

**DEVELOPMENT OF HIGH PERFORMING GREEN CHILLI
(*CAPSICUM ANNUUM* L.) BREEDING LINE THROUGH
HYBRIDIZATION AND SELECTION**

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ABSTRACT

Department of Agriculture has recommended several chilli (*Capsicum annum* L.) varieties for general cultivation. MI-2 and KA-2 are the most popular varieties for green chilli production due to their wide adaptability. However, the productivity level of these varieties has gone down with increasing the susceptibility to pests and diseases due to continuous cultivation. Therefore, new varieties with desirable characters are essential to overcome the risk associated with the pest and disease incidences in chilli cultivation. This study was conducted at the Field Crops Research and Development Institute (FCRDI), Mahalluppallama, Sri Lanka with the objective of selecting a well adapted green chilli variety coupled with better agronomic traits, through hybridization and selection processes. Three selected breeding lines MICH-1, 2 and 6 were evaluated with five other selections and varieties, namely, *Galkiriyagama* Selection, ARL95, *Makandura* selection, MI-Hot and MI-2 in the dry and intermediate zones of Sri Lanka. The dual purpose variety MI-2 was selected as the control variety considering the suitability for both *yala* and *maha* seasons. The breeding line MICH-06 showed a higher positive mean deviation (D) across environments, performed better with yield increase of more than 3.5 t over the check varieties and was moderately tolerant to major pest and diseases. Suitability for green chilli production, high yield, better quality with attractive colour and appearance with high pungency favoured the recommendation of this variety for extensive cultivation in Sri Lanka.

KEYWORDS: Agronomic traits, Breeding line, Green chilli, Hybridization, MICH-06.

INTRODUCTION

Chilli or pepper (*Capsicum annum* L.) is one of the important commercially grown vegetables and the largest commodity after black pepper (*Piper nigrum* L.) in the international trade as a condiment. Chilli is a member of the family Solanaceae rich in vitamins, minerals and antioxidants (Pickersgill, 1997). It is an indispensable spice crop essentially used in every Sri Lankan cuisine due to its pungency, colour, taste, appealing odour and flavour. China and India are the leading chilli producers in the Asian region. In 2012, the annual extent and production of green chilli in Sri Lanka was about 14,728 ha and 61,541 t, respectively (Agstat, 2012). The chilli production has declined drastically

during the last two decades and, consequently volume and value of imports have been increased significantly.

Although the Department of Agriculture has recommended eight varieties of chilli during last few decades, and MI-2 and KA-2 are the varieties still preferred by more than 90 % of the chilli growers. High rate of out-crossing in chilli has favoured the changes of the genetic characters of these varieties with time. Sexual reproduction in plant species enhances genetic diversity due to the random exchange of genes (Richards, 1986). The productivity levels of these early recommended varieties also have gone down with increasing susceptibility to pests and diseases due to continuous cultivation. Hence, the chilli growing farmers, especially green chilli producers used to cultivate exotic chilli hybrids due to their better appearance and comparatively higher yield than the local open pollinated varieties. However, most of the exotic hybrids have been rejected by the farmers due to their poor performances especially low pungency and susceptibility to major pests and diseases.

The yield potential of available open pollinated chilli varieties is around 12 t/ha of green chilli. However, the national average green chilli yield is still as low as 4.18 t/ha in 2012. The reasons identified for the low chilli yields are the high pest and disease incidence, moisture stress, inadequate use of good quality seeds of recommended varieties and less use of control measures due to high input costs for agro-chemicals. Consequently, developing high yielding green chilli varieties which can compete with exotic hybrid varieties having high consumer acceptability is a challenging task to chilli breeders. Therefore, the objective of the research study was to develop a high performing green chilli breeding line through hybridization and selection process.

MATERIALS AND METHODS

Several single crosses of the following chilli varieties were carried out during *yala* season 2000 with the objectives of developing high yielding and pest and disease resistant varieties with desirable pod characteristics at the chilli breeding division of FCRDI, Mahailuppallama. The chilli varieties and breeding lines used were; MI-1, MI-2, KA-2, IR, PP9852173, PP977127, PP977644, BL98144 and Wonder Hot (hybrid). All possible crosses were made and the generations were advanced up to F₈ from *maha* 2000/01 to *maha* 2004/05 seasons to obtain uniform progenies. Single plant and progeny selection methods were followed to produce the pure lines. Based on the observations made at the field trials, sixteen breeding lines were selected out of 50 advanced breeding lines. Higher yield, resistance to major pest and diseases including leaf curl complex

