Report to the Oregon Processed Vegetable Commission
2001–2002

1. Title: Broccoli Breeding and Evaluation

2. Project Leaders: James R. Myers, Horticulture
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3. Project Status: Terminating 30 June 2002

4. Project Funding: $7,571 breeding
$1,000 processing
$8,571 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.

5. Objectives:

A. Develop broccoli varieties adapted to western Oregon with the following attributes:

i. Relatively tall plants with exserted heads for easy mechanical harvest.

ii. Large openly branched heads with heavy, clean stem for easy trimming and separation into spears and chunks.

iii. Medium fine, firm, uniform florets of good color and short pedicels, and which are retained after freezing.

iv. Early to midseason maturity, concentrated yield potential.

v. Head rot, clubroot and downy mildew resistance.

B. Evaluate cytoplasmic male sterility (CMS) as a method for producing F_1 hybrid seed.

6. Report of Progress:

We continued to refine and focus the program to identify the best hybrids for production and develop sustainable seed production systems.

Greenhouse inbred and hybrid seed production: Cuttings taken from the Vegetable Farm in the 2001 season were grown in the greenhouse and used to produce selfed and hybrid seed. Thirteen S300 and S400 series inbreds were intercrossed, with the focus on testing

S438, S446 and S454 with as many of the best inbred lines as possible. Seeds for yield trials were produced for 17 crosses and reciprocals. Also, quantities of seed sufficient for an observation trial were obtained for 32 cross combinations (crosses and reciprocals combined).

Field Hybrid Seed Production: The cross S387 x S 454 was planted in April in isolation to determine the potential for hybrid seed from this cross combination. Seed set was high on S454 (the self-fertile parent) but unexpectedly low on S387, the self-incompatible parent. It appears that this cross combination will not work *per se*. A third backcross was made in the greenhouse between the Arnand cytoplasmic male sterile (CMS) line and S410, S411, and S454. Seed from these crosses were taken to the field and were planted in isolation with either S410, S411, or S454 at the Lewis Brown Farm. Plots were direct seeded but late enough that seed was not set before the onset of winter rains. We did, however, obtain data on plant and head characteristics. Cuttings were taken into the greenhouse to make another set of backcrosses during the spring of 2002.

Yield Trial: Seventeen OSU hybrids and three commercial checks were grown in a yield trial replicated four times (Tables 1 and 2, Figures 1 and 2). The trial was direct seeded 9 July for the main fall harvest. We used 36 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 this year. We also encountered a significant number of blind plants, indicative of early growing point damage. The greatest number of blind plants was found in the check varieties (Table 1.) Highest yielding based on unadjusted yields were S398 x S 454 followed by S438 x S442 S445 x S454 and S387 x S454. Adjusted yield ranking was similar, except for S411 x S454, whose yield was inflated because of poor stand. The OSU hybrids was more concentrated in maturity, producing a greater economic yield than Regal and Excelsior, which had a greater number of young heads and culls. Head size of S387 x S454 appears comparable to the check hybrids.

S454 continues to be a good combiner, and the cross combination S387 x S454 is holding up well in two years of testing (table below). Other hybrid combinations tested for two years generally showed lower yields, although the cross S410 x S454 is promising with its large head size.

	2000				2001				2000 - 2001 Average			
Entry	DAP	No. blind	Lb/ head	T/A adj	DAP	No. blind	Lb/ head	T/A adj	DAP	No. blind	Lb/ head	T/A adj
Regal	72	5.3	0.65	4.4	79	1.3	0.72	4.4	76	3.3	0.68	4.4
S387 x S454	77	2.0	0.60	4.3	77	1.5	0.68	4.1	77	1.8	0.64	4.2
Excelsior	79	3.0	0.45	2.8	83	1.5	0.86	4.6	81	2.3	0.65	3.7
S410 x S454	79	2.5	0.54	3.9	76	3.8	0.65	2.9	78	3.1	0.60	3.4
S411 x S454	79	2.3	0.49	3.5	73	2.5	0.42	2.6	76	2.4	0.45	3.1
S400 x S454	77	4.3	0.41	3.0	73	1.8	0.50	3.1	75	3.0	0.45	3.0

Observation data shown in Table 2 indicates that some entries (S398 x S446, S442 x S454) were of lower quality, and/or had less plot uniformity. The two lines given the highest overall ratings were S387 x S454 and S411 x S446. The former hybrid has desirable all around processing characteristics while the latter cross also has the potential for large head size and long harvest window.

