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Varietal improvement of baby corn (*Zea mays* L.) in Southern Thailand

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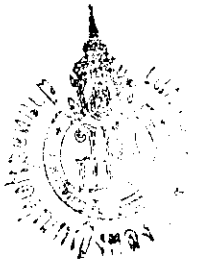

Abstract

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Breeding of single-cross baby corn hybrids is one of methods used for increase quality and quantity yield. Thus baby corn inbred lines were developed from two open-pollinated varieties, Chiangmai 90 and Suwan 2, and nine commercial hybrids, Pacific 1, Pacific 5, Pacific 7, Pacific 421, Pioneer, CP 45, G-5406, Jia Tai F_1 and Cargill 23, by S_1 and S_3 topcross methods and evaluation of primary hybrid among S_3 lines of each Pacific, Pioneer, CP 45, G-5406, Jia Tai F_1 and Cargill 23 group. CM90(1)-S_4-30, CM90(1)-S_4-63, CM90(1)-S_4-137, CM90(1)-S_4-143, CM90(1)-S_4-173, SW2(1)-S_4-133 and SW2(1)-S_4-181 lines were chosen on the basis of S_3 topcross young ear weight of standard size. Cargill-S_4-3-3 line was chosen on the basis of S_3 topcross and primary hybrid young ear weight of standard size. All possible single-cross hybrids were developed among these lines. Evaluation of single-cross hybrids was carried out during September-October, 1998 using a randomized complete block design. The top ten single-cross hybrids with high young ear weight of standard size were CM90(1)-S_4-63xCM90(1)-S_4-173, Cargill 23-S_4-3-3xCM90(1)-S_4-137, Cargill 23-S_4-3-3xCM90(1)-S_4-63, CM90(1)-S_4-30xCM90(1)-S_4-63, SW2(1)-S_4-133xCM90(1)-S_4-173, SW2(1)-S_4-181xCM90(1)-S_4-

63, SW2(1)-S_4-133xCM90(1)-S_4-63, Cargill 23-S_4-3-3xCM90(1)-S_4-173, CM90(1)-S_4-173xCM90(1)-S_4-137 and SW2(1)-S_4-133xCM90(1)-S_4-30. They yielded between 524.93 to 766.52 kg ha^{-1} and had ratio of unhusked to husked weight between 4:1-6:1. The hybrid CM90(1)-S_4-63xCM90(1)-S_4-174 showed the highest young ear weight of standard size, exceeding that of the least square mean yield of hybrid Pacific 421 by 31%. However, the yield of two hybrids were not different statistically.

Key words : *Zea mays* L., baby corn improvement, single-cross, topcross

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บทคัดย่อ

การปรับปรุงพันธุ์ข้าวโพดฝักอ่อนลูกผสมเดี่ยวเป็นวิธีการหนึ่งของการเพิ่มผลผลิตข้าวโพดฝักอ่อนทั้งด้านคุณภาพและปริมาณ ดังนั้นจึงได้สร้างข้าวโพดฝักอ่อนสายพันธุ์แท้จากพันธุ์ผสมเปิด เชียงใหม่ 90 และสุวรรณ 2 และจากพันธุ์ลูกผสมทางการค้า Pacific 1, Pacific 5, Pacific 7, Pacific 421, Pioneer, CP 45, G-5406, Jia Tai F_1 และ Cargill 23 โดยใช้วิธีการ Topcross กับสายพันธุ์ S_1 และ S_3 และการทดสอบลูกผสมเบื้องต้นระหว่างสายพันธุ์ S_3 ในกลุ่มลูกผสม Pacific, Pioneer, CP 45, G-5406, Jia Tai F_1 และ Cargill 23 ผลการทดสอบผลผลิตของลูก Topcross และลูกผสมเบื้องต้นของสายพันธุ์ S_3 ได้คัดเลือกสายพันธุ์ CM90(1)-S_4-30, CM90(1)-S_4-63, CM90(1)-S_4-137, CM90(1)-S_4-143, CM90(1)-S_4-173, SW2(1)-S_4-133, SW2(1)-S_4-181 and Cargill-S_4-3-3 มาสร้างเป็นลูกผสมเดี่ยว และทำการทดสอบผลผลิตลูกผสมเดี่ยวโดยวางแผนการทดลองแบบสุ่มภายในบลอก ระหว่างเดือนกันยายน-ตุลาคม 2541 ผลการทดสอบผลผลิตลูกผสมเดี่ยวพบว่า ลูกผสมเดี่ยวที่มีน้ำหนักฝักดีสูง 10 อันดับแรก คือ CM90(1)-S_4-63xCM90(1)-S_4-173, Cargill 23-S_4-3-3xCM90(1)-S_4-137, Cargill 23-S_4-3-3xCM90(1)-S_4-63, CM90(1)-S_4-30xCM90(1)-S_4-63, SW2(1)-S_4-133xCM90(1)-S_4-173, SW2(1)-S_4-181xCM90(1)-S_4-63, SW2(1)-S_4-133xCM90(1)-S_4-63, Cargill 23-

