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Hybrid Improvement of Chinese Radish

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ABSTRACT

Nine inbred lines of Chinese radish were investigated for their self-incompatibility levels using fluorescent microscope technique and seed set analysis. The results showed that most of the inbred lines were self-incompatible. They were crossed in all combinations to be selected for the best hybrid variety. From varietal trial and ability to set seeds, it was found that hybrid 27 x 18 and some of hybrid 77 x 18 had good horticultural characteristics such as uniformity, dark green leaf without hair, cylindrical shape, smooth skin, firm texture of root and root weight of about 360-400 g. These characteristics are market acceptable. Root yield of these hybrids in the previous experiments was a lot higher than marketed varieties. The hybrid varieties should be further tested in farmer's field.

Key words: self-incompatibility, cross in all combinations and horticultural characteristic.

INTRODUCTION

Chinese radish *Raphanus sativus* var. *Longipinnatus* L., is one of the popular vegetables in Thailand. It can be used for making varieties of food, both fresh and pickle. F1 hybrid seed of Chinese radish is more popular than open-pollinated seed, but F1 hybrid seed is more expensive than the open-pollinated one. However, F1 hybrid varieties give higher yield and better quality than open-pollinated varieties. All F1 hybrid seeds were imported. If male and female lines for the F1 hybrid seeds could be produced in the country, the price of F1 hybrid seeds would be decreased.

Chinese radish is a cross-pollinated crop and it has a sporophytical reaction for self-incompatibility. The self-incompatibility is controlled by S gene which has many alleles (Haruta, 1962). It was used in F1 hybrid seed production by developing male and female parental lines which were self-incompatible lines. There are two ways of checking self-incompatibility ; seed set analysis (Shinohara, 1981) and fluorescent microscope technique (Kho and Baer, 1968). The first method is a field test by selfing unopened flowers and opened flowers within the same inflorescence. The method is a time consuming, but yielding reliable results. The second method, fluorescent microscope technique, is a laboratory test by observing pollen tubes in styles of female flowers after selfed-or crossed-pollination. The later method is fast but the results are not as reliable as the former.

Varieties of Chinese radish used in this studies were supported by the International Development Research Centre (IDRC) through the Faculty of Agriculture, Chiang Mai University. Originally, they were imported from Japan, Taiwan

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and Korea, and also found as local varieties in the country. They were tested at a few locations for their adaptability and performances. Good varieties were selected from these experimental trials (Wivutvongvana, 1987). The selected varieties were self-pollinated for a few generations using a bud pollination technique (Wivutvongvana, 1987). Inbred lines obtained were tested for their self-incompatibility levels using seed set analysis and fluorescent microscope techniques. The inbred lines which had high levels of self-incompatibility were lines No. 27, 30, 54, 59, 62, 75 and 84 (Nikornpun and Tan-Kim-Yong, 1990-91). These lines were used in the experiments as parental lines.

MATERIALS AND METHODS

Inbred lines of Chinese radish which were developed at Chiang Mai University were used in the experiments. They had high level of self-incompatibility as mentioned above. However, they were tested again for their self-incompatibility levels. Two methods of testing were used : seed set analysis and fluorescent microscope technique. The former method is a common method for testing self-incompatibility. Three to four inflorescences per plant were bagged before flower opened. Three to five days later, the bags were taken off. Unopened and opened flowers were marked with a thread. Emasculation was needed for all flowers tested. They were pollinated with pollen of the same plant. After pollination, the inflorescences were bagged for two weeks. About 10 plants were used for an inbred line, then the pods were counted, the young flowers should be able to bear seeds while the opened flowers should not be able to bear seeds if they are self-incompatible.

Fluorescent microscope technique was used to test self-incompatibility levels (Kho and Baer, 1968). Unopened and opened flowers were taken from the same plant. They were put on a slide in a petridish containing potassium dichromate solution. The potassium dichromate ($K_2Cr_2O_7$) when boiled and kept in a tight chamber, will bring about the level of humidity to 98% RH. The flowers were emasculated before pollinated with pollen from the same plants. Another opened flower was required on the slide, it was cross-pollinated with pollen from different varieties, and was used as a control flower. The flowers were kept in the petridish for one night. Styles of these flowers were sectioned in sodium hydroxide (NaOH) which was heated to 60°C for one hour. Then the styles were stained with 0.2 % aniline blue in 2% potassium phosphate ($K_3PO_4.3H_2O$) for 24 hours. They were squashed on a slide which had a drop of glycerol. Pollen tubes were counted using a fluorescent microscope.