Observation Trials: An unreplicated observation trial of hybrids, inbreds and commercial lines was also planted on 5 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 inbreds was examined by averaging performance by inbred (Table 4). Rated best in this trial was S411 x S454.

Inbred lines used to make crosses were grown with the observation trial, and observation data were recorded (Table 5). S300 and S400 series inbreds with the highest ratings were S391, S440, S442, and S454. Some inbreds may have potential for release as an open pollinated variety.

Small scale commercial field trial: Approximately 1,000 seeds of the cross S387 x S454 were provided to a grower in the Donald area. He produced transplants that were planted into two rows in a commercial broccoli field with product intended for Norpak. The crop was harvested with a two row Brussels sprout harvester. OSU material yielded 3.6 T/A. At an eight inch within row spacing, head size seemed small for the OSU material. The OSU hybrid was also susceptible to downy mildew (not a problem previously observed at the Vegetable Farm) and was rated as not having as sweet a flavor as other commercial broccoli.

7. Summary:

Thirteen inbreds used for hybrid production were propagated in the greenhouse, selfed and intercrossed to produce 32 combinations for field-testing. Seventeen of the best hybrids based on observation data were grown with three commercial hybrids in a replicated yield trial. Four OSU hybrids had unadjusted yields better than the commercial hybrids (although not significantly different), while also possessing an exserted plant habit with segmented heads. OSU hybrids and inbreds were evaluated in an observation trial. S454 appears to be the best inbred for use in hybrid combinations with other OSU

lines, and will be the focus of future evaluation efforts. It may be fortuitous that S454 is self-compatible, and can be incorporated into a CMS background for easy crossing to other inbred lines.

8. Signatures:

Redacted for Privacy

Project Leader: _____

Redacted for Privacy

Department Head _____

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Table 1. Yield data from a hybrid broccoli trial, Corvallis, 2001.[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
S387 x S438	73	19.0	1.8	1.3	0.0	17.0	0.57	2.82	3.09	2.4
S387 x S446	74	18.0	1.8	1.8	0.0	14.0	0.65	2.73	2.83	6.4
S387 x S454	77	24.8	3.8	0.3	0.0	20.8	0.74	4.14	4.33	1.9
S396 x S446	69	16.5	2.8	2.8	0.0	10.0	0.64	1.83	1.94	25.1
S396 x S454	73	24.3	2.5	1.5	0.3	19.3	0.47	2.64	2.64	5.0
S398 x S438	71	18.0	2.5	1.0	0.0	15.0	0.41	1.88	2.01	3.2
S398 x S446	74	16.5	2.5	0.8	0.0	12.5	0.60	2.56	2.56	4.4
S398 x S454	79	21.8	1.3	0.5	0.0	19.8	0.74	4.37	4.37	0.5
S400 x S438	72	19.5	2.3	1.5	0.3	14.5	0.43	1.84	1.84	6.6
S400 x S454	73	22.0	2.3	1.5	0.0	18.0	0.45	2.36	2.36	5.7
S410 x S454	76	19.0	1.3	1.0	0.8	16.0	0.76	3.72	3.72	3.6
S411 x S446	83	15.8	1.8	0.3	0.0	11.8	0.93	3.70	3.85	1.3
S411 x S454	83	16.3	1.5	0.5	0.0	14.0	0.89	3.96	4.59	1.4
S438 x S442	76	20.5	1.8	1.5	0.8	16.3	0.83	4.22	4.22	6.2
S442 x S454	77	20.8	2.0	1.0	0.3	17.5	0.65	3.65	3.65	8.0
S443 x S454	74	22.5	1.5	1.8	0.0	19.3	0.53	3.14	3.14	6.2
S445 x S454	77	22.0	1.5	1.0	0.0	19.5	0.72	4.07	4.07	3.1
Regal	66	21.8	3.0	1.8	0.5	16.5	0.72	3.63	3.63	17.0
SBC 7408	76	17.8	3.8	0.8	0.0	12.5	0.69	2.89	2.89	18.8
Excelsior	83	23.3	2.3	1.8	1.0	17.8	0.72	3.78	3.78	14.6
LSD @ 5%		3.4	2.4	1.5	NS	3.7	0.18	0.84	0.85	4.8

[z]Planted July 9 in 30' plots, rows 36" apart, thinned to 12" between plants. Mean of four replications.

