

CHAPTER IV

RESULTS

1. Varietal collection and inbred seeds production.

Twelve local bitter gourd accessions, accession numbers 1, 3, 5, 7, 8, 10, 11, 12, 13, 16 and 21 were collected from many provinces of Thailand and one accession (accession number 20) was chosen from commercial seed. Each accession and accession number 20 were self-pollinated for inbred seed production. They were selected for similarity to the mother plant at Phichit Horticultural Research Center (PHRC). They were planted from January 11 to December 24, 1999. Three generations of inbred seeds were produced. Inbred seeds of 13 local bitter gourd accessions were planted in the field at PHRC in February, 2000.

2. Yield and horticultural characteristics.

2.1 Botanical characteristics

2.1.1 Leaf

Leaves of all local bitter gourd accessions were alike. They were circular in leaf shape, open shape of petiole sinus, concave shape of teeth and seven lobes. Base of leaf was cordate, margin of leaf was parted, type of leaf was simple, surface covering was pubescent, arrangement of leaf was alternate and duration of leaf was marcescent. They were two types of apex of leaves; acute and obtuse. The accessions showed differences in color and size of leaves (Table 2). The color dimension in lightness scale of leaf (L) ranged from 34.46 to 87.44. Leaf of accession number 6 had the most lightness of color (L = 87.44) and accession number 12 had the least lightness of color (L = 34.46). The color dimension in greenness scale of leaf (a) ranged from 0.94 to -6.83. Leaf of accession number 10 had the most green leaf (a = -6.83) and accession number 10 had the least green leaf (a = 0.94). The color dimension in yellowness of leaf ranged

from 1.66 to 14.83. Leaf of accession number 10 had the most yellow leaf ($b = 14.83$) and accession number 6 had the least yellow leaf ($b = 1.66$).

When the L, a, b values of leaf color were converted into CIE values and a plot of x versus y was placed in CIE chromaticity diagram (Figure 2), the results found that leaf color of all accessions were illuminant C. The values of a and b in each accession was assembly. When L, a, b values were easily converted to the most commonly used color system, the results indicated that accession numbers 1, 10 and 12 were mostly in green leaves. Accession numbers 5, 6, 7 and 13 were least in greenness color.

Considering leaf size, leaf of accession numbers 8, 6 and 20 were the widest of 15.4, 14.8 and 14.3 cm, respectively. They were significantly different from others. Accession number 6 had the longest leaf of 11.2 cm which was significantly different from others. Petiole length of leaves was significantly different among accessions. Accession number 10 had the longest petiole of 9.3 cm and accession number 3 had the shortest petiole of 4.7 cm.

Table 2 Color and size of leaf of local bitter gourd.

Accession number	Color of leaf					Size of leaf (cm) ^{3/}		
	L ^{1/}	a ^{1/}	b ^{1/}	x ^{2/}	y ^{2/}	Width	Length	Petiole length
1	35.19	-5.22	10.33	0.35	0.39	10.9 c	8.0 de	6.7 c
3	53.05	-4.97	9.18	0.33	0.36	10.0 de	7.1 e	4.7 e
5	87.19	-1.23	1.79	0.31	0.32	11.4 cd	7.2 e	5.8 d
6	87.44	-1.30	1.66	0.31	0.32	14.8 ab	11.2 a	7.5 bc
7	78.85	0.94	10.05	0.33	0.34	13.4 b	9.2 bc	8.8 c
8	51.34	-4.89	7.67	0.32	0.35	15.4 a	9.9 b	7.3 bc
10	38.01	-6.83	14.83	0.37	0.42	13.5 b	8.7 cd	9.3 a
11	51.72	-4.89	9.67	0.33	0.36	10.7 cd	7.5 e	5.4 de
12	34.46	-6.35	13.03	0.36	0.41	10.8 e	7.9 de	5.6 d
13	65.64	-2.16	7.52	0.33	0.34	10.0 de	7.3 e	5.8 d
16	65.64	-2.16	7.52	0.33	0.34	10.8 cd	7.1 e	6.9 bc
20 ^{4/}	51.37	-4.80	8.41	0.33	0.35	14.3 ab	10.2 b	7.6 b
21	50.36	-4.03	6.74	0.32	0.35	10.5 cd	7.7 de	5.1 de
F-test	-	-	-	-	-	**	**	**
CV(%)	-	-	-	-	-	13.1	12.1	13.2

^{1/} Average of 3 mature leaves by Color QUEST II Hunter Lab.

L = the color dimension in lightness scale from black (L=0) to white (L=100).

a = the color dimension from redness (+a) to greenness (-a).

b = the color dimension from yellowness (+b) to blueness (-b).

^{2/} CIE values were calculated from L, a, b values.

^{3/} Average of 10 mature leaves.

Means followed by a common letter are not significantly different at P = .05 by Duncan's multiple range test (DMRT).

** = significant at .01 level.

^{4/} Bitter gourd called Deak bin brand was used as a control variety.

2.1.2 Flower

Pistillate and staminate flowers of all accessions had the same rotationally symmetrical shape (Figures 3 and 4), corolla shape was rotate and yellow in color. Pistillate and staminate flowers were different. The former was axillary but the later was terminal. Petal size and peduncle lengths were significantly different statistically among accessions. Sessile bracts of pistillate and staminate flowers were reniform in shape. Size of the sessile bracts and the distance from the sessile bracts to peduncle base were significantly different (Tables 3 and 4).



Figure 3 Pistillate flower of local bitter gourd accession.



Figure 4 Staminate flower of local bitter gourd accession.

Table 3 Botanical characteristics and sessile bract of pistillate flowers of local bitter gourd.

Accession number	Pistillate flower ^{1/}		Sessile bract of pistillate flower ^{1/}			
	Petal (mm)		Peduncle	Width	Length	Distance to
	Width	Length	Length (mm)	(mm)	(mm)	peduncle base (mm)
1	8.4 cdef	10.9 fgh	29.0 g	7.7 cde	5.5 bc	3.5 ef
3	11.2 a	14.5 c	47.8 cde	8.4 bcde	6.2 bc	9.3 a
5	10.3 ab	13.5 cd	29.4 g	8.9 abcd	5.8 bc	7.3 abcd
6	9.3 bcde	11.6 ef	37.4 efg	7.4 cde	5.1 bc	2.9 g
7	8.4 cdef	11.1 fg	33.8 fg	10.6 ab	8.3 a	3.9 efg
8	7.5 ef	11.3 efg	52.7 bcd	11.0 a	6.7 ab	5.2 cdef
10	9.8 abcd	12.6 de	41.7 defg	6.7 de	4.6 cd	2.8 fg
11	6.7 f	10.0 gh	44.6 cdef	9.5 abc	5.9 bc	8.5 abc
12	11.3 a	18.9 a	87.7 a	8.9 abcd	5.6 bc	8.8 ab
13	10.1 abc	16.1 b	63.7 b	7.2 cde	4.7 cd	5.0 cdef
16	7.1 f	9.5 h	45.3 cdef	6.3 e	4.6 cd	3.9 cdef
20 ^{2/}	8.1 def	10.7 fgh	55.1 bc	3.7 f	3.2 d	5.8 bcde
21	6.8 f	10.2 fgh	51.1 cd	7.4 cde	4.9 bcd	6.6 abcd
F-test	**	**	**	**	**	**
CV(%)	21.4	12.5	27.4	29.4	33.1	27.0

^{1/} Average of 10 pistillate flowers.

Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

Table 4 Botanical characteristics and sessile bract of staminate flowers of local bitter gourd.

Accession number	Staminate flower ^{1/}			Sessile bract of staminate flower ^{1/}		
	Petal (mm)		Peduncle	Width	Length	Distance to
	Width	Length	Length (mm)	(mm)	(mm)	peduncle base (mm)
1	9.4 cdef	15.1 bcd	66.2 bc	8.5 bc	6.9 ab	10.1 def
3	13.6 a	20.3 a	69.6 abc	7.6 cd	5.4 bc	20.4 b
5	10.7 cd	15.8 bcd	50.9 e	8.8 bc	6.7 ab	15.2 c
6	9.5 cdef	13.9 de	52.2 e	10.0 ab	7.4 a	8.6 cfg
7	10.4 cde	15.1 bcd	29.9 f	6.6 cd	4.3 cd	4.6 g
8	8.4 ef	16.3 bc	61.8 cd	10.5 ab	7.5 a	10.5 def
10	10.0 cde	16.5 bc	48.6 e	6.0 d	4.2 cd	5.2 g
11	10.0 cde	14.8 cd	51.8 e	10.3 ab	6.6 ab	14.1 cd
12	12.9 ab	21.3 a	68.3 abc	11.2 a	6.2 ab	12.6 cde
13	11.3 bc	17.1 b	75.5 ab	6.2 d	4.5 cd	7.6 fg
16	9.0 def	12.3 e	54.7 de	5.7 d	3.5 d	5.6 g
20 ^{2/}	10.9 cd	14.8 cd	72.2 a	7.7 cd	5.7 bc	28.0 a
21	7.8 f	12.7 e	45.2 e	7.8 cd	5.6 bc	12.4 cde
F-test	**	**	**	**	**	**
CV(%)	19.5	12.9	17.7	27.7	28.9	34.9

^{1/} Average of 10 staminate flowers.

Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

2.1.3 Fruit

There were four types of fruit shapes; elliptic, globose, oblong and oval among accessions (Table 5). Elliptic shape was the common one. Skin color of immature fruits of the accessions was different. The color dimension in lightness scale from black to white of fruit (L) ranged from 29.03 to 64.37. Fruit of accession number 7 had the most lightness of color (L = 64.37) and accession number 20 had the least lightness of color (L = 29.03). The color dimension in greenness scale of fruit (a) ranged from -04.03 to -09.47. Fruit of accession number 6 had the most greenness (a = -09.47) and accession number 7 had the least greenness (a = -04.03). The color dimension in yellowness of fruit ranged from 09.61 to 23.07. Fruit of accession number 10 had the most yellowness (b = 23.07) and accession number 8 had the least yellowness (b = 09.61). When the L, a, b values were converted to CIE values in the CIE chromaticity diagram which shown in Figure 2, results found that the skin colors of fresh fruits of accessions were divided into 2 groups. Accession numbers 6, 16 and 20 were greenish yellow and another accessions were illuminant C.

Fruit peduncle length was significantly different among accessions. Fruit peduncle length ranged from 3.35 to 7.49 cm. Accession number 12 had the longest fruit peduncle of 7.49 cm. Accession number 1 had the shortest fruit peduncle of 3.35 cm. Fruit base to sessile bract of the accessions ranged from 2.79 to 7.05 cm. The differences were significantly different among accessions. Accession number 13 had the longest fruit base to sessile bract of 7.05 cm. Accession number 5 had the shortest fruit base to sessile bract of 2.79 cm. Fruit sizes of the accessions were significantly different. Fruit lengths of the accessions ranged from 4.02 to 11.44 cm. Accession number 8 had the longest fruit of 11.44 cm. The shortest fruit accession was No. 1 that had 4.02 cm. Fruit diameters of accessions ranged from 2.08 to 4.23 cm. The differences were significantly different among accessions. Accession number 10 had the highest fruit diameter of 4.23 cm. Accession number 12 had the lowest fruit diameter of 2.08 cm. Fruit length/fruit diameter (L/D) ratios of the accessions were significantly different. L/D ratio ranged from 1.31 to 3.08. The highest L/D ratio was accession number 8 which had 3.08. The lowest L/D ratio was accession number 1 which had 1.31. Flesh thickness of the accessions ranged from 2.35 to 6.29 mm. The differences were significantly different. Accession number 10 had the

highest flesh thickness of 6.29 mm. Flesh thickness of this accession was not significantly different from those of accession number 7. Accession number 12 had the lowest flesh thickness.

Table 5 Botanical characteristics of fruit of local bitter gourd.

Accession number	Shape of fruit	Skin color of fresh fruit					Fruit peduncle length (cm) ^{3/}
		L ^{1/}	a ^{1/}	b ^{1/}	x ^{2/}	y ^{2/}	
1	Globose	49.96	-8.04	19.40	0.37	0.41	3.35 f
3	Elliptic	53.13	-6.33	15.51	0.38	0.41	4.49 dc
5	Elliptic	52.24	-7.25	19.19	0.37	0.41	3.40 f
6	Elliptic	44.33	-9.47	21.27	0.39	0.45	4.46 dc
7	Oblong	64.37	-4.03	17.18	0.35	0.37	3.51 ef
8	Oblong	39.35	-5.29	9.61	0.34	0.37	5.13 cd
10	Oval	60.89	-6.38	23.07	0.37	0.41	5.90 bc
11	Elliptic	30.67	-6.14	11.77	0.36	0.42	5.24 cd
12	Oval	51.22	-8.01	19.29	0.37	0.41	7.49 a
13	Elliptic	60.74	-6.28	20.05	0.38	0.39	7.43 a
16	Oval	39.56	-8.28	17.99	0.38	0.44	5.66 bc
20 ^{4/}	Elliptic	29.03	-6.93	12.37	0.37	0.43	5.78 bc
21	Elliptic	50.68	-6.25	17.88	0.36	0.40	5.38 cd
F-tst	-	-	-	-	-	-	**
CV(%)	-	-	-	-	-	-	20.2

^{1/} Average of 3 fresh fruits measured by Color QUEST II Hunter Lab.

L = the color dimension in lightness scale from black (L = 0) to white (L = 100).

a = the color dimension from redness (+a) to greenness (-a).

b = the color dimension from yellowness (+b) to blueness (-b).

^{2/} CIE values were calculated from L, a, b values.

^{3/} Average of 10 fresh fruits.

Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{4/} Bitter gourd called Deak bin brand was used as a control variety.

Table 5 (continue)

Accession number	Fruit base to sessile bract (cm) ^{3/}	Fruit length (cm) ^{5/}	Fruit diameter (cm) ^{5/}	L/D ^{5/}	Flesh thickness (mm) ^{5/}
1	2.96 f	4.02 h	3.06 e	1.31 i	3.71 e
3	3.82 ef	4.72 g	2.11 gh	2.23 c	2.47 f
5	2.79 f	4.81 g	2.18 gh	2.21 cd	2.58 f
6	4.40 de	6.70 d	3.26 d	2.05 ef	4.70 c
7	2.94 f	10.29 b	3.59 c	2.87 b	6.07 a
8	4.39 de	11.44 a	3.72 b	3.08 a	5.41 b
10	5.71 bc	8.52 c	4.23 a	2.02 f	6.29 a
11	4.43 de	6.88 d	3.02 ef	2.28 c	3.71 e
12	6.51 ab	4.70 g	2.08 h	2.26 c	2.35 f
13	7.05 a	4.69 g	2.20 g	2.13 de	2.73 f
16	4.50 de	6.08 e	3.25 d	1.87 gh	4.35 cd
20 ^{4/}	5.78 bc	6.10 e	3.18 d	1.92 g	4.38 cd
21	5.38 cd	5.20 f	2.93 f	1.78 h	4.03 de
F-test	**	**	**	**	**
CV(%)	23.0	3.2	2.3	3.0	7.2

^{3/} Average of 10 fresh fruits.

^{4/} Bitter gourd called Deak bin brand was used as a control variety.

^{5/} Average of 50 fresh fruits. L/D = Fruit length/fruit diameter.

Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

2.1.4 Seed

Number of seeds per plant and seed size were different among accessions (Table 6). There was a significant positive correlation between width of seed and seed length (Figure 5). However, there was not correlation between width of seed and seed thickness nor width of seed and number of seeds per fruit.

Table 6 Botanical characteristics of seeds of local bitter gourd.

Accession number	Number of seed/fruit ^{1/}	Seed size (mm) ^{2/}		
		Width	Length	Thickness
1	8 g	7.25 bcd	12.40 cde	3.91 a
3	14 de	4.78 h	9.65 g	3.22 b
5	9 fg	5.75 f	9.43 g	3.25 b
6	8 g	7.37 bc	12.36 cde	4.05 a
7	31 a	6.63 e	12.76 cd	3.85 a
8	28 b	7.80 a	14.93 a	4.07 a
10	26 b	7.00 cde	12.51 cde	3.89 a
11	15 cd	6.95 de	13.64 b	3.48 b
12	9 g	5.23 g	10.66 f	3.23 b
13	13 de	5.53 fg	11.16 f	3.22 b
16	17 c	7.64 ab	12.91 c	3.49 b
20 ^{3/}	11 ef	7.43 ab	12.34 de	4.09 a
21	8 g	7.32 bcd	12.18 c	4.06 a
F-test	**	**	**	**
CV(%)	18.2	6.2	4.7	7.9

^{1/} Average of 10 mature fruits.

^{2/} Average of 10 dry seeds.

Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{3/} Bitter gourd called Deak bin brand was used as a control variety.

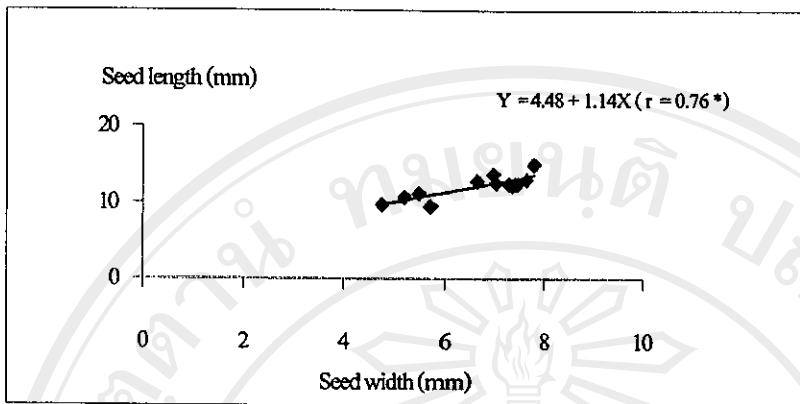


Figure 5 Correlation of width and length of seeds of local bitter gourd.