Inbred lines No. 18, 27, 56, 59, 62, 75 and 77 were vernalized for 15 day at 10°C. They were grown in a controlled room at 25 °C under continuous light and 80% relative humidity. They were cross-pollinated in all combination by hands. F1 hybrid seeds were grown in winter 1996 by one seed company in Chiang Mai. Thirty six commercial varieties of Chinese radish were in a trial as control varieties. These varieties were obtained from local seed companies and seed companies abroad. They were grown in comparison with the F1 hybrid varieties, randomly grown for two replications without experimental design. After 48-55 days, horticultural characteristics of a plant were recorded (e.g. plant growth, plant uniformity, leaf color, leaf margin, days to harvest, yield, root shape, root position in soil, root skin, root size, lateral root and root texture, disease, and over all rating).

RESULTS

Self-incompatibility levels of parental lines as evaluated by seed set analysis and fluorescent microscope techniques showed that all lines were self-incompatible. However, different levels of self-incompatibility were obtained (Table 1). Strong self-incompatible lines showed no pollen tube in female style (Figure 1). While weak self-incompatible lines showed some pollen tubes in the

Table 1 Seed yield and incompatibility levels of Chinese radish by seed set analysis and fluorescent microscope techniques.

Cross	Seed weight (g/pod)	SSA	FM	Cross	Seed weight (g/pod)	SSA	FM
18 x 27	0.34	SixSI	SIxWSI	59 x 62	0.11	SIxSI	SIxSI
18 x 56	0.59	SIxWSI	SIxWSI	59 x 75	0.21	SIxSI	SIxSI
18 x 59	0.13	SIxSI	SIxSI	59 x 77	0.10	SIxSI	SIxWSI
18 x 62	0.32	SIxSI	SIxSI	62 x 18	0.12	SIxSI	SIxSI
18 x 75	1.43	SIxSI	SIxSI	62 x 27	0.07	SIxSI	SIxWSI
18 x 77	0.40	SIxSI	SIxWSI	62 x 56	0.15	SIxWSI	SIxWSI
27 x 18	0.68	SIxSI	WSIxSI	62 x 59	0.09	SIxSI	SIxSI
27 x 56	0.43	SIxWSI	WSIxWSI	62 x 75	0.09	SIxSI	SIxSI
27 x 59	0.59	SIxSI	WSIxSI	62 x 77	0.08	SIxWSI	SIxWSI
27 x 62	0.22	SIxSI	WSIxSI	75 x 18	0.88	SIxSI	SIxSI
27 x 75	0.29	SIxSI	WSIxSI	75 x 27	-	SIxSI	SIxWSI
27 x 77	0.22	SIxSI	WSIxWSI	75 x 56	-	SIxWSI	SIxWSI
56 x 18	0.49	WSIxSI	WSIxSI	75 x 59	-	SIxSI	SIxSI
56 x 27	-	WSIxSI	WSIxWSI	75 x 62	-	SIxSI	SIxSI
56 x 59	-	WSIxSI	WSIxSI	75 x 77	-	SIxSI	SIxWSI
56 x 62	-	WSIxSI	WSIxSI	77 x 18	0.14	SIxSI	WSIxSI
56 x 75	0.51	WSIxSI	WSIxSI	77 x 27	0.16	SIxSI	WSIxWSI
56 x 77	0.14	WSIxSI	WSIxWSI	77 x 56	0.13	SIxWSI	WSIxWSI
59 x 18	0.09	SIxSI	SIxSI	77 x 59	0.34	SIxSI	WSIxSI
59 x 27	0.08	SIxSI	SIxWSI	77 x 62	0.16	SIxSI	WSIxSI
59 x 56	0.25	SIxWSI	SIxWSI	77 x 75	0.14	SIxSI	WSIxSI

SSA : Seed set analysis
FM : Fluorescent microscope
SI : Self-incompatibility
WSI : Weak self-incompatibility.

style (Figure 2).

Several lines had strong self-incompatibility as tested with both methods such as No. 18, 59, 62 and 75. Two varieties or lines were self-incompatible when tested by seed set analysis and they were weak self-incompatible when tested by fluorescent microscope technique such as No. 27 and 77. The line which was weak self-incompatible when tested with both methods was No. 56.

The inbred lines were crossed in all combinations. Most crosses yielded some seed as shown in Table 1. Some of these F1 hybrid seeds were further tested in the field using commercial varieties as control varieties. Horticultural characteristics of these hybrid and control varieties were recorded. Root yield was not recorded. However, it was shown in previous experiments that the hybrid varieties yielded higher than many control varieties (Nikornpun, 1988-92). They showed 1-3 times higher than Everest variety which

was a hybrid variety. They also showed 0.5-3 times higher than Jiatai 1 and 2 which were open-pollinated varieties (Nikornpun, 1995).

