Research Report to the
Agricultural Research Foundation
and the
Oregon Processed Vegetable Commission
2003

Title: Developing an Integrated Management Tool to Predict Hairy Nightshade Growth in Snap Beans

Project leader

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Summary

- *Hairy nightshade (HNS) removal for 3 weeks after planting (WAP) eliminated berry production in all plantings except the May 20 planting, which required 4 weeks of HNS removal to eliminate berry production.*
- Plants flowered slower in early plantings but degree day requirements did not differ significantly for the time to first flower.
- Degree days required for HNS berry production varied by planting date, with the greatest requirement (774) on the May 20 planting date.
- HNS seedlings that emerged from May 20 to June 3 had the greatest potential to produce berries that could significantly impact crop quality.
- HNS berry production is likely related to day length as well as degree days.

Introduction

Raptor herbicide effectively controls weeds in snap beans; tolerance is acceptable and weed control is very good. Disadvantages of using Raptor are cost and crop rotation restrictions. Raptor controls black and hairy nightshade (HNS) very well, but in some cases, Raptor may not be needed because nightshade may have emerged too late to produce berries or seeds. The difficulty is predicting when Raptor is needed based on the potential for nightshade berry production. The objective of this study was to determine when intervention with postemergence herbicides or cultivation would preclude hairy nightshade berry or seed production.

Procedures

Snap beans were planted every two weeks beginning on May 7. Treflan was applied and incorporated before snap beans were planted to eliminate grasses and broadleaves, but allow emergence of hairy nightshade. Within each planting, five treatments were applied to plots with four replications. Treatments included removal of HNS seedlings until 2, 3, 4 and 5 weeks after

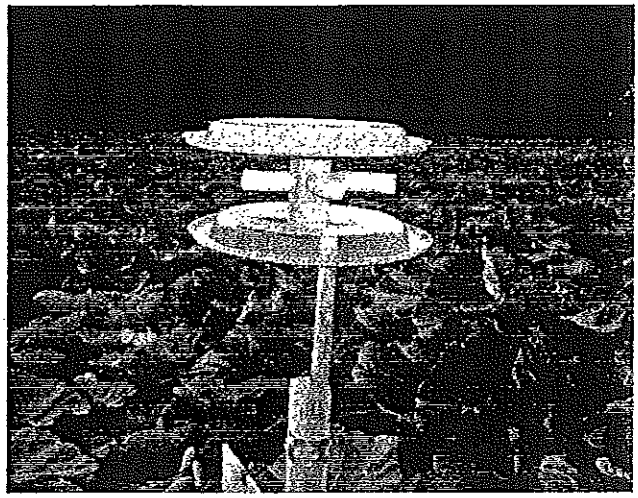

Fig. 10. New 4-direction kairomone dispenser, used in first rate experiment, 0 - 400 mg/trap.

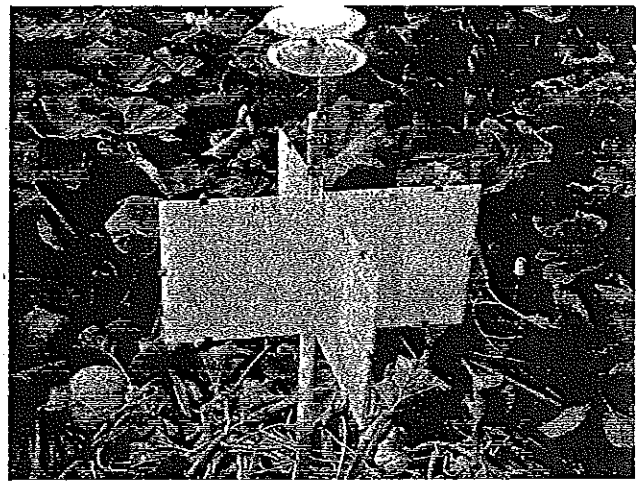

Fig. 11. Kairomone dispenser attached to wing traps for evaluating optimum kairomone rate.