2.2 Fruit yield

Fruit yield and number of fruits were significantly different among the accessions (Table 7). Fruit yield of the accessions ranged from 766 to 2,244 kg/rai. Accession numbers 7 and 10 (Figure 6) gave the highest yield of 2,244 and 2,186 kg/rai, respectively. The lowest yielding accession was number 16, which gave 766 kg/rai. Mean fruit weight of the accessions ranged from 4.69 to 51.21 g/fruit. Accession numbers 8, 10 and 7 gave the highest fruit weight at 51.21, 45.75, and 42.89 g/fruit, respectively. The lowest fruit weight was accession number 12 which gave 4.69 g/fruit. Number of fruits per plant of the accessions ranged from 20 to 143 fruits. The highest number of fruits per plant were accession numbers 3 and 13 which gave 143 and 131 fruits/plant, respectively. However, they were not significantly different. Accession numbers 8 and 16 gave the lowest number of fruits per plant 20 and 24 fruits/plant, respectively. Correlation analysis revealed a significantly positive correlation between fruit yield and fruit weight per fruit (Figure 7).

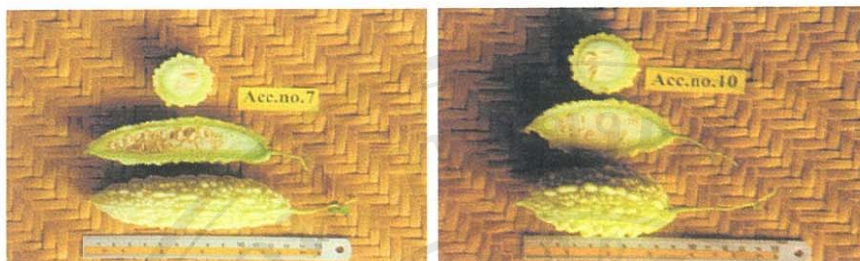


Figure 6 Fruits of accession numbers 7 and 10.

Table 7 Fruit yield of local bitter gourd.

Accession number	Fruit yield ^{1/} (kg/rai)	Fruit weight (g)/fruit ^{1/}	Number of fruit/plant ^{1/}
1	1,466 bc	12.03 g	76 cd
3	1,216 cd	5.31 h	143 a
5	890 e	5.87 h	94 bc
6	1,260 cd	20.30 d	38 e
7	2,244 a	42.89 c	32 e
8	1,710 b	51.21 a	20 e
10	2,186 a	45.75 b	30 e
11	772 e	16.12 ef	30 e
12	806 e	4.69 h	107 b
13	1,004 de	4.94 h	131 a
16	766 e	19.89 d	24 e
20 ^{2/}	888 e	17.91 de	31 e
21	1,312 c	13.73 fg	59 d
F-test	**	**	**
CV(%)	14.6	8.7	20.5

^{1/} Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

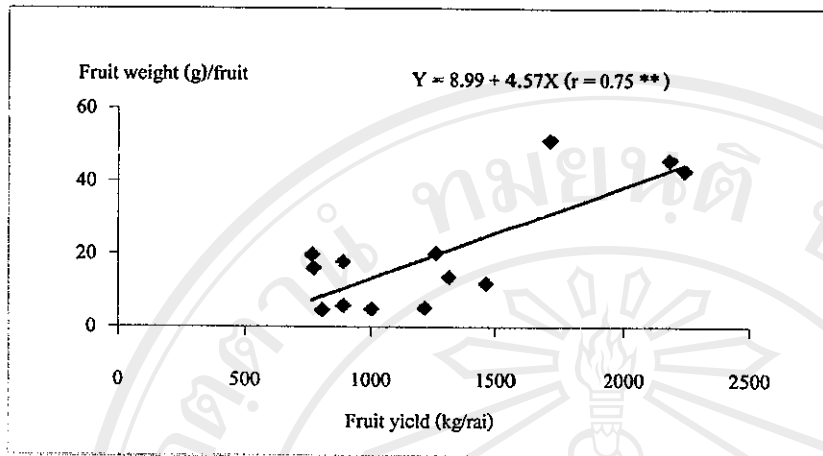


Figure 7 Correlation between fruit yield and fruit weight/fruit of local bitter gourd.

2.3 Horticultural characteristics

Horticultural characteristics of local bitter gourd accession numbers and control variety were shown in Table 8. Number of days to 50% female flowers of the accessions ranged from 40 to 53 days, the differences were significantly different. Accession number 7 was the earliest accession which gave 40 days and accession number 11 was the latest accession which gave 53 days to reach 50% female flowers. First pistillate flower node on the main stem was significantly different among the accessions, the node of the accessions ranged from 17 to 33 nodes per plant. Accession number 21 gave the first pistillate flower at the lowest node which was at the seventeenth node and this was not significantly different from accession numbers 1, 3, 5, 6, 7, and 13 which were at the nineteenth node. Accession number 11 gave the first pistillate flower at the highest node which was at the thirty-third node. Number of female flowers per plant on the lateral branches of the first 25 nodes was significantly different among accessions. Number of female flowers per plant ranged from 1 to 22. The differences of the number of female flowers per plant were significantly different. Accession number 3 gave the highest number of female flower at 22 flowers/plant which was not significantly different from accession numbers 12 and 13 which gave 20 and 20 flowers/plant, respectively. The lowest number of female flowers was accession number 11, which gave 1 flower/plant. Female/male flower ratio of the accessions

ranged from 0.21 to 1.18. The differences of the ratio were significantly different among the accessions. Accession number 11 gave the highest female/male flower ratio at 1.18 and this was not significantly different from accession number 13 which had the ratio of 1.01. Days after anthesis of fresh fruit ranged from 9 to 13.25 days and the differences were significantly different. Accession numbers 11 and 1 took only 9 and 9.75 days after anthesis, respectively. The difference was not significantly different. Accession numbers 10 and 16 gave the longest days after anthesis, 13.25 days. Days to first harvest were significantly different among the accessions. Days to first harvest of the accessions ranged from 56 to 67 days. Accession numbers 7 and 10 took 56 days to the first harvest while accession number 11 took 67 days. Number of days to last harvest of the accessions did not show any differences statistically. However, the differences were observed in number of harvesting times. Number of harvesting times ranged from 15 to 19. Results showed that the accessions that gave high yields always had more harvesting times than those which gave low yields. Number of nodes per plant of the accessions ranged from 59 to 100 nodes. The differences of the number of node per plant were significantly different among accessions. Number of nodes was the highest in accession number 3, which had 100 node/plant. Number of nodes of this accession was not significantly different from those of accession numbers 5 and 12 that gave 95 and 96 nodes/plant, respectively. Accession number 8 gave the lowest number of node per plant at 59 nodes. Main stem lengths were significantly different among the accessions. Main stem length of the accessions ranged from 2.97 to 4.94 m. Main stem length of accession number 5 was the longest, 4.94 m. It was followed by accession number 3, which gave 4.74 m in main stem length. Number of lateral vines of the accessions ranged from 20 to 34, the differences were significantly different. Accession number 3 gave the highest number of lateral vines at 34 vines/plant that was not significantly different from accession numbers 1, 5, 11, 12, 13 and 21. Accession number 20 gave the lowest number of lateral vines at 20 vines/plant which was not significantly different from accessions 10 and 16.

Table 8 Horticultural characteristics of local bitter gourd.

Accession number	Days to 50% female flower	First pistillate flower node	Number of male flower/plant ^{1/}
1	44 cde	19 cd	5 cd
3	42 ef	19 cd	22 a
5	43 de	19 cd	14 b
6	46 bcd	19 cd	13 cde
7	40 f	19 cd	12 b
8	45 cde	22 bc	4 cde
10	42 ef	22 bc	5 cd
11	53 a	33 a	1 e
12	44 cde	23 bc	20 a
13	47 bc	19 cd	20 a
16	48 b	21 bc	2 cde
20 ^{2/}	52 a	24 b	2 de
21	46 bcd	17 d	6 c
F-test	**	**	**
CV (%)	4.2	12.5	26.5

^{1/} Average of the flowers on the lateral branches of the first 25 nodes.

Means followed by a common letter are not significantly different at $P = .05$ by DMRT.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

Table 8 (continue)

Accession number	Female/male flower ^{1/}	Days after anthesis of fresh fruit	Days to first harvest
1	0.25 de	9.75 ab	60 def
3	0.58 b	10.25 bc	56 g
5	0.47 bcd	11.00 cde	58 fg
6	0.33 cde	10.50 bcd	61 cde
7	0.53 bc	12.75 fg	56 g
8	0.33 cde	11.75 ef	60 def
10	0.34 cde	13.25 g	56 g
11	1.18 a	9.00 a	67 a
12	0.64 b	10.25 bc	59 ef
13	1.01 a	10.25 bc	60 def
16	0.37 cde	13.25 g	64 bc
20 ^{2/}	0.21 c	11.75 ef	66 ab
21	0.35 cde	11.50 de	62 cd
F-test	**	**	**
CV (%)	27.2	6.4	3.3

^{1/} Average of the flowers on the lateral branches of the first 25 nodes.

Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

Table 8 (continue)

Accession number	Days to last harvest	Number of harvesting time	Number of node/plant	Main stem length (m)	Number of lateral vine/plant
1	96	19 a	69 efg	3.85 cde	30 ab
3	93	18 a	100 a	4.74 ab	34 a
5	93	17 ab	95 ab	4.94 a	31 ab
6	93	16 ab	70 efg	3.94 c	27 bc
7	94	18 a	64 fgh	3.34 ef	27 bc
8	94	18 a	59 h	2.97 f	27 bc
10	94	19 a	72 def	4.36 bc	24 cd
11	94	15 b	89 bc	3.90 cd	30 ab
12	91	17 ab	96 ab	4.35 bc	30 ab
13	92	17 ab	81 cd	3.87 cde	31 ab
16	93	15 b	77 de	4.00 c	24 cd
20 ^{1/}	94	15 b	61 gh	3.39 dcf	20 d
21	93	17 ab	78 de	3.91 cd	31 ab
F-test	ns	**	**	**	**
CV (%)	1.8	7.6	7.8	8.6	10.9

Means followed by a common letter are not significantly different at $P = .05$ by DMRT.

ns = nonsignificant.

** = significant at .01 level.

^{1/} Bitter gourd called Deak bin brand was used as a control variety.

2.4 Correlation analysis of yield and some horticultural characteristics

There was a negative correlation between fruit yield and number of days to 50% female flower. The same trends of correlation were also obtained between fruit yields and numbers of days to first harvest and also between fruit yield and number of nodes per plant (Figures 8 and 9).

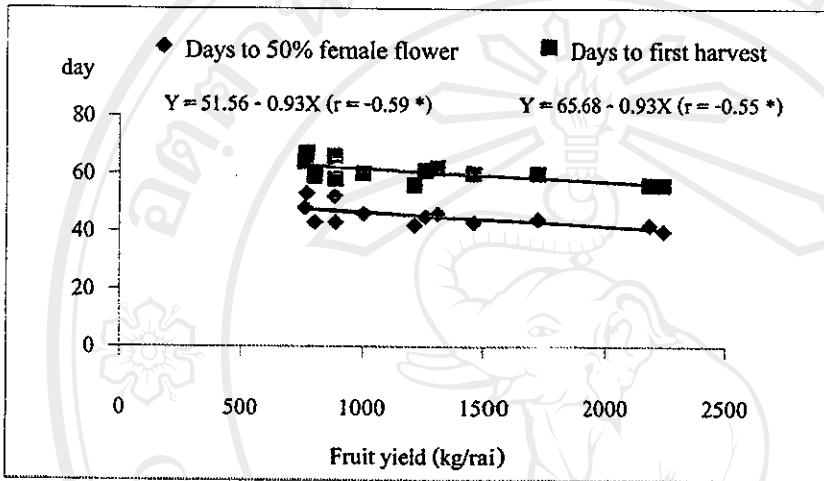


Figure 8 Correlation between fruit yield and days to 50% female flower and days to first harvest of local bitter gourd.

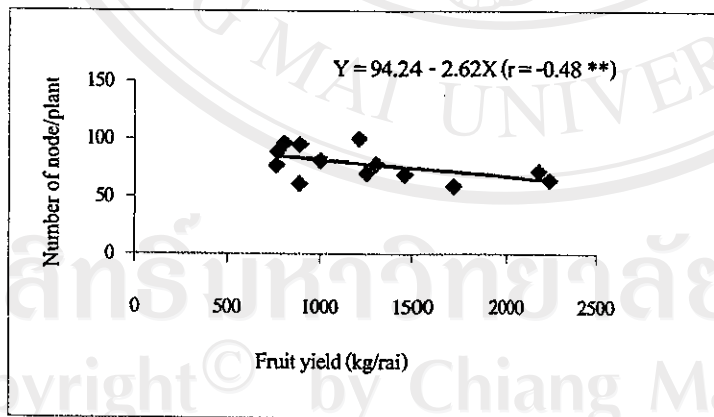


Figure 9 Correlation between fruit yield and number of node/plant of local bitter gourd.

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Main stem length and number of lateral vines showed positive correlation with number of fruits per plant (Figures 10 and 11). Main stem length and number of lateral vines showed negative correlation with fruit weight per fruit (Figures 12 and 13).

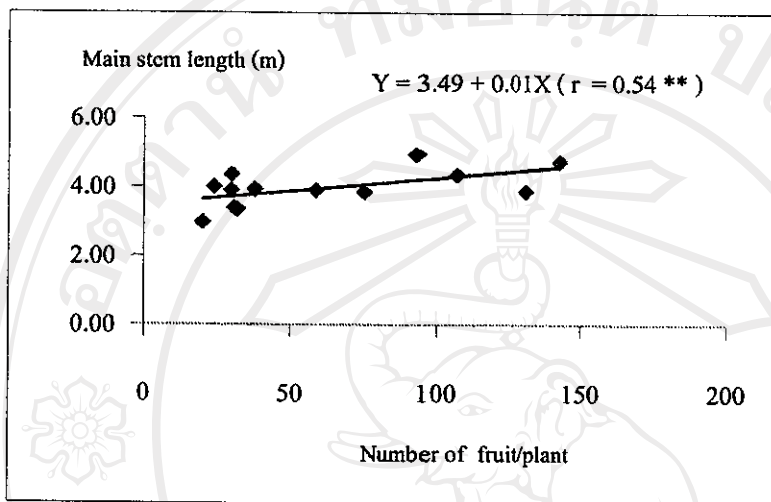


Figure 10 Correlation between number of fruit/plant and main stem length of local bitter gourd.

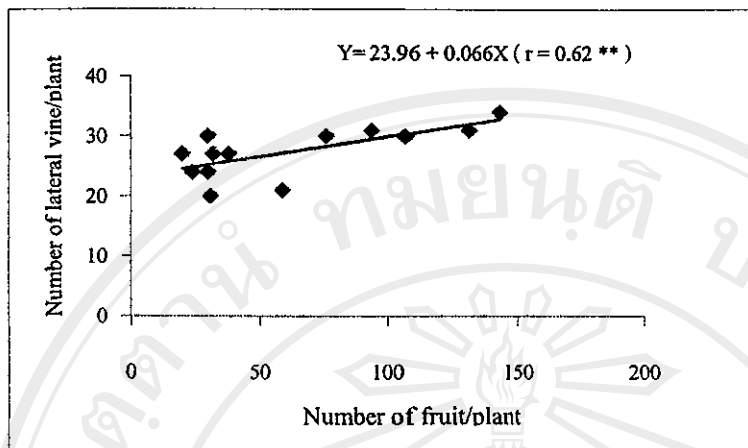


Figure 11 Correlation between number of fruit/plant and number of lateral vine/plant of local bitter gourd.

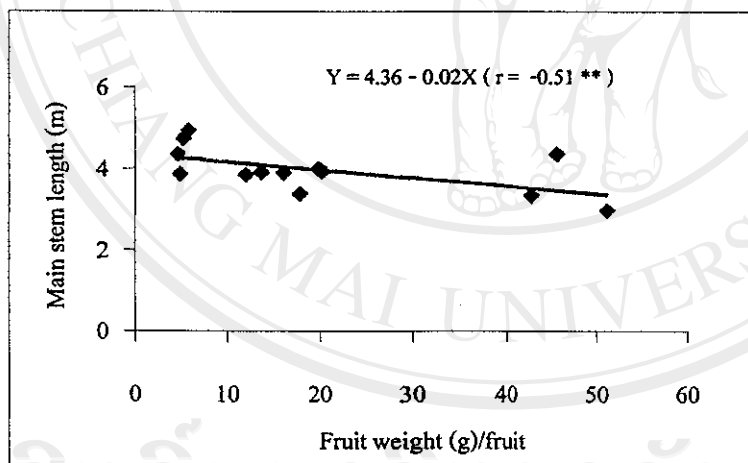


Figure 12 Correlation between fruit weight/fruit and main stem length of local bitter gourd.

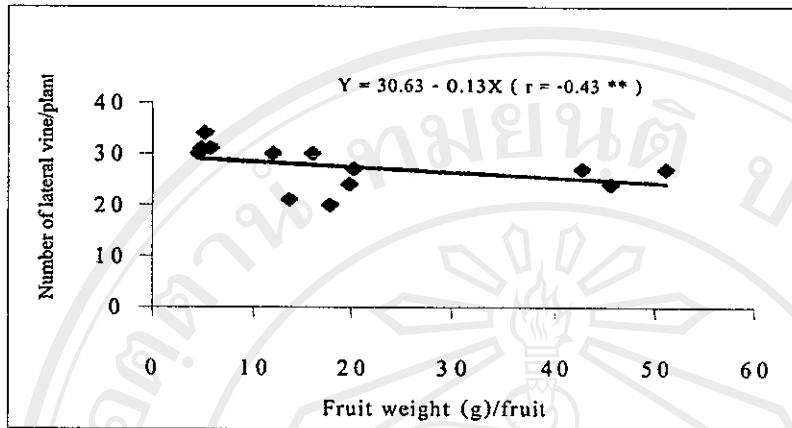


Figure 13 Correlation between fruit weight/fruit and number of lateral vine/plant of local bitter gourd.