Not all crosses were evaluated for their horticultural characteristics (Table 2). Among F1 hybrid varieties tested, only hybrids of 27 x 18 (Figure 3) and some hybrids of 77 x 18 were acceptable. Other hybrid varieties were not acceptable due to poor plant performances, especially, short roots. Good F1 hybrid varieties were 27-1-3 x 18-1, 27-1-3 x 18-2, 27-1-3 x 18-3, 27-1-3 x 18-6, 77-2 x 18-11 and 77-4 x 18-7. These varieties should be tested again in farmer's field.

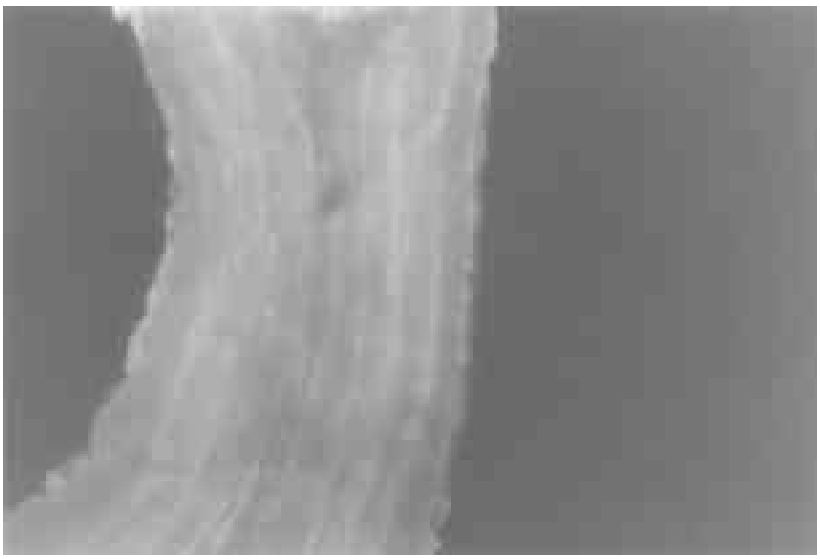

Figure 1 Style of opened flower which was self-incompatible, showed no pollen tube.

Figure 2 Style of opened flower which was weak self- incompatible, showed some pollen tubes.

Table 2 Horticultural characteristics of F1 hybrid Chinese radish and control varieties.

Cross	Growth	Uniformity	Leaf			Days to Harvest
			Color	Shape	Spine	
Hybrid						
27-1-3x18-1	Extremely vigorous	Uniform	Green	Lyrate	None	40
27-1-3x18-2	Extremely vigorous	Uniform	Dark green	Entire	None	40
27-1-3x18-3	Extremely vigorous	Uniform	Dark green	Lyrate	None	40
27-1-3x18-6	Extremely vigorous	Uniform	Dark green	Lyrate	None	40
27-1-3x18-7	Extremely vigorous	Uniform	Dark green	Lyrate	None	40
59-10x18-1	Extremely vigorous	Variation	Dark green	Entire	Few	45
59-10x18-2	Extremely vigorous	Partly uniform	Green	Entire	Few	40
59-10x18-5	Extremely vigorous	Variation	Green	Entire	Few	40
62-2x18-1	Extremely vigorous	Variation	Dark green	Entire	Few	45
62-2x18-5	Extremely vigorous	Variation	Green	Entire	Few	45
62-2x18-6	Extremely vigorous	Variation	Green	Entire	None	40
77-2x18-1	Extremely vigorous	Variation	Green	Serrate	Few	40
77-2x18-2	Extremely vigorous	Variation	Green	Serrate	Few	40
77-2x18-11	Extremely vigorous	Uniform	Green	Serrate	Few	40
77-4x18-7	Extremely vigorous	Uniform	Green	Serrate	Few	40
Control						
55 Days, CT	Vigorous	Variation	Green	Serrate	-	40
A-1, Fighter car	Vigorous	Variation	Dark green	Entire	None	40
Himalai, Thepwatana	Extreme Vigorous	Uniform	Dark green	Entire	None	40

Table 2 Contnued.

