DEVELOPMENT AND EVALUATION OF A PROCESSING TYPE TOMATO (*LYCOPERSICON ESCULENTUM* MILL.) VARIETY

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ABSTRACT

In the past, varietal development of tomato in Sri Lanka mainly focussed on yield potential, resistance to pests and diseases, and other agronomic characters rather than fruit quality. Sri Lanka imports annually about 488 tons of processed products of tomato worth 52 million rupees. Therefore, there is an urgent need to breed processing type tomato varieties to meet the increasing demand for processed products. In view of this, a hybridization programme commenced in 1993 using single, double and three way crosses with varieties available at the Horticultural Crop Research and Development Institute (HORDI). Selection of desirable genotypes from the segregating populations was performed using the modified bulk method. The elite line HT 148-3-11, a derivative of the cross between T 244 and Roma, consistently recorded a comparable (24.3 t/ha) or significantly higher yield (16%) than the recommended variety T 245 in replicated yield trials conducted during 1996 -1998, and showed resistance to bacterial wilt disease; it also qualified as a variety in the Distinctness, Uniformity and Stability Test, which is a basic requirement for varietal release. The fruit quality analysis based on the data on fruit colour, fruit pH, titratable acidity, total soluble solids, fruit firmness and fruit cracking were carried out separately on tested varieties. HT 148-3-11 appears to be ideal for processing, precisely for pulp/paste/sauce making due to its acceptable fruit characters such as dark red pulp colour, acidic pH of 4.3, high total soluble solids in terms of a brix value of 5.5, moderate fruit firmness, non-cracking and high pulp content.

KEY WORDS : Hybridization, *Lycopersicon esculentum*, Processing type tomato

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetables widely grown in Sri Lanka. It contains as much as 93 to 94 % water, with high nutritive value, being a good source of vitamins A and B and an excellent source of vitamin C. It is very appetising, removes constipation and has a pleasing and refreshing taste. Tomato has been described as a versatile commodity that can be eaten fresh or processed for a wide range of products, such as paste, juice, and sauce powder or as whole (Villareal, 1980).

Recently, the local demand for processed products of tomato is increasing and Sri Lanka imports annually about 488 tons of processed products of tomato at a cost of 52 million rupees (External Trade Statistics, 1996). In the past, crop improvement activities in this crop at the Horticultural Crop Research and Development Institute (HORDI) have been mainly directed towards the development of varieties with high yield potential, pest and disease resistance, and other desirable horticultural traits rather than fruit quality, and these varieties recommended by the Department of Agriculture lack fruit quality characters for processing. As a result, an urgent need to breed processing tomato varieties has become inevitable. A study was therefore undertaken to develop processing tomato varieties.

MATERIALS AND METHODS

The research was carried out from *maha* 92/93 to *yala* 99 at HORDI, Gannoruwa. In 1993, the hybridization *via* single, double and three way crosses were initiated, with Punjab Chhuhara, Roma, CLN5915-93-1-04, T244, C-32-d-01-2-0, Bianz, Solar set, Superma, BL 355 and CLN 65-349D5-2-0 as parents (Table 1). Modified bulk method was used in the selection process in which generation advancement was made by means of bulk method in F_2, F_3 and F_4 generations followed by progeny selections in F_5, F_6 generations. Seven promising lines in F_6 generation were identified on the basis of plant type, yield, reaction to bacterial wilt (BW) disease and fruit quality characters. During *maha* 95/96 and *yala* 96 the seven elite lines shown in Table 2 with a recommended variety, T 245 were tested in preliminary and major yield trials in the fields of Gannoruwa.

