APres. APres. UNIVERSION

APPENDIX A

Descriptors for capsicum (IBPGR et al. 1995)

1. Plant descriptors

1.1 Stem color

Recorded on young plants before transplanting

- 1 Green
- 2 Green with purple stripes
- 3 Purple
- 4 Other

1.2 Nodal anthocyanin (whole plant)

Recorded at plant maturity

- 1 Green
- 3 Light purple
- 5 Purple
- 7 Dark purple

1.3 Stem shape

Observed at plant maturity

- 1 Cylindrical
- 2 Angled
- 3 Flattened

1.4 Stem pubescence

Recorded on mature plants, excluding the first two nodes below the shoot

- 3 Sparse
- 5 Intermediate
 - Dense

1.5 Plant growth habit

Observed when 50% of the plants bear ripe fruits

- 3 Prostrate
- 5 Intermediate (compact)
- 7 Erect
- 9 Other

1.6 Branching habit

- 3 Sparse
- 5 Intermediate
- 7 Dense

1.7 Leaf density

Recorded in healthy, mature plants. Average of 10 plants

- 3 Sparse
- 5 Intermediate
- 7 Dense

1.8 Leaf color

- 1 Yellow
- 2 Light green
- 3 Green
- 4 Dark green
- 5 Light purple
- 6 Purple
- Variegated
 - Other

1.9 Leaf shape 1 D

3

- Deltoid
- 2 Ovate
 - Lanceolate

1.10 Lamina margin

- 1 Entire
- 2 Undulate
- 3 Ciliate

1.11 Leaf pubescence

Observed on the youngest mature leaves

- 3 Sparse
- 5 Intermediate
- 7 Dense

1.12 Plant height (cm)

Recorded when in 50% of the plants the first fruit has begun to ripen

1.13 Plant canopy width (cm)

Measured immediately after first harvest, at the widest point

1.14 Stem length (cm)

Height to first bifurcation. Measured immediately after first harvest

1.15 Mature leaf length (cm)

1.16 Mature leaf width (cm)

Measured on the widest part of the leaf

2. Inflorescence descriptors

Recorded on fully open flowers in the first fresh flowering

2.1 Days to flowering

Number of days from sowing/transplanting until 50% of plants have at least

one open flower

2.2 Flower position

- 3 Pendant
- 5 Intermediate
- 7 Erect

2.3 Corolla color

- 1 White
- 2 Light yellow
- 3 Yellow
- 4 Yellow-green
- 5 Purple with white base
- 6 White with purple base
- 7 White with purple margin
- 8 Purple
- 9 Other

2.4 Corolla spot color

- 1 White
- 2 Yellow
- 3 Green-yellow
- 4 Green
- 5 Purple
- 6 Other

2.5 Corolla shape

- 1 Rotate
- 2 Campanulate
- 3 Other

2.6 Male sterility

1

- 0 Absent
 - Present

97

2.7 Calyx Pigmentation

- 0 Absent
- 1 Present

2.8 Calyx margin

- 1 Entire
- 2 Intermediate
- 3 Dentate
- 4 Other

2.9 Calyx annular constriction

At junction of calyx and pedicel. Observed at mature stage

- 0 Absent
- 1 Present

3. Fruit descriptors

Recorded on mature fruits in the first harvest unless specified

3.1 Anthocyanin spots or stripes

Recorded just before the ripening stage

Absent

0

1

2

5

6

7

Present

3.3 Fruit color at intermediate stage

Recorded on fruits just before the ripening stage

- White
- Yellow
- Green
- 4 Orange
 - Purple
 - Deep purple
 - Other

98

3.3 Fruit set

Recorded before harvest

- 3 Low
- 5 Intermediate
- 7 High

3.4 Fruit color at mature stage

- 1 White
- 2 Lemon-yellow
- 3 Pale orange-yellow
- 4 Orange-yellow
- 5 Pale orange
- 6 Orange
- 7 Light red
- 8 Red
- 9 Dark red
- 10 Purple
- 11 Brown
- 12 Black
- 13 Other

