

**Report to the Oregon Processed Vegetable Commission
2005–2006**

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, 2006
4. Project Funding: \$8,000 breeding
 \$3,000 processing
 \$11,000 total

Research efforts were focused on testing various inbred combinations for hybrid production, and developing a viable seed production program. Breeding funds were used for a major portion of the support of a vegetable breeding technician, student labor, supplies, and research farm expenses. Processing funds were used for processing samples of experimental hybrids.

5. Objectives:
 - I. Develop broccoli varieties adapted to western Oregon with suitable quality, high yields, and disease resistance. Specific traits include:
 - a. Early to midseason maturity
 - b. Concentrated yield potential
 - c. Downy mildew resistance
 - d. Exerted heads with large openly branched heads with heavy, clean stem for easy trimming and separation into spears and chunks
 - e. Firm, uniform florets of good color
 - f. Fine beads with short pedicels, which are retained after freezing
 - II. Evaluate cytoplasmic male sterility (CMS) as a method for producing F₁ hybrid seed.

6. Report of Progress:

Greenhouse inbred and hybrid seed production: Cuttings were taken from inbreds and breeding lines grown in the field in 2004 to establish material for crossing and hybrid seed production in the greenhouse during the winter of 2004-2005. A total of seven cross combinations (Tables 1-3) were obtained. The number of combinations tested was lower this year mainly due to poor establishment of cuttings, thus having fewer plants for crossing. Cuttings were lost to microbial contamination, which may be in turn, related to the high incidence of head rot in 2004.

Yield Trial: Sufficient seed was available to test five hybrid combinations in replicated yield trials (Table 1). These were direct seeded on July 1 in 30 ft rows spaced 30 in between rows with four replications. After emergence, plots were thinned to 12 in between plants. Data were collected at harvest maturity on plant and head characteristics, yield, and a sample of each hybrid was collected for processing and evaluation at the OSU Food Science and Technology Pilot Plant. Data from the Pilot Plant had not been completed at the time of this report and will be reported separately. Three check hybrids (Regal, Excelsior, and Emerald Pride) were included for comparison to experimental hybrids. Four of five experimental hybrids had maturities similar to Emerald Pride (82 d) while one was later and more similar to Excelsior (87 d). Emerald Pride followed by Regal were highest yielding in the trial (Table 1, Figures 1 & 2). Highest yielding among the experimental materials were S410 x S442 and S447 x S454, which were significantly lower than Emerald Pride, but similar to Regal (adjusted T/A). Other parameters (no. blind plants, no. young heads, no. culls, and % leaves) showed that there was a high degree of variability for maturity in plots (Table 1). Three of five experimental hybrids had number of blind plants similar to Excelsior and Regal, the other two experimentals being significantly lower but not significantly different from Emerald Pride. All experimental hybrids except S410 x S442 had a relatively large number of immature and over mature heads, and the same set had a higher proportion of leaves on trimmed heads (indicative of immature heads). In past years, OSU hybrids have mostly shown better uniformity compared to checks, but this pattern was not apparent in 2005. It may be that an interaction of the hybrid cross combinations tested with environmental conditions specific to 2005 contributed to greater variability in growth uniformity. Only S410 x S 442 exhibited the uniformity expected for OSU materials. In addition, average head sizes were smaller in the OSU materials compared to the checks.

Data from more than one year of trial are available for two cross combinations
Two yr average of selected broccoli hybrids

Entry	Maturity (Days)	No. Blind	Lbs/Head	T/A
S387 x S410	84	2.9	0.50	3.0
S410 x S446	85	3.3	0.57	2.4
Emerald Pride	83	1.3	0.70	4.4
Excelsior	86	3.5	0.70	2.8
Regal	74	2.3	0.71	3.7
LSD @ 5%		1.6	NS	1.3

(Table 4, text table left). Both hybrid combinations had better performance in 2004; S387 x S410 was ranked second and S410 x S446 was tied with Excelsior for 7th place (Table 4). In 2005, yield of Regal and Excelsior, but not Emerald Pride was also lower than that observed in previous years (Table 4). Overall, not all factors are known that contributed to lower yields, however,

the second half of the growing season in 2005 was warmer than normal, with average deviations from normal of 3.0, 5.3 and 1.2° F for July, August, and September, respectively. We were able to take advantage of the heat to evaluate OSU materials for heat tolerance.

Observation Trials: These trials included the five experimental hybrids included in the yield trial (Table 2), as well as two experimental hybrids that had insufficient seed for yield trials, and cytoplasmic male sterile (CMS) based hybrids produced in the field in

2004 (Table 3). The two hand-crossed hybrids have been tested in yield trials in previous years (Table 4), and both continue to show desirable traits and performance.