(LCC) and anthracnose, desirable pod size and shape, attractive green colour with gloss surface, high pungency and good keeping quality as green chilli were the characteristics considered during selection. The advanced breeding lines MICH-1, MICH-2 and MICH-6 were selected from the sixteen lines tested including four recommended standard varieties during *maha* season 2005/06. The yield and other agronomic characters of MICH-1, MICH-2 and MICH-6 breeding lines were evaluated in Advanced Yield Trials (AYT) for three consecutive seasons from *yala* 2006, *maha* 2006/07 and *yala* 2007 seasons. *Galkiriyagama* selection, ARL 95 and Makandura selection were included in the experiment as entries received from other regional stations. The recommended dual purpose varieties MI-2 and MI-hot which are suitable for both *yala* and *maha* seasons were used as standard recommended varieties. In *yala* season 2007, only four entries were included (MICH-1, MICH-2, MICH-6 and Makandura selection). The severity of LCC was scored according to 0-5 scale at 28, 42, 56, 70, 84 and 98 days after planting under minimum spraying conditions.

The adaptability and stability of the selected pure lines with two recommended varieties were tested at six locations (research stations) in four agro-ecological zones; at Makandura (IL_{1a}), Aralaganvila (DL_{2b}), Thinnaveli (DL₃), Kalpitiya (DL₃), Angunakolapellessa (DL_{1b}) and FCRDI at Mahalluppallama (DL_{1b}) under the National Coordinated Varietal Trials (NCVT) in *yala* season 2007. The pod yield and the level of farmer preference of selected pure lines were evaluated in *maha* 2007/08, *yala* 2008 and *maha* 2008/09 seasons under the Varietal Adaptability Trials (VAT) in farmers fields in Anuradhapura, Madatugama, Kekirawa, Thambuththegama, Hettipola, Hasalaka, Makandura and Nochchiyagama. Yield data were analyzed using the deviation of plot-yield from the environmental mean by the method proposed by Abey Siriwardena *et al.* (1991). Selection of highly adaptable varieties was done based on the highest positive mean deviation (D) across environments.

RESULTS AND DISCUSSION

Yield performances and quality characters of tested varieties and promising breeding lines in *maha* season 2005/06 at FCRDI, Mahalluppallama are given in Table 1. Breeding lines MICH-1, MICH-2 and MICH-6 performed better than the recommended varieties of MI-2, KA-2 and Arunalu in preliminary yield trial (PYT) conducted at FCRDI, Mahalluppallama. Even though the yield of MICH-6 was little lower than the recommended variety MI-Hot and some of the other entries, the quality characters pungency, colour of the mature pods and length of the pods of MICH-6 were better than that of all other varieties and breeding lines (Table 1).

Yield (t/ha) and number of pods per plant of advanced chilli breeding lines with two recommended varieties tested at FCRDI during three seasons are shown in Tables 2 and 3, respectively. The promising breeding line MICH-6 has shown a significantly higher yield than the recommended varieties during all three seasons. The yields of MICH-6 during these three seasons were 4.31 t/ha and 3.62 t/ha greater than the recommended varieties of MI-2 and MI-Hot, respectively. Significantly higher number of pods/plant was also shown by the MICH-6 breeding line (Tables 2 and 3).

Table 1. Yield performances and quality characters of promising breeding lines tested in preliminary yield trial of *maha* season 2005/06 at FCRDI, Mahailuppallama.