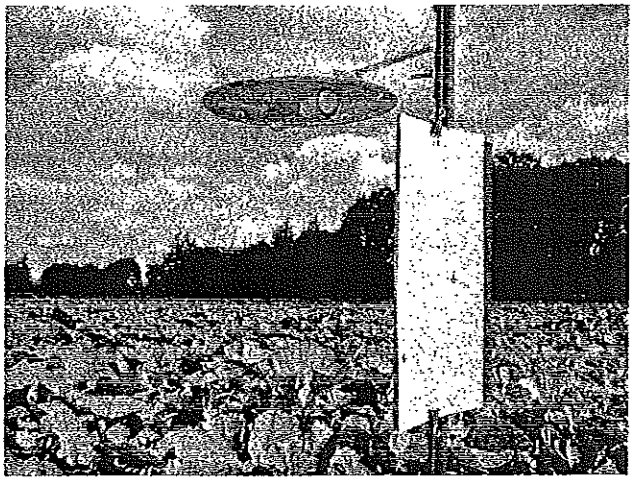

Fig. 12. Single-tube kairomone dispense used in the 0-1200 mg/trap optimum rate study.

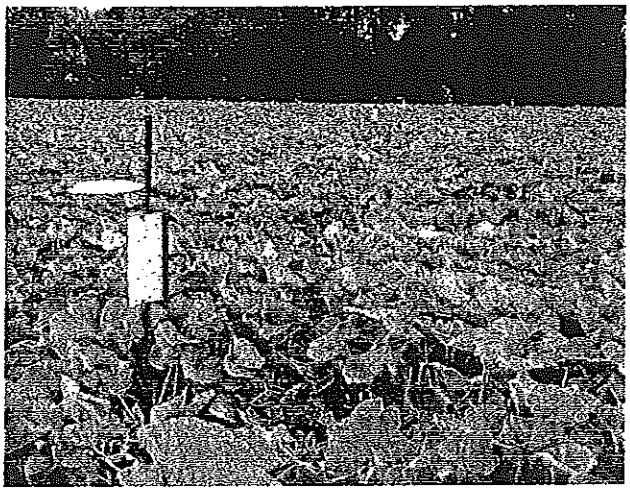

Fig. 13. Arrangement of kairomone-baited traps in lines with traps 90' apart.

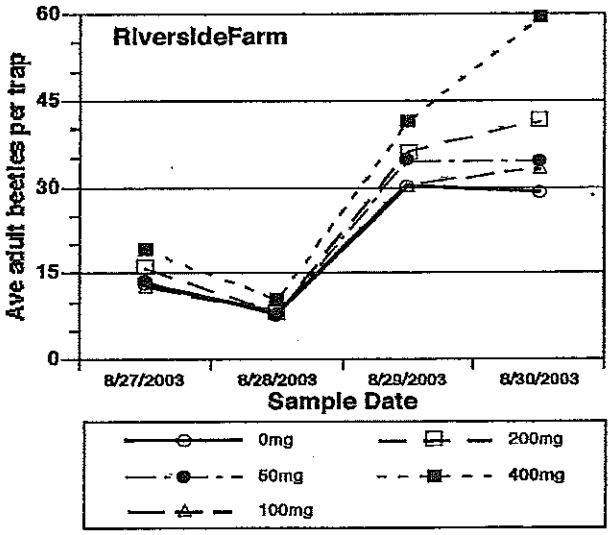

Fig. 14. Effect of kairomone (0-400 mg/trap) on catch of adult beetles on yellow sticky traps.

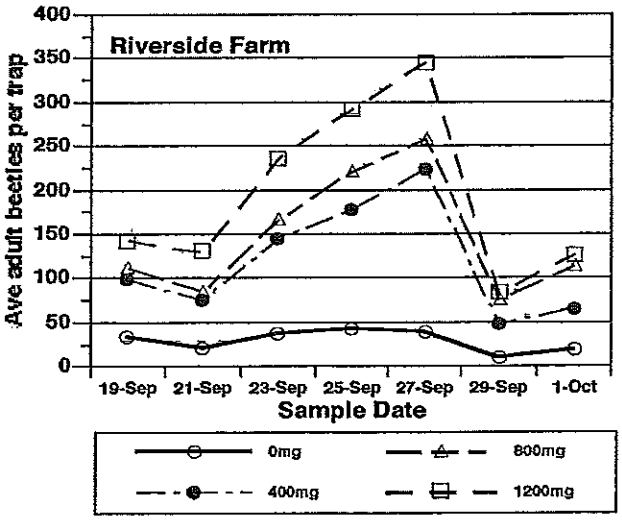

Fig. 15. Effects of kairomone rate (0 - 1200 mg/trap on adult beetle catch in yellow sticky traps

