SCREENING CRUCIFERS FOR GERMPLASM RESISTANCE TO CLUBROOT PLASMODIOPHORA BRASSICAE

Morgan S. Chiang and René Crête [1]

Abstract

A total of 334 varieties and lines of Brassica spp. were tested for resistance to Plasmodiophora brassicae race 6 under greenhouse conditions, and to races 6 and 2 under field conditions. Information on number of plants in each disease grade as well as disease indices from greenhouse and field tests for each entry are provided. Plant distribution in each disease grade is recommended as a guide in selecting germplasm resistance to clubroot rather than relying on disease indices alone. Some accessions and lines of cabbage showed a high degree of resistance to clubroot and are being used for breeding stocks.

Resume'

Un total de *334* lignées et variétés de Brassica spp. ont été soumises, en serre, à une infestation artificielle de la race 6 de Plasmodiophora brassicae et en plein champ, à une infestation naturelle des races 6 et 2 du même champignon dans le but de sélectionner du plasma germinatif résistant à la hernie. Ce plasma servira à des croisements ultérieurs de résistance.

Introduction

In 1967, the publication of a short paper (2) summarizing our results from screening tests of crucifers for resistance to clubroot proved to be useful in that many requests were received for the complete list of entries, including the distribution of disease grades for each entry, so that a more critical selection for developing resistant varieties could be effected. Since then more than 200 accessions, selections, lines, and varieties of crucifers were received from Plant Introduction Stations in the USA. In addition many breeding lines from institutions throughout the world were tested to select new clubroot resistant lines which could be used in our breeding program. The object of this report is to supply further information to those interested in searching for germplasm resistance to clubroot in crucifers, thus avoiding duplication or repetition of work.

Materials and methods

Greenhouse tests. In all greenhouse tests clubroot-free organic soil was infested with a suspension of resting spores of Plasmodiophora brassicae Wor. race 6. The technique of infestation was the same as described previously (2). Each plant was graded according to the four categories of disease severity used by Crête et al. (3).

Field tests. Field tests were conducted on mineral soil at L'Acadie, Que., and on well decomposed organic soil at Ste. Clotilde, Que. The soil at the L'Acadie farm was naturally infested with P. brassicae race 2 and possibly with race 3. At the Ste. Clotilde farm in the early part of the testing experiments race 6 was predominant with the presence of race 2; but gradually there seemed to be a shift in ratio between race 6 and race 2, with race 2 increasing in prevalence during the past few years. The procedures used in the field experiments were identical to those described elsewhere (2) except that in 1967 and thereafter grades of infection and disease indices were scored and calculated according to the method of Crête et al. (3) with the slight modification of increasing from four to five the grades of disease severity, as follows:

Grade	Disease severity (% of root system affected) 1966	1967–1971
0	0	0
1*	1–29	1–10
2	30–59	11–30
3	60–100	31–60
4**		61–100

* Small nodules only.

** Partial to complete decay.

[1] Plant Geneticist and Plant Pathologist, Research Station, Canada Department of Agriculture, St. Jean, Québec.

Most of the Plant Introduction accessions and the commercial varieties were tested in 1966 using the four-grade classification, therefore for most entries column 4 in Table 1 is blank.

All materials tested and their origins are listed in Table 1.

Results and discussion

The distribution of test plants in four or five disease grades and the disease index of each entry from greenhouse and field tests are presented in Table 1.

Of the 334 entries, the following showed promise and are now used in our breeding program: PI 215513, PI 215514, PI 215515, PI 261643, PI 330389, 192264 A, 192261 G, 192264 B, 1922879 BC, 1922907 BC, 1922916 BC, Witte Kool, and 8-41. Entry 8-41 is a selection from 61-L-104, which was a hybrid of Wisc. 8351 x 1922-52-0, and is our most resistant line. It is immune to race 1, highly resistant to race 6, but susceptible to race 2 (1).