Variety/ Breeding line	Pedigree	Green chilli yield (t/ha)	Pods/ plant	Pod length (cm)	Pod colour	Pungency
1-1	KA-2 x PP9852-173	9.85 bcde	53 cdefgh	8.20	LG.	2
MICH-1	KA-2 x PP977127	15.12 a	81 ab	11.20	LG	4
MICH-7	BL98144 x Wonder Hot	9.56 cde	41 hi	9.72	G	3
MICH-5	BL98144 x Wonder Hot	9.24 cdef	34 i	8.58	LG	4
MICH-4	BL98144 x Wonder Hot	11.34 bcd	39 hi	8.88	G	3
9-2	BL98144 x Wonder Hot	11.23 bcd	65 cde	8.62	LG	2
MICH-2	BL98144 x Wonder Hot	11.56 bc	58 cdefg	9.21	G	3
14-1	KA-2 x IR	9.78 bcde	50 defgh	8.58	G	2
16-1	PP977127 x BL98144	9.57 cde	45 fghi	9.78	G	2
23-1	IR x PP977644	7.91 efg	42ghi	9.20	DG	1
25-1	IR x PP977644	9.17 cdef	64 cde	9.32	DG	1
MICH-6	MI-1 x Wonder Hot	10.75 bcde	51 defgh	10.10	DG	4
MICH-3	MI-1 x Wonder Hot	12.52 ab	67 bc	9.24	G	3
29-1	MI-1 x Wonder Hot	6.63 ab	49 efghi	10.26	G	3
MICH-9	MI-1 x Wonder Hot	11.65 bc	60 cdef	8.62	LG	3
35-1	MI-1 x Wonder Hot	11.33 bcd	66 bcd	8.92	LG	3
KA-2*		8.44 def	65 cde	8.22	DG	4
Arunalu*		5.66 g	55 cdefgh	8.20	G	4
MI-2*		9.31 cdef	84 a	6.82	G	4
MI-HOT*		12.52 b	84 a	7.88	G	2
CV (%)		14.89	14.69			

Note: Within each column, the means followed by the same letter are not significantly different at $p=0.05$;

* = Standard recommended varieties. Pod colour classification is based on LG=Light green, G=Green and DG=Dark green. Pungency of pods is assessed according to 0-4 scale where 0=Non pungent; 1=Very low pungent; 2=Low pungent; 3=Pungent; 4=Highly pungent.

The non significant stability parameter indicated that all the entries were stable at the tested locations (Table 4). However, the entries MICH-6 and *Galkiriyagama* selection showed higher positive mean deviations over the rest of NCVT during *yala* season 2007. Therefore, it could be concluded that both MICH-6 and *Galkiriyagama* selection were highly adaptable compared to the recommended varieties (MI-2 and MI-hot).

Table 2. Yield of advanced chilli breeding lines and two recommended varieties tested at FCRDI, Mahailluppallama during *yala* 2006, *maha* 2006/07 and *yala* 2007 seasons.

Breeding line/ Variety	Green chilli yield (t/ha)		
	<i>yala</i> 2006	<i>maha</i> 2006/2007	<i>yala</i> 2007
MICH-1	11.20 b	9.41 d	7.60 b
MICH-2	8.75 b	8.12 e	6.60 bc
MICH-6	14.48 a	14.28 a	10.12 a
Makandura sel.	11.30 b	10.41 c	8.07 b
Galkiriyagama sel.	12.28 ab	13.71 b	na
ARL95	8.92 b	na	na
MI-Hot - (std)	10.66 b	na	6.50 bc
MI-2 - (std)	10.17 b	9.36 d	5.50 c
CV (%)	19.42	1.47	17.20

Note: Within each column, the means followed by the same letter are not significantly at different $p=0.05$; "na"- not assessed during that season. "std" -standard recommended varieties.

Table 3. Number of pods per plant of advanced chilli breeding lines and two recommended varieties tested at FCRDI, Mahailuppallama during *yala* 2006, *maha* 2006/07 and *yala* 2007 seasons.

Breeding line/Variety	Number of pods per plant		
	2006 <i>yala</i>	2006/07 <i>maha</i>	2007 <i>yala</i>
MICH-1	68 ab	48.5 c	53 abc
MICH-2	41 d	48.4 c	48 bc
MICH-6	81 a	94.0 a	66 a
Makandura sel.	50 cd	68.5 b	41 c
Galkiriyagama sel.	74 ab	91.0 a	na
ARL95	52 bcd	na	na
MI-Hot - (std)	62 bc	na	58 ab
MI-2 - (std)	63 bc	100.0 a	51 abc
CV (%)	18.89	19.80	19.64

Note: Within each column, the means followed by the same letter are not significantly at different $p=0.05$; "na"- not assessed during that season. "std" -standard recommended varieties.

Mean deviation (D) and Stability parameter (S^2) values of tested entries in farmers fields of Anuradhapura, Madatugama, Kalaththewa and Mahalluppallama in Anuradhapura district during *yala* season 2008 are shown in Table 5. Repeatedly, MICH-6 and *Galkiriyagama* selection recorded higher positive mean deviations in VAT during *yala* 2008 season over the control variety MI-2. The stability parameter of the selected pure line is not significant ($p>0.05$) and showed a high adaptability (Table 5). Similar results were also obtained during *maha* 2007/08 and *maha* 2008/09 seasons (data are not shown).