planting and a treatment without HNS removal. Removal of seedlings at these intervals allowed determination of the potential of HNS to produce berries or seeds after the four different planting dates. For instance, seedlings that emerged 2 weeks after planting represent seedlings that would have emerged after a cultivation or postemergence herbicide applied at 2 WAP. After the seedling removal period was complete, the first emerged seedling was flagged and all other competitors removed for the duration of the crop. Seedlings were located in the middle 1/3 of the area between 30 inch bean rows. When snap beans reached approx. 55-60% 1-4 sieve by weight, HNS plants were pulled, weighed, and berries stripped. Berries were weighed and graded according to snap bean sieve size (Table 1). Seeds were extracted from 1 berry of each size class for each harvested plant, counted and stored at 35 F for 4 months. (Seeds will be germinated at 86/70 F after at least 6 months in cold storage). Temperature was measured at the top of the snap bean canopy and data used to predict the number of degree days (base 40 F) needed for nightshade to produce berries.

Table 1. Snap bean sieve sizes and conversions.

Sieve size	Bean diameter	
	1/64"	mm
1	< - 14.5	< - 5.8
2	14.5 - 18.5	5.8 - 7.3
3	18.5 - 21	7.3 - 8.3
4	21 - 24	8.3 - 9.5
5	24 - 27	9.5 - 10.7
6	27 - 30	10.7 - 11.9
7	30 - >	11.9 - >

Results

Hairy nightshade removal for 3 WAP eliminated berry production in all plantings except the May 20 planting (Table 2). All treatments with HNS emerging 2 WAP produced berries. The total number of berries produced was greatest in the May 20 and June 3 plantings.

Plants flowered slower in early plantings but degree requirements did not differ significantly for the time to first flower. Degree days required for berry production varied by planting date, with the greatest requirement (774) on the May 20 planting date. HNS that emerged after the May 20 planting produced the most berries, but also required the most degree days for berries to reach 5mm diameter (Fig. 1).

Interestingly, trends over the four plantings for the number of degree days required to produce a 5 mm berry and the relationship between degree days and total berry weight differed significantly for the June 3 and Jun 17 plantings (Fig. 1). Berry production was as great at the June 3 planting as the May 20 planting, yet the number of degree days required to produce a 5mm berry was less. This indicates that the relationship between berry production and degree days is not equal between the planting dates, and that HNS is in some ways more 'efficient' at producing 5mm berries later in the season. We have noted this in HNS seedlings that emerge very late in the season (Aug/Sept when very small plants produce berries) but have not documented this in earlier plantings. HNS berry production is likely related to day length as well as degree days, at least in the proportion of berries that reach a significant size class. There was no difference in average berry weight among planting dates.

The impact on actual HNS seed production is under evaluation because it takes several months of storage before nightshade seeds will germinate after they are extracted from the

berries. Visual observations indicate that the number of viable seeds was much lower in berries that were less than 5.8 mm in diameter than those greater than 5.8 mm. The treatment with 3 weeks of removal planted on May produced a few berries greater than 5.8 mm that would likely have germinable seeds. Therefore, the data indicate that in times of optimum emergence and growth, (e.g. May 20 2003) all HNS seedlings that emerge within the 4 weeks after snap bean planting would need to be removed to prevent berry contamination or seed production. The removal period could be reduced to 3 weeks for other plantings.

Table 2. Effect of planting date and removal period on hairy nightshade berry production in snap beans, Corvallis, 2003.