The disease indices obtained from greenhouse tests were, in general lower than those from field tests. This might be because in the field the roots remained in soil much longer (2 to 3 months) than in the greenhouse (45 days) and consequently more infected plants were decayed at the time of examination. Also under field conditions new physiological races of P. brassicae could have developed, possibly by mutation of the pathogen, particularly in the field of organic soil that has been planted with crucifers continuously for the past 15 years. This hypothesis is supported by the fact that the cabbage variety Badger Shipper was totally susceptible to the disease in this field in 1970 and 1971 trials; Badger Shipper is known for its resistance to race 6 (4, 5). However, with multiple races of the pathogen in the field, we are hopeful of selecting plant lines each with resistance to several races, and many plants have been selected under these conditions for further investigation.

One should keep in mind that the disease index of an entry is a weighted average of infection; therefore, a breeder should look at the frequency of plant distribution in each disease grade of the entry rather than depend only on the index. For example, PI 212971 from India had a disease index as high as 96% at the Ste. Clotilde Farm, and one may consider that this accession should be discarded. However by examining the plant distribution in the five grades, one finds that this entry might be as useful as an entry with a low disease index, because there were two plants showing small nodules only (grade 1); with further testing these two plants might be useful in developing a new resistant variety.

Acknowledgments

The authors express their appreciation to R. Monast and G. Samoisette for technical assistance and to Drs. D. D. Dolan, Plant Introduction Station, Geneva, N.Y., USA; L. A. Mullen, Plant Introduction Station, Pullman, Washington, USA; M. Niewwhof, Institute of Horticultural Plant Breeding, Wageningen, The Netherlands; R. J. Snyder, University of Maryland, College Park, Maryland, USA; K. F. Thompson, Plant Breeding Institute, Cambridge, England; G. Weisaeth, Agricultural College, Vollebekk, Norway; C. Walkof, CDA Research Station, Morden, Manitoba; and P. H. Williams, University of Wisconsin, Madison, Wisconsin, USA, for supplying samples of crucifer seeds

Literature cited

1. Chiang, M. S., and R. Crête. 1970. Inheritance of clubroot resistance in cabbage (Brassica oleracea L. var. capitata). Can. J. Genet. Cytol. 12:253-256.

2. Crête, R., and M. S. Chiang. 1967. Screening tests of crucifers for resistance to clubroot soils of Quebec. Plant Dis. Rep. 51:991-002

3. Crête, R., J. Laliberté, et J. J. Jasmin. 1963. Lutte chimique contre la hernie, Plasmodiophora brassicae Wor., des crucifères en sols minéral et organique. Can. J. Plant Sci. 43:349-354.

4. Seaman, W. L., J. C. Walker, and R. H. Larson. 1963. A new race of Plasmodio hora brassicae affecting Badger Shipper cabbage. Phytopathology 53:1426-1429.

5. Williams, P. H. 1965. A system for the determination of races of Plasmpdiophora brassicae that infect cabbage and rutabaga. Phytopathology 56:624-626.

Table 1. List of *Brassica* entries tested for resistance to clubroot, their scientific names and origin, number of plants in each disease grade and disease indices from greenhouse tests with race 6 of *Plasmodiophora* brassicae (figures in left hand column under each heading) and from field tests in mineral soil containing races 2 and 3 (figures underlined) and in organic soil containing races 6 and 2 (figures in parentheses)