Table 4. Mean deviation (D) and Stability parameter (S^2) values of tested entries under NCVT in *yala* season 2007.

<i>Variety/Breeding line</i>	<i>Mean green chilli yield (t/ha)</i>	<i>Mean deviation (D)</i>	<i>Stability parameter (S^2)</i>
MICH-1	9.40 c	- 1.443 c	ns
MICH-2	8.10 d	- 2.69 d	ns
MICH-6	14.12 a	+ 3.32 a	ns
<i>Galkiriyagama</i> Selection	13.61 a	+ 2.76 a	ns
MI-2	9.23 c	- 1.619 c	ns
MI-Hot	10.53 b	- 0.314 b	ns
C.V. (%)	7.84		

Note: Within each column, the means followed by the same letter are not significantly different at $p=0.05$ by the Duncan's Multiple Range Test. ns=Not significant.

Table 5. Mean deviation (D) and Stability parameter (S^2) values of tested entries in farmer's fields of Anuradhapura, Madatugama, Kalaththewa and Mahalluppallama in Anuradhapura district *yala* season 2008.

<i>Variety/Breeding line</i>	<i>Mean green chilli yield (t/ha)</i>	<i>Mean Deviation (D)</i>	<i>Stability Parameter (S^2)</i>
MI-2	10.10 b	- 1.906 b	ns
<i>Galkiriyagama</i> selection	12.70 a	+ 0.680 a	ns
MICH-6	13.30 a	+ 1.220 a	ns
CV (%)	4.87		

Note: Within each column, the means followed by the same letter are not significantly different at $p=0.05$ by the Duncan's Multiple Range Test. ns=Not significant.

Severity of leaf curl complex disease (LCC) of new breeding lines and recommended varieties during two *yala* seasons at Mahalluppallama are given in Table 6. Minimum damage by the LCC was observed at the early stage of the crop in MICH-6

than the control variety MI-2 during *yala* 2006 and *yala* 2010 seasons. Even at 84 days after planting, the breeding line MICH-06 showed a lower susceptibility to LCC than the recommended varieties tested. However, the severity of LCC is almost similar compared with the variety KA-2 (Table 6).

Table 6. Severity of LCC of new breeding lines with the recommended varieties during two *yala* seasons at Mahailuppallama.

Variety/Breeding line	LCC Severity - Days after planting (DAP)					
	28	42	56	70	84	98
MICH-1	1/na	1/na	2/na	3/na	4/na	5/na
MICH-2	1/na	1/na	2/na	3/na	4/na	5/na
MICH-6	1/0	1/0	2/1	2/1	3/2	4/3
<i>Galkiriyagama</i> selection	1/0	1/1	2/1	2/1	3/2	4/3
Makandura selection	1/na	2/na	2/na	4/na	4/na	5/na
ARL95	1/na	1/na	3/na	4/na	5/na	5/na
PC-1	na/0	na/0	na/1	na/1	na/2	na/3
Waraniya selection	na/0	na/0	na/0	na/0	na/1	na/1
TVC-4	na/1	na/2	na/2	na/3	na/4	na/4
TVC-5	na/1	na/2	na/2	na/3	na/4	na/5
MI-Hot	1/na	1/na	2/na	4/na	4/na	4/na
MI-2	1/1	2/1	3/2	4/3	4/4	5/5
KA-2	na/0	na/0	na/1	na/2	na/2	na/3
MI-Green	na/0	na/1	na/1	na/2	na/3	na/3
<i>Galkiriyagama</i> selection	1/0	1/1	2/1	2/1	3/2	4/3

Note: First values followed by the second value of each cell separated by / indicate the LCC during *yala* 2006 and *yala* 2010 seasons, respectively. "na" indicates=not assessed during the particular season. Severity of LCC was assessed according to 0-5 scale where 0=No symptoms (immune); 1=1-10 % of leaves affected (resistant/ tolerant); 2=11-25 % of leaves affected (moderately resistant/tolerant); 3=26-50 % of leaves affected (moderately susceptible); 4=51-75 % of leaves affected (susceptible); and 5= 76-100 % of leaves affected (highly susceptible).

CONCLUSIONS

The breeding line, MICH-06 showed a high yield potential for green chilli production with a green chilli yield of more than 14.48 t/ha and moderate level of resistance to leaf curl complex at the field level with farmer acceptable quality characteristics such as the moderate size of pods (8-10 cm in length) with glossy, dark green colour at maturity.

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