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GENETIC IMPROVEMENT OF TOMATO VARIETY, *MANIK*, THROUGH INDUCED MUTATIONS

R. PEIRIS
Horticultural Crop Research and Development Institute, Gannoruwa, Peradeniy

ABSTRACT

In recent years, the demand for tomato has tremendously increased due to its attractive market price and multifarious uses in raw, cooked and processed forms. At present people are much concerned about the fruit quality and yield. Therefore, attention is being paid for development of genotypes having high yield potential (20 t/ha) with desirable fruit quality characters. In this study, application of induced mutations which is a tool to create genetic variability by altering one or a few characters of a well-adapted variety within a short period of time as compared with hybridization was practiced on *Manik* variety. The gamma rays from CO_{60} source was used as a physical mutagen and the seedling growth depression test indicated that the desirable dose rate for the induction of mutations in *Manik* as 32.0 Kr. Four promising mutants, M 120, M 121 and M 127 for fresh market and M_{65} for processing purpose were identified from *Manik* which has resistance to Bacterial wilt, high yield potential and poor fruit quality characters such as irregular shape, large empty locular cavities and low fruit weight. The yield evaluation trials conducted in mid-country wet zone during 1996-99 revealed that these mutants recorded a significantly higher or comparable yields to the recommended variety T 245. The fruit quality characteristics of the mutants such as fruit size, shape colour and size of locular cavity were very much improved than the original variety.

KEY WORDS: Genetic, Mutations, Tomato, Variability

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill), is one of the most popular vegetables in Sri Lanka. It is cultivated in an area of 5,788 ha with an average yield of 7.6 t/ha. During the recent past, much attention has been focused on this crop by the farming community of Sri Lanka due to its multifarious benefits in income, export potential, human nutrition, health and employment avenues.

The production of tomatoes in Sri Lanka is beset by many problems. Bacterial wilt (BW) caused by *Ralstonia solanacearum* (formerly *Pseudomonas solanacearum*) is the most serious constraint for successful and extensive cultivation of tomato. Therefore, in the past, crop improvement activities have been mainly directed towards the development of BW resistance. Nevertheless, at present the producers and consumers are much concerned about the yield and fruit quality. Hence, there is a need to produce genotypes having resistance to BW disease, high yield potential and better fruit quality characters for table and processing purposes. Keeping this fact in view, the application of induced mutations, which is a tool to create genetic variability by altering one or a few characters of well-adapted cultivars within a short period of time as compared to hybridization was utilized, to develop new tomato genotypes.

MATERIALS AND METHODS

The research was carried out from *maha 96/97 to yala 1999* at the Horticultural Crop Research & Development Institute, Gannoruwa (HORDI).

Tomato variety

The variety *Manik* was used in all experiments. *Manik* has resistance to BW disease but lacks fruit quality characteristics like colour and shape. Fruits of *Manik* are large but the locular cavities are very large resulting very low fruit weight and irregular shape.

Seed treatment and estimation of desirable dosage of gamma irradiation

Gamma rays from Co_{60} source available at HORDI was used as the physical mutagen. Before gamma irradiation the moisture content of the seeds was adjusted to 14% by storing the seeds in a desiccators containing 60% glycerol for four days. Uniform dormant seeds were exposed to different doses of gamma radiation *i.e.* 0, 20, 25, 30, 35 and 40 Kr. For each treatment 50 seeds were irradiated and the experimental design was Complete Randomized Design with three replications. The seeds were sown in plastic trays containing soil and kept in the greenhouse at HORDI during *maha* 96/97. The seedling height was measured ten days after sowing and 50% lethal dose (LD50) value was determined according to the procedure described by Gaul (1963).

Raising of M_1 generation

During *maha* 96/97, about 5,000 uniform dormant seeds were irradiated with 32.0 Kr and sown in upland nursery beds to establish M_1 generation. The 14 day-old seedlings were transplanted in the research field at Gannoruwa. The spacing was 80 cm between rows and 50 cm between plants. Recommended fertilizer levels of 50 kg N/ha, 150 kgP_2O_5 /ha and 80 kg K_2O/ha were applied at appropriate time. Staking of plants was done 20 days after transplanting. Weeding and irrigation were carried out as required. Three rows of control (untreated) seedlings were planted at both ends of each plot. Various preliminary observations from seeding to maturity were recorded on 100 randomly tagged plants of treated and untreated material. At maturity, fruits from first raceme and second raceme were harvested separately from each surviving M_1 plant to form M_2 population.

Raising of M_2 generation

During *yala* 97, fruit progenies of M_2 generation were raised. M_2 population consisted of about 10,000-15,000 plants. Each fruit progeny had 21 seedlings. Three rows of original variety (control) were planted at both ends of each plot for screening. The cultural practices and fertilizer applications were done according to departmental recommendations as in M_1 generation. The M_2 populations were thoroughly screened for mutations at all the stages of crop growth in the field and the desirable mutants of these fruit progenies were visually selected. The visual selection was mainly based on BW resistance, earliness, plant height, fruit colour, size and shape.