[y]Yield adjusted to eliminate gaps in stand.

Table 2. Broccoli yield trial observation data, Corvallis, 2001.[z]

Line	Maturity (days)	Plt Ht (cm)	Head Dia (cm)	Head Shape[y]	Head Color[x]	Bead Size[w]	Stem Color[x]	Head Exsertion[x]	Head Segment-ation[x]	Plot Unifor-mity[x]	Branch-ing[x]	Overall Score[x]	Notes
S387 x S438	74	53	14.0	4	7	2	7	6	7	5	1	6	
S387 x S446	75	54	14.0	7	7	3	7	7	3	7	1	5	
S387 x S454	78	58	14.5	6	7	2	6	7	7	7	1	9	uniform florets
S396 x S446	70	62	12.0	5	7	3	7	7	3	3	5	5	
S396 x S454	74	59	14.0	5	7	1	7	7	7	5	1	8	
S398 x S438	72	55	13.5	5	7	2	7	7	5	3	3	5	
S398 x S446	75	53	13.0	6	7	3	5	5	3	3	1	3	
S398 x S454	80	63	14.0	6	7	2	7	8	7	8	1	8	head branching may be too low
S400 x S438	73	58	11.0	7	7	2	7	8	5	7	1	7	small heads
S400 x S454	74	57	13.5	7	7	2	7	6	7	6	1	7	
S410 x S454	77	55	15.0	6	7	1	7	7	7	7	1	6	loose head; irregular shape
S411 x S446	84	60	15.0	7	8	2	7	7	7	7	1	9	potential for very large heads; quality holds for a long time
S411 x S454	84	57	13.0	5	7	2	7	7	9	6	3	7	
S438 x S442	77	57	13.5	6	7	1	6	7	7	7	1	7	
S442 x S454	78	58	13.0	7	7	1	7	7	7	3	3	3	
S443 x S454	75	50	13.0	5	9	2	7	5	5	3	1	5	
S445 x S454	78	53	16.0	6	7	1	7	7	7	5	1	8	
Regal	67	37	12.0	4	3	2	5	3	2	7	1	5	
SBC 7408	77	44	15.0	4	5	1	5	3	7	5	1	3	
Excelsior	84	51	10.0	4	5	2	6	5	5	5	1	5	

[z]Planted July 9 in 36" rows, thinned to 12" apart.

[y]Scale of 1-9 where 1 = extreme concave, 3 = slight concave, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

[x]Scale of 1-9 where 1 = poor and 9 = excellent.

[w]Scale of 1-9 where 1 = small and 9 = large.

Table 3. Broccoli observation trial, OSU hybrids, Corvallis, 2001.[z]

Hybrid	Maturity (days)	Plt Ht (cm)	Head Diam (cm)	Head Shape[y]	Head Color[x]	Bead Size[w]	Stem Color[x]	Head Exsertion[w]	Head Segment-ation[x]	Plot Uniform-ity[x]	Branch-ing[x]	Overall Score[x]	Notes
S387 x S438	70	47	15.0	3	7	2	5	7	7	7	1	7	
S396 x S438	70	54	13.0	5	7	2	5	7	5	5	3	7	
S398 x S438	88	71	17.0	4	7	2	7	9	7	3	3	5	slightly cabbagey
S400 x S438	70	65	13.0	7	7	2	7	8	5	3	3	5	
S410 x S438	80	60	16.0	4	6	1	5	7	9	5	5	5	soft heads
S411 x S438	80	54	16.0	4	7	1	7	6	9	7	1	7	
S442 x S438	80	53	15.5	4	8	2	7	6	8	7	3	6	segments somewhat irregular
S433 x S438	80	52	12.5	3	7	1	7	7	7	3	5	3	
S445 x S438	80	58	15.0	5	7	2	7	7	7	5	3	5	
S446 x S438	80	59	14.0	5	7	2	7	7	7	7	1	7	
S447 x S438	80	53	21.0	3	7	1	7	6	7		7	4	2 plants only
S454 x S438	80	55	12.5	4	7	1	7	6	6	5	3	4	quality holds for a long time
S387 x S446	80	59	12.0	5	7	3	7	6	6	5	1	5	
S396 x S446	80	60	14.0	5	7	3	7	7	3	5	3	3	
S398 x S446	80	64	16.0	4	7	2	7	7	5	5	3	4	
S400 x S446	70	51	12.0	7	9	2	3	5	7	3	1	5	
S410 x S446	80	56	13.0	4	7	1	6	6	8	5	3	4	irregular segments
S411 x S446	88	56	21.0	5	7	2	5	7	7	3	1	5	heavy stem; sweet
S442 x S446	80	61	15.0	7	8	2	7	7	8	7	5	6	
S443 x S446	80	66	14.0	6	6	2	7	8	3	7	1	5	
S445 x S446	80	66	14.0	6	7	2	7	8	9	7	1	8	
S454 x S446	80	63	14.5	6	7	2	6	7	5	3	5	5	many blind plants
S387 x S454	80	64	14.0	4	6	2	7	7	8	7	3	7	
S396 x S454	80	65	15.5	4	6	2	7	7	7	5	3	5	
S398 x S454	80	65	17.0	5	7	2	5	7	7	7	1	7	
S400 x S454	80	64	16.0	5	7	2	7	7	7	7	1	8	
S410 x S454	80	59	16.0	4	6	1	6	6	9	5	3	5	irregular segments
S411 x S454	88	53	19.0	4	7	2	7	8	9	9	2	9	bland flavor
S442 x S454	80	56	14.0	5	7	1	7	6	8	1	5	3	head rot