2.5 Ripe fruit, seed and endosperm

2.5.1 Ripe fruit

Yield of ripe fruit ranged from 516 to 1,106 kg/rai (Table 9). However, the differences were not significantly different among accessions. Accession number 13 gave the highest ripe fruit yield of 1,106 kg/rai (Figure 14) and accession number 1 gave the lowest ripe fruit yield of 516 kg/rai. Number of ripe fruits ranged from 10,200 to 108,800 fruits/rai. The differences of number of ripe fruits were significantly different among accessions. Accession number 13 gave the highest number of ripe fruit of 108,800 fruits/rai which was not significantly different from accession numbers 5 and 12 which gave of 92,200 and 105,000 fruits/rai, respectively. Accession number 8 gave the lowest number of ripe fruit of 10,200 fruits/rai but was not significantly different from accession number 10 which gave 11,600 fruits/rai.

Table 9 Yield of ripe fruit of local bitter gourd.

Accession number	Ripe fruit yield (kg/rai) ^{1/}	Number of ripe fruit/rai ^{1/}
1	516.0	27,400 cde
3	616.4	71,800 b
5	704.6	92,200 a
6	793.0	28,200 cde
7	830.2	14,200 de
8	722.6	10,200 e
10	780.4	11,600 e
11	860.2	30,600 cd
12	772.4	105,000 a
13	1106.0	108,800 a
16	827.0	24,000 cde
20 ^{2/}	742.4	22,200 de
21	912.2	40,800 c
F-test	ns	**
CV (%)	27.1	25.1

^{1/} Means followed by a common letter are not significantly different at P = .05 by DMRT.

ns = nonsignificant.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

2.5.2 Seed and endosperm

Seed yield of the accessions ranged from 50 to 134.8 kg/rai. The differences of seed yield were significantly different among accessions. Accession number 13 gave the highest ripe fruit yield and also gave the highest seed yield of 134.8 kg/rai. Accession number 10 gave the lowest seed yield of 50 kg/rai. Endosperm yield was significantly different among the accessions. Endosperm yield of the accessions ranged from 29 to 61.9 kg/rai. Accession number 13 gave the highest endosperm yield of 61.9 kg/rai. Accession number 10 gave the lowest seed yield also gave the lowest endosperm yield of 29 kg/rai (Table 10).

Table 10 Yield of seed and endosperm of local bitter gourd.

Accession number	Seed yield (kg/rai) ^{1/}	Endosperm yield (kg/rai) ^{1/}
1	57.6 cd	30.9 gh
3	62.4 cd	30.3 gh
5	85.4 bc	43.7 c
6	67.2 bcd	30.5 gh
7	61.2 cd	36.9 e
8	60.8 cd	32.9 f
10	50.0 d	29.0 h
11	77.6 bcd	36.3 e
12	97.6 b	46.5 b
13	134.8 a	61.9 a
16	76.4 bcd	40.8 d
20 ^{2/}	68.6 bcd	31.6 fg
21	80.2 bcd	36.1 e
F-test	**	**
CV (%)	25.3	3.0

^{1/} Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

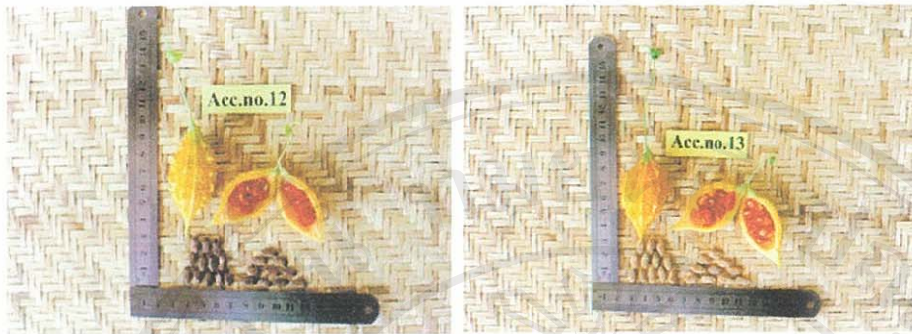


Figure 14 Ripe fruit and seed of accession numbers 12 and 13.

2.5.3 Some horticultural characteristics

Some horticultural characteristics of local bitter melon accessions such as days after seed germination to 50% female flower, days after seed germination to first harvest of ripe fruit, days after seed germination to last harvest of ripe fruit, number of times to harvest of ripe fruit and days after anthesis of ripe fruit were significantly different among accessions (Table 11). Days to 50% female flower ranged from 53 to 66 days. Accession number 7 gave the least days of 50% female flower, 53 days, and this was not significantly different from other accessions. Accession number 11 gave the highest number of days to 50% female flower, 66 days, it was not significantly different from accession number 8 which gave 62 days. Days to the first harvest of ripe fruit ranged from 59 to 75 days. Accession number 7 gave the least days to the first harvest of ripe fruit, 59 days and accession number 11 gave the highest days to first harvest of ripe fruit, 75 days. Days to last harvest of ripe fruit ranged from 98 to 118 days. Accession number 7 gave the least days to last harvest of ripe fruit, 98 days, and this was significantly different from other accessions. Accession number 6 gave the highest days to last harvest of ripe fruit, 118 days but this was not significantly different from accession numbers 3, 5, 11, 12 and 13 which gave 117 days. Number of times to harvest ripe fruit ranged from 23 to 50 times. Accession number 13 gave the highest number of times to harvest ripe fruit, 50 times, and this was not significantly different from accession numbers 3, 5 and 12 which gave 45, 48 and 49 times, respectively. Accession number 7 gave the least number of times to harvest ripe fruit, 23 days, but this was not significantly different from accession numbers 8 and 10 which gave 24 days. Days after anthesis

of ripe fruit ranged from 17.25 to 22 days. Accession number 3 gave the least days after anthesis of ripe fruit, 17.25 days, and this was not significantly different from accession number 12 and 13 which gave 17.50 and 17.75 days, respectively. Accession number 8 and 10 gave the highest days after anthesis of ripe fruit, 22 days, and they were not significantly different from accession numbers 6, 7, 16 and 20.

Table 11 Some horticultural characteristics of local bitter gourd .

Accession number	Days to 50% female flower ^{1/}	Days to first harvest of ripe fruit ^{1/}	Days to last harvest of ripe fruit ^{1/}	Number of times to harvest ripe fruit ^{1/}	Days after anthesis of ripe fruit ^{1/}
1	57 abcd	68 c	107 cd	33 de	20.00 c
3	59 bcd	70 cd	117 a	45 ab	17.25 a
5	55 ab	68 bc	117 a	48 a	19.00 b
6	61 cd	71 cd	118 a	39 bcd	21.50 de
7	53 a	59 a	98 f	23 f	21.75 de
8	62 de	69 c	109 bc	24 f	22.00 e
10	56 abc	62 ab	101 e	24 f	22.00 e
11	66 e	75 d	117 a	36 cde	19.00 b
12	57 abcd	66 bc	117 a	49 a	17.50 a
13	55 ab	66 bc	117 a	50 a	17.75 a
16	56 abc	68 bc	106 d	34 de	21.75 de
20 ^{2/}	57 abcd	70 cd	107 cd	32 e	21.00 cde
21	55 ab	67 bc	110 b	41 bc	20.75 cd
F-test	**	**	**	**	**
CV (%)	6.0	5.4	1.8	11.6	3.4

^{1/} Means followed by a common letter are not significantly different at P = .05 by DMRT.

** = significant at .01 level.

^{2/} Bitter gourd called Deak bin brand was used as a control variety.

3. Extraction of 30 kDa protein in inbred seeds.

3.1 Weight of partially purified protein

Weight of partially purified protein ranged from 104.33 to 208.67 mg/5 g endosperm. They were not significantly different among accessions. The highest weight of partially purified protein was accession number 10 which gave 208.67 mg/5 g endosperm. The lowest weight of partially purified protein was accession number 13 which gave 104.33 mg/5 g endosperm (Figure 15).

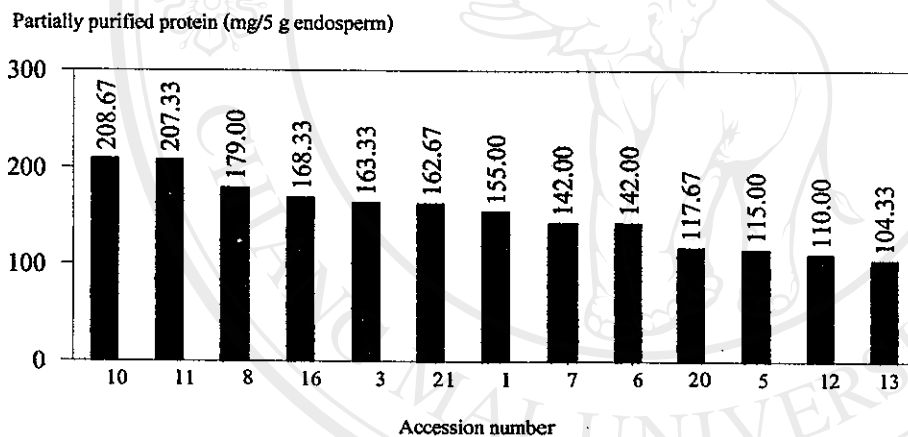


Figure 15 Weight of partially purified protein of endosperm of local bitter gourd.

