

**Report to the Oregon Processed Vegetable Commission  
2002–2003**

1. Title: Broccoli Breeding, Evaluation and Seed Production
2. Project Leaders: James R. Myers, Horticulture  
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3. Project Status: Terminating 30 June 2003
4. Project Funding: \$7,158 breeding  
\$1,000 processing  
\$8,158 total

Breeding funds were used for a major portion of the support of a vegetable breeding technician, student labor, supplies, greenhouse, and research farm expenses. Processing funds were used for blanching and freezing whole heads for evaluation.

Objectives:

- A. Develop broccoli varieties adapted to western Oregon with:
  1. Relatively tall plants with exerted heads for easy mechanical harvest.
  2. Large openly branched heads with heavy, clean stem for easy trimming and separation into spears and chunks.
  3. Medium fine, firm, uniform florets of good color and short pedicels, and which are retained after freezing.
  4. Early to midseason maturity, concentrated yield potential.
  5. Head rot, clubroot and downy mildew resistance.
- B. Evaluate cytoplasmic male sterility (CMS) as a method for producing F<sub>1</sub> hybrid seed.
- C. Produce seed for limited scale on-farm trials.
5. Report of Progress:

Research efforts were focused on testing various inbred combinations for hybrid production, and developing a viable seed production program.

*Greenhouse inbred and hybrid seed production:* Cuttings taken from the Vegetable Farm in the 2001 season were grown in the 2002 – 2003 greenhouse and used to produce self pollinated and hybrid seed. Thirteen S300 and S400 series inbreds were intercrossed, with the focus on testing S438, S440, S445, S446 and S454 with as many of the best in-

bred lines as possible. Seeds for yield trials were produced for 14 crosses and reciprocals. Also, quantities of seed sufficient for an observation trial were obtained for 33 cross combinations (crosses and reciprocals combined). Seed of five hybrids was produced for grower field trials.

*Yield Trial:* Fourteen OSU hybrids and three commercial checks were grown in a yield trial replicated four times (Tables 1 and 2, Figure 1). Data were recorded for only two of the checks because of poor stand for Regal. The trial was direct seeded 11 July for the main fall harvest. We used 30 inch rows with a within row spacing of 12 inches, attempting to get 30 plants per plot. Primary heads were harvested once, simulating a direct harvest operation. Heads were trimmed to a six-inch head plus stem length prior to weighing. Samples were processed at the OSU Food Science Pilot Plant and frozen for evaluation and display of processing characteristics.

Plant stands were generally lower than target populations, indicating some problems with germination and emergence. Yield data are accordingly based on plant number per plot rather than pounds per unit length. Blind plant frequency was lower in 2002 compared to 2001, but still a significant problem in Excelsior, S445 x S411, and S454 x S411. S454 x S411 also had significantly more young heads compared to other hybrids. Highest yielding based on unadjusted and adjusted yields was S454 x S446, but these yields are inflated because poor plant stand reduced plant competition and allowed oversized head production. Also, yield for S454 x S446 was based on only one plot. While this hybrid has some merit for its very low production of branches, it will need further testing to determine if germination and emergence problems were specific to this year, or are a general phenomenon. Among the top yielding five hybrids were S454 x S387 followed by S454 x S410, S454 x S400, S454 x S398, and Excelsior (Table 1). Over the past three years, S454 x S387 has had the highest average yield (table right). The best OSU hybrids were more uniform and concentrated in maturity than the checks. Head size of S387 x S454 appears comparable to the check hybrids. Two other hybrid combinations that have performed well over years is S400 x S454 and S410 x S454. All hybrids had significantly less leaf in the upper six inches compared to the checks (Table 1).

The best hybrids include S454 as a parent crossed to one of the older inbreds (S387, S400, S410). S445 does not appear to nick well with other inbreds judging by the fact that the majority of crosses to it are in the lower half of the trial for yield. Observation data shown in Table 2 supports the general ranking of hybrids based on yield data. Based on the observation data, S454 x S400 would be preferred over S454 x S410.