Entry	scientific name*	Origin	Disease grade 0	1	2	3	4	Disease indices
Plant introduction								
155061	1	Japan	1	0	0	0		0
156701	1	Japan	2 (0)	0 (0)	0 (0)	0 (1)	(10)	0 (98)
156702	1	Japan	1	0	0	1 (1)		50 (100)
163490	1	India	2	3	0	3		14
164275	1	India	15	0	1	6		30
164534	1	India	4	0	0	3		43
165054	1	Turkey	2	1	1	21		88
165067	1	Turkey	7	1	0	6 (6)		45 (100)
169039	1	Turkey	20	2	1	2		13
169040	1	Turkey	5	3	0	1 15 (29)		22 go- (100)
169041	1	Turkey	5	1	0	3 (9)		37 (100)
169046	1	Turkey	5	0	0	6		55
169047	1	Turkey	15	8	0	3 (24)		22 (100)
169048	1	Turkey	16	1	1	4 (43)		23 (100)
169049	1	Turkey	3	1	0	1		27
169051	1	Turkey	21	7	2	6 12 (41)		27 100 (100)
169052	1	Turkey	16	5	2	7 21 (40)		33 100 (100)
169053	1	Turkey	13	5	4	7 (10)		39 (100)
169055	1	Turkey	8	3	1	17 (8)		64 (100)
171523	1	Turkey	4	0	3	6 (9)		62 (100)
171529	1	Turkey	5	0	1	21		80
171530	1	Turkey	6	3	2	4 (9)		47 (100)
171531	1	Turkey	8	2	3	17 (9)		66 (100)
171532	1	Turkey	4	3	1	9 (8)		63 (100)
172743	1	Turkey	9	7	1	5 (8)		56 (100)
179188	1	Turkey	0	0	0	28		100
181720	1	Syria	4	0	1	6 (9)		61 (100)
181721	1	Lebanon	5	4	2	11		62
181722	1	Lebanon	6	6	2	18		65
182148	1	Turkey	8	3	5	12 (7)		58 (100)
182150	1	Turkey	2	3	2	6		64
194069	1	Germany	3	1	0	6 (7)		63 (100)
194070	1	Germany	2	0	2	9 (3)		80 (100)
194226	1	Germany	15	3	3	5 17 (23)		31 100 (100)
199787	1	Holland	18	4	1	8 11 (37)		32 100 (100)
204563	1	Turkey	7	4	4	5 (9)		45 (100)
204679	1	Turkey	8					41
211907	1	Afghanistan	8					59 (100)
212080	1	Afghanistan	0 (0)	2 (0)	1 (1)	4 (7)		86 (96)
212971	1	India	17 0 (0)	9 0 (2)	4 1 (0)	2 21 (31)		24 99 (96)
215513	1	Germany	23 2 (0)	2 6 (13)	1 0 (7)	1 3 (13)		9 45 (77)
215514	1	Germany	27 3 (0)	1 5 (9)	0 1 (4)	0 0 (4)		1 26 (57)
215515	1	Germany	36 14 (16)	1 15 (8)	0 0 (4)	0 29 (11)		1 17 (42)
222237	1	Iran	6	5	2	1		43
225855	1	Denmark	4	3	1	14		71
225856	1	Denmark	8	8	2	4		36
225858	1	Denmark	0	1	0	0		33
225860	1	Denmark	3	1	1	8		69
225861	1	Denmark	19	8	0	5		23
225862	1	Denmark	15	7	2	9 (9)		38 (100)
227012	1	Iran	4	4	4	8 (9)		60 (100)
227232	1	Iran	4	6	1	20 (3)		73 (100)
229470	1	Turkey	7	6	7	13 (4)		60 (100)
229747	1	Iran	9	1	1	14		60
230721	1	Holland	11	7	2	11 (6)		58 (100)
230722	1	Holland	9	5	4	9 (9)		49 (100)
232071	1	Holland	7	0	1	7		51
235041	1	Brazil	5	2	0	7 (7)		55 (100)
235042	1	Brazil	8	3	0	14 (6)		60 (100)
235043	1	Brazil	13	2	3	10		45
235044	1	Brazil	6	4	1	12		61
235045	1	Brazil	3	3	3	17		77
244986	1	England	7	6	3	11 (5)		56 (100)
244988	1	England	13	6	3	11		46
244990	1	England	2	3	3	16 (8)		79 (100)
244994	1	England	9 (0)	0 (0)	0 (1)	15 (10)		63 (97)
244996	1	England	1	2	1	15 (8)		86 (100)
244998	1	England	2	4	3	12		73
244999	1	England	5	6	3	21		71
245000	1	England	4	2	3	14		72
245001	1	France	1	0	0	2		67
245009	1	France	1	3	2	5		67
245010	1	France	10	6	0	8		42
245011	1	France	11	3	1	12 (9)		51 (100)
245012	1	France	10	3	1	15		58
245014	1	France	11	3	0	18		59
245015	1	France	0	2	1	7		83
245017	1	France	10	7	2	12 (9)		51 (100)
245018	1	France	1	3	0	5 (26)		67 (100)
245019	1	France	3	1	1	12 (8)		77 (100)
245020	1	France	9	11	1	3 11 (26)		31 100 (100)
245021	1	France	4	3	6	7 (9)		60 (100)

