Kasetsart J. (Nat. Sci.) 34 : 190 - 196 (2000)

Studies on Heterosis of Chili (*Capsicum annuum* L.)

Nogluck Milerue and Maneechat Nikornpun

ABSTRACT

Ten varieties of local chili were collected from different locations in Thailand. Observation and evaluation of those varieties were made in comparison with five male sterile varieties introduced from abroad. Five varieties were selected among these ten varieties as male parents. They were self-pollinated for two generations before crossing with two male sterile lines. Ten F1 hybrid lines were obtained and compared with the male parents at a private company in Chiang Rai and at the Department of Horticulture, Chiang Mai University. The results showed that the three F1 hybrid lines, K Y1-1 x Bang-Chang, KY 1-1 x Nhum Khiew and KY 1-1 x Nhum Khiew Maejo yielded 76.96%, 39.13% and 8.09% higher than the male parents which are landrace varieties. Moreover, the fruit quality was also higher than those of the male parents. They also have a rather good shape, smooth skin and big fruits. The degree of pungency as measured by spectrophotometer was different from that measured by human bite test. The highest pungency of bite test was found in Fang chili whereas the spectrophotometer methods indicated that Bang-Chang chili had the highest pungency.

KY 1-1 x Nhum Khiew Maejo, CF21789 x Nhum Khiew and KY 1-1 x Nhum Khiew showed high percentage of heterosis. Pungency of F1 hybrid tested by spectrophotometer methods indicated that different male parents produce different degree of pungency. Pungency was segregated between their male and female parents, revealing that the trait was polygenically controlled with mainly dominant gene action. Variation in degree of pungency was also controlled by environment.

Key words : pungency-hotness, spectrophotometer-instrument, polygenic-many genes

INTRODUCTION

Pepper or chilli is one of the important economical vegetables. Besides being used as fresh vegetable, it is used in many processing industries such as pepper sauce, pickled pepper, ground pepper and dried pepper. Pepper is grown throughout the country. The biggest production of pepper is in the Northeast, seconded by the North. The amount of pepper produced locally, is not enough for local consumption. Thailand imports dry pepper from abroad about 30 million Baht per year. Dry pepper from other countries had good fruit quality such as thick rind, good color, less amount of seeds, low pungency and cheap price. Fruit yield of pepper in Thailand is low because farmers prefer to use their own seeds or cheap seeds from markets. They are open pollinated varieties and mixture of varieties. Good Fl hybrid varieties of pepper are available in the markets. Farmers are reluctant to buy them because of their high prices. Local F1 hybrid improvement should be a good approach to decrease

Department of Horticulture, Faculty of Agriculture, Chiang Mai University, Chiang Mai 50200, Thailand.

cost of Fl hybrid seeds. Fl hybrid pepper has been used and found to be successful. Owens (1992) reported that fruit yield of 'Jalapeno' pepper increased 200-300 percent by varietal improvement. Fruit quality, fruit cotor and fruit shape were also improved. Another improvement in yield was found in 'Anaheim' pepper due to an increase in fruit length and fruit thickness. Improvement in fruit quality by hybridization was reported by Joshi *et al*. (1992). Hybrid Y02 and Y70 showed the improvement in fruit sweetness and pungency, while hybrid EC-203599 x Kt-PI-18 showed the improvement in fruit sweetness and hybrid EC-203600 x Kt-PI-19 showed the improvement in fruit pungency. Improvement in disease resistance such as virus disease by hybridization was reported by Ganashan (1992). New varieties were reported to have good disease resistance, resistant to environment, high yield and high levels of pungency in fruit. Pungency caused by capsaicin ($C_{12}H_{27}NO_3$) is quite important for pepper taste in Southeast Asia. It is a fat soluble compound, colorless, and without smell (Nelson, 1920).

Cost of hybrid pepper seeds is quite high due to high labor cost. One way of reducing labor cost is by using female parent which male pollen is unfertile. Cytoplasmic male sterility can be used for this purpose. Pollen of cytoplasmic male sterile plant is sterile because of reaction between sterile cytoplasm (S-type) and recessive gene in nucleus (ms gene). This recessive gene appears only in sterile cytoplasm. If there is a dominant gene (Ms) or fertile cytoplasm (N-type), the recessive gene will not express male sterility in the pollen.

