Release of Chinese Cabbage Lines Derived from Recurrent Selection for Resistance to Soft Rot Disease

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Yield and market quality of Chinese cabbage (*Brassica rapa* subsp. *Pekinensis* L.) are seriously affected by soft rot disease caused by *Erwinia carotovora* subsp. *carotovora*. Control of this disease is difficult because of host susceptibility and lack of effective bactericides. Researchers have been looking for resistance within the species or from related species (Asian Vegetable Research and Development Center, 1990; Nishi et al., 1970; Ren et al., 2000, 2001a; Shimizu et al., 1962, 1964), but no reliable, resistant sources have

been found or developed. Resistance to soft rot disease appears to be a quantitative trait controlled by multiple additive genes (Nishi et al., 1970; Ren et al., 2001b; Yamagishi et al., 1990). Here, we introduce four Chinese cabbage breeding lines (C3-26, C3-27, C3-28, and C3-29) derived from three cycles of recurrent selection that are more resistant than the original parents.

Origin

The initial population (cycle-0) consisted of the best 23 accessions of vegetable *B. rapa* of 300 evaluated for resistance to soft rot disease (Ren et al., 2001b). Most of the germplasm was obtained from the U.S. Dept. of Agriculture–Agriculture Research Service, Plant Genetic Resources Unit, Geneva, N.Y.; and the Institute of Vegetables and Flowers, Chinese Academy of Agricultural Sciences, Beijing. Information on PI numbers, subspecies names, and disease severity ratings are listed in Ren (1998). Recurrent selection was performed as described in Ren et al. (2001b) (Fig. 1). In each cycle, 18 plants from each line

(defined as the progeny from a cross) were evaluated using a mist-chamber seedling inoculation method (Ren et al., 2001a), in which a needle was dipped into bacterial colonies and pricked into two leaf-petioles of 3-week-old seedlings. Inoculated seedlings were placed in a mist-chamber (23 °C and 100% RH) and rated after 24 to 36 h based on a rating scale of 1 to 9 (1 = no disease, 9 = plant dead). The most resistant plants were selected from the 20 most resistant lines [the lowest mean disease severity rating (MDSR) and highest percentage of plant survival]. Three or four selected plants from each selected line were crossed with plants from four other lines (partial-diallel crosses) by bud pollination. Some crosses were omitted because of variation in blooming periods. Following evaluation and selection of the progeny, additional cycles of crosses were made until three cycles were completed. About 69 to 77 crosses were made in each cycle. Detailed information on all crosses mentioned above is given in Ren (1998).

Description

C3-26, C3-27, C3-28, and C3-29 are the four cycle-3 lines released. The plants grow vigorously, form upright, barrel-shaped heads with leaves that curve inward without overlapping at the top, and are 45 to 50 cm high and 35 to 40 cm wide, with dark-green wrapper leaves and yellow-green inner leaves. Plants are ready for harvest between 80 and 85 d after planting.

Four to six parental accessions were involved in each of these four particular lines (Table 1). The parental accessions probably contained different resistance genes with additive effects (Ren et al., 2001b), which were pyramided within the cycle-3 lines by three generations of intercrossing and selection. During trials with four replications at the seedling stage, as described above, and at the

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Fig. 1. Diagram of three cycles of recurrent selection of Chinese cabbage for resistance to soft rot disease.

Table 1. Parental accessions and pedigree of four cycle-3 lines of Chinese cabbage derived from recurrent selection for resistance to soft rot disease.

Accessions ^z	Origin	Cycle-3 lines	Pedigree
C2 (2837)	AVRDC ^y	C3-26	{[(C2 x C3) x (C4 x C2)] x [(C9 x C4) x (C8 x C3)]}
C3 (G30444)	---	C3-27	{[(C13 x C2) x (C9 x C4)] x [(C3 x C2) x (C5 x C4)]}
C4 (G30449)	---		
C5 (G30450)	---	C3-28	{[(C3 x C2) x (C5 x C4)] x [(C9 x C4) x (C8 x C3)]}
C8 (PI508415)	Korea		
C9 (G30786)	Japan	C3-29	{[(C2 x C3) x (C5 x C4)] x [(C3 x C2) x (C4 x C2)]}
C13 (G30451)	---		

^zAccessions (except 2837 from AVRDC) were obtained from the USDA-ARS, Plant Genetic Resources Unit, Geneva, N.Y.