3.5 Fruit shape

- 1 Elongate
- 2 Almost round
- 3 Triangular
- 4 Campanulate
- 5 Blocky
- 6 Other

3.6 Fruit shape at pedicel attachment

1 Acute

2

Obtuse

- 3 Truncate
- 4 Cordate
- 5 Lobate

3.7 Neck at base of fruit

- 0 Absent
 - Present

3.8 Fruit shape at blossom end

Average of 10 fruits

1

- 1 Pointed
- 2 Blunt
- 3 Sunken
- 4 Sunken and pointed
- 5 Other

3.9 Fruit blossom end appendage

0 Absent

1

7

Present

3.10 Fruit cross-sectional corrugation

Average of 10 fruits (1/3 from pedicel end)

- 3 Slightly corrugated
- 5 Intermediate
 - Corrugated

3.11 Number of locules

Observe 10 fruits, if the locule (chamber) number is uniform, record it; if not, record the most frequent two numbers (or the percentage of the all categories)

3.12 Fruit surface 1 Smooth 2 Semiwrinkled

Wrinkled

3.13 Placenta length

3

2

3

- 1 < 1/4 fruit length
 - 1/4-1/2 fruit length
 - > 1/2 fruit length

3.14 Fruit length (cm)

Average fruit length of 10 ripe fruits of the second harvest

3.15 Fruit width (cm)

Measured at the widest point. Average fruit width of 10 ripe fruits of the second harvest

3.16 Fruit weight (g)

Average fruit weight of 10 ripe fruits of the second harvest

3.17 Fruit pedicel length (cm)

Average length of 10 pedicels of the second harvest to one decimal place

3.18 Fruit wall thickness (mm)

Average of 10 ripe fruits of the second harvest, measured at point of maximum width to one decimal point

4. Seed descriptors

4.1 Seed color

2 3

- Straw (deep yellow)
- Brown
- Black
- Other

4.2 Seed surface

- 1 Smooth
- 2 Rough
- 3 Wrinkled

4.3 1000-seed weight (g)

4.4 Number of seeds per fruit

Average of at least 10 fruits selected from 10 random plants

ลิ<mark>ปสิทธิ์มหาวิทยาลัยเชียงใหม่</mark> Copyright[©] by Chiang Mai University All rights reserved

APPENDIX B

Data analysis : All recorded parameters were analysed according to Virmani *et al.* (1977), Kempthorne (1957) and Karladee (2002) as following procedures:

1. Analysis of variance:

Correction Factor (C.F.)

Total Sum of square (T.S.S.)

Replication S.S. (R.S.S.)

Treatment S.S. (Tr.S.S.)

Error S.S.(E.S.S.)

T.S.S. - Tr.S.S. - R.S.S.

 $\Sigma Y i j^2$

 $\Sigma Y j^2$

 $\Sigma Y i^2$

=

 $(Grand total)^2$

Total number of observation

- C.F.

C.F.

- C.F.

where

Yij is the observation for i x jth

Yjj is the observation for jth parents

r is the number of replications

t is the number of treatments

2. Line x tester analysis:

Correction Facter (crosses) = $\frac{[Grand total (crosses)]^2}{Total number of crosses x number of replications}$

S.S. (crosses)

 $\Sigma\Sigma Cij^2$ - C.F.(crosses)

(Grand total for parents)²

number of parents x number of replications

Correction Facter (parents)

S.S. (crosses)

 $\Sigma\Sigma Pij^2$ - C.F.(parents)

S.S. (parents vs. crosses) = S.S.treatment - S.S.(crosses) - S.S.(parents) or C.F.(crosses) - C.F.(parents) - C.F.(overall)

where

C*ij* is the observation for *i* x *j*th crosses P*ii* is the observation for *i*th parents *r* is the number of replication