Table 3. Broccoli observation trial, OSU hybrids, Corvallis, 2001 (cont).[z]

Hybrid	Maturity (days)	Plt Ht (cm)	Head Diam (cm)	Head Shape[y]	Head Color[x]	Bead Size[w]	Stem Color[x]	Head Exsertion[w]	Head Segment-ation[x]	Plot Uniform-ity[x]	Branch-ing[x]	Overall Score[x]	Notes
S443 x S454	80	61	15.0	4	7	2	7	8	6	5	5	6	
S445 x S454	80	66	18.0	5	7	2	7	8	7	7	3	7	
S447 x S454	80	58	14.0	4	7	1	3	6	5	3	5	4	

[z]Planted July 10 in 36" rows, thinned to 12" apart.

[y]Scale of 1-9 where 1 = extreme concave, 3 = slight concave, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

[x]Scale of 1-9 where 1 = poor and 9 = excellent.

[w]Scale of 1-9 where 1 = small and 9 = large.

Table 4. Average inbred performance of broccoli hybrids, Corvallis, 2001.[z]

Source	Maturity (days)	Plt Ht (in)	Head Dia. (in)	Head Shape[y]	Head Color[x]	Bead Size[w]	Stem Color[x]	Head Exsertion[x]	Head Segment-ation[x]	Plot Uniform-ity[x]	Branch-ing[x]	Overall Score[x]
S387 crosses	76	56.2	14.0	3.8	6.6	2.2	6.2	6.8	7.2	6.6	1.8	6.6
S396 crosses	77	59.7	14.2	4.7	6.7	2.3	6.3	7.0	5.0	5.0	3.0	5.0
S398 crosses	81	66.3	16.8	4.5	7.0	2.0	6.0	7.5	6.5	5.5	2.0	5.8
S400 crosses	72	59.2	13.2	6.6	7.8	2.0	5.4	6.6	6.2	3.8	1.8	5.6
S410 crosses	79	58.3	15.0	4.0	6.3	1.0	5.7	6.3	8.7	5.0	3.7	4.7
S411 crosses	85	54.3	18.7	4.3	7.0	1.7	6.3	7.0	8.3	6.3	1.3	7.0
S438 crosses	78	56.7	15.0	4.4	7.0	1.6	6.4	6.9	7.1	5.3	3.1	5.5
S442 crosses	80	55.8	14.8	5.4	7.6	1.6	7.0	6.2	8.0	5.0	4.2	4.8
S443 crosses	80	63.5	14.5	5.0	6.5	2.0	7.0	8.0	4.5	6.0	3.0	5.5
S445 crosses	80	62.0	15.5	5.3	7.0	2.0	7.0	7.5	7.5	6.0	2.5	6.3
S446 crosses	79	58.8	14.2	5.5	7.4	2.0	5.9	6.5	6.5	4.7	2.5	5.1
S447 crosses	80	56.3	16.3	3.7	7.0	1.0	4.3	6.0	5.7	3.0	5.7	4.0
S454 crosses	80	60.8	15.3	4.7	6.7	1.6	6.1	6.8	7.0	5.1	3.4	5.6

[z]Planted July 10 in 36" rows, thinned to 12" apart.