*Observation Trials:* An unreplicated observation trial of hybrids and inbreds was also planted on 11 July (Tables 3 and 5). Plots varied in size from one to 20 plants. Data were recorded for plant and head characteristics. General combining ability of the in-

Entry	Three Year Average			
	DAP	No. blind	Lb/ head	T/A (adj)
Regal <sup>2</sup>	76	3.3	0.69	4.4
S387 x S454	79	1.8	0.71	4.7
Excelsior	82	3.1	0.69	4.1
S410 x S454	79	2.3	0.64	4.1
S411 x S454	78	2.7	0.53	3.1
S400 x S454	78	2.5	0.53	3.7

<sup>2</sup>Data for Regal from only 2000 & 2001.

breeds was examined by averaging performance by inbred (Table 4). Hybrids with the highest overall rating were S446 x S438, S454 x S440, and S446 x S445. The inbred that stands out in confirming high average inbred performance was S446 followed by S454 (Table 4). Particularly desirable with S446 is its strong central stem and attractive head. It rarely branches, even when cut (we were unable to take cuttings from the field this year because no branches formed after topping). Such a strongly dominant head would be preferred for a single destructive harvest. Further crosses to this inbred need to be tested and evaluated.

Inbred lines used to make crosses were grown with the observation trial, and observation data were recorded. Inbred characteristics are shown in Table 5.

*Small scale commercial field trial:* We produced sufficient seed of five hybrids (S454 x S387, S454 x S410, S454 x S445, S454 x S400 and S454 x S398) – approximately 1,000 seeds of each – for small scale trials in a grower's field. With our annual production cycle, it is not possible to have seed ready for a spring trial, which is when the processors would prefer to trial this material. Instead of planting a fall harvest trial, seeds were saved for the 2003 growing season.

*Backcross program to CMS inbred:* Backcross 2 seeds were produced in the greenhouse and lines were grown in the field for evaluation. Recurrent parents were chosen for a lack of self-incompatibility, and include S410, S411, and S454. As backcrossing proceeds, lines are beginning to resemble the inbred parents but are sterile at flowering. Lines were evaluated and the best single plants selected for further backcrossing. A final round of backcrossing will be done in the winter 2002-2003 greenhouse.

*Downy mildew resistance:* The trial exhibited a moderate downy mildew infection this year so hybrids and inbreds were rated for this disease. In general, OSU materials were susceptible with the exception of an older, non-exserted inbred (S315). Some resistance was noted in commercial hybrids and in two germplasm lines developed for downy mildew resistance by the Charleston South Carolina USDA breeding program.

## 7. Summary:

Thirteen inbreds used for hybrid production were propagated in the greenhouse, selfed and intercrossed to produce 32 combinations for field-testing. Fourteen of the best hybrids based on observation data were evaluated along with two commercial hybrids in a replicated yield trial. The consensus from three years of trial data are that S454 x S387 and S454 x S410 are the best OSU hybrids on the basis of yield and quality characteristics. Crosses to S446 need additional evaluation because of the desirable non-branching trait of this inbred. OSU hybrids and inbreds were evaluated in an observation trial. S454 and S446 appear to be the best inbreds for use in hybrid combinations with other OSU lines, and will be the focus of future evaluation efforts. Backcrossing into a CMS background continued. A downy mildew epidemic confirmed that limited resistance is present in OSU breeding material. This disease will be the focus of future breeding efforts.