In 2004, we established a set of six isolation plots to evaluate possibility of field crossing using a CMS inbred line as the female parent, and a normal inbred as the male. The F₁ hybrids from cross combinations that set seed in 2004 were grown in 2005 for observation (Table 3). Plot size varied from 30 to 300 ft depending on quantity of seed available. Our main objective was to evaluate for the presence of off types and selfs that might have arisen during field production. The only cross combination where off types were found was (CMS14-4 x S411) x S445 (Table 3). These, however, did not appear to be selfs, but may have come from an outcross to non OSU hybrids. All other cross combinations showed a high degree of uniformity, particularly (CMS13-1 x S454) x S387, which was also the most productive for seed production. Other crosses that produced hybrids with good horticultural characteristics were (CMS 12-2 x S410) x S454, and (CMS 13-1 x S454) x S411. Best seed production was obtained with CMS 13-1 x S454 used as the female parent.

CMS crossing at the Vegetable Research Farm in 2005

Female	Male	Notes
CMS14-1 x S411	S454	Found 1 fertilized silique in CMS line, copious seed on S454
CMS 12-2 x S410	S446	Very low frequency seed set on CMS line, low freq on S446
S445	S454	Copious seed set on S454, more limited seed set on S445
CMS13-1 x S454	S446	Moderate seed set on CMS line and inbred
CMS14-1 x S411	S446	No seed set on CMS line Sporadic Seed set on S446

CMS seed production: In 2005 we established five isolation crossing plots for testing seed production. Four combinations were of a CMS female by fertile inbred as the male line (text table, left). In the case of S445 x S454, both were male and female fertile inbreds, with S445 possessing self incompatibility while S454 is self fertile. We are investigating whether self incompatibility in S445 could be used to produce hybrid seed. As found in 2004, CMS 13-1 x S454 showed relatively high seed set, whereas other CMS cross combinations had low seed set. Moderate seed set was observed on S445. Seed from these crosses will be grown out in 2006 to continue evaluation of hybrid performance.

Broccoli crosses made in 2003 and 2004	
Female	Male
S454	S387
S411	S446
S454	S446
Emerald Pride	S454
S454 x S387	S411 x S446
S454 x S446	USVL 089

Breeding program: A series of crosses initiated among elite OSU inbred, with commercial lines and to sources of downy mildew resistance (USVL 089) were made in 2003 and 2004. From these, selections were made in 2004 and have been further inbred and advanced in 2005. Our objective is to develop improved broccoli hybrids with qualities needed for processing, while adding resistance to head rot and downy mildew. In 2004, crosses were heavily selected for head rot resistance, and in 2005, they were selected for heat tolerance.

Only low levels of disease were observed in 2005.

7. Summary:

While yield trials in 2005 showed reduced productivity, the above average temperatures allowed us to evaluate our materials and commercial hybrids for heat tolerance. Progress was made in developing seed production systems. At least one hybrid combination based on CMS will produce acceptable hybrid seed.

The broccoli breeding program is in a transition phase. We have tested 36 S300 – S400 inbred cross combinations during the past six years (Table 5), and have identified several inbreds that combine well to produce acceptable yields and processed product (Table 4). Seed production systems are near to being established. We are looking to a new cycle of inbred development to rectify perceived problems with existing inbreds in the area of downy mildew and head rot.

Table 1. Yield data from a hybrid broccoli trial, Corvallis, 2005.^z

Hybrid	Days to Harvest	No. Plts/ Plot	No. Blind Plants	No. Young Heads	No. Culls	No. Good Heads	Lbs/ Good Head	T/A Good Heads	T/A Good Heads (Adj) ^y	% Leaves ^x
S387 x S410	83	26.3	1.5	3.0	2.8	19.0	0.26	1.39	1.33	27.1
S410 x S442	91	22.5	1.3	0.8	0.0	17.5	0.46	2.32	2.58	6.1
S410 x S446	83	23.8	2.3	2.3	2.5	16.8	0.28	1.36	1.42	33.2
S410 x S447	83	25.0	3.8	1.5	4.0	15.8	0.33	1.46	1.46	18.8
S447 x S454	80	23.0	2.0	4.0	1.3	16.3	0.48	2.24	2.45	28.7
Emerald Pride	82	26.0	0.5	2.3	0.0	23.5	0.63	4.32	4.13	27.1
Excelsior	87	26.0	3.0	5.8	0.5	14.8	0.53	2.25	2.17	32.0
Regal	73	26.8	3.0	3.0	0.5	20.3	0.56	3.30	3.11	23.4
LSD @ 5%		4.2	1.6	2.7	1.7	5.7	0.08	0.79	0.65	12.4

^zPlanted July 1 in 30' plots, rows 30" apart, thinned to 12" between plants. Mean of four replications.