MATERIALS AND METHODS

Ten varieties of pepper 'Cayenne type' were collected in Thailand. These varieties are Nhum Kwar Meakung, Nhum Khiew, Nhum Khiew Maejo, Bang-Chang, Fang, Mung, Yang Kramg, Roung, Chie Fa and Nan. Most of them are popular varieties used in the North. Big fruit type is popular for making pepper paste. Only one variety, Bang-Chang was collected in the Central part of Thailand. All of them were self pollinated for two generations. They were tested for high yield and selected for good horticultural characteristics such as good fruit set, fruit shape, disease resistant, strong plant type, heavy flower, and uniformity. Five varieties were selected as male parents to cross with male sterile pepper.

Five varieties of male sterile pepper (Sms ms) were imported from other country. These varieties are CF22209, CF21789, KY1-1, T888 (x) and T999 (x). They were pollinated with their own maintainer (Nms ms) for seed production. They were selected for healthy plant, disease resistance, male sterile flower, heavy flower, and good fruit set. Two varieties were screened from the five varieties tested. Two male sterile varieties, No.12 and 13 were used as female parents. They were pollinated with male fertile varieties, No. 2, 3, 6, 8 and 9. Ten hybrid varieties were obtained. They were tested at Chiang Mai University and a research station of a private company in Chiang Rai. Five male parents were also tested as control varieties in a randomized complete block design with 3 replications. Fruit yield and levels of pungency were recorded. Levels of pungency were tested by Anan's method (Anan, 1996) and human bite test. Capsaicin level was measured by a spectrophotometer (Bausch and Lomb, spectronic 20) at 750 nanometer. Heterosis of pungency of both methods was calculated as

$$\frac{\text{pugency of hybrid - pungency of male parent}}{\text{pungency of male parent}} \times 100$$

RESULTS

Ten varieties of male fertile pepper and five male sterile peppers were grown for horticultural

evaluation and selection. Among male fertile varieties, interesting varieties were Nhum Kwar Maekung, Nhum Khiew and Fang. Variety Nhum Kwar Maekung had good fruit set, big and long fruit with white-yellow color and good pungency. Variety Nhum Khiew had strong stems, light green fruit color, long fruit with medium pungency. Variety Fang had tall and strong stems, long harvesting period and good pungency. Five varieties were selected and used as male parents; varieties No.2 (Nhum Khiew Maejo), No.3 (Nhum Khiew), No.6 (Nhum Kwar Maekung), No.8 (Bang-Chang), and No.9 (Fang). Among five male sterile varieties, two varieties : No. 12 (CF21789) and No. 1 3 (KY 1 -1) were selected and used as female parents.

Ten hybrid varietie, of which male sterile varieties CF 21789 and KY 1-1 were used as female parents, were tested at Chiang Mai University in winter. Three hybrid varieties gave highest fruit yield (Table 1). These varieties were hybrid KY 1 -1 x Nhum Khiew, KY 1-1 x Bang-Chang and Nhum Khiew Maejo (Figure 1, 2 and 3). They gave 4,489, 4,153 and 4,014 kg/rai, respectively. When they were tested at a private company in the North of Thailand; hybrid KY 1-1 x Nhum Khiew, KY 1-1 x Nhum Kwar Maekung and KY 1-1 x Bang-Chang (Figure 1, 2 and 4) gave highest fruit yield. They gave 3,156, 3,033 and 2,853 kg/rai, respectively. Heterosis of yield of all varieties was calculated. Most hybrid varieties

Table 1 Fruit yield and plant height of Fl hybrid chili in comparison with their male parents.

Variety	Plant height (cm)		Yield (kg/rai)	
	Chiang Mai	Chiang Rai	Chiang Mai	Chiang Rai
Male parents				
Nhum Kwar Maekung	68.80 ab	58.93 ab	3,446 cd	2,793 cde
Nhum Khiew	64.50 ab	60.33 ab	3,105 bcd	2,533 bcde
Nhum Khiew Maejo	63.90 a	60.56 ab	3,606 d	2.763 cde
Bang-Chang	66.83 ab	59.20 a	2,487 abc	2,393 bcde
Fang	67.13 ab	69.26 b	1,073 a	1,213 a
F 1 hybrids				
CF 21789 X Nhum Kwar Maekung	65.46 ab	59.53 a	3,493 cd	2,360 bcd
CF 21789 X Nhum Khiew	69.46 ab	66.66 ab	3,800 d	2,606 bcde
CF 21789 x Nhum Khiew Maejo	66.00 ab	60.60 ab	3,220 cd	2,623 bcde
CF 21789 x Bang-Chang	68.40 ab	65.83 ab	3,686 d	2,186 bc
CF 21789 x Fang	75.10 b	69.30 b	1,586 a	2,193 bc
KY 1-1 x Nhum Kwar Maekung	64.80 ab	62.33 ab	3,830 d	3,033 de
KY 1-1 x Nhum Khiew	66.30 ab	59.83 a	4,189 d	3,156 e
KY 1-1 x Nhum Khiew Maejo	65.23 ab	58.10 a	4,014 d	2,180 bc
KY 1 -1 x Bang-Chang	63.33 a	60.13 a	4,153 d	2,853 cde
KY 1-1 x Fang	72.36 ab	62.46 ab	1.813 ab	1,900 b
LSD 0.05	0.176	0.242	0.781	1.21
CV (%)	3.3	4.46	13.06	5.0