**Table 1. Yield data from a hybrid broccoli trial, Corvallis, 2002.<sup>2</sup>**

Hybrid	Days to Harvest	No. Plts/ Plot	No. Blind Plants	No. Young Heads	No. Culls	No. Good Heads	Lbs/ Good Head	Total T/A	T/A Good Heads	% Leaves
S445 x S387	78	22.3	1.0	2.5	0.0	19.3	0.50	3.89	3.79	11.6
S445 x S396	78	23.0	0.8	2.5	0.0	20.8	0.47	3.74	3.66	6.0
S445 x S398	81	24.8	1.3	4.8	0.5	20.5	0.59	4.64	4.24	1.2
S445 x S400	78	22.8	1.0	3.0	0.0	19.0	0.41	3.15	3.06	9.8
S445 x S410	78	23.8	1.5	4.5	0.5	18.5	0.57	4.08	3.87	10.7
S445 x S411	83	17.5	3.3	6.0	0.0	12.0	0.61	4.40	3.58	6.6
S454 x S387	83	22.5	1.8	5.3	0.0	16.8	0.86	6.35	5.67	9.9
S454 x S396	78	24.5	0.3	3.3	0.0	21.5	0.54	4.24	4.12	8.9
S454 x S398	83	23.0	1.8	5.8	0.3	18.5	0.72	5.52	4.99	3.6
S454 x S400	83	21.0	1.5	4.8	0.0	18.0	0.68	5.61	5.10	3.2
S454 x S410	81	21.8	0.5	4.0	1.0	18.5	0.73	5.85	5.35	5.9
S454 x S411	83	22.0	3.3	10.3	0.0	12.5	0.67	4.31	3.30	11.7
S454 x S446*	85	18.0	0.0	5.0	0.0	13.0	1.19	7.50	8.30	5.0
S454 x S445	81	25.0	0.5	6.3	1.0	18.5	0.67	4.93	4.32	5.4
Excelsior	83	17.5	4.8	5.8	1.0	13.3	0.76	6.03	4.97	27.5
Legend	78	21.5	1.0	4.8	0.0	15.5	0.73	5.12	4.71	28.0
LSD @ 5%		3.4	1.6	2.7	0.8	4.4	0.14	1.29	1.39	8.9

<sup>2</sup>Planted July 11 in 30' plots, rows 30" apart, thinned to 12" between plants. Mean of four replications, except in the case of S454 x S446\*, which had only 1 good plot.

Table 2. Broccoli yield trial observation data, Corvallis, 2002.<sup>z</sup>

Line	Maturity (days)	Plt Ht (cm) <sup>y</sup>	Head Dia (cm)	Head Shape <sup>x</sup>	Head Color <sup>w</sup>	Bead Size <sup>v</sup>	Stem Color <sup>w</sup>	Head Exser-tion <sup>w</sup>	Head Segment-ation <sup>w</sup>	Plot Unifor-mity <sup>w</sup>	Branch-ing <sup>w</sup>	Downy Mildew <sup>u</sup>	Overall Score <sup>w</sup>	Notes
S445 x S387	78	56/54	13.0	3	7	M	5	7	7	3	1	5	5	
S445 x S396	78	61/63	18.0	7	7	C	7	7	3	5	1	3	7	
S445 x S398	81	62/59	15.0	6	7	C	7	7	7	5	1	5	6	
S445 x S400	78	61/62	13.0	6	8	M	5	7	7	5	1	5	7	
S445 x S410	78	54/55	17.0	4	7	F	5	7	5	3	5	5	3	Small, soft segments
S445 x S411	83	61/57	14.0	5	7	F	7	8	7	5	1	5	7	
S454 x S387	83	59/66	17.0	5	7	F-M	7	5	7	5	3	6	6	Large heads
S454 x S396	78	60/62	16.0	5	7	M	7	6	7	5	1	5	7	
S454 x S398	83	65/70	15.0	5	6	M	7	7	7	3	3	5	5	
S454 x S400	83	61/58	14.0	6	7	M	7	8	7	5	1	5	7	
S454 x S410	81	63/58	14.0	4	5	F	7	7	7	5	1	6	5	Small irregular florets
S454 x S411	83	63/64	17.0	5	5	F	5	7	8	3	1	5	5	Slightly irregular segments
S454 x S446*	85	55/63	15.0	5	7	M	5	6	7	3	3	5	5	Nice appearance; lack of uniformity is only detriment
S454 x S445	81	57/60	15.0	6	7	F	7	6	3	5	1		6	Irregular segmentation
Excelsior	83	41/68	13.0	5	5	F	3	3	5	3	1	6	3	
Legend	78	40/74	16.0	4	3	M	3	3	3	5	1	2	3	

<sup>z</sup>Planted July 11 in 30" rows, thinned to 12" apart.