^yYield adjusted to 25 plants per plot.

^xPercentage leaves remaining on head trimmed to 6 in.

Table 2. Observation data from a hybrid broccoli trial, Corvallis, 2005.^z

Line	Maturity (days)	Plant Ht (cm) ^y	Head Dia (cm)	Head Shape ^x	Head Color ^w	Bead Size ^v	Stem Color ^w	Head Exsertion ^w	Head Segmentation ^w	Plot Uniformity ^w	Branching ^w	Overall Score ^w	Notes
S387 x S410	83	51/69	14	6	7	M	7	8	7	2	6	5	Variable maturity
S410 x S442	91	45/61	11	6	7	F	7	6	9	3	5	3	
S410 x S446	83	56/71	10	9	7	F	6	5	7	3	4	5	
S410 x S447	83	51/69	13	8	6	F	5	4	6	2	5	5	Variable maturity; discolored culls with white and brown florets
S447 x S454	80	43/62	16	7	7	M	6	5	6	2	2	4	
Emerald Pride	82	50/73	16	6	5	M	5	3	6	5	4	6	
Excelsior	87	44/66	12	6	3	F	3	4	7	3	3	5	
Regal	73	32/49	12	6	4	C	5	3	3	5	5	3	

^zPlanted July 1 in 30" rows, thinned to 12" apart.

^yFirst value is height of the head, second value is height of the tallest leaves.

^xScale of 1-9 where 1 = concave, 5 = flat, and 9 = extreme dome.

^wScale of 1-9 where 1 = poor and 9 = excellent.

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

Table 3. Broccoli observation trial, OSU hybrids, Corvallis, 2005.^z

Hybrid	Maturity (days)	Plant Ht (cm) ^y	Head Diam (cm)	Head Shape ^x	Head Color ^w	Bead Size ^v	Stem Color ^w	Head Exsertion ^w	Head Segmentation ^w	Plot Uniformity ^w	Branching ^w	Overall Score ^w	Notes
S442 x S454	92	57/62	17	6	7	F	7	7	8	7	4	7	One plant with somewhat irregular florets, but otherwise very nice
S454 x S446	92	66/76	17	8	7	F	5	7	6	8	3	8	Very nice large dense heads; good dome shape
(CMS12-2 x S410) x S400	90	79/80	15	8	6	M	7	9	6	5	5	5	Very tall and exserted but small light weight heads
(CMS12-2 x S410) x S454	92	64/70	14	6	7	F	7	6	6	5	3	7	Attractive but not as uniform as desired
(CMS13-1 x S454) x S387	91	66/72	15	7	7	F-M	7	7	7	7	3	7	Very uniform maturity
(CMS13-1 x S454) x S411	89	55/79	18	6	7	F	7	7	7	5	1	7	Very uniform in appearance; some variability in maturity
(CMS14-1 x S411) x S398	86	66/66	14	7	5	F	6	9	7	3	3	6	Some variability in maturity
(CMS14-4 x S411) x S445	90	55/61	14	7	6	F-M	5	7	7	1	7	3	Highly variable; best plants very nice but also contains a small headed, coarse beaded variant

^zPlanted July 1 in 30" rows, thinned to 12" apart.

^yFirst value is height of the head, second value is height of the tallest leaves.

^xScale of 1-9 where 1 = concave, 3 = flat, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

^wScale of 1-9 where 1 = poor and 9 = excellent.

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

Table 4. Yield data from six years of broccoli yield trials, Corvallis, 2005

Entry	Tons/Acre					
	2000	2001	2002	2003	2004	2005
S387 x S410					4.62	1.39
S387 x S411					2.45	
S387 x S438		2.82				
S387 x S445			3.79			
S387 x S446		2.73		5.40		
S387 x S454 ^z	3.83	4.14	5.67	6.40	3.34	
S396 x S445			3.66			
S396 x S446		1.83		4.90		
S396 x S454 ^z		2.64	4.12	4.30		
S398 x S438		1.88				
S398 x S445			4.24			
S398 x S446		2.56		5.20		
S398 x S454 ^z		4.37	4.99			
S399 x S453	3.26					
S399 x S454	3.36					
S400 x S438		1.84				
S400 x S445			3.06			
S400 x S446				3.90		
S400 x S453	3.05					
S400 x S454 ^z	2.87	2.36	5.10	3.80		
S410 x S442						2.32
S410 x S445			3.87			
S410 x S446					3.43	1.36
S410 x S447						1.46
S410 x S453	3.44					
S410 x S454 ^z	3.79	3.72	5.35	5.70	3.79	
S411 x S445			3.58			
S411 x S446		3.70		5.30		
S411 x S453	2.96					
S411 x S454 ^z	3.49	3.96	3.30		2.72	
S438 x S442		4.22				
S440 x S446				5.10		
S442 x S454		3.65			3.92	
S443 x S454		3.14				
S445 x S454 ^z		4.07	4.32	6.10	3.40	
S446 x S454				3.70	4.83	
S447 x S454					2.31	2.24
Arcadia	3.73					
Excelsior	2.43	3.78	4.97	3.90	3.43	2.25
Legend	3.23		4.71			
Regal	3.95	3.63		5.30	4.17	3.30
Emerald Pride				3.40	4.54	4.32
LSD @5%	0.52	0.84	1.39	0.90	0.93	0.79

^zCross and reciprocal combined.