^yAVRDC: Asian Vegetable Research and Development Center, P.O. Box 42, Shanhua, Tainan 74199, Taiwan.

^xAccessions with unknown origin.

heading stage in the field, the cycle-3 lines showed better resistance than the parental accessions (Table 2). Field plants were inoculated by dipping a sharpened wooden dowel in an agar slurry of bacteria and forcing the dowel twice horizontally through the centers of the plants. Inoculated plants were overhead-irrigated for 7 min three times daily. Individual plants were rated 10 d later based on a 1–9 scale (where 1 = no disease, 9 = whole plant rotten). Field data presented in Table 2 are from the first replication only because of severe club-root infection in some plots.

Performance

Mist-chamber assays. In 1995, the average MDSR of the cycle-3 lines was significantly reduced from 5.7 (parental lines) to 4.0, and average survival was increased from 72% to 89% at 23 °C and 100% RH. In a more severe test at 28 °C and 100% RH in 1996, the average MDSR of the cycle-3 lines was again significantly reduced from 6.5 to 3.1, and the average survival was increased from 63% to 99%. The susceptible control CC25 had a MDSR of 7.3 to 7.6 and only 30% to 45% of the plants survived. Resistance of the cycle-3 lines and the parental accessions at seedling stage is compared in Fig. 2.

Field assays. Data from field trials also indicated improved resistance in the cycle-3 lines. The average MDSR was reduced from 4.2 to 1.9 in the 1996 trial and from 5.9 to 3.9 in the 1997 trial. Resistance of C3-28 at early heading stage is compared with that of G30449 in Fig. 3.

Availability

Seeds of C3-26, C3-27, C3-28, C3-29, and their self-progeny can be obtained from Dr. Phillip Griffiths, Dept. of Horticultural Sciences, New York State Agricultural Experiment Station, Geneva, NY 14456-0462.

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Table 2. Mean disease severity ratings of parental accessions of Chinese cabbage and the selected cycle-3 lines following inoculation with soft rot bacteria.

	Mist-chamber seedling evaluation				Field evaluation	
	MDSR ^z		Plant survival (%)		MDSR	
	1995	1996	1995	1996	1996	1997
Parents						
2837	4.1	5.3	75.0	70.8	---	---
G30444	5.5	5.8	78.3	91.8	4.3 ± 0.6	4.1 ± 0.7
G30449	5.6	6.9	75.0	50.0	3.9 ± 0.3	6.8 ± 0.3
G30450	5.2	6.1	87.0	75.0	---	---
PI508415	6.4	7.7	70.8	29.2	5.1 ± 0.5	6.8 ± 0.2
G30786	6.5	7.2	58.3	54.2	4.3 ± 0.3	---
G30451	6.3	6.7	58.7	70.8	3.6 ± 0.6	---
Average	5.7	6.5	71.9	63.1	4.2 ± 0.5	5.9 ± 0.4
C-3 lines						
C3-26	3.8	3.0	91.7	100	2.1 ± 0.3	---
C3-27	4.5	3.7	87.5	100	1.9 ± 0.3	3.3 ± 0.7
C3-28	3.8	2.7	95.8	100	2.0 ± 0.4	3.6 ± 0.5
C3-29	4.2	2.9	79.2	95.8	1.4 ± 0.3	4.9 ± 0.7
Average	4.0	3.1	88.9	98.6	1.9 ± 0.3	3.9 ± 0.7
Susceptible control						
CC25	7.3	7.6	45.7	30.6	---	---
LSD _{0.05} ^y	1.5	1.6	30.4	28.8	---	---

^zMDSR: Mean disease severity rating from 1 (no disease) to 9 (plant dead).

^yBased on Fisher multiple comparison.

Fig. 2. Comparison of parental accessions and cycle-3 lines of Chinese cabbage in response to soft rot disease in 2 years of seedling evaluation in mist-chamber: (A) 1995 and (B) 1996.

Fig. 3. Comparison of a parental accession and a cycle-3 line of Chinese cabbage in response to soft rot disease following inoculation in the field: (C) C3-28 and (D) G30449.

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