Entry	Scientific name*	Origin	Disease grade 0		1		2		3		4	Disease indices	
Plant introduction (cont'd)													
245022	1	France	9	(0)	4	(0)	1	(1)	5	(5)		37	(94)
245023	1	France	2		4		2		8	(7)		15	(100)
246046	1	Holland	14		4		1		10	(4)		41	(100)
246048	1	Holland	9		6		4		12			54	
246052	1	Holland	1		3		0		7			73	
246053	1	Holland	6		3		1		13	(8)		64	(100)
246054	1	Holland	10		2		0		8			48	
246055	1	Holland			2		2		10	(6)		60	(100)
246057	1	Holland	0	(0)	0	(0)	1	(3)	14	(13)		64	(94)
246063	1	Holland	13		3		2		9			42	
246064	1	Holland	10		1		1		8	(9)		45	(100)
246066	1	Holland	14		7		0		5			28	
246067	1	Holland	2		0		2		0			33	
246068	1	Holland	5		5		0		6			48	
246069	1	France	1		2		1		8			78	
246071	1	France	0		3		1		10			83	
246072	1	France	9		4		2		10			51	
246075	1	France	7		4		2		4			39	
246076	1	France	9		5		1		17			7	
246078	1	France	7		3		1		13			61	
246079	1	France	1		3		1		10	(7)		78	(100)
246080	1	France	3		4		2		18	(9)		77	(100)
246081	1	France	5		8		4		6			57	
246083	1	France	3	(1)	2	(0)	3	(0)	14	(7)		76	(88)
246084	1	Germany	0		4		0		10			81	
146085	1	Germany	1		2		1		14			85	
246087	1	Germany			5		1		15	(9)		67	(100)
246088	1	Germany	3	(0)	1	(0)	1	(1)	10	(4)		73	(93)
246090	1	Germany	13		1		2		0			10	
246093	1	Germany	7		4		1		8			50	
246094	1	Germany	12		5		3		12			49	
246096	1	Germany	3		2		1		12			74	
246098	1	Germany	8		12		5		7			45	
246100	1	Germany	10		3		1		19	(8)		63	(100)
246101	1	Germany	1		1		3		7	(9)		52	(100)
246102	1	Germany	16		6		2		8	(9)		35	(100)
246103	1	Germany	9		1		1		18	(7)		66	(100)
246104	1	Germany			2		1		5			63	
246109	1	Holland	9		1		2		12			[illegible]	
246110	1	Holland	18		4		0		2	13		14	100
246111	1	Holland	18		2		2		8	12	(30)	33	100 (100)
246113	1	Holland	3		4		5		16		(16)	14	(100)
246116	1	Holland	11		4		1		12		(6)	50	(100)
246117	1	Holland	13		7		4		8		(6)	41	(100)
246119	1	Holland	0		5		1		5		(3)	67	(100)
246565	1	England	12		7		2		9		(8)	42	(100)
246567	1	England	3		2		4		13			4	
246568	1	England	9		5		5		9			50	
249557	1	Thailand	6		3		1		8			54	
250419	1	Czechoslovakia	1		2		0		8			79	
250420	1	Czechoslovakia	2		5		1		8			65	
250421	1	Czechoslovakia	2		3		0		5			60	
250422	1	Czechoslovakia	4		3		1		5			51	
250423	1	Czechoslovakia	1		1		0		6			79	
150424	1	Czechoslovakia	13	(0)	7	(0)	2	(1)	5		(2) (20)	32	(96)
25555B	1	Yugoslavia	1		2		2					70	
255559	1	Yugoslavia	6		2		1		9			57	
255560	1	Yugoslavia	3		3		1		6			59	
255561	1	Yugoslavia	0		0		0		27			100	
255562	1	Yugoslavia	14	(0)	2	(0)	0	(1)	13		(1) (45)	47	(98)
255581	1	Iran	3		1		0		18			48	
261600	1	Spain	14		2		0		18			55	
261601	1	Spain	12		8		2		11			69	
261602	1	Spain	3		4		0		24			77	
261603	1	Spain	0		5		2		5			41	
261604	1	Spain	8		5		3		13			[illegible]	
261605	1	Spain	8		8		0						
261642	1	Holland	25	(1)	7	(3)	1	(3)	2		(1) (0)	14	(50)
261643	1	Holland	22	(4)	0	(12)	0	(4)	6		(6) (6)	21	(45)
261151	1	Belgium	9	(0)	2	(0)	0	(2)	18		(1) (36)	13	(97)
261758	1	Belgium	23		5		4				(48)	41	(100)
261769	1	France	22		11		0		11		(29)	33	(100)
261170	1	France	8		1		0		8		(34)	44	(100)
261171	1	France	16	(0)	3	(0)	0	(0)	14		(1) 1361	14	(99)
261772	1	France	23		5		2						
261773	1	France	22		5		0		4		(42)	18	(100)
261774	1	France	5		3		3		9			60	
263058	1	USSR	12		4		1		5		(39)	32	(100)
263059	1	USSR	9		4		2		10			51	
263063	1	USSR	3		1		1		5			60	
263066	1	USSR	8		12		1		6			40	
263640	1	USSR	2		0		0		3			60	
263861	1	Greece	2		2		0		17			84	
269433	1	Pakistan	7		7		3		3			37	
273243	1	California	1		3		2		16			83	
274242	1	California	0		2		1		33			97	
275003	1	Bulgaria	0		1		1		17			95	