Table 1. The crosses performed in 1993 at HORDI, Gannoruwa

Single Cross	*Double Cross*	*Three way Cross*
Punjab Chhuhara/T244	C-32-d-01-2-0/CLN	T244 / Roma//Punjab
C-32- d – 01 – 2 - 0/BL 355	5915-93-1-04//T244 /	Chhuhara
Solar set/BL 355	Bianz	BL 355/CLN 65 – 349 D5
T244/Roma	T244/Bianz 2//C-32-	– 2 0//Superma
BL 355/Solar set	d-01-2-0/CLN 5915-	
Bianz/BL 355	93-1-04	
Superma/Roma		
Roma/BL 355		
Solar set/CLN 65-349 D5 – 2 – 0		
CLN 65-349D5 – 2 0/Bianz		
Superma/C –32 –d-01- 2 – 0		

Table 2. A list of seven promising lines in F_6 generation and their pedigree

Variety/Line	*Pedigree*
HT 66-2-1	T244 / Roma
HT 23-11-6	C-32-d-01-2-0/CLN 5915-93-1-04//T244/Bianz
HT 146-6-10	T244/Roma// punjab chhuhara
HT 148-3-11	T244 / Roma
HT 44-4-2	T244/Bianz//C-32-d-01-2-0/CLN 5915-93-1-04
HT 7-1-10	C-32-d-01-2-0 / CLN 5915-93-1-04 // T244 / Bianz
HT 65-5-2	T244 / Roma

The experiment was a randomized complete block design (RCBD) with three replications. The plot size was 2.4m x 3.5m with 3 rows/plot and 21 plants/plot. The spacing was 80 cm between rows and 50 cm between plants. The seeds of these 8 varieties were sown in nursery beds and 14 day-old seedlings were transplanted in the field at one seedling per hill. The recommended fertilizer levels of 90 kg N/ha, 150 kg P_2O_5/ha and 80 kg K_2O/ha were applied at the appropriate times. Staking of plants

was done at 20 days after transplanting. Weeding and irrigation were carried out as and when necessary.

The fruit quality analysis based on the data on fruit colour, fruit pH, titratable acidity, total soluble solids, fruit firmness and fruit cracking were carried out separately on tested varieties. Based on yield, reaction to BW disease and fruit quality characters, the elite line HT 148-3-11 was included in the National Co-ordinated Varietal Trial (NCVT) which was conducted at Gannoruwa, Makandura, Bandarawela, Girandurukotte and Maha Illuppallama representing different agroecological zones, from *maha* 96/97 to *yala* 98. The standard evaluation methodology was followed in all experiments. In *maha* 98/99, HT 148-3-11 was tested in varietal adaptability in farmers' fields in Kandy and Kegalle districts. Distinctness, uniformity and stability of the new variety, HT 148-3-11 was also carried out by the Seed Division of the Department of Agriculture.

The data on days to 50% flowering, plant height at first harvest, growth type, reaction to pest and diseases, and fruit quality characters and marketable yield were recorded and the collected data were subjected to ANOVA. The significant models were further tested by using the mean separation method, DMRT (Gomez and Gomez, 1976).

RESULTS AND DISCUSSION

Hybridization and selection

The successful 15 crosses performed during 1993 are presented in Table 1. In the selection process by modified bulk method, seven promising lines in F_6 generation from 4 crosses were identified mainly on the basis of fruit quality, reaction to bacterial wilt and yield (Table 2).

Fruit quality characters

Fruit quality characters are presented in Table 3. The total soluble solids (TSS) which is composed of all fruit components except water and those volatilized during drying was estimated by refractive index and reported as brix. In this study it varied from 4.0 – 5.5. The variety HT 148-3-11 had the highest total soluble solid content (brix =5.5). Roma is one of the parents of this variety which is high in TSS. The variety HT 7-1-10 showed the lowest total soluble solid content (brix=4.0). This parameter of quality has been of major interest to the processing industries that manufacture concentrated tomato products. Titratable acidity provides a measure of organic acids (total acidity) present in a fruit sample which in turn estimates tartness. The acidity percentage as citric acid of the tested varieties ranged from 0.63 – 1.18 and the variation in pH was from 3.7 – 4.5. Lambeth *et al.* (1966) reported that there was tremendous variations among tomato genotypes for titratable acid (TA) and pH. In a study of 250 tomato (*L. esculentum*) accessions, they reported a variation in pH from 4.26 to 4.82 and percentage citric acid ranged from 0.40 to 0.91.