Cross	Root									
	Shape	Position in soil	Skin surface	Weight (g)	Width (cm)	Length (cm)	Scar	Lateral root	Fresh texture	Overal rating
Hybrid										
27-1-3x18-1	Cylindrical	Half buried	Smooth	450	3.7-4.3	30	Narrow	More than half	Firm	Very good
27-1-3x18-2	Cylindrical	Mostly buried	Smooth	400	3.3-4	37	Absent	More than half	Firm	Good
27-1-3x18-3	Cylindrical	Mostly buried	Smooth	450	3.4-4	30	Wide	More than half	Firm	Very good
27-1-3x18-6	Cylindrical	Mostly buried	Smooth	360	3.3-4.2	29	Absent	More than half	Firm	Good
27-1-3x18-7	Taper	Mostly buried	Smooth	350	3.4-3.9	28	Wide	More than half	Firm	Reject
59-10x18-1	Short	Half buried	Smooth	160	2.7-3.6	15	Absent	Few	Firm	Reject
59-10x18-2	Short	Half buried	-	310	2.4-4.2	23	Wide	More than half	Firm	Reject
59-10x18-5	Short	Half buried	-	250	2.6-4.2	22	Wide	More than half	Firm	Reject
62-2x18-1	Short	Half buried	Smooth	280	3.1-4.4	18	Narrow	Few	Firm	Reject
62-2x18-5	Short	Half buried	-	400	3.4-4.7	17	Narrow	Few	Firm	Reject
62-2x18-6	Short	Mostly buried	Smooth	340	2.8-4.5	18	Narrow	Few	Firm	Reject
77-2x18-1	Short	Mostly buried	Smooth	240	3	20	Narrow	More than half	Firm	Reject
77-2x18-2	Short	Mostly buried	Smooth	250	2.9-4	22	Narrow	More than half	Firm	Reject
77-2x18-11	Cylindrical	Mostly buried	Smooth	430	3.4-4.7	26	Narrow	More than half	Firm	Good
77-4x18-7	Cylindrical	Mostly buried	Smooth	390	3.4-5.3	23	Narrow	Few	Firm	Good
Control										
55 Days, CT	Cylindrical & Taper	Mostly buried	Smooth	300	3.3-4.2	22	Narrow	More than half	Firm	Reject
A-1, Fighter car	Cylindrical	Mostly buried	Smooth	350	3.8-5.2	23	Absent	Morr than half	Firm	Good
Himalia, Thepwatana	Cylindrical	Mostly buried	Smooth	280	4.0	22	Absent	Lower	Firm	Sale

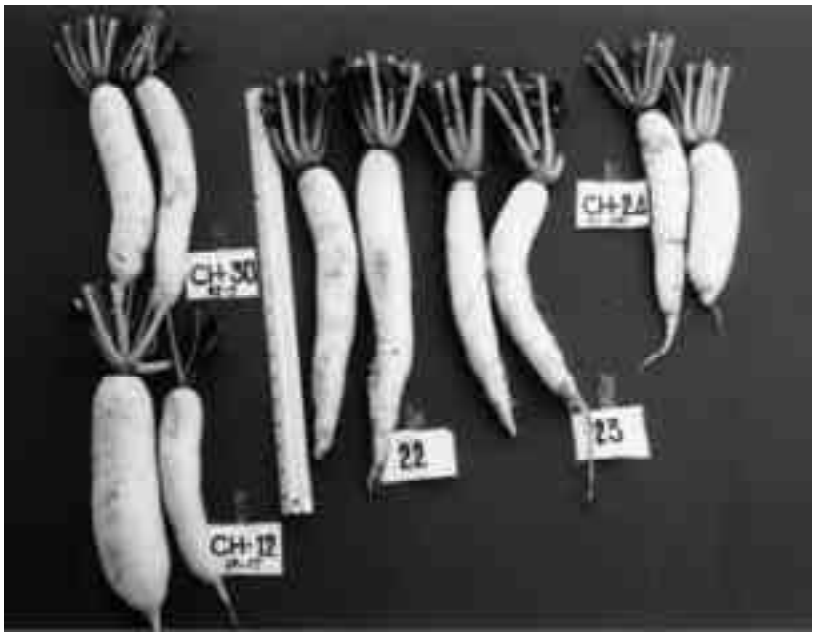

Figure 3 Good F1 hybrid varieties No. 22 (27-1-3 x 18-1) , No. 23 (27-1-3 x 18-2), No. 24 (27-1-3 x 18-3) and No. 25 (27-1-3 x 18-6) compared with control varieties : No. 12 (55 Days CT OP #2) and No. 30 (RF-3).

CONCLUSION AND DISCUSSION

It was shown from seed set analysis and fluorescent microscope techniques that most of the inbred lines of Chinese radish were self-incompatible and weak self-incompatible. They could be further used for F1 hybrid production. When these inbred lines were crossed in all combinations, most of them gave some hybrid seeds. Some crosses were tested in the field by the private company, characteristics, only crosses 27 x 18 and 77 x 18 were acceptable. They had long cylindrical shape of root with smooth skin surface, no scar or narrow scar, firm texture and good weight. Yield was not tested in this experiment, but we had shown that these hybrid varieties had much higher yield than open-pollinated and commercial F1 hybrid varieties (Nikornpun, 1988-92).

F1 hybrid Chinese radish always give higher root yield than open-pollinated varieties. Local selection for male and female lines of the hybrid would give good F1 hybrid varieties because they are adapted to our local climatic conditions. Therefore, our F1 hybrid varieties always give higher root yield than imported F1 hybrid varieties.

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