Entry	Scientific name*	Origin	Disease grade 0		1		2		3		4		Disease indices	
Plant introduction (cont'd)														
275004	1	Bulgaria	3	(0)	5	(0)	5	(0)	18	(1)	(16)	82		(99)
275005		Bulgaria	0		1		1		28			97		
275006	1	Bulgaria	0		0		0		34			100		
275007	1	Bulgaria	0		0		0		34			100		
277278	1	Bulgaria	1		0		1					95		
280065	1	Scotland	0		0		0					100		
280066	1	Scotland	0		1		0					97		
280067	1	Scotland	0		0		0					100		
280068	1	Scotland	0		1		1		35			97		
281547	1	Japan	0		1		0		31			98		
281548	1	Japan	1		2		1		32			93		
281519	1	Japan	2		1		2		14			82		
281550	1	Japan	0		1		0		34			98		
281551	1	Japan	0		0		0		30			100		
281552	1	Japan	0		0		0		35			100		
287135	1	Japan	0		1		0		26			98		
288229	1	Egypt	0		0		1		26			99		
288210	1	Egypt	0		1		0		25			97		
288231	1	Egypt	0		0		0		31			100		
289697	1	Australia	1		0		0		21			95		
294591	1	Denmark	0		2		0		33			96		
296130-A	1	USA	3		10		2		15			66		
296132	1	USA	0		0		0		34			100		
296133		USA	6		5		3		19			69		
296134	1	USA	1		1		0		3			67		
296135		USA	0		0		1		25			96		
296135	1	USA	0		1		1		25			96		
296136	1	USA	1		0		0		28			97		
296209	1	USA	16		6		0		9					
296330	1	S. Africa	9		2		0		14			59		
296331	1	S. Africa	8		6		1		6			41		
302442		Taiwan	5		6		0		16			--		
303629		S. Africa	11		9		0		14			50		
320069	1	India									19 (8)		100	(100)
320913	1	Hungary	8	(18)	5	(0)	5	(0)	4	(2)	29 (23)		70	(57)
320914	1	Hungary	12	(0)	10	(0)	0	(1)	3	(1)	18 (33)		53	(98)
329192	1	Holland	4		8		1		0		1 (9)		23	(100)
330389	1	Norway	8	(1)	0	(2)	4	(2)	4	(0)	11 (7)		58	(71)
330392	1	Norway	2	(0)	2	(0)	1	(1)		(1)	1 (4)		30	(88)
330393	1	Norway	7	(0)	1	(0)	0	(0)	0	(1)	0 (10)		3	(98)
343500	1	USSR	2		3		0		0		2 (8)		39	(100)
343515	1	USSR	1		0		1		2		2 (8)		67	(100)
343516	1	USSR	2		6		0		1		5		52	
343560	1	USSR ex. Bulg.	2		0		1		2		0 (10)		40	(100)
343569		USSR ex. Ger.	1		1		0		0		6 (14)		78	(100)
343619	1	USSR ex. India									5		100	