showed higher percentage of heterosis than male parental varieties at both locations tested (Table 2). Highest percentage of heterosis was found in hybrid CF 21789 x Fang, KY 1-1 x Fang and KY 1-1 x Bang-Chang. They gave 261.58, 267.93 and 233.97 %, respectively. However, from horticultural characteristics, hybrid KY 1-1 x Nhum Khiew and KY 1-1 x Nhum Kwar Maekung were acceptable for fresh fruit consumption. For dry fruit consumption, hybrid KY 1-1 x Bangchang, KY 1-1 x Nhum Kwar Maekung and KY 1-1 x Fang were acceptable.

Capsaicin levels of 17 varieties were tested by Anan's method (Anan, 1996). Highest level of capsaicin was found in Bang-Chang variety. Pungency of the variety was 0.01175 scoville unit (Table 3). The second highest level was found in hybrid CF 21789 x Nhum Khiew which showed 0.00949 scoville unit. It was followed by KY 1-1 x Nhum Khiew Maejo, KY 1-1 x Nhum Khiew and CF 21789 x Bang-Chang, they showed 0.00632, 0.00560, and 0.00379 scoville unit, respectively. Heterosis of pungency levels in Table 3 showed that KY 1-1 x Nhum Khiew Maejo, CF 21789 x Nhurn Khiew and KY 1-1 x Nhum Khiew had the highest levels. However, the results were opposited

Figure 1 Fruits of hybrid KY 1-1 x Nhum Khiew.

Figure 2 Fruits of hybrid KY 1-1 x Bang-Chang.

Figure 3 Fruits of hybrid KY 1-1 x Nhum Khiew Maejo.

Figure 4 Fruits of hybrid KY 1-1 x Nhum Kwar Maekung.

Table 2 Percent heterosis of fruit yield of Fl hybrid chili and their male parents at different locations.

Variety	Chiang Mai		Chiang Rai	
	Yield (kg/rai)	% heterosis	Yield (kg/rai)	% heterosis
Male parents				
Nhum Kwar Maekung	3,446	00	2,793	00
Nhum Khiew	3,105	00	2,533	00
Nhum Khiew Maejo	3,606	00	2,763	00
Bang-Chang	2,487	00	2,393	00
Fang	1,073	00	1,213	00
Fl hybrids				
CF 21789 X Nhum Kwar Maekung	3,493	102.72	2,360	68.99
CF 21789 X Nhum Khiew	3,800	144.76	2,606	105.76
CF 21789 x Nhum Khiew Maejo	3,220	78.59	2,623	89.86
CF 21789 x Bang-Chang	3,686	196.42	2,186	82.69
CF 21789 x Fang	1,586	195.61	2,193	261.58
KY 1-1 x Nhum Kwar Maekung	3,830	122.28	3,033	117.18
KY 1-1 x Nhum Khiew	4,189	169.82	3,156	149.19
KY 1-1 x Nhum Khiew Maejo	4,014	122.62	2,180	57.79
KY 1 -1 x Bang-Chang	4,153	233.97	2,853	138.44
KY 1-1 x Fang	1,813	237.93	1,900	213.27

from the Human bite test which showed that Fang was the most pungent variety which scored 4.8. It was seconded by hybrid KY 1-1 x Nhum Kwar Maekung which showed 4.3 score and hybrid KY 1-1 x Fang showed 4.0 score.