3.2 Weight of total protein

Weight of total protein was not significantly different among accessions. Weight of total protein of the accessions ranged from 3.54 to 17.66 mg/5 g endosperm. The highest weight of total protein was accession number 16 which gave 17.66 mg/5 g endosperm. The lowest weight of total protein was accession number 6 which gave 3.54 mg/5 g endosperm (Figure 16).

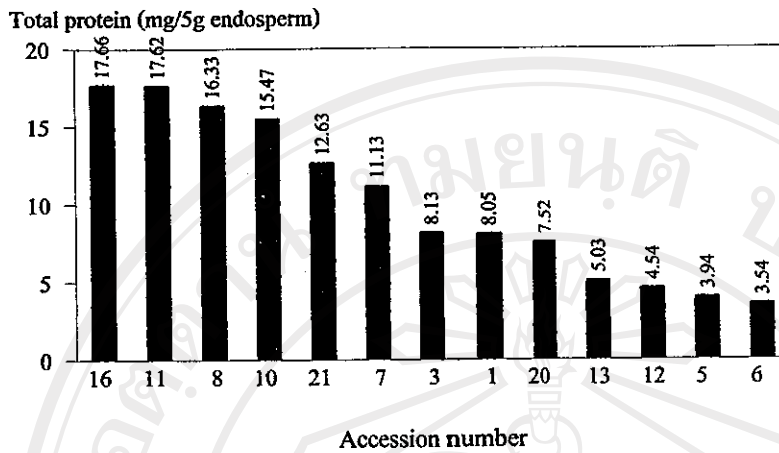


Figure 16 Weight of total protein of endosperm of local bitter gourd.

3.3 Weight of 30 kDa protein

Weight of 30 kDa protein of the accessions ranged from 104.86 to 265.42 $\mu\text{g}/5$ g endosperm (Figure 17). The differences of 30 kDa protein weight were not significantly different among accessions. Accession numbers 16, 10 and 3 gave the highest yields of 30 kDa protein at 265.42, 215.91 and 206.39 $\mu\text{g}/5$ g endosperm, respectively. Accession number 13 gave the lowest yields of 30 kDa protein at 104.86 $\mu\text{g}/5$ g endosperm (Figure 18).

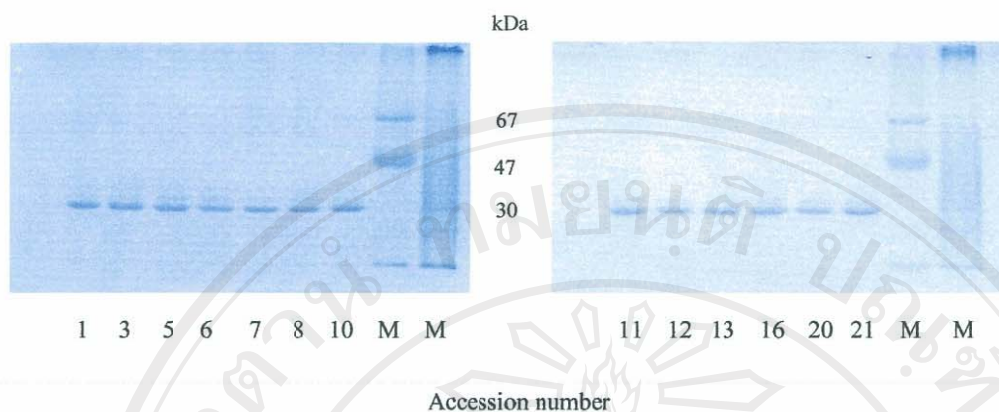


Figure 17 Protein fractions with molecular weight at 30 kDa of endosperm of local bitter gourd.

(M = standard marker molecular weight 30, 47 and 67 kDa)

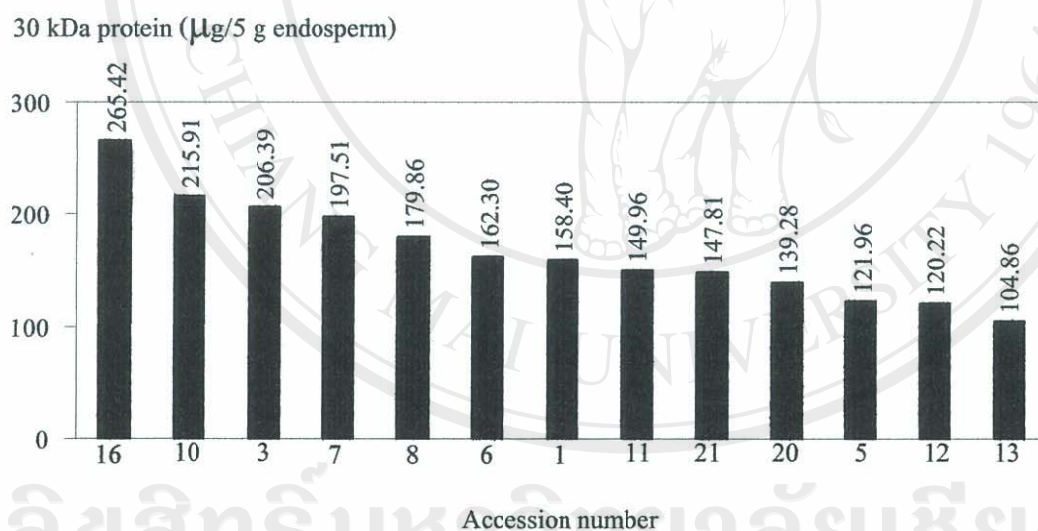


Figure 18 Weight of 30 kDa protein of endosperm of local bitter gourd.

3.4 Correlation analysis of weights of partially purified protein, total protein and 30 kDa protein in inbred seeds

There was a positive correlation between partially purified protein and total protein (Figure 19). The positive correlation was also found between 30 kDa protein and total protein (Figure 20).

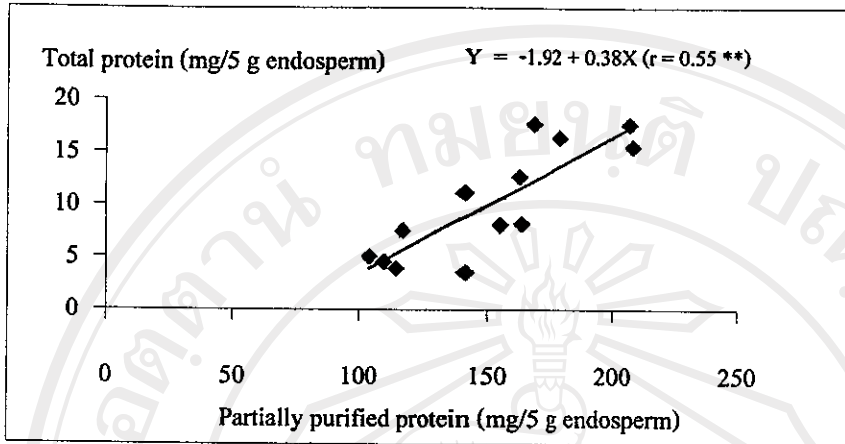


Figure 19 Correlation between partially purified protein and total protein of endosperm of local bitter gourd.

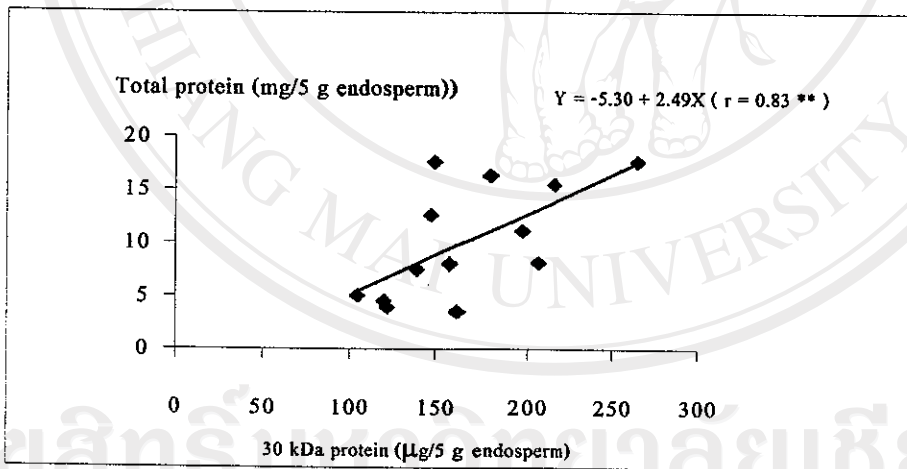


Figure 20 Correlation between 30 kDa protein and total protein of endosperm of local bitter gourd.

4. 30 kDa protein in F_1 hybrid seeds.

When the differences of 30 kDa protein weight were found to be not significantly different among the accessions, two inbred lines of local bitter melon accession numbers 13 and 12 which gave the first and second highest seed yield and the two inbred lines of local accession numbers 10 and 1 (Figure 21) which gave the lowest and second lowest seed yield were selected. The four of inbred lines were used as parental lines in diallel crossing which gave rise to 16 treatments. These treatments had 4 parental lines, 6 F_1 hybrid accessions and 6 reciprocal F_1 hybrid accessions. Four parental lines were accession numbers 13, 12, 10 and 1. Six F_1 hybrid accessions were F_1 hybrid accessions 13×12 , 13×10 , 13×1 , 12×10 , 12×1 and 10×1 . Six reciprocal F_1 hybrid accessions were F_1 hybrid accessions 12×13 , 10×13 , 1×13 , 10×12 , 1×12 and 1×10 .