[y]Scale of 1-9 where 1 = extreme concave, 3 = slight concave, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

[x]Scale of 1-9 where 1 = poor and 9 = excellent.

[w]Scale of 1-9 where 1 = small and 9 = large.

Table 5. Broccoli observation trial, OSU inbreds, Corvallis, 2001.[z]

Line	Maturity (days)	Plt Ht (cm)	Head Dia (cm)	Head Shape[y]	Head Color[x]	Bead Size[w]	Stem Color[x]	Head Exsertion[x]	Head Segment-ation[x]	Plot Unifor-mity[x]	Branch-ing[x]	Overall Score[x]	Notes
HS 143	85	50	14.0	5	6	3+	7	7	3	5	1	3	flavor not sweet; spicy
HS 161-3	88	58	11.0	4	5	1-3	5	8	3	7	1	3	sweet but spicy; rosetting
HS 179-1	85	62	7-15	3-5	7	3	7	9	9	1	1	1	highly variable; strong flavor, not sweet
S233B	88	40	14.0	5	7	3	5	7	3	5	1	3	strong flavor
S240-1	88	49	13.0	3	7	2	5	7	7	5	1	5	leafy head; spicy flavor; head
S240-5-1	100	56	11.0	4	7	1	7	7	9	5	3	5	highly segmented heads; small florets
S240-5-5	100	52	15.0	5	7	1	5	6	9	5	3	5	highly segmented heads; small soft florets
S240-5-8	92	67	12.5	9	9	1	7	7	7	7	3	5	soft head; sweet
S240-5-12	100	66	12.0	7	9	1	7	7	9	5	3	5	highly segmented
S240-5-17	100	45	12.0	5	7	1	7	5	7	5	3	5	leafy head
S240-5-20	88	56	12.0	5	8	2	7	9	7	3	3	7	flavor bland, slightly sweet
S240-5-24	100	64	16.0	4	7	1	7	7	9	7	1	3	highly segmented head with small soft florets
S240-5-26	100	48	11.0	5	7	1	5	7	7	7	3	5	
S240-5-30	100	40	15.0	5	7	1	7	4	7	3	1	5	soft head
S310	80	48	13.0	4	5	1	5	5	7	1	5	3	
S315	70	36	10.5	5	5	3	5	3	1	3	1	3	rosetting; blind plants
S352	88	43	14.0	4	7	3	5	4	1	5	1	3	sweet, spicy
S370	70	45	9.0	7	7	3	7	7	1	5	1	5	
S384	88	49	15.0	7	7	3	5	7	7	3	1	1	flavor mild and sweet; powdery mildew susceptible
S387	80	52	14.0	3	7	3	7	7	7	6	3	6	leaves in head; strong flavor
S389	80	52	13.0	5	7	2	5	5	2	3	7	3	
S391	85	66	17.0	5	7	2	5	9	9	7	1	7	
S392	80	72	14.0	5	6	2	5	8	7	3	3	5	
S396	80	61	12.0	7	7	2	7	9	5	5	3	5	
S398	80	56	13.0	5	7	3	7	7	7	3	3	5	
S399	80	55	14.0	6	7	3	7	6	3	5	5	4	
S400	80	59	11.0	5	7	3	7	7	5	5	3	5	head stays firm
S403	80	66	14.5	4	7	2	7	6	8	7	5	6	

Table 5. Broccoli observation trial, OSU inbreds, Corvallis, 2001[z] (cont).

Line	Maturity (days)	Plt Ht (in)	Head Dia (in)	Head Shape[y]	Head Color[x]	Bead Size[w]	Stem Color[x]	Head Exsertion[x]	Head Segmentation[x]	Plot Uniformity[x]	Branching[x]	Overall Score[x]	Notes
S410	80	47	14.0	3	6	1	8	6	9	7	5	4	loose heads; sunken centers
S414	80	49	11.0	4	8	2	7	5	2	5	1	3	
S438	80	52	12.5	5	6	1	7	6	7	3	7	3	small segments
S440	80	58	13.5	7	7	2	7	8	8	5	3	8	
S442	88	55	18.0	5	9	1	7	8	9	7	3	7	head rot; rosetting; sweet flavor
S443	80	55	12.0	4	7	2	7	8	3	4	1	5	
S445	88	62	14.0	5	7	2	5	9	9	3	1	6	heavy stem; sweet, slightly spicy flavor
S446	88	61	12.0	5	7	1	3	7	5	3	1	5	rosetting; heavy stem; slightly spicy; not sweet
S447	88	56	13.0	7	9	1	7	8	7	3	3	6	good flavor
S453	100	47	17.0	2	7	2	5	7	7	7	1	5	flat head
S454	88	61	14.0	7	7	2	5	9	7	9	1	9	sweet, slightly spicy