S_4-3-3xCM90(1)-S_4-173, CM90(1)-S_4-173xCM90(1)-S_4-137 และ SW2(1)-S_4-133xCM90(1)-S_4-30 ซึ่งให้ผลผลิตระหว่าง 524.93 - 766.52 กิโลกรัม เฮกตาร์$^{-1}$ และอัตราส่วนของน้ำหนักฝักอ่อนทั้งเปลือกต่อน้ำหนักฝักอ่อนหลังปลอกเปลือกระหว่าง 4:1-6:1 ลูกผสมเดี่ยว CM90(1)-S_4-63xCM90(1)-S_4-174 ให้ผลผลิตน้ำหนักฝักดีสูงสุด และมากกว่าผลผลิตลูกผสม Pacific 421 ประมาณ 31% แต่ไม่พบความแตกต่างทางสถิติ

Baby corn is one of the most important economic crops in Thailand. It is consumed by people as a fresh vegetable and used in agro-industry as a canned vegetable. The total export value of canned baby corn is about 756-1,071 million baht per annum (MAC, 1996). Baby corn production of farmers has problems about low quality and quantity of yield, especially sounthern Thailand, due partly to the lack of alternative, appropriate technologies such as different varieties. Thus breeding of single-cross baby corn hybrids research, is a priority.

Halluer (1967) applied reciprocal full-sib selection to develop single-cross hybrids. The selection in each generation of inbreeding was based on single-cross hybrid developed from individual plant crosses. Sfakianakis (1995) developed maize inbred lines from two diverse population by a reciprocal half-sib selection. Selection, base on half-sib progenies, was carried out both among and within lines during the S_0xS_0 through S_5xS_5 generations. Welsh (1981) and Hallauer and Miranda (1988) reported that evaluating inbred lines for combining abilities is improtant in determining the appropriate inbred lines to utilize in a hybrid breeding program. Sangtong (1990) found that the topcross method is more effective in selection of inbreds for baby corn hybrids than the line *per se* method. Aekatasanawan (1997) reported that hybrid maize technology, especially single-cross, allows maximum exploitation of heterosis.

The purpose of this study were (i) to develop inbred lines from open-pollinated varieties and commercial hybrids and (ii) to identify high performences single-cross hybrids.

Materials and Methods

Plant materials

The open-pollinated varieties used were Chiangmai 90 (CM90) and Suwan 2 (SW2). The commercial hybrid varieties used were Pacific 1, Pacific 5, Pacific 7, Pacific 421, Pioneer, CP 45, G-5406, Jia Tai F_1 and Cargill 23.

Development of single-cross hybrid scheme

The development of single-cross scheme described below was conducted at the Faculty of Natural Resources, Prince of Songkla University, Hat Yai Campus, Songkhla, Thailand from 1995-1998.

First season : Developing S_1 lines

Seeds of each variety were sown during October 1995 to January 1996. At flowering, a number of good plants were selfed. The self seeds of 160 plants of CM90, 142 plants of SW2 and 60 plants of commercial hybrid varieties were harvested separately. Seeds from each plant were called a S_1 line.