Figure 21 Ripe fruits and seeds of accession numbers 1 and 10.

4.1 Seed yield

Seed yield of the F_1 hybrids and their parental lines of local bitter melon ranged from 8.15 to 10.45 g/5 g endosperm, the differences were significantly different (Table 12). F_1 hybrid accession 13×12 gave the highest seed yield of 10.45 g/5 g endosperm. F_1 hybrid accessions 13×10 , 13×1 , 12×10 and parental line accession 13 gave seed yield of 10.07, 10.15, 10.11 and 9.71 g/5 g endosperm, respectively. F_1 hybrid accession 10×1 and parental line accession 10 gave the lowest seed yield of 8.16 and 8.15 g/5 g endosperm, respectively.

4.2 Partially purified protein

When partially purified protein was extracted from endosperm of the hybrids and their parental lines, weight of partially purified protein ranged from 91 to 253 mg/5 g endosperm (Table 12). The differences of partially purified protein weight were significantly different. The parental line accession 10 gave the highest partially purified protein weight of 253 mg/5 g endosperm. It was not significantly different from F_1 hybrid accessions 10×1 , 1×10 and parental lines accession 1 which gave the partially purified protein weight of 233.5, 216.5 and 227 mg/5 g endosperm, respectively. F_1 hybrid accession 12×10 gave the lowest partially purified protein weight of 91 mg/5 g endosperm and did not show any different statistically from other F_1 hybrid and parental lines of local bitter gourd.

4.3 Total protein

When total protein was measured from partially purified protein which was extracted from endosperm of the hybrids and their parental lines, weight of total protein ranged from 6.13 to 19.58 mg/5 g endosperm (Table 12). The differences of total protein weight were significantly different. The parental line accession 10 gave the highest total protein weight of 19.58 mg/5 g endosperm. The lowest weight of total protein was F_1 hybrid accession 12×10 which gave 6.13 mg/5 g endosperm.

4.4 30 kDa protein

30 kDa protein was measured from partially purified protein which was extracted from endosperm of the hybrids and their parental lines. There was significantly different of 30 kDa protein weight among F_1 hybrid and parental lines of local bitter gourd (Table 12). Weight of 30 kDa protein of the F_1 hybrid ranged from 65.65 to 140.70 $\mu\text{g}/5$ g endosperm. F_1 hybrid accession 10×1 gave the highest 30 kDa protein weight of 140.70 $\mu\text{g}/5$ g endosperm, the difference was not significantly different from F_1 hybrid accession 1×12 which gave 30 kDa protein weight of 119.10 $\mu\text{g}/5$ g endosperm. F_1 hybrid accession 12×10 gave the lowest 30 kDa protein weight of 65.65 $\mu\text{g}/5$ g endosperm. Weight of 30 kDa protein of the parental lines ranged from 95.78 to 155 $\mu\text{g}/5$ g endosperm. Parental line accession number 10 gave the highest protein weight of

155 $\mu\text{g}/5 \text{ g}$ endosperm, the difference was not significantly different from the parental line accession numbers 13, 1 and the F_1 hybrid accessions 10×1 and 1×12 . Reciprocal crosses of parental line accession numbers 1 and 10 showed that there were maternal effects when accession number 10 was used as female.

Table 12 Mean values of seed yield, partially purified protein, total protein and 30 kDa protein in 5 g endosperm of F_1 hybrid and parental lines of local bitter gourd.

Cross/parent	Seed yield (g)	Partially purified protein weight (mg)	Total protein weight (mg)	30 kDa protein weight (μg)
13 \times 12	10.45 a	107.50 b	8.87 c	83.41 cd
13 \times 10	10.07 abc	97.50 b	7.13 c	84.16 cd
13 \times 1	10.15 ab	122.00 b	10.63 bc	97.03 bcd
12 \times 13	10.05 ab	113.50 b	8.69 c	87.25 cd
12 \times 10	10.11 ab	91.00 b	6.13 c	65.65 d
12 \times 1	9.78 abc	109.30 b	8.35 c	85.61 cd
10 \times 13	8.49 de	109.00 b	6.79 c	73.82 cd
10 \times 12	8.19 e	96.50 b	7.89 c	77.33 cd
10 \times 1	8.16 e	233.50 a	15.12 ab	140.70 ab
1 \times 13	8.98 cde	93.00 b	6.95 c	96.60 bcd
1 \times 12	9.39 bcd	126.50 b	9.51 c	119.10 abc
1 \times 10	9.36 bcd	216.50 a	14.59 b	99.46 bcd
13	9.71 abc	103.50 b	9.08 c	110.00 abcd
12	9.94 ab	104.00 b	8.13 c	95.78 bcd
10	8.15 e	253.00 a	19.58 a	155.00 a
1	9.65 abc	227.00 a	15.20 ab	110.00 abcd
F-test	**	**	**	*
CV (%)	4.2	20.4	21.3	20.9

^{1/} Means followed by a common letter are not significantly different at $P = .05$ by DMRT.

* = significant at .05 level.

** = significant at .01 level.

4.5 Correlation of partially purified protein, total protein and 30 kDa protein in F_1 hybrid seeds

There were positive correlations between partially purified protein and total protein (Figure 22), between partially purified protein and 30 kDa protein (Figure 23) and between total protein and 30 kDa protein (Figure 24) in F_1 hybrid and parental lines local bitter gourd.

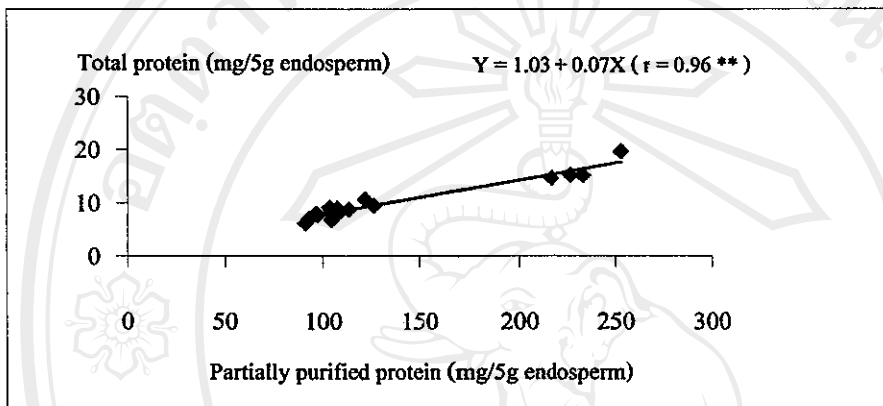


Figure 22 Correlation between partially purified protein and total protein of endosperm of F_1 hybrid and parental lines of local bitter gourd.

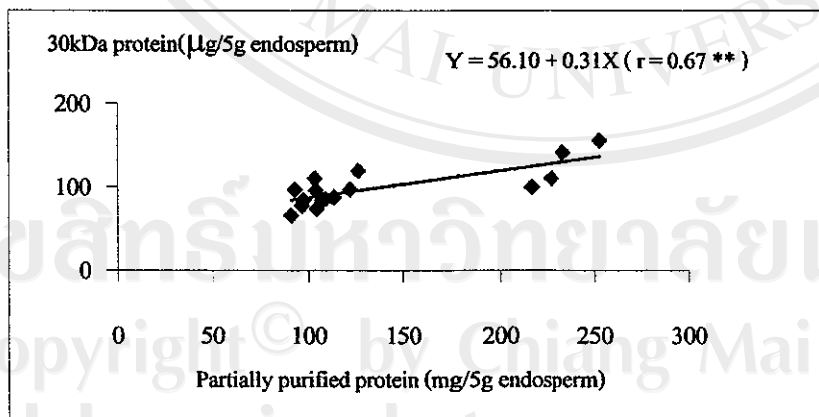


Figure 23 Correlation between partially purified protein and 30 kDa protein of endosperm of F_1 hybrid and parental lines of local bitter gourd.

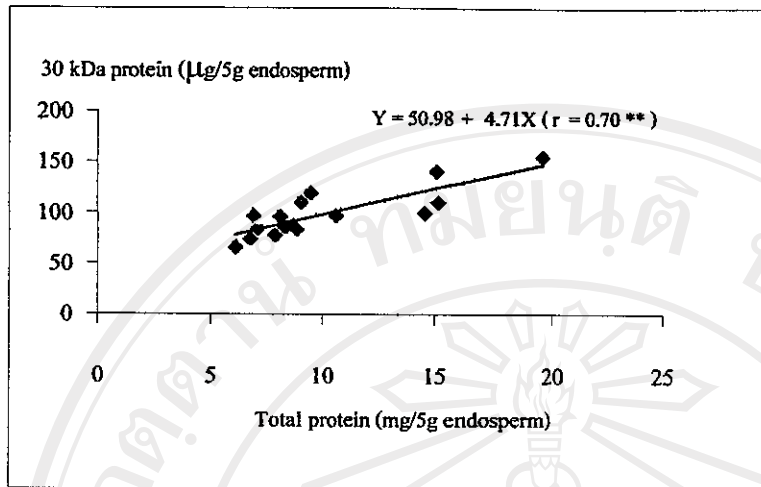


Figure 24 Correlation between total protein and 30 kDa protein of endosperm of F_1 hybrid and parental lines of local bitter gourd.