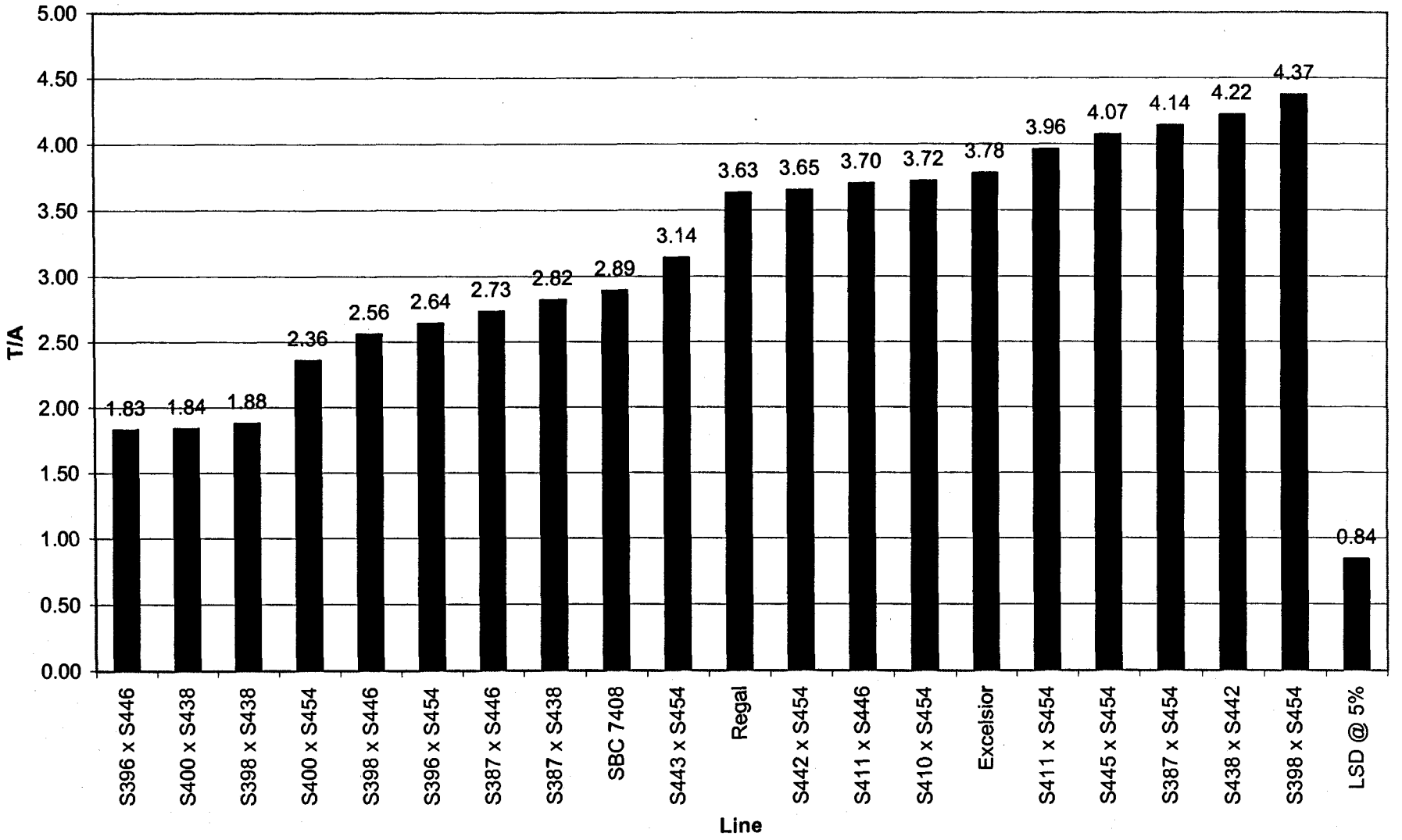
[z]Planted July 10 in 36" rows, thinned to 12" apart.