Second season : Developing S_2 lines and making S_2 topcrosses

In June 1996, S_1 seeds of each S_1 line were grown in single row plot, 5 m long, spaced 75 cm between rows and 25 cm between hills with two plants per hill. At flowering, the best 3-5 plants of each S_1 line were selfed to produce each S_2 line. Another 3-5 plants of each SW2-S_1, Pacific 1-S_1, Pacific 5-S_1, Pacific 7-S_1, Pacific 421-S_1, Pioneer-S_1, CP 45-S_1, G-5406-S_1, Jia Tai F_1-S_1 and Cargill 23-S_1

lines were topcrossed by tester Chiangmai 90 and 3-5 plants of each CM90-S_1 line were topcrossed by tester Suwan 2.

Third season : Developing S_3 lines and S_1 topcross progeny test

During November 1996 to May 1997 developing S_3 lines were advanced by self-pollination. They had the same procedure as developing S_2 lines. At the same time, the progenies of the S_1 topcrosses were evaluated with a Pacific 7 check variety. The experimental design was a systemic check arrangment with one replication. Each plot consisted of one row and 25 cm between hills. Plots were seeded and thinned to two plants per hill for a final plant density of 106,666 plants ha^{-1}. Two S_1 topcross plots alternated with one check plot.

At planting, 312 kg ha^{-1} of 15-15-15 fertilizer was applied and 312 kg ha^{-1} of urea was top-dressed at 20 days after plant emergence. Alachlor (48%EC) was sprayed as a pre-emergence herbicide at the rate of 1.5 kg a.i. ha^{-1}. Hand weeding was carried out at later stages of growth. Plants were thinned to two plants per hill at 14 days after plant emergence.

At the flowering stage, tassels were removed to increase baby corn yield except for Kasetsart 1 variety, which was cytoplasmic male sterile. The young corn ears were harvested when the silk was 1-3 cm long. After harvest, unhusked young ears were separated into two groups: standard ear size (ear length 4-9 cm, ear diameter 1-1.5 cm and no clear fluid endosperm) and non-stardard ear size (ear length did not fit in the 4-9 cm range, ear diameter did not fit in the 1-1.5 cm range and ear had clear fluid endosperm). All plants in the one-row plots were harvested and yield per plot was converted to kg ha^{-1}.

Fourth season : Developing S_4 lines and making S_3 topcrosses and primary hybrids

Developing S_4 lines and making S_3 topcrosses

From the result of S_1 topcross progeny test, 13 lines of CM90-S_3, 18 lines of SW2-S_3 and 28 S_3 lines of Pacific 1-S_3, Pacific 5-S_3, Pacific 7-S_3, Pacific 421-S_3, Pioneer-S_3, CP 45-S_3, Jia Tai F_1-S_3 and Cargill 23-S_3 were chosen on the basis of S_1 topcross young ear weight of standard size.

Seeds of the best four lines out of 18 lines of SW2-S_3 were combined, 200 seeds per line, to from a tester line (tester A). Liskewise, another tester was fromed by combining the seeds of the best four lines out of 13 lines of CM90-S_3, this tester was called tester B.

In June 1997, 3-5 plants each of 18 lines of SW2-S_3 and 28 lines of Pacific 1-S_3, Pacific 5-S_3, Pacific 7-S_3, Pacific 421-S_3, Pioneer-S_3, CP 45-S_3, G-5406-S_3, Jia Tai F_1-S_3 and Cargill 23-S_3 were topcrossed by testers B. And 13 lines of CM90-S_3 were topcrossed by testers A. Another 3-5 plants of each lines were self-pollinated to produce S_4 lines.

Making primary hybrids

Fourteen primary hybrids, excluding reciprocals, were made among S_3 lines of each Pacific, Pioneer, CP 45, G-5406, Jia Tai F_1 and Cargill 23 group.

Fifth season : S_3 topcross and primary hybrid progeny test

Fourteen primary hybrids, thirteen topcrosses of CM90-S_3, eighteen topcrosses of SW2-S_3 as well as twenty-eight topcrosses of Pacific 1-S_3, Pacific 5-S_3, Pacific 7-S_3, Pacific 421-S_3, Pioneer-S_3, CP 45-S_3, G-5406-S_3, Jia Tai F_1-S_3 and Cargill 23-S_3 were evaluated in each randomized complete block design with two replication. The evaluation was conducted during September 1997 to October 1997. Each plot consisted of two rows 5 m long, spaced 75 cm between rows and 25 cm

between hills. The other procedure used in these experiments was repeated for S_1 topcross progeny test.