<sup>y</sup>First value is height of the head, second value is height of the tallest leaves.

<sup>x</sup>Scale of 1-9 where 1 = concave, 3 = flat, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

<sup>w</sup>Scale of 1-9 where 1 = poor and 9 = excellent.

<sup>v</sup>F = fine, M = medium, C = coarse.

<sup>u</sup>Scale of 1-9 where 1 = no symptoms and 9 = severe.

Table 3. Broccoli observation trial, OSU hybrids, Corvallis, 2002.<sup>2</sup>

Hybrid	Maturity (days)	Plt Ht (cm) <sup>y</sup>	Head Diam (cm)	Head Shape <sup>x</sup>	Head Color <sup>w</sup>	Bead Size <sup>v</sup>	Stem Color <sup>w</sup>	Head Exsertion <sup>w</sup>	Head Segmentation <sup>w</sup>	Plot Uniformity <sup>w</sup>	Branching <sup>w</sup>	Overall Score <sup>w</sup>	Notes
S387 x S438	78	55/50	15.0	4	6	M-C	6	6	7	6	1	4	Flat head; rapidly developing coarse beads
S396 x S438	78	61/53	16.0	4	5	M-C	7	7	6	5	2	5	
S398 x S438	78	55/58	14.0	5	5	M-C	6	7	6	5	1	5	
S400 x S438	78	63/57	14.0	5	6	M-C	7	7	4	5	1	5	
S410 x S438	79	57/56	16.0	5	6	F	6	7	8	6	3	7	Irregular floret size
S411 x S438	87	56/56	12.0	5	7	F	7	7	7	3	1	5	
S442 x S438	85	56/58	18.0	4	7	F	7	7	9	4	3	5	Florets are somewhat irregular
S445 x S438	85	60/59	18.0	4	7	F-M	8	7	9	6	3	7	Fairly flat heads
S446 x S438	85	64/66	17.0	5	7	F	7	7	8	6	3	9	
S454 x S438	87	57/64	14.0	5	7	F	7	6	7	6	3	7	
S387 x S440	81	58/60	16.0	3	6	C	5	7	8	6	4	4	
S396 x S440	78	60/63	13.0	6	6	M-C	6	7	7	3	4	3	
S398 x S440	80	57/51	15.0	5	6	M-C	6	8	7	5	2	4	
S400 x S440	78	60/55	14.0	6	5	C	8	8	5	4	2	4	Loose heads
S410 x S440	79	62/58	18.0	4	4	F-M	7	7	9	5	3	5	Loose heads
S411 x S440	78	62/65	15.0	5	5	C	6	7	7	5	1	5	
S442 x S440	80	59/54	17.0	5	7	M-C	7	7	8	5	1	7	
S445 x S440	83	53/52	16.0	5	7	F-M	6	6	8	5	2	5	
S446 x S440	80	59/63	14.0	6	7	M-C	5	7	7	5	1	7	Very strong single stem
S454 x S440	79	60/60	15.0	6	7	M-C	5	7	7	6	1	8	
S396 x S445	79	68/64	15.0	4	7	C	7	8	7	4	1	5	
S398 x S445	80	60/58	14.0	5	6	M-C	7	8	7	5	1	5	
S400 x S445	79	59/56	14	6.0	7	M	7	7	7	7	1	7	
S410 x S445	79	60/54	17.0	4	5	F	7	7	9	3	1	3	Tendency to loose, small, floretted heads
S411 x S445	83	59/64	16.0	5	7	F-M	6	7	8	3	3	3	Too variable
S446 x S445	87	68/71	13.0	6	7	F-M	7	8	7	5	1	9	Very tall; heads may be too small but otherwise very nice