Seed yield did not correlate with the levels of partially purified protein (Figure 25), total protein (Figure 26) and 30 kDa protein (Figure 27) among F_1 hybrid and parental lines of local bitter gourd.

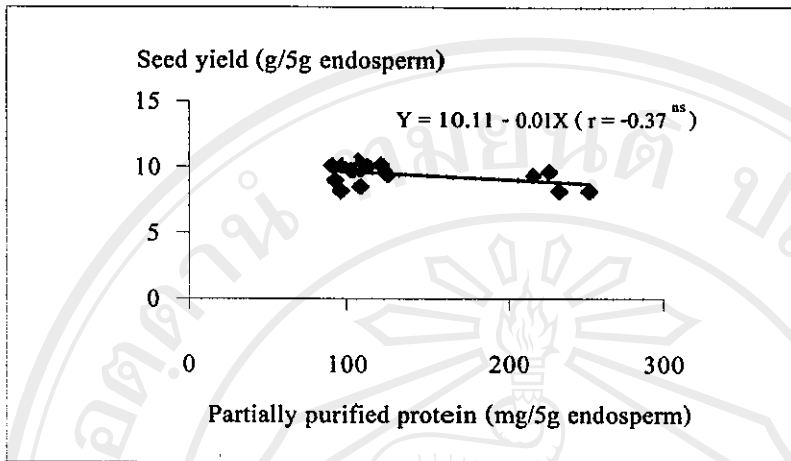


Figure 25 Correlation between partially purified protein and seed yield of endosperm of F₁ hybrid and parental lines of local bitter gourd.

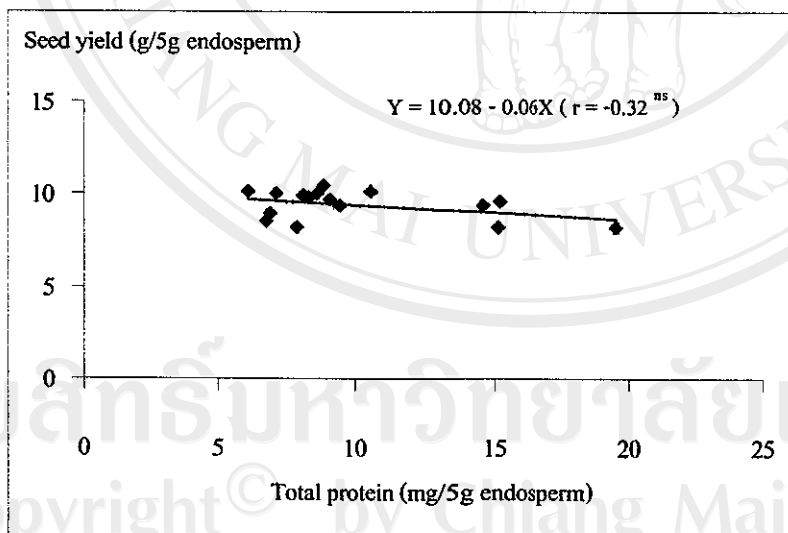


Figure 26 Correlation between total protein and seed yield of endosperm of F₁ hybrid and parental lines of local bitter gourd.

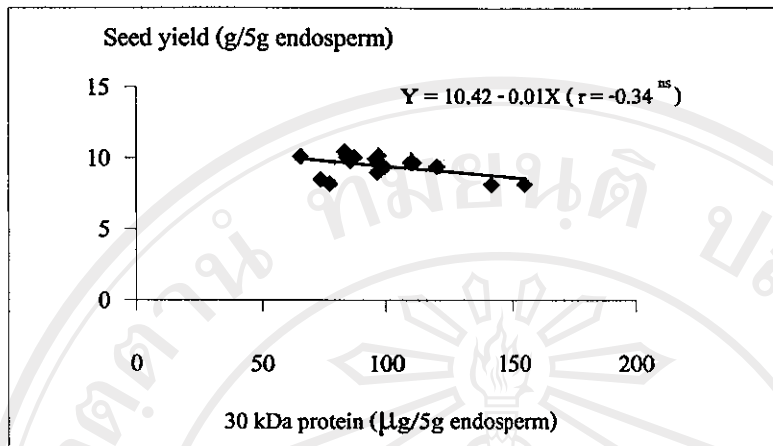


Figure 27 Correlation between 30 kDa protein and seed yield of endosperm of F_1 hybrid and parental lines of local bitter gourd.

5. Genetic analysis of 30 kDa protein in F_1 hybrid seeds.

Seed yield, partially purified protein, total protein and 30 kDa protein in 5 g endosperm of all treatments (12 F_1 hybrids and 4 parental lines) of local bitter gourd were analyzed (Table 13). Variance due to replications was no significant different for partially purified protein and 30 kDa protein except seed yield and total protein. Variance due to treatments was significant different for all treatments. Variance due to general combining ability was not significant for partially purified protein, total protein and 30 kDa protein weight except seed yield. Variance due to specific combining ability was not significantly different for total protein and 30 kDa protein weight except seed yield and partially purified protein. Variance due to reciprocal effects was not significant for partially purified protein, total protein and 30 kDa protein weight except seed yield.

When all treatments were estimated the effects of the combining ability (Table 14). Results showed that none of the crosses and the parental lines of local bitter gourd showed significant combining ability effects for seed yield, partially purified protein, total protein and 30 kDa protein weight.

Table 13. Analysis of variance and combining ability for seed yield, partially purified protein, total protein and 30 kDa protein in 5 g endosperm of F₁ hybrid and parental lines of local bitter gourd.

Source of variation	Degree of freedom	Mean square			
		Seed yield	Partially purified protein weight	Total protein weight	30 kDa protein weight
Replications	1	1.06 *	1785.03 ^{ns}	24.02 *	796.54 ^{ns}
Treatments	15	1.23 **	6699.68 **	29.83 **	1140.78 *
General combining ability	3	0.35 **	26.19 ^{ns}	0.02 ^{ns}	1.79 ^{ns}
Specific combining ability	6	59.19 **	133.49 *	0.08 ^{ns}	2.03 ^{ns}
Reciprocal effects	6	0.39 **	0.64 ^{ns}	0.12 ^{ns}	0.06 ^{ns}
Error	20	0.01 ^{ns}	39.31 ^{ns}	0.24 ^{ns}	21.30 ^{ns}

ns = nonsignificant.

* = significant at .05 level.

** = significant at .01 level.

Table 14 Estimates of the effects of combining ability for seed yield, partially purified protein, total protein and 30 kDa protein in 5 g endosperm of F₁ hybrid and parental lines of local bitter gourd.

Cross/parent	Seed yield	Partially purified protein	Total protein	30 kDa protein
		weight	weight	weight
13 × 12	0.12 ^{ns}	1.79 ^{ns}	-0.07 ^{ns}	0.13 ^{ns}
13 × 10	0.08 ^{ns}	-1.77 ^{ns}	0.11 ^{ns}	-1.07 ^{ns}
13 × 1	-0.05 ^{ns}	-1.50 ^{ns}	-0.01 ^{ns}	-0.23 ^{ns}
12 × 13	0.12 ^{ns}	1.79 ^{ns}	-0.07 ^{ns}	0.13 ^{ns}
12 × 10	0.00 ^{ns}	-2.18 ^{ns}	0.07 ^{ns}	-1.24 ^{ns}
12 × 1	-0.06 ^{ns}	-1.04 ^{ns}	0.16 ^{ns}	0.26 ^{ns}
10 × 13	0.08 ^{ns}	-1.77 ^{ns}	0.11 ^{ns}	-1.07 ^{ns}
10 × 12	0.00 ^{ns}	-2.18 ^{ns}	0.17 ^{ns}	-1.24 ^{ns}
10 × 1	-0.03 ^{ns}	1.25 ^{ns}	0.17 ^{ns}	0.26 ^{ns}
1 × 13	-0.05 ^{ns}	-1.50 ^{ns}	-0.01 ^{ns}	-0.23 ^{ns}
1 × 12	-0.06 ^{ns}	-1.04 ^{ns}	0.16 ^{ns}	0.26 ^{ns}
1 × 10	-0.03 ^{ns}	1.25 ^{ns}	-0.01 ^{ns}	0.26 ^{ns}
13	0.15 ^{ns}	-1.58 ^{ns}	-0.06 ^{ns}	-0.30 ^{ns}
12	0.16 ^{ns}	-1.54 ^{ns}	0.05 ^{ns}	-0.50 ^{ns}
10	-0.29 ^{ns}	1.54 ^{ns}	0.03 ^{ns}	0.38 ^{ns}
1	-0.01 ^{ns}	1.60 ^{ns}	-0.02 ^{ns}	0.43 ^{ns}

ns = nonsignificant.