Sixth season : Making single-cross hybrids among S_4 lines

SW2-S_4 and CM90-S_4 lines were chosen on the basis of S_3 topcross young ear weight of standard size. Pacific 1-S_4, Pacific 5-S_4, Pacific 7-S_4, Pacific 421-S_4, Pioneer-S_4, CP 45-S_4, G-5406-S_4, Jia Tai F_1-S_4 and Cargill 23-S_4 lines were chosen on the basis of S_3 topcross and primary hybrid young ear weight of standard size. Selected S_4 lines were CM90(1)-S_4-30, CM90(1)-S_4-63, CM90(1)-S_4-137, CM90(1)-S_4-143, CM90(1)-S_4-173, SW2(1)-S_4-133, SW2(1)-S_4-181, CP 45-S_4-9-2, Jia Tai F_1-S_4-9-2 and Cargill-S_4-3-3. CP 45-S_4-9-2 and Jia Tai F_1-S_4-9-2 lines were discarded because of no pollen. Thus all possible single-cross hybrids, excluding reciprocals, were made among CM90(1)-S_4-30, CM90(1)-S_4-63, CM90(1)-S_4-137, CM90(1)-S_4-143, CM90(1)-S_4-173, SW2(1)-S_4-133, SW2(1)-S_4-181 and Cargill-S_4-3-3 lines in March 1998. Three single-cross hybrids were discarded because of insufficient crossed seed.

Seventh season : Single-cross hybrid progeny test

The randomized complete block experiment design with two replications yielded entries (25 hybrids and 5 checks). The two check open-pollinated varieties were CM90 and Kasetsart 1. The two check hybrids were Pac 421 and Cargrill-Golden Ear. The one synthetic vareity check was SYN 1. The evaluation was conducted on 3 September, 1998. The same procedure used in this experiment was repeated for S_3 topcross progeny test.

Data were collected for unhusked young ear weight, husked young ear weight, young ear weight of standard size (ear length 4-11 cm, ear diameter 1-2 cm), unhusked to husked young ear weight ratio, ears plant^{-1} (number of ears per plant), days to first ear harvest (number of days from planting to the first ear

harvest), duration of harvest (number of days from the first ear harvest to the last ear harvest), first ear height (distance from soil surface to the highest ear-bearing node averaged from 10 competitive plants), and plant height (distance from soil surface to the base of the flag leaf averaged from 10 competitive plants). The traits were analysed by PROC GLM (Freund *et al.*, 1986). We used least square means and Type III sums of squares (Freund *et al.*, 1986) because some of the single-cross hybrids died early in the experiment.

Results and Discussion

From results of single-cross hybrid progeny test, the top ten single-cross hybrids with high young ear weight of standard size were CM90(1)-S_4-63xCM90(1)-S_4-173, Cargill 23-S_4-3-3xCM90(1)-S_4-137, Cargill 23-S_4-3-3xCM90(1)-S_4-63, CM90(1)-S_4-30xCM90(1)-S_4-63, SW2(1)-S_4-133xCM90(1)-S_4-173, SW2(1)-S_4-181xCM90(1)-S_4-63, SW2(1)-S_4-133xCM90(1)-S_4-63, Cargill 23-S_4-3-3xCM90(1)-S_4-173, CM90(1)-S_4-173xCM90(1)-S_4-137 and SW2(1)-S_4-133xCM90(1)-S_4-30 (Table 1). They yielded between 524.93 to 766.52 kg ha^{-1} and had ratio of unhusked to husked weight between 4:1-6:1.

The hybrid CM90(1)-S_4-63xCM90(1)-S_4-174 showed the highest young ear weight of standard size, exceeding that of the least square mean yield of hybrid Pacific 421 by 31%. However, the yield of two hybrids were not different statistically. The hybrid CM90(1)-S_4-63xCM90(1)-S_4-174 averaged ear 2.1 ears $plant^{-1}$, 47 days to the first ear harvest, 11 days of duration for harvest, 98 cm for the first ear height and 145 cm for plant height (Table 2).

Clearly, there is a need to evaluate the top ten single-cross hybrids in several environments of southern Thailand before recommending them to farmers.

The analysis of ears $plant^{-1}$, days to the first ear harvest, duration for harvest, the first ear height and plant height, showed non significance among entries(Table

2). It indicates that selection, based on the yield of topcrosses, did not influence on these traits.