**Table 3. Broccoli observation trial, OSU hybrids, Corvallis, 2002 (cont).<sup>z</sup>**

Hybrid	Maturity (days)	Plt Ht (cm) <sup>y</sup>	Head Diam (cm)	Head Shape <sup>x</sup>	Head Color <sup>w</sup>	Bead Size <sup>v</sup>	Stem Color <sup>w</sup>	Head Ex-ertion <sup>w</sup>	Head Segment-ation <sup>w</sup>	Plot Uni-form-ity <sup>w</sup>	Branch-ing <sup>w</sup>	Overall Score <sup>w</sup>	Notes
S387 x S454	84	55/69	13.0	5	7	C	5	6	6	6	3	4	
S396 x S454	81	64/67	17.0	5	7	M	7	7	7	5	4	7	
S398 x S454	81	61/60	15.0	5	6	M	7	7	7	7	1	8	
S400 x S454	81	58/62	12.0	5	7	F-M	7	7	7	5	3	7	
S410 x S454	87	63/69	16.0	5	6	F-M	5	7	7	5	3	5	Irregular heads and bead size
S411 x S454	87	63/71	14.0	5	7	F-M	6	7	7	6	3	7	Some rough irregular heads
S445 x S454	84	63/65	16.0	6	7	F-M	8	8	7	4	2	7	

<sup>z</sup>Planted July 11 in 30" rows, thinned to 12" apart.

<sup>y</sup>First value is height of the head, second value is height of the tallest leaves.

<sup>x</sup>Scale of 1-9 where 1 = concave, 3 = flat, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

<sup>w</sup>Scale of 1-9 where 1 = poor and 9 = excellent.

<sup>v</sup>F = fine, M = medium, C = coarse.

**Table 4. Average inbred performance of broccoli hybrids, Corvallis, 2002.<sup>z</sup>**

Source	Maturity (days)	Plt Ht (cm) <sup>y</sup>	Head Dia. (in)	Head Shape <sup>x</sup>	Head Color <sup>w</sup>	Bead Size <sup>v</sup>	Stem Color <sup>w</sup>	Head Exser-tion <sup>w</sup>	Head Seg-ment-ation <sup>w</sup>	Plot Uni-form-ity <sup>w</sup>	Branch-ing <sup>w</sup>	Overall Score <sup>w</sup>
S387 crosses	81	56/60	14.5	3.3	6.1	M-C	5.1	6.7	7.4	5.6	2.9	3.6
S396 crosses	79	64/62	15.4	4.8	6.4	M-C	6.7	7.5	6.7	4.6	2.7	5.3
S398 crosses	80	58/56	14.6	4.7	5.8	M-C	6.6	7.3	6.8	5.4	1.3	5.5
S400 crosses	79	60/58	13.7	5.5	6.0	M-C	7.3	7.3	5.7	5.0	2.0	5.5
S410 crosses	81	60/58	17.1	3.9	4.9	F-M	6.6	6.7	8.6	4.7	2.6	4.7
S411 crosses	84	61/68	14.3	4.7	6.3	F-M	6.3	6.5	7.2	4.6	2.3	5.3
S438 crosses	78	59/59	15.4	4.6	6.4	F-C	6.9	6.8	7.2	5.1	2.1	6.1
S440 crosses	80	59/58	14.9	4.8	6.1	M-C	6.1	7.0	7.1	5.0	2.0	5.3
S442 crosses	82	59/58	17.4	4.4	7.0	F-M	7.0	6.9	8.8	4.8	2.0	6.0
S445 crosses	83	60/60	15.3	4.9	6.5	F-M	6.9	7.0	7.6	4.9	1.8	5.9
S446 crosses	84	64/66	13.9	5.5	7.0	F-M	6.5	7.5	7.3	5.5	1.5	8.9
S454 crosses	83	61/65	14.7	5.1	6.6	F-M	6.5	6.9	6.9	5.6	2.4	6.6

<sup>z</sup>Planted July 11 in 30" rows, thinned to 12" apart. Number of crosses differed for each inbred.