The variety HT 148-3-11 had an acidity percentage of 1.18 and pH of 4.3. The fruit pH affects the heating time required to achieve sterilization of the processed commodity. Longer times are required as the product pH increases. Therefore, pH values above 4.5 are generally unacceptable for processing purposes. The variety HT 148-3-11 had a pH of 4.3 which is highly acceptable for processing purpose.

Table 3. Fruit quality characters of seven promising tomato varieties and a standard variety

Variety	*Averge fruit weight (g)*	*Colour*	*Interior flesh colour*	*Fruit length (cm)*	*Fruit width (cm)*	*Fruit shape*	*Locules*	*Juice content (%)*	*pH*	*Acidity % as citric acid*	*Brix*
HT 66-2-1	72.5	OR	OR	17.2	8.2	High round	3-5	78.2	4.3	0.67	5.0
HT 65-5-2	94.7	OR	OR	18.7	9.6	High round	4	71.2	4.3	0.79	4.9
HT 23-11-6	80.5	OR	R	17.7	8.4	Slightly flattened	3-6	85.4	3.9	1.09	4.2
HT 146-6-10	34.8	OR	OR	13.0	6.0	Round no ridges	3	49.5	3.8	0.66	4.8
HT 148-3-11	43.2	R	DR	14.1	6.5	High round	3	47.7	4.3	1.18	5.5
HT 44-4-2	73.0	OR	OR	17.3	8.0	Round	3	76.1	4.5	0.63	4.7
HT 7-1-10	39.7	O	O	11.7	7.6	Pear shaped	2	63.9	3.7	0.76	4.0
T245 (check)	72.0	O	O	17.5	8.4	Slightly flattened	3-6	53.2	3.8	0.84	5.0

O- Orange; OR -Orange Red; R - Red; DR -Dark Red

Maximum fruit length of 18.7cm and maximum fruit width of 9.6cm was recorded in variety HT 65-5-2 which had mostly round and big fruits. Fruit width was minimum at 6.0 cm in HT 146-6-10 which was round and small. Minimum fruit length was noted in HT 7-1-10 which had pear-shaped small fruits. The variety HT 148-3-11 had high round shaped small fruits. The fruit size and shape may be of less importance if they are to be used for processing purpose. The external peel colour and interior flesh colour of the tested entries clearly showed that the variety HT 148-3-11 had the suitable colour (Dark red) for processing purpose. Colour is considered an important tomato quality characteristic. For the processor, colour is paramount since for many products, colour of the fruits is a primary determinant of the quantity of tomatoes required to make high quality products.

Fruit cracking of the tested entries showed a value range of 0.7–25.7%. Significant differences among varieties in terms of crack resistance were observed. Level of cracking was lowest in variety HT 148-3-11. The varieties HT 66-2-1, and HT 65-5-2 had soft fruits. HT 7-1-10 gave solid fruits. All the other varieties had fruits of medium firmness (Table 4).

Fruit quality parameters for processing tomato are very critical and it demands a great deal of specificity. Bhattarai (1993) determined that the requirements for processing tomato as high total soluble solids (brix at least 4 to 5), pH of 4 to 4.5, high TA, firm fruits, resistance to cracking and excellent red pulp colour.

Table 4 . Plant and fruit characters of seven promising tomato varieties and the check variety

Variety	*Growth type*	*Days to 50% flowering after transplanting*	*Plant height at 1st harvest (cm)*	*Fruit cracking (%)*	*Firmness*
HT 66-2-1	D	29 a	53.3 ab	19.2 abc	Soft
HT 65-5-2	D	26 bc	51.6 ab	20.6 abc	Soft
HT 23-11-6	D	25 cd	51.6 ab	9.4 cd	Medium
HT 146-6-10	D	25 cd	48.0 ab	14.3 bcd	Medium
HT 148-3-11	D	24 cd	46.3 ab	0.8 d	Medium
HT 44-4-2	D	24 cd	52.6 ab	25.7 ab	Medium
HT 7-1-10	D	27 b	45.7 b	3.2 d	Solid
T 245(check)	D	25 cd	54.6 a	2.8 a	Medium
CV (%)		3.0	8.8	12.2	

D - Determinate; Means followed by the same letters were not significantly different at 5% level, based on DMRT.