Planting date	Removal period	Obs.	Berry number/plant		Berry wt/plant		Berries ≥ sieve 2/plant		Berry wt ≥ sieve 2/plant	
	weeks		Mean	SE	Mean	SE	Mean	SE	Mean	SE
			no.		g		no.		g	
7-May	0	4	107	14	13	2	43	7	8.3	1.4
7-May	2	4	60	28	6	4	21	14	3.6	2.6
7-May	3	1	0	.	0	.	0	.	0.0	.
7-May	4	3	0	0	0	0	0	0	0.0	0.0
7-May	5	3	0	0	0	0	0	0	0.0	0.0
20-May	0	4	225	46	35	8	128	34	25.8	7.0
20-May	2	4	50	34	6	5	22	18	3.9	3.1
20-May	3	2	3	5	0	0	1	1	0.0	0.1
20-May	4	3	0	0	0	0	0	0	0.0	0.0
20-May	5	2	0	0	0	0	0	0	0.0	0.0
3-Jun	0	3	211	50	34	8	123	24	24.5	5.2
3-Jun	2	3	70	42	14	5	36	22	7.2	5.8
3-Jun	3	3	0	0	0	0	0	0	0.0	0.0
3-Jun	4	3	0	0	0	0	0	0	0.0	0.0
3-Jun	5	0	-	.	-	.		.	-	.
17-Jun	0	4	135	27	23	7	55	21	14.7	4.3
17-Jun	2	4	31	18	7	2	8	6	1.2	0.9
17-Jun	3	4	0	0	0	0	0	0	0.0	0.0
17-Jun	4	2	0	0	0	0	0	0	0.0	0.0
17-Jun	5	2	0	0	0	0	0	0	0.0	0.0

Table 3. Effect of planting date on days to first flower, degree day requirements, and berry production of hairy nightshade.

Planting date	Days to first flower		Degree days to first flower (dd)		Degree days to berries ≥ 5 mm in diameter (dd)		Total berry wt/plant ≥ to sieve size 2 (g)		Total berry number/plant ≥ to sieve size 2 (no/plant)	
	Mean	SE	Mean	SE	Mean	SE	Mean	SE	Mean	SE
7-May	48 a[a]	1	509 a	6	677 b	31	13 b	2	107 b	28
20-May	42 b	0	562 a	21	774 a	26	35 a	8	225 a	91
3-Jun	38 c	2	516 a	34	686 ab	0	34 ab	8	211 ab	87
17-Jun	36 c	0	566 a	45	675 b	25	23 ab	7	135 ab	54

[a] Values followed by the same letter do not differ significantly (P=0.05)

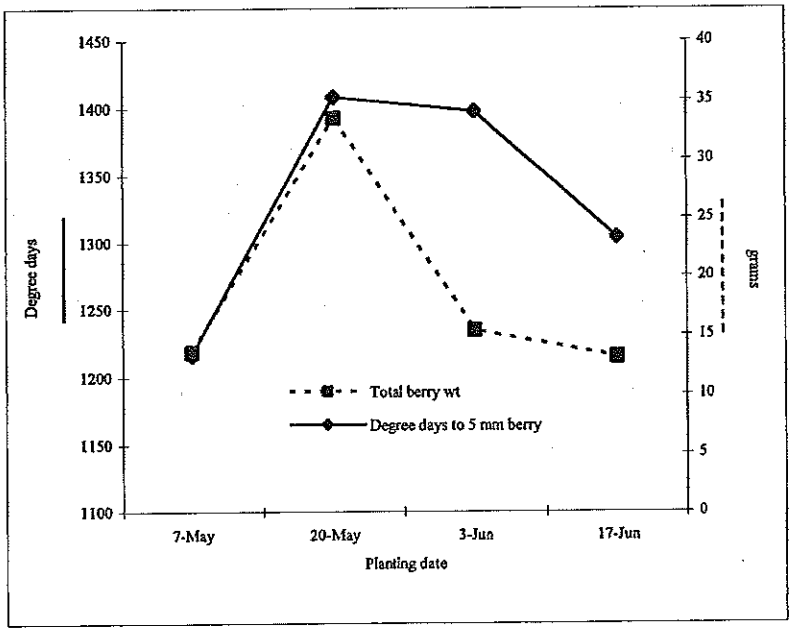

Figure 1. Effect of planting date on the number of degree days to produce a 5 mm diameter berry and total berry weight.