S.S. due to lines

 $\frac{\Sigma Y i^2..}{r \ge t} - C.F.(crosses)$

S.S. due to testers

 $\underline{\Sigma Y i^2}$... - C.F.(crosses)

S.S. due to line x tester = S.S.(crosses) - S.S.(lines) - S.S.(testers)

where

r, l, t is the number of replication, lines and testers, respectively

- 3. Estimation of combining ability:
- 3.1 General combining ability (GCA) effects:
 - i) GCA effects of lines

$$gi = \underbrace{xi..}_{tr} - \underbrace{x..}_{ltr}$$

where

xi.. = Total of *i*th line over testers

x.. = Grand total

r, l, t is the number of replication, lines and testers, respectively

check:

$$\Sigma g i = 0$$

ii) GCA effects of testers

$$gj = \underline{x.j.} - \underline{x..}$$

 lr ltr

where

xi.. = Total of *j*th tester over lines

x.. = Grand total

r, l, t is the number of replication, lines and testers, respectively

check: $\Sigma g j = 0$

3.2 Specific combining ability (SCA) effects:

$$\begin{array}{rcl} \mathrm{S}ij & = & \underline{\mathrm{x}ij.} & - & \underline{\mathrm{x}.i.} & - & \underline{\mathrm{x}.j.} & - & \underline{\mathrm{x}..} \\ & r & tr & lr & ltr \end{array}$$

where

 x_{ij} . = Value of *j*th line with *i*th tester

 $x_{i..}$ = Total of *i*th line over all testers

x.j. = Total of jth tester over all lines

x... = Grand total

r, l, t is the number of replication, lines and testers, respectively

4. Estimates of heterosis

Mid-parent heterosis (MPH) (%) = $\frac{F_1 - MP}{MP} \times 100$

Better-parent heterosis (BPH) (%) = $\underline{F_1} - \underline{BP} \times 100$ or heterobeltiosis BP

where

 F_1 = Mean of F_1 population MP = Mean of both parents (mid-parent) = $(P_1 + P_2) / 2$

BP = Better parent value

ลิ<mark>ปสิทธิ์มหาวิทยาลัยเชียงใหม่</mark> Copyright[©] by Chiang Mai University All rights reserved

Mean Square Source of d.f. Variance Fruit weight Number of Plant height **Plant width** Yield Fruit weight fruits per plant per plant Replication 2 32.7467 88.3558 0.0118 0.489 19.5616 0.9369 0.0960** Treatment 238.8496** 3.928** 149.6236** 387.8264** 17 64.7060 Error 34 38.3560 49.2929 0.0072 0.299 8.6940 6.2865 9.11 12.44 C.V. (%) 9.29 12.34 11.15 7.45

Table B.1 Analysis of variance of horticultural characteristics of Capsicum annuum L.

Table B.2	Analysis of	of variance	of horticultural	characteristics	and phys	sico-chemica	al properties	of Capsicum	annuum L.
	I IIIai Joio	or ranance	or nornealtaitai	ental accertiseles	and phys		a properties	or corporetine.	

	Mean Square							
d.f.	Fruit width	Fruit length	Pericarp Thickness	LRS	Chroma	Hue		
2	0.0012	1.1990	0.00002	5.7036	10.8983	1.4704		
17	0.7105**	15.7266**	0.00312**	60.3898**	36.0007**	20.2636**		
34	0.0162	0.4930	0.00019	3.5440	5.3614	2.0199		
8	4.82	4.09	5.88	3.65	5.12	1.12		
	d.f. 2 17 34	d.f. Fruit width 2 0.0012 17 0.7105** 34 0.0162 4.82	d.f.Fruit widthFruit length20.00121.1990170.7105**15.7266**340.01620.49304.824.09	d.f. Fruit width Fruit length Pericarp Thickness 2 0.0012 1.1990 0.00002 17 0.7105** 15.7266** 0.00312** 34 0.0162 0.4930 0.00019 4.82 4.09 5.88	d.f. Fruit width Fruit length Pericarp Thickness L 2 0.0012 1.1990 0.00002 5.7036 17 0.7105** 15.7266** 0.00312** 60.3898** 34 0.0162 0.4930 0.00019 3.5440 4.82 4.09 5.88 3.65	d.f. Fruit width Fruit length Pericarp Thickness L Chroma 2 0.0012 1.1990 0.00002 5.7036 10.8983 17 0.7105** 15.7266** 0.00312** 60.3898** 36.0007** 34 0.0162 0.4930 0.00019 3.5440 5.3614 4.82 4.09 5.88 3.65 5.12		