343622	1	USSR ex. Italy	1		1		0		1		1		50	
341625	1	USSR ex. Japan	0	(0)	0	(0)	1	(0)	0	(2)	5 (10)		92	(96)
343628	1	USSR ex. Japan	0	(0)	3	(0)	0	(0)	0	(1)	4 (10)		68	(98)
343630	1	USSR ex. Japan	3		4		0		1		3 (11)		43	(100)
343631	1	USSR ex. Japan	4		1		1		2		4 (15)		52	(100)
343633	1	USSR ex. Neth.	15		0		0		2		14 (19)		97	(100)
343634	1	USSR ex. Neth.	0		3		1		2		4 (6)		68	(100)
343635	1	USSR ex. Neth.	22		5		6		2		8		32	
343636	1	USSR ex. Neth.	1		0		0		0		7 (6)		88	(100)
343638	1	USSR ex. Neth.	0		0		0		0		7 (10)		100	(100)
343632	1	USSR ex. Neth.									11 (6)		100	(100)
206942	2	Turkey	8		0		2		20			71		
209751	2	Netherlands	0		2		0		0			33		
209756	2	Netherlands	2		2		1		2			47		
209757	2	Netherlands	2		0		1		2			53		
212592	2	Afghanistan	1		1		0		0		(5)	2		(100)
213209	2	Italy	2		1		1		9			77		
217517		Pakistan	5		5		0		14			65		
232070	2	S. Africa	8		4		2		12		(32)	56		(100)
277273	2	India	4		10		2		9	23	(42)	55	100	(100)
236257	3	Japan	1		0		0		1			50		
236258	3	Japan	1	0	1	0	0	1	0	7		17	96	
236259	3	Japan	7	1	3	2	0	5	4	10		36	78	
257229	5	Thailand	1		3		0		26			90		
273640	5	Ethiopia	2		0		0		24			92		
Plant breeder														
TK 499-2023	1	Norway	24		24		2		0		0 (47)		14	(100)
K 504-2024		Norway	22	(0)	26	(0)	0	(2)	0	(5)	0 (38)		14	(95)
K 512-2004	1	Norway	2	(0)	11	(0)	5	(0)	5	(8)	13 (36)		61	(96)
K 512-2028	1	Norway	16	(0)	27	(0)	5	(3)	0	(12)	0 (28)		19	(90)
K 512-2034	1	Norway	6	(0)	26	(0)	4	(0)	1	(15)	3 (41)		28	(97)
K 512-2041	1	Norway	4	(0)	31	(0)	3	(1)	0	(10)	0 (32)		24	(93)
TK 704-2006	1	Norway	0	(0)	5	(0)	4	(1)	16	(8)	21 (36)		79	(94)
K 707-2008	1	Norway	3	(0)	14	(0)	13	(2)	11	(3)	1 (41)		46	(96)
K 707-2044	1	Norway	12	(0)	17	(0)	2	(7)	0	(15)	0 (20)		17	(83)
K 707-2047	1	Norway	16	(0)	18	(0)	3	(1)	1	(3)	2 (44)		22	(97)
K 716-2013	1	Norway	14	(0)	26	(1)	2	(2)	1	(13)	0 (29)		19	(89)
K 716-2022	1	Norway	36	(0)	10	(1)	0	(2)	0	(6)	0 (37)		5	(93)