Raising of M_3 generation

During *maha* 97/98, to confirm the breeding behaviour, offspring of putative mutants were grown in plant progeny rows. Three progeny rows of the control variety were grown after every tenth progeny row of mutants for comparison. On the basis of agronomic data and visual comparison true breeding mutants were selected. These mutants were also screened for BW disease in the laboratory.

Raising of M_4 generation

During *yala* 98, seven most promising mutants (M110, M120, M121, M65, M51, M127, M47) with the check variety T245 were further evaluated in preliminary yield trials at Gannoruwa field. The experimental design was a Randomized Complete Block Design with three replications. The plot size was 2.4 x 3.5 m with 3 rows/plot and 21 plants/row. The field establishment method was similar to raising of M1 generation. Data on days to 50% flowering, plant height at first harvest, plant type, reaction to BW disease, marketable fruit yield/plot and fruit quality characteristics such as fruit weight, fruit size, shape, colour, brix, number of locules and % acidity as citric acid were recorded.

Testing of promising mutants in major yield trials

Yield tests were repeated during *maha* 98/99 and *yala* 99. Experimental design and data collection were similar to preliminary yield testing.

RESULTS AND DISCUSSION

Estimation of desirable dose rate

Seedling height decreased linearly as the dosage of gamma irradiation increased from 0 to 40 Kr (Table 1). A seedling growth reduction of 20% to 30% in 10 day-old seedlings resulting from seed treatment with physical mutagens is generally assumed to give a high mutation rate. The results indicated that 20 to 30% reduction in seedling height was between 25.9 and 37.4 Kr. Therefore, the mid value is taken as the LD_{50} value in this study. The mutagenic dose that should be applied is considered as 10% higher and 10% lower than the LD_{50} value (Gaul, 1963). Therefore, in this study it was found out that the best dose rate for the induction of mutations in tomato variety *Manik* was 32.0 Kr.

Table 1. Effect of different dosages of gamma irradiation on seedling growth of tomato cv *Manik*

Dose (Kr)	*Average Seedling Height(cm)*
0	11.7 a
20	10.2 a
25	9.6 b
30	8.5 bc
35	8.5 c
40	7.5 d
cv (%)	16.5

Means followed by the same letters are not significantly different at 5% level based on DMRT.

Performance of M_1 generation

From preliminary studies on M_1 generation materials the following conclusions were drawn. Seedling emergence, seedling survival at 14 days and at maturity decreased in treated population. Flowering and maturity were also delayed in treated plants (Table 2). The data clearly indicated that the injury induced by the mutagen treatment was not severe.

Table 2. Effect of gamma irradiation on different growth stages of M_1 population of tomato cv. *Manik*

Parameter	*Untreated Control*	*Treated*
Emergence at 7 d (%)	98.5	86.5
Seedling survival at 14 d (%)	86.0	62.0
Days to 50% flowering	42.0	49.0
Plant survival at harvest (%)	82.0	52.7

Selection of desirable mutants of M_2 generation

In the treated populations, several putative mutants were isolated for different desirable attributes. The characteristics of desirable mutants were early flowering, short stature, very small to large fruit size, heavy bearing, attractive fruit colour and shape (Table 3).

Table 3. Comparison of desirable characteristics of identified mutants and parent variety *Manik*

Character	*Mutant* [1]	*Parent*
Fruit shape	Fl, SF, R, HR, H, LC	Blocky
Fruit colour	OR, OG, R, RG	OR
Numberof fruits per plant	6-62	10
Plant height (cm)	33-102	104
Days to 50% flowering	31-58	42
Fruit weight (g)	>10-100	76

[1]Fl-Flattened H-Heart HR-High Round LC-Lengthened cylindrical
OG-Orange Green OR-Orange Red RG-Red Green R-Red
R-Round SF-Slightly Flattened

Confirmation of true breeding mutants in M_3 generation

Forty one true breeding mutants were selected on the basis of superior agronomic traits and these were screened for BW disease. After screening, 41 true breeding mutants were selected on the basis of superior agronomic traits. Out of these only one mutant was highly resistant to bacterial BW disease. Eighteen mutants showed moderate resistances while one mutant showed moderate susceptibility.

Most of the mutants showed a reaction of moderate/resistant/highly resistant to BW disease. Therefore, most of these could be utilized as donors of BW disease resistance in the development of improved tomato varieties. These findings are in full agreement with the results reported by other researchers (Rahaman *et al.*, 1975)

Agronomic evaluation of mutants

Marketable fruit yield: During *yala* 98, *maha* 98/99 and *yala* 99, yield evaluation studies were carried out in the fields of HORDI with seven most promising mutants which were selected on the basis of the BW resistance, earliness and acceptable fruit quality characters in the M_2, M_3 generations. The results clearly revealed that there were significant differences in yield among mutants or varieties (Table 4).