[y]Scale of 1-9 where 1 = extreme concave, 3 = slight concave, 5 = slight dome, 7 = moderate dome and 9 = extreme dome.

[x]Scale of 1-9 where 1 = poor and 9 = excellent.

[w]Scale of 1-9 where 1 = small and 9 = large.

Figure 1. Broccoli Yield 2001 - Unadjusted Yield



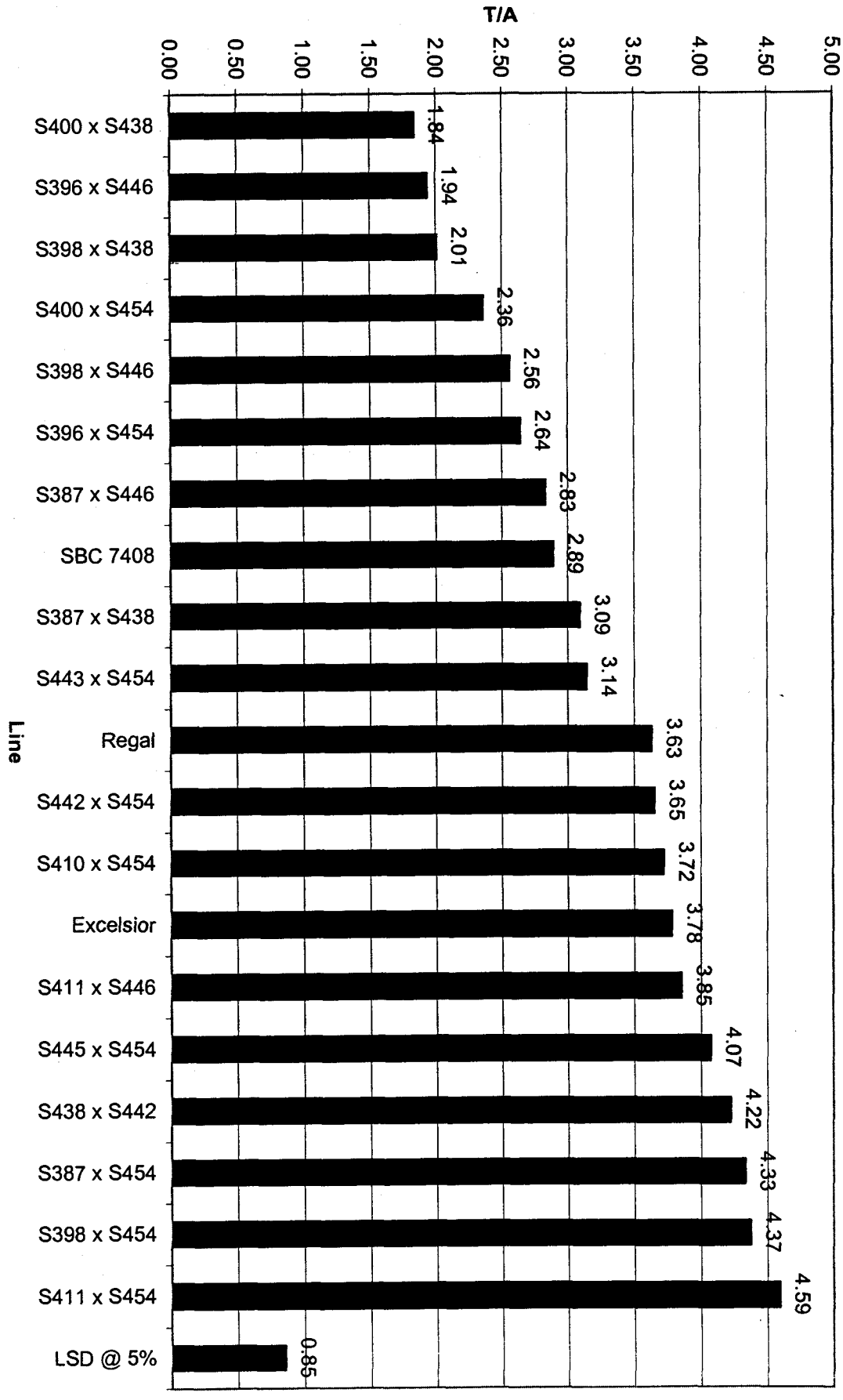


Figure 2. Broccoli Yield Adjusted to Remove Gaps in Stand