Entry	Scientific name*	origin	Disease grade 0	1	2	3	4	Disease indices
Plant breeder (cont'd)								
K 716–2026	1	Norway	17 (0)	24 (0)	3 (0)	0 (9)	1 (36)	19 (90)
K 732–2014	1	Norway	21 (0)	25 (2)	0 (0)	0 (3)	0 (41)	14 (95)
K 873–2018	1	Noway	38 (0)	0 (0)	0 (0)	0 (3)	0 (42)	0 (98)
K 873–2025	1	Norway	13 (0)	18 (0)	3 (6)	1 (5)	0 (34)	19 (91)
192261 G	1	Wisconsin	5 (0)	2 (10)	0 (1)	0 (16)		1 (85)
192262 L	1	Wisconsin	2	8 (27)	0 (2)	0 (0)		27 (36)
192264 A	1	Wisconsin	5 (1)	12 (21)	0 (5)	0 (1)		24 (40)
192265 B	1	Wisconsin	17 (2)	7 (23)	0 (6)	1 (5)	(1)	13 (37)
1922879 BC	1	Wisconsin	8 (1)	11 (8)	0 (1)	25 (3)	(28)	55 (99)
1922907 BC	1	Wisconsin	8 (2)	13 (13)	0 (6)	8 (4)	(29)	43 (55)
1922916 BC	1	Wisconsin	5	7	2	5		46
Badger Shipper	1	Wisconsin	253 24 (0)	6 11 (1)	0 3 (1)	0 0 (4)	9 (55)	1 29 (96)
Badger Inbred #1	1	Wisconsin	(0)	(1)	(1)	(5)	(32)	(94)
Badger Inbred #7	1	Wisconsin	(0)	(0)	(2)	(1)	(31)	(96)
Badger Inbred #9	1	Wisconsin					(29)	(100)
Badger Inbred #10	1	Widconsin	(0)	(1)	(3)	(6)	(24)	(89)
Badger Inbred 812	1	Wisconsin					(35)	(100)
Sanibel	1	Wisconsin	(21)	(2)	(1)	(1)	(36)	(62)
Junior	1	Morden, Man.	1 3	4	28		(32)	88 (100)
Little Leaguer	1	Morden, Man.	0 2	2	33		(35)	95 (100)
Pee Wee	1	Morden, Man.	0 1	3	31		(41)	95 (100)
Witte Kool	1	Holland	28 (1)	0 (14)	0 (10)	0 (8)	(10)	0 (57)
8–41 (61–L–104)	1	St. Jean, Que.	24 (31)	11 (18)	0 (0)	0 (0)		11 (12)
63–L–101	1	St. Jean, Que.	27 1	11 5	0 1	0 23		10 84
60–305	1	St. Jean, Que.	10	3	1	5 (41)		35 (100)
60–309	1	St. Jean, Que.	16	6	1	8		34
60–331	1	St. Jean, Que.	5	4	0	5 (45)		45 (100)
60–332	1	St. Jean, Que.	9	3	1	12 (46)		54 (100)
Md 8	1 x 2	Maryland	(0)	(4)	(6)	(17)		(78)
Md 16	1 x 2	Maryland	(1)	(15)	(1)	(22)		(71)
Md. 17	1 x 2	Maryland	(1)	(6)	(2)	(21)		(81)
Md. 19	1 x 2	Maryland	(1)	(7)	(3)	(13)		(72)
Md. 21	1 x 2	Maryland	(3)	(4)	(4)	(26)		(89)
Wild Cabbage	5	England	1	3	3	2	1	48
Commercial varieties								
Baby Head	1	Stokes	10	0	0	12	(42)	55 (100)
Badger Ballhead 14	1	Asgrow	3	1	0	4		70
Badger Ballhead Y.R.	1	Asgrow	4	2	5	19		77
Badger Ballhead Y.R.	1	Sem. Supér.†	9	1	1	7		44
Badger Market	1	Letherman's	0	0	0	9		100