None of the mutants were inferior in yield to the check variety T245. Out of the tested mutants, M121 mutant, was found to be the most, promising giving an average yield of 36 t/ha.

Table 4. Yield performances of seven new tomato mutants and a standard variety in the field of HORDI, Gannoruwa

Mutant/Variety	*Marketable Fruit Yield (t/ha)*[1]		
	Yala 98	*Maha 98/99*	*Yala 99*
M110	26.8 bc	25.4 bc	37.6 ab
M120	20.8 ef	20.0 d	38.5 ab
M121	32.4 a	30.4 a	45.4 a
M65	18.5 f	19.5 e	17.0 de
M51	25.8 cd	24.2 bc	37.1 abc
M127	28.2 b	27.5 b	44.8 a
M47	22.0 e	20.5 d	25.5 bcd
T245 (check)	19.8 ef	18.6 ef	26.7 bcd
CV(%)	11.2	10.2	10.8

[1] Means followed by the same letter are not significantly different at 5% level based on DMRT

Horticultural characters of the promising mutants

Growth type, plant height at first harvest and days to 50% flowering.

All tested entries were determinate type and their plant heights varied from 62.0 to 96.2cm. No significant differences were observed among mutants in days to 50% flowering (Table 5).

Table 5. Some horticultural traits of the tested mutants

Mutannt/Variety	*Growth Type*	*Days to 50% Flowering afterTransplanting*	*Plant Height at 1st Harvest (cm)*
M10	D	31	83.2 b
M120	D	32	80.0 c
M121	D	33	72.0 e
M65	D	33	68.0 f
M51	D	33	96.2 a
M127	D	31	62.0 g
M47	D	32	76.0 d
T245 (check)	D	31	84.0 b
CV %		ns	10.6

D – determinate, ns - non significant

Fruit Traits of the promising mutants

It is clearly observed that changes in fruit characters had occurred during irradiation process (Table 6).

Table 6. Fruit quality characters of seven promising tomato mutants, *Manik* and a standard variety, T245

Variety/ mutant	*Weight (g)*	*Colour*[1]	*Fruit Length (cm)*	*Circum- ference (cm)*	*Shape*[2]	*Locules*	*acidity as citric acid (%)*	*Size*[3]	*Brix*	*Locular Cavity*[4]
M127	158.6	R	11.5	22.0	SF	5	1.1	B	4.5	F
M47	61.0	R	7.0	18.0	R	3	0.5	S	4.3	F
M120	115.2	OR	11.0	21.0	SF	5	1.0	B	4.0	F
M51	62.4	OR	7.0	18.5	R	6	1.0	M	4.2	F
M121	140.1	R	11.0	21.0	SF	8	1.0	B	4.5	F
M65	10.0	DR	4.2	8.0	R	4	1.0	S	5.7	F
M110	110.6	OR	10.6	21.0	SF	6	0.9	B	4.4	F
T245	80.5	OR	8.6	18.0	SF	6	0.9	M	4.1	F
Manik	50.2	ORYS	9.2	19.2	B	7	0.4	B	4.0	E

[1]R–Red, OR–Orange Red, DR–Dark Red, ORYS–Orange Red with Yellow shoulder.
[2]R–Round,SF–SlightlyFlattened, B-Blocky,
[3]M-medium, S - Small , B–Big,
[4]E-Empty, F–Filled.

The original variety had blocky shape, but the mutants were slightly flattened or round. It is very interesting to observe that the mutants possess reduced locular cavities thus resulting in uniform shape and higher fruit weight and size than the original variety *Manik*. However, the mutant M65 had dark red small fruits (10g/fruit) resembling cherry type tomatoes which are highly acceptable by the consumer. Except M65, all the other mutants showed a brix value similar to the original variety. For fresh market purpose usually large sized, round fruits with uniform red colour are preferred. Out of the tested mutants M127, M120, and M121 had an average fruit weight more than 115g/fruit. Therefore these mutants are highly acceptable for fresh market purpose. Mutant M65 which had high brix value (5.7) and dark red coloured fruits is suitable for processing purpose.

CONCLUSIONS

The best dose rate of gama rays for induction of desirable mutations in *Manik* variety found to be 32 Kr. The results of this long-term study revealed that M121, M127, M120, and M65 are promising tomato mutants having desirable horticultural traits, high yield potential, resistance to BW disease and fruit quality characteristics. These mutants are better than the original variety *Manik*, especially in fruit quality characteristics.

This study clearly demonstrated that induced mutations can be successfully utilized to create genetic variability when it is desired to improve one or few specific traits in a well adapted variety.

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