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Table 1 Least square means for young ear weight and unhusked to husked young ear weight ratio of the top ten single-cross baby corn, evaluated at Hat Yai, Songkhla in 1998

Entry	Young ear weight			% Rel. to check	Unhusked to husked young ear wt. ratio
	Unhusked	Husked	Standard size		
	kg ha^{-1}				
CM90(1)-S_4-63-XCM90(1)-S_4-173	6095.13 ab	1263.84 ab	766.52 a	130.95	5:1
Cargill-S_4-3-3XCM90(1)-S_4-137	4070.40 bc	970.70 abc	708.18 a	120.98	5:1
Cargill-S_4-3-3XCM90(1)-S_4-63	4042.73 bc	893.95 abc	689.14 a	117.73	5:1
CM90(1)-S_4--30XCM90(1)-S_4-63	5110.90 abc	1059.09 abc	658.79 a	112.54	5:1
SW2(1)-S_4-133-XCM90(1)-S_4-173	6465.54 a	1092.98 ab	632.00 a	107.97	6:1
SW2(1)-S_4-181-XCM90(1)-S_4-63	5229.93 abc	912.79 abc	576.24 a	98.44	6:1
SW2(1)-S_4-133-XCM90(1)-S_4-63	4783.80 abc	837.37 bc	571.27 a	97.59	6:1
Cargill-S_4-3-3XCM90(1)-S_4-173	4866.75 abc	1082.57 ab	557.59 a	95.25	4:1
CM90(1)-S_4--173XCM90(1)-S_4-137	4429.09 abc	870.97 bc	525.28 a	89.73	5:1
SW2(1)-S_4-133-XCM90(1)-S_4-30	5700.07 ab	968.67 abc	524.93 a	89.67	6:1
SYN 1	4171.67 abc	862.72 bc	229.22 b	39.15	5:1
Chiangmai 90	3025.67 c	576.10 c	193.07 b	32.97	5:1
Kasetsart 1	3259.60 c	589.34 c	134.06 b	22.89	6:1
Cargill-Golden Ear	4665.27 abc	1184.84 ab	781.11 a	133.44	4:1
Pacific 421 (check)	6269.02 ab	1320.21 a	585.38 a	100	5:1
F-test	**	*	**	-	-
CV(%)	27.02	26.06	31.77	-	-

*,** significance at $p<.05$ and $p<.01$, respectively

Least square means within columns of each entry not sharing the same letter are statistically different at $p<.05$

Table 2 Least square means for ears plant^{-1}, days to the first ear harvest , duration of harvest, the first ear height and plant height of the top ten single-cross baby corn, evaluated at Hat Yai, Songkhla in 1998

Entry	Ears plant	Days to first ear harvest	Duration of harvest	First ear height	Plant height
	no	d		cm	
CM90(1)-S_4-63-XCM90(1)-S_4-173	2.1	47	11	98	145
Cargill-S_4-3-3XCM90(1)-S_4-137	1.4	49	10	93	154
Cargill-S_4-3-3XCM90(1)-S_4-63	1.9	45	13	100	147
CM90(1)-S_4--30XCM90(1)-S_4-63	2.0	45	9	100	164
SW2(1)-S_4-133-XCM90(1)-S_4-173	2.2	45	12	103	153
SW2(1)-S_4-181-XCM90(1)-S_4-63	1.9	43	13	100	166
SW2(1)-S_4-133-XCM90(1)-S_4-63	1.7	44	11	89	150
Cargill-S_4-3-3XCM90(1)-S_4-173	1.5	51	11	92	139
CM90(1)-S_4--173XCM90(1)-S_4-137	1.8	45	12	93	153
SW2(1)-S_4-133-XCM90(1)-S_4-30	1.9	47	11	97	159
SYN 1	2.1	47	12	98	162
Chiangmai 90	1.7	46	9	91	154
Kasetsart 1	1.3	46	9	90	152
Cargill-Golden Ear	1.5	54	10	96	159
Pacific 421 (check)	1.7	47	10	96	152
F-test	ns	ns	ns	ns	ns
CV(%)	17.05	5.89	14.94	17.72	11.96

ns non significance