Badger Market Y.R.	1	Asgrow	8	3	4	5		100
Bonanza	1	Twilley's	29	1	0	1	(33)	4 (100)
Copenhagen Market	1	sem. Supér.	4	1	0	2		33
Copenhagen Market No. 86	1	Asgrow	6	3	0	7		50
Danish Ballhead	1	Asgrow	16	0	2	18		52
Danish Ballhead Tall Stemmed	1	Sem. Supér.	1	0	0	2		67
Earlihead	1	sem. Supér.	6	1	1	10		61
Early Greenball	1	Stokes	7	0	1	13		65
Earlygreen Ballhead	1	stokes	12	4	1	1		46
Early Jersey Wakefield	1	Vaughan's	0	0	1	26		99
Early Marvel	1	Stokes	10	2	1	6		39
Early Wonder	1	Sem. Supér.	0	0	0	3		100
Extra Early 2	1	Sem. Supér.	1	3	0	6		70
F_1 Hybrid Cabbage NO. 18		Sakara	3	3	0	7		61
F_1 Hybrid Cabbage No. 21	1	Sakara	12	2	1	11		47
F_1 Hybrid Cabbage No. 26	1	Sakara	3	6	1	13		68
Ferry's Round Dutch	1	Twilley's	35 (0)	2 (0)	0 (0)	0 (1)	(31)	2 (99)
Golden Acre Elite #3072	1	Sem. suplr.	1	0	0	3	(40)	75 (100)
Golden Acre Y.R.	1	Harris	6	3	1	17		69
Golden Acre No. 84	1	Harris	0	0	1	10		97
Greenback	1	Stokes	11	1	1	18		61
Houston Evergreen	1	Stokes	10	3	1	14	(90)	56 (100)
Pennstate	1	Sem. Supér.	6	5	0	7 (35)		54 (100)
Red Acre	1	Sem. Supér.	5	0	0	2	(38)	29 (100)
Rest. Detroit Y.R.	1	Asgrow	7	0	1	14		67
Savoy Cabbage Atlas	1	Sem. Supér.	8	2	1	11		56
Savoy Cabbage Early	1		8	0	0	7		47
Savoy Cabbage Wrener Kapuziner	1	Sem. Supér.	9	3	1	16		61
Savoy Iron Head	1		5	2	1	8		58
Viking Extra Early Strain	1	Stokes	8	1	1	13		61
Wisconsin All Season Y.R.	1	Letherman's	1	1	0	20		92
Wisconsin Ballhead Y.R.	1	Vaughan's	0	1	1	37		97
Wisconsin Hollander Y.R.	1	Sem. Supér.	8	1	0	10		54
cottager	4	Sem. suplr.	8	2	1	2		26
Dwarf Thousand–Headed	4	Sem. Supér.	4	4	0	8		58
Green Asparagus Kale	4	sem. suplr.	5	0	0	0		0
Hungary Gap	4	Sem. Supér.	11 (30)	4 (0)	0 (0)	0 (4)		9 (12)
Marrow Stem Green	4	Sem. Supér.	9	1	1	3		29
Rape Kale	4	Sem. Supér.	22	0	2	0		1
Tall Green Kale	4	Sem. suplr.	1 (0)	0 (1)	0 (0)	0 (24)		0 (97)
Thousand–Headed	4	Sem. Supér.	2	1	0	2		47
Varieoated Kale	4	Sem. suplr.	10 (23)	3 (0)	0 (1)	3 (3)		1 (14)

1 = B. oleracea L. var. capitata L.
2 = B. oleracea L. var. *botrytis* L.
3 = B. oleracea L. var. *viridis* L.
4 = B. oleracea L. var. *acephala* DC.
5 = *Brassica* sp.
† Sem. Supér. = Semences Supérieures.