Copyright[©] by Chiang Mai University A I I rights reserved

Source of								
Variance	d.f.	Total soluble solids	Moisture	Vitamin C	Chlorophyll a	Chlorophyll b	Total Chlorophyll	Capsaicin
Replication	2	0.2585	0.0422	0.2800	1.852E-06	1.852E-06	7.407E-06	31938.8889
Treatment	17	2.0288**	14.5665**	2.4474**	1.313E-04**	1.483E-04**	3.734E-04**	6412764.7059**
Error	34	0.0803	0.6333	0.2379	7.734E-06	1.852E-06	7.407E-06	24868.3007
C.V. (%)		5.38	0.92	8.56	27.34	20.65	14.91	8.89

Table B.3 Analysis of variance of physico-chemical properties of Capsicum annuum L.

ລິບສິກຣິ້ນหາງົກຍາລັຍເຮີຍວໃหม Copyright[©] by Chiang Mai University All rights reserved

		Mean Square					
Source of Variance	d.f. –	Plant height	Plant width	Fruit weight per plant			
Replications	2	35.55	80.04	0.010			
Treatments	14	215.98**	75.48	0.108**			
Parents	5	310.07**	57.71	0.056**			
Parents vs. Crosses	1	0.20	44.86	0.228**			
Crosses	8	184.15**	90.41	0.125**			
Lines	2	302.38	61.40	0.135			
Testers	2	210.16	30.60	0.072			
Lines x Testers	4	112.02*	134.83*	0.147**			
Error	28	39.57	48.75	0.008			
C.V. (%)		9.51	9.25	13.32			
		1007 10011	1 . 1				

Table B.4 Analysis of variance of horticultural characteristics of Capsicum annuum L.

*, ** significant difference at P<0.05 and P<0.01 levels, respectively.

Table B.4 Analysis of variance of horticultural characteristics of
Capsicum annuum L. (continued)

		Mean Square				
Source of Variance	d.f. —	Yield	Number of fruits per plant	Fruit weight		
Replications	2	0.410	22.597	1.31		
Treatments	14	4.416**	124.087**	439.23**		
Parents	- 5	2.293**	44.744**	610.85**		
Parents vs. Crosses	1	9.326**	0.001	13.11		
Crosses	8	5.130**	189.188**	385.24**		
Lines	2	5.530	365.410	485.44		
Testers	2	2.967	43.416	431.27		
Lines x Testers	4	6.011**	173.963**	312.12**		
Error	28	0.329	7.938	7.26		
C.V. (%)	9	13.34	11.26	7.72		

*, ** significant difference at P<0.05 and P<0.01 levels, respectively.

		Mean Square	
d.f. –	Fruit width	Fruit length	Pericarp ¹ thickness
2	0.000	1.110	0.000
14	0.665**	18.425**	0.010**
5	0.997**	19.679**	0.016**
1	0.092*	39.721**	0.002
8	0.530**	14.978**	0.008**
2	0.868	1.719	0.013
2	0.504	10.836	0.003
4	0.373**	23.679**	0.008**
28	0.019	0.559	0.001
	5.02	4.39	8.38
	d.f. -	January Fruit width 2 0.000 14 0.665** 5 0.997** 1 0.092* 8 0.530** 2 0.868 2 0.504 4 0.373** 28 0.019 5.02	Mean Square d.f. Fruit width Fruit length 2 0.000 1.110 14 0.665** 18.425** 5 0.997** 19.679** 1 0.092* 39.721** 8 0.530** 14.978** 2 0.868 1.719 2 0.504 10.836 4 0.373** 23.679** 28 0.019 0.559 5.02 4.39

Table B.4 Analysis of variance of horticultural characteristics of Capsicum annuum L. (continued)

¹ Transformed data by log(x)+1.