Phenological characteristics

Days to 50% flowering

Significant differences were observed among the eight tested varieties. HT 66-2-1 variety was the latest to flower at 29 days after transplanting. There were no significant differences in days to 50% flowering among varieties HT 65-5-2, HT 23-11-6, HT 146-6-10, HT 148-3-11, HT 44-4-2 and T 245 (Table 4).

Growth type and plant height at first harvest

All the tested entries were determinate type. Nghiem (1992) reported that determinate tomato cultivars are widely grown in the world and are used for both fresh market and processing. Plant height for the varieties ranged from 45.7–54.6 cm. A significant difference in plant height was observed only between T 245 and H 7-1-10 (Table 4).

Reaction to BW disease

The reaction to BW disease in laboratory screening studies clearly revealed that the varieties possess highly resistant to moderately susceptible reaction. The variety HT 148-3-11 showed a highly resistant reaction to bacterial wilt (Table 5).

Yield

Marketable fruit yield

Yield evaluation studies of the eight varieties conducted during *maha* 95/96 and *yala* 96 in the fields of HORDI, clearly showed that there were significant differences in yield among varieties. None of the varieties were inferior in yield to the

check variety T245 (Table 6). The yield increments of HT 148-3-11 over T 245 (check variety) in preliminary and major yield trials were 2.5% and 12.5%, respecptively. However, there was no significant difference in yield between HT 148-3-11 and T 245.

Table 5. Reaction to bacterial wilt of the eight new tomato varieties

Variety	*Reaction*
HT 66-2-1	MR – HR
HT 65-5-2	R – HR
HT 23-11-6	R
HT 146-6-10	MS – HR
HT 148-3-11	HR
HT 44-4-2	R – HR
HT 7-1-10	HR
T 245	MS - HR
Marglobe*	S
KWR**	HR

* Susceptible check variety; ** Resistant check variety; HR - Highly resistant; R - Resistant; MS -Moderately susceptible; S-Susceptible

Table 6. Yield performance of seven new tomato varieties and a standard variety at the fields of HORDI, Gannoruwa

Variety	*Marketable fruit yield (t/ha)*	
	maha 95/96	*yala 96*
HT 66-2-1	28.89 a	43.07 ab
HT 65-5-2	33.93 a	45.69 a
HT 23-11-6	26.50 c	45.25 ab
HT 146-6-10	32.15 a	42.60 ab
HT 148-3-11	27.49 bc	41.78 abc
HT 44-4-2	27.72 bc	40.67 abcd
HT 7-1-10	29.15 b	36.03 d
T 245 (check)	26.81 c	37.12 cd
CV (%)	3.1	6.5

Means followed by the same letter were not significantly different at 5% level, based on DMRT

The performance of the promising processing tomato variety HT 148-3-11 with the check variety T 245 in NCVT is presented in Table 7. In mid country wet zone, the variety HT 148-3-11 has performed well and gave comparable (24.3 t/hā) or higher yields (34.8 t/ha) than T 245. It is interesting to note that fruit setting was not observed during *yala* seasons in dry zone areas (Maha Illuppallama and Girandurukotte). Kuo *et al.* (1979) reported that the optimum night temperature for fruit set is in the range of 15-20°C and the most serious effect of high temperature is reduction or prevention of fruit set. Therefore, the variety HT 148-3-11 is not a heat tolerant variety.

The marketable fruit yield data of the adaptability trials conducted in farmers' fields of Kandy and Kegalle districts, during *maha* 98/99 revealed that the variety HT 148-3-11 gave yields lower than the check variety T 245.

DUS test report indicated that the variety HT 148-3-11 can be distinguished from the recommended variety which exhibits close similarities to this variety and it is sufficiently uniform and stable in morphological characteristics.