DISCUSSION

From 15 collected varieties of pepper, five varieties were selected and used as male parents. These varieties were Nhum Khiew Maejo, Nhum Khiew, Nhum Kwar Maekung, Bang-Chang and Fang. Two varieties were selected and used as female parents. These varieties were CF 21789 and KY 1-1. Ten crossed were produced from the two female parental varieties. They were tested at Chiang Mai University and at a private company in Chiang Rai. Hybrids KY 1-1 x Nhum Khiew, KY 1-1 x Bang-Chang and KY 1-1 x Nhum Khiew Maejo gave the highest fruit yield of 4,189, 4,153 and 4,014 kg/rai, respectively at Chiang Mai University. At Chiang Rai, it showed that hybrids KY 1-1 x Nhum Khiew, KY 1-1 x Nhum Kwar Maekung and KY 1-1 x Bang-Chang gave the highest yield of 3,156, 3,033 and 2,853 kg, respectively. Fruit yield at Chiang Mai was higher than Chiang Rai because of differences in planting technique. Chiang Mai 's experiment was field-grown while pot experiment was employed at Chiang Rai. Limitation in space and short-term water stress could decrease yield of pepper (Tachawongsatian, 1997).

The results of heterosis of the hybrids showed that some male parental varieties were suitable because they gave good hybrids in terms of

Table 3 Pungency levels and percentage of heterosis of Fl hybrid chili and their male parents.

Variety	Pungency value[1/] (scoville unit)	% heterosis[2/]	Pungency level[3/]
Male parents			
Nhum Kwar Maekung	0.00153	0	3.1
Nhum Khiew	0.00094	0	2.1
Nhum Khiew Maejo	0.00056	0	2.5
Bang-Chang	0.01175	0	1.3
Fang	0.00045	0	4.8
Fl hybrids			
CF 21789 X Nhum Kwar Maekung	0.00054	-64.70	2.7
CF 21789 X Nhum Khiew	0.00949	909.57	1.7
CF 21789 X Nhum Khiew Maejo	0.00090	60.71	2.2
CF 21789 X Bang-Chang	0.00379	-67.74	0.4
CF 21789 X Fang	0.00027	40.00	1.5
KY 1 -1 X Nhum Kwar Maekung	0.00345	125.49	4.3
KY 1-1 X Nhum Khiew	0.00560	495.74	2.4
KY 1-1 X Nhum Khiew Maejo	0.00632	1028.57	3.2
KY 1 -1 X Bang-Chang	0.00117	-90.04	1.8
KY 1 -1 x Fang	0.00244	81.55	4.00

1/ Pungency value was measured by light absorption at 750 nanometer with spectrophotometer (the greater the value of scoville unit the higher the capsaicin content).

2/ % heterosis was calculated as indicated in the materials and methods by the use of the data on light absorption at 750 nanometer.

3/ The average of pungency level as measured by human bite test (1 - plain, 2 - slightly hot, 3 - medium hot, 4 - very hot, 5 - the hottest).

fruit yield and pungency. Kaladee (1988) illustrated that overdominance or heterosis of hybrids was due to the heterozygosity of self pollinated crops.

Differences in measurement methods of capsaicin gave different results. Anan's method showed that Bang-Chang variety had the highest pungancy level while Human bite test showed that Fang variety had the highest level. Difference in the results might be caused by age of pepper fruit at picking time or variation of capsaicin in each variety. From hybridization of pepper variety, it can conclude that pungency is controlled by a group of dominant genes. Environment can modify gene actions to a certain level.

LITERATURE CITED

Anan, T., H. lto, and H. Matsunaga. 1996. A simple method for determining the degree of pungency of peppers. Capsicum and Eggplant Newsletter. 15 : 51-54.

Ganashan, P. 1992. Developing hot pepper cultivars in Sri Lanka, pp.226-228. *In* Proceedings of the conference on chili pepper production in the tropics. 13-14 October. Concorde Hotel. Kualalumpur.

Joshi, S., P.C. Thakur, and T. S. Verma. 1992. Progress in paprika breeding at Katrain (India), pp. 226-228. *In* Proceedings of the conference on chili pepper production in the tropics. 13-14 October. Concorde hotel, Kualalumpur.

Kaladee, D. 1998. Improvement of Self Pollinated Crop. Department of Agronomy, Faculty of Agriculture, Chiang Mai University. 250 p. (in Thai)

Nelson, E.K. 1920. The constitutions of capsaicin, the pungency principle of Capsicum III. J. Am. Chem. Soc. 42 : 597-599.

Owens, K. 1992. Breeding pepper varieties for commercial processing, pp. 195-201.*In* Proceedings of the conferences on chili pepper production in the tropics. 13-14 October. Concorde Hotel, Kualalumpur.

Tachawongsatian, S. 1997. Improvement of drought tolerant pepper, pp. 155-169. *In* 15th National Vegetable Meeting 11-14 August. Ramagarden Hotel. Bangkok.

Received date : 6/03/00
Accepted date : 30/06/00