Table 5. Inbred line combinations tested in 6 years of broccoli yield trials, Corvallis, 2005^z.

Inbred Line	S410	S411	S438	S442	S445	S446	S447	S453	S454
S387	2	1	1	0	1	2	0	0	5
S396	0	0	0	0	1	2	0	0	3
S398	0	0	1	0	1	2	0	0	2
S399	0	0	0	0	0	0	0	1	1
S400	0	0	1	0	1	1	0	1	4
S410	-	0	0	1	1	2	1	1	5
S411		-	0	0	1	2	0	1	4
S438			-	1	0	0	0	0	0
S440				0	0	1	0	0	0
S442				-	0	0	0	0	2
S443					0	0	0	0	1
S445					-	0	0	0	4
S446						-	0	0	2
S447							-	0	2

^zNumber in each cell indicates the number of times this combination has been tested.

Figure 1. Broccoli Yield Trial, OSU Vegetable Research Farm, 2005

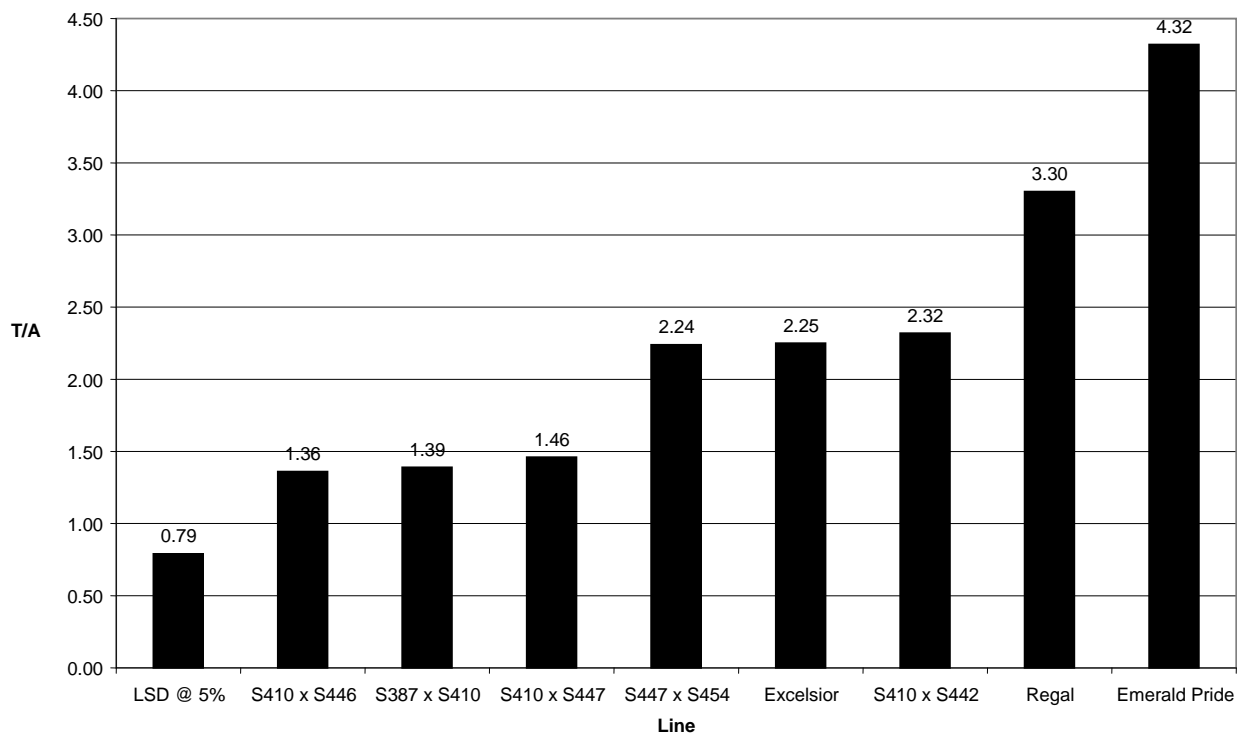


Figure 2. Broccoli Yield 2005 Adjusted to 25 Plants Per Plot