Table 7. Yield performance of HT 148-3-11 and T245 in NCVT

Season	*Variety*	*Marketable fruit yield (t/ha)*				
		Gn	*MK*	*Bn*	*GK*	*MI*
maha 96/97	T 245	20.87 ab	4.40	-	10.47	2.73
	HT148-3-11	28.62 a	2.40	-	13.30	6.58
yala 97	T 245	27.90 a	8.67	NA	NF	NF
	HT148-3-11	25.90 a	14.87	NA	NF	NF
maha 97/98	T 245	11.78 b	1.53	27.7	5.41	-
	HT148-3-11	17.66 a	0.25	9.5	10.98	-
yala 98	T 245	33.76 b	4.88	-	NF	NF
	HT148-3-11	52.10 a	5.47	-	NF	NF

Gn - Gannoruwa ;MK - Makandura; Bn - Bandarawela; GK - Girandurukotte; MI-Maha Illuppallama; NF - No fruit setting; NA - Not available ; NS - Non significant; Means followed by the same letters were not significantly different at 5% level, based on DMRT

CONCLUSIONS

The results of this long-term study indicated that the variety HT 148-3-11, a derivative from a cross between T 245 and Roma, had desirable horticultural traits, high level of resistance to BW disease, and fruit quality characteristics such as high total soluble solid content (brix =5.5), high TA, fruit pH of 4.3, moderate fruit firmness, cracking resistance and dark red coloured pulp, which are acceptable characteristics for processing.

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stages as a result of change of virulence of the causal agents. Consequently, these varieties were predisposed to many biotic and abiotic stresses in the field thus affecting the grain yield. Therefore it became imperative to develop new varieties to replace already recommended cultivars.

MATERIALS AND METHODS

Breeding lines/varieties used as parental sources of germplasm were identified based on their various attributes to suit the ultimate objectives of the varieties to be developed (Table 1). Crosses were made among the selected parents and F_1 progenies as the case may be, to create desirable genetic variability for selection, screening and evaluation. Crosses made were, for Bg 352 = Bg 367-4/ Bg 380, for Bg 304 = Co 10/ IR 50// 84-1587/ Bg 300, for Bg 357 = Bg 797/ Bg 300 // 85-1580 / Senerang M-17, for Bg 2039 = 88-5089/Bg 379-2 and for Bg 2426-2 = Bg12-1/Bg304. The subsequent F_1 generations were evaluated and bulk method of selection procedure was adopted for the selection of individual plants and progenies from F_2 generation to F_8 generation (Allard, 1960). Breeding lines thus developed were evaluated for resistance to biotic stress as well as for desired agro-morphological traits (IRRI, 1998). Elite breeding lines were indentified and then evaluated in Station Yield Trials (SYT), National Coordinated Rice Varietal Testing Trials (NCRVT) and under Varietal Adaptability Testing Trials (VATT) in many locations across diverse environments in Sri Lanka before recommendation for release (Table 2).

Table 1. Parents and their beneficial attributes

Parents	*Beneficial attributes*
Bg 367-4	Resistant to BPH, BL, moderately resistant to rice thrips and GLH
Bg 380	Large panicle. good culm strength, resistant to RGM 1
CO 10	Resistant to BPH and GLH
IR 50	Short maturity duration, premium grain quality, resistant to RGM and BLB
84-1587	Large panicles, good culm strength
Bg 300	Resistant to BL,BLB and RGM 1, moderately resistant to BPH and GLH
Bg 797	Resistant to BL and RGM 1, large panicles, moderately resistant to GLH
85-1580	Good agronomc characters, resistant to BL, BPH and RGM 1
Senerang M-17	Premium grain quality, tolerance to iron toxicity, resistant to RGM
Bg 379-2	Moderately resistant to BPH, GLH and BL, good grain quality
88-5089	Beneficial attributes of Bg 379-2 and Senerang M-17
Bg 12-1	Samba grains, resistant to RGM 1, and strong culm
Ptb 33	Resistant to BPH and GLH
Tetep	Resistant to BL

BPH= Brown planthopper; GLH= Green leafhopper; RGM 1&2= Rice gall midge biotypes 1 & 2; BL=Blast; BLB= Bacterial blight