility %	1000 grain weight (g)	Yield kg/ha
Basmati-370	c 183.45	a 113.06	b 45.41	b 6.07	c 27.40	c 28.54	c 20.46	c 15.59	b 10.80	a 12.16	b 31.36	b 89.11	b 20.29	a 3933.57
DM-16-5-1	b 155.10	a 113.06	a 41.01	ab 5.27	b 24.24	b 23.11	b 14.85	b 11.33	a 7.18	ab 12.93	ab 29.56	bc 91.44	b 20.09	b 5466.12
DM-16-5-2	a 142.66	a 111.86	a 39.23	a 4.35	ab 22.53	a 19.76	a 13.10	a 9.24	a 6.16	c 15.90	ab 29.32	c 93.45	a 18.23	ab 4785.98
DM-2	a 142.53	b 117.16	a 39.96	ab 5.35	a 21.24	ab 21.80	ab 12.87	a 9.67	a 5.92	bc 15.40	a 28.09	a 83.58	b 20.57	b 5522.88

Figures followed by the same letter are not significantly different at 5% level of significance according to Duncan's Multiple Range test.

Table 2. Performance of Basmati-370 and ts dwarf mutants of Gujranwala during 1978-79.

Variety/ mutant	Plant height (cm)	Tillers/ plant	Panicle length (cm)	Branches/ panicle	Fertility percentage	1000 grain weight (g)	Yield kg/ha
Basmati-370	d 175.07	a 11.75	c 30.57	a 10.81	a 88.40	b 20.87	a 2767.16
DM-16-5-1	a 145.87	a 12.02	b 29.08	b 11.06	a 88.37	b 20.19	b 3303.21
DM-16-5-2	b 139.73	b 14.31	b 28.57	b 11.80	a 90.91	b 19.24	bc 3473.93
DM-2	a 121.64	b 15.18	a 27.19	b 11.13	a 85.47	a 21.05	bc 3587.96

Figures followed by the same letter are not significantly different at 5% level of significance according to Duncan's Multiple Range test.

Table 3. Physical, cooking and sensory characteristics of Basmati-370 and its short statured mutants.

	Dimenstions*						Cooking characters				Sensory evaluation**	
Variety/ mutant	Length mm L	Width mm W	Thickness mm (T)	L/W ratio	L/WxT ratio	Shape and size	Water absorption ratio	Volume expansion ratio	Elongation ratio	Total solids gm/100 ml gruel	Stickiness (1–5)	Aroma (1–5)
Basmati-370	6.75	1.76	1.59	3.84	2.41	Long slender	a 4.31	a 5.64	a 1.90	a 3.43	a 4.60	a 3.80
DM-16-5-1	6.39	1.75	1.54	3.65	2.37	"	a 4.43	a 5.75	a 1.88	b 3.88	a 4.50	b 3.00
DM-16-5-2	6.36	1.76	1.53	3.61	2.36	"	a 4.39	a 5.75	b 1.74	c 4.42	a 4.20	b 2.80
DM-2	6.55	1.78	1.53	3.68	2.40	"	a 4.26	a 5.64	b 1.70	b 3.92	a 4.20	b 2.80

Values followed by the same letters are non significant at 5%. *Average of 10 determination. **Average of five judgements.
1 = pasty and no aroma. 5 = Well separated and very strong aroma.

was lower than that of DM-16-5-1, DM-16-5-2 and Basmati-370 yet, the deficiency of unfilled grains was compensated by increased number of tillers. High yielding semi-dwarf mutants in scented rice have also been reported by Gangadharan et al. [15] Reddy and Reddy [16].

In order to be acceptable to the consumers, an agronomically superior genotype should also possess desirable milling, cooking and eating characteristics. Basmati-370 and all the mutants are classified as long, slender and fine as the grain length is between 6 and 7 mm, length/width ratio is over 3 and quality index is above 2 in all the cases (Table 3).

Cooking and eating quality of rice in Pakistan is related to good weight and volume, more proportionate increase in length during cooking, less soluble solids in the cooking gruel, less stickiness and more aroma. There was no significant difference in water absorption and volume expansion ratios among the mutants and Basmati-370. However, Basmati-370 and mutant DM-16-5-1 manifested more proportionate increase ($P<0.05$) in length during cooking as compared to other mutants. A significantly less solid loss in Basmati-370 ($P<0.05$), as compared to its mutants during cooking was noticed. Maximum solid loss was observed in mutant DM-16-5-2.

Regarding eating quality of cooked rice, there was no significant difference for stickiness among parent variety and its mutants. The cooked rice in all the samples were fluffy, non-sticky and well separated. Basmati-370 was scored best for flavour as this variety had strong aroma as compared to its mutants, which were scored for moderately strong aroma.

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REFERENCES

1. A. Gustafsson, and I. Gadd, Hereditas, **55**, 293 (1966).
2. T. Kawai, H. Sato and I. Mashima. (IAEA, Vienna, 1961), p. 565.
3. T.P. Reddy, A. Padma and G.M. Reddy. Indian J. Genet. Plant Breed, **35**, 31 (1975).
4. S.S. Saini, M.R. Gagneja and G.S. Brar. Sci. Cult., **43**, 259 (1977).
5. D.H. Grist, *Varieties and Their Classification. In Rice.* (Longmans. Green and Co, Lted., 1965), P. 81.
6. M.A. Aziz, Cereals and Pulses. In Fifty Years of Agricultural Education and Research at Punjab Agricultural College and Research Institute, Lyallpur, West Pakistan. (Department of Agriculture, West Pakistan, 1, 1960), p. 62.
7. O. Juliano, L.U. Onato and A.M. Del Mundo, Food Tech., **19**, 1006 (1965).
8. O.M. Batcher, K.F. Helmintoller and E.H. Dawson. Rice. J., **59**, 4 (1956).
9. M.A. Aziz and M. Shafi. Quality in Rice (Department of Agriculture, Technical Bulletin 13, West Pakistan, 1966(, p. 50.
10. E. Larmond. *Methods of Sensory Evaluation of Food.* (Canada. Dept. Agr. Publ. 1284, 1967).
11. W.G. Cochran and G.M. Cox, *Experimental Designs.* (J. Wiley, New York, second edition., 1965).
12. B. Sigurbjornsson, A. Micke. IAEA Vienna. Pl. 53/ **40** :303 (1974).
13. J.N. Rutger, M.L. Peterson, C.H. Hu, and W.F. Lehman, Crop. Sci., **16**, 631 (1976).
14. J.N. Rutger and M.L. Peterson, California Agriculture, **30**, 46 (1976).
15. G. Gangadharan, R.N. Misra and A.K. Ghosh, Curr. Sci., **45**, 597 (1976).
16. M. Reddy and T.P. Reddy. Rad. Bot., **13**, 181 (1973).