*, ** significant difference at P<0.05 and P<0.01 levels, respectively.

Table B.5 Analysis of variance of physico-chemical properties of
Capsicum annuum L.

	1.6	Mean Square				
Source of Variance	a.ı. –	L	Chroma	Hue		
Replications	2	8.80	11.30	2.22		
Treatments	14	53.47**	29.92**	19.73**		
Parents	5	41.68**	22.51**	18.99**		
Parents vs. Crosses	1	14.79*	10.80	3.43		
Crosses	8	65.67**	36.95**	22.23**		
Lines	2	68.84	47.35	15.43		
Testers	2	99.62	40.48	27.01		
Lines x Testers	4	47.11**	29.98**	23.23**		
Error	28	3.43	5.82	2.21		
C.V. (%)	9	3.56	5.31	1.17		

*, ** significant difference at P<0.05 and P<0.01 levels, respectively.

9		Mean Square		
d.f	Chlorophyll a ¹	Chlorophyll b ¹	Total Chlorophyll ¹	
2	0.004	0.003	0.002	
14	0.528**	0.786**	0.616**	
5	0.961**	1.037**	0.983**	
1	0.914**	2.581**	1.610**	
8	0.209**	0.405**	0.263**	
2	0.129	0.588	0.239	
2	0.051	0.088	0.053	
4	0.327**	0.471**	0.380**	
28	0.002	0.002	0.002	
	2.47	2.64	2.16	
	d.f. - 2 14 5 1 8 2 2 4 28	d.f. Chlorophyll a^1 2 0.004 14 0.528** 5 0.961** 1 0.914** 8 0.209** 2 0.129 2 0.051 4 0.327** 28 0.002 2.47	Mean Squared.f.Chlorophyll a^1 Chlorophyll b^1 20.0040.003140.528**0.786**50.961**1.037**10.914**2.581**80.209**0.405**20.1290.58820.0510.08840.327**0.471**280.0020.0022.472.64	

Table B.5 Analysis of variance of physico-chemical properties of
Capsicum annuum L. (continued)

¹ Transformed data by log(x)+4.

*, ** significant difference at P<0.05 and P<0.01 levels, respectively.

Table B.5	Analysis of variance of physico-chemical properties of
	Capsicum annuum L. (continued)

		Mean Square						
Source of Variance	d.f.	Total soluble solids	Moisture	Vitamin C	Capsaicin			
Replications	2	0.15	0.09	0.32	26246.67			
Treatments	14	2.11**	17.19**	2.67**	7493985.71**			
Parents	5	2.91**	18.45**	3.28**	5516400.00**			
Parents vs. Crosses	1	1.16**	3.25*	0.22	16333.33			
Crosses	8	1.72**	18.15**	2.60**	9664683.33**			
Lines	2	4.05	8.07	8.75**	11864633.33			
Testers	2	0.11	37.44	0.55	7238233.33			
Lines x Testers	4	1.36**	13.54**	0.55	9777933.33**			
Error	28	0.09	0.67	0.24	22989.52			
C.V. (%)		5.65	0.94	8.59	8.53			

*, ** significant difference at P<0.05 and P<0.01 levels, respectively.

CURRICULUM VITAE

NameMr. Sarujpisit PayakhapaabDate of birthAugust 15, 1974

Education background

1992-1995 B.S. (Agriculture), Chiang Mai University, Chiang Mai, Thailand1996-1999 M.S. (Agriculture), Chiang Mai University, Chiang Mai, Thailand

ลิขสิทธิ์มหาวิทยาลัยเชียงใหม่ Copyright[©] by Chiang Mai University All rights reserved