<sup>y</sup>First value is height of the head, second value is height of the tallest leaves.

<sup>x</sup>Scale of 1-9 where 1 = concave, 3 = flat, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

<sup>w</sup>Scale of 1-9 where 1 = poor and 9 = excellent.

<sup>v</sup>F = fine, M = medium, C = coarse.



**Table 5. Broccoli observation trial, OSU inbreds, Corvallis, 2002.<sup>z</sup>**

Inbred	Maturity (days)	Plt Ht (cm) <sup>y</sup>	Head Diam (cm)	Head Shape <sup>x</sup>	Head Color <sup>w</sup>	Bead Size <sup>v</sup>	Stem Color <sup>w</sup>	Head Ex-ertion <sup>w</sup>	Head Segment-ation <sup>w</sup>	Plot Uni-form-ity <sup>w</sup>	Branch-ing <sup>w</sup>	Overall Score <sup>w</sup>	Notes
S310	85	43/61	19	3	3	F-C	5	5	5	1	5	3	Variable bead size
S315	76	47/53	14	5	5	C	7	5	3	3	1	5	
S370	78	56/49	10	7	7	M	7	9	3	7	1	7	
S384	93	51/58	13	7	7	M	5	5	7	5	5	3	
S387	87	55/60	16	3	7	C	7	6	5	5	3	5	Leaves in head
S389	79	44/49	12	5	7	C	5	6	3	1	7	3	
S391	81	48/49	13	5	5	M	7	6	5	3	5	7	
S392	87	70/66	11	6	7	M	7	9	9	3	5	5	
S396	78	64/58	12	7	7	M	7	9	5	7	1	7	
S398	81	54/49	13	3	5	C	5	7	9	5	3	5	Loose head; irregular florets
S399	79	53/53	12	7	5	C	5	7	1	7	1	7	
S400	77	67/56	13	5	5	M	7	9	3	5	1	7	
S403	80	64/67	12	7	9	F	5	7	7	1	7	3	Several blind plants
S410	85	61/57	13	4	7	F	7	7	7	5	3	7	
S411	85	55/57	12	5	7	F	7	8	8	7	1	7	Distinct leaf--long and narrow
S414	81	58/52	14	3	7	M	7	9	8	5	3	5	Some rosetting
S438	78	56/48	12	5	7	M	7	7	5	1	1		Bad plot--low spot in field
S440	81	56/49	12	5	7	C	5	8	7	1	3	5	Might be good home garden
S442	91	57/56	14	5	7	F	7	7	9	7	1	7	Loose heads but good florets
S443	78	53/53	14	4	7	M	7	7	7	1	5	3	Flat head; holding well
S445	81	57/52	13	5	6	M	7	8	8	3	1	7	small heads
S446	91	68/71	11	7	7	M	5	8	7	5	1	7	Small heads but strong central stem
S447	89	68/69	13	6	5	VF	7	7	8	3	1	7	Must be picked with very fine beads or heads get soft
S454	89	44/42	15	5	8	F	5	7	6	3	3	7	

<sup>z</sup>Planted July 11 in 30" rows, thinned to 12" apart.

<sup>y</sup>First value is height of the head, second value is height of the tallest leaves.

<sup>x</sup>Scale of 1-9 where 1 = concave, 3 = flat, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

\*Scale of 1-9 where 1 = poor and 9 = excellent.

^F = fine, M = medium, C = coarse.