Report to the Oregon Processed Vegetable Commission
2002–2003

1. Title: Broccoli Breeding, Evaluation and Seed Production

2. Project Leaders: James R. Myers, Horticulture
Brian Yorgey, Food Science and Technology

3. Project Status: Terminating 30 June 2003

4. Project Funding:

$7,096	breeding
$3,321	processing
$10,418	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:

I. Develop broccoli varieties adapted to western Oregon with:
   a. Relatively tall plants with exerted heads for easy mechanical harvest.
   b. Large openly branched heads with heavy, clean stem for easy trimming and separation into spears and chunks.
   c. Medium fine, firm, uniform florets of good color and short pedicels, and which are retained after freezing.
   d. Early to midseason maturity, concentrated yield potential.
   e. Head rot, clubroot and downy mildew resistance.

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

III. Produce seed for limited scale on-farm trials.

6. 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 2002 season were grown in the 2002 – 2003 greenhouse and used to produce self pollinated and hybrid seed. Eleven S300 and S400 series inbreds were intercrossed, with the focus on testing S438, S440, S445, and S454 with as many of the best inbred lines as

possible. Seeds for yield trials were produced for 12 crosses and reciprocals. Also, quantities of seed sufficient for an observation trial were obtained for 20 cross combinations (crosses and reciprocals combined). Seed of five hybrids were evaluated in an on-farm field trial.

Yield Trial: Twelve OSU hybrids and three commercial checks were grown in a yield trial replicated four times (Tables 1 and 2, Figure 1). The trial was direct seeded 10 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 (Table 1). The hybrid combination S411 x S446 had particularly low stands, a problem that seems to be associated with the S446 parent. We retain S446 in test crosses because it possesses a very strong apical dominance with little tendency to side branching. Yield ranged from 3.7 to 6.6 T/A (gross). Once again, S387 x S454 was highest yielding, followed by Regal. Little cullage was observed among the OSU hybrids. Blind plant frequency was similar to that observed in 2002. Greatest variability in head maturity was observed in the checks Emerald Pride and Excelsior whereas all of the OSU hybrids except S398 x S446 had significantly fewer young heads (Table 1). Over the past four years, S454 x S387 has had the highest average yield (table right). Head size of S387 x S454 appears comparable to the check hybrids. However, bead size for this hybrid is probably coarser than preferred by processors. Two other hybrid combinations that have performed well over years are S400 x S454 and S410 x S454. All OSU hybrids except S400 x S446 had significantly less leaf in the upper six inches compared to Emerald Pride and Regal (Table 1).

Four year average of selected broccoli hybrids

Entry	Maturity (Days)	No. Blind	Lbs/ Head	T/A
S387 x S454	80	1.6	0.74	5.1
S400 x S454	78	2.4	0.53	3.7
S410 x S454	80	1.7	0.65	4.4
Excelsior	82	2.5	0.68	4.1
Regal[z]	76	2.7	0.72	4.7

[z]Data for Regal is a 3 year average.

The best hybrids include S454 as a parent crossed to S387, S400, S410, S411 or S445. Despite the desirability of the S446 growth habit, it does not appear to combine well. Further improvement of this inbred is contemplated. Observation data shown in Table 2 supports the general ranking of hybrids based on yield data. S454 x S400 and S454 x S410 appear to have better quality attributes compared to S387 x S454.

Observation Trials: An unreplicated observation trial of hybrids and inbreds was also planted on 11 July (Table 3). 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). Hybrids with the highest overall rating were S410 x S446, and S446 x S447. We feel that nearly all possible hybrid cross combinations have been tested from the current genetic pool, and any further pro-

gress will be made with the derivation of additional inbreds. To this end, selections were made from a random mated mass recurrent selection population to initiate the inbreeding process. Inbred lines used to make crosses were grown with the observation trial, and qualitative observation data were recorded (not shown). Also incorporated into crossing are downy mildew resistant lines from the USDA – ARS Charleston, South Carolina breeding program.

Small scale commercial field trial: Five hybrids (S454 x S387, S454 x S410, S454 x S445, S454 x S400 and S454 x S398) with approximately 1,000 seeds of each were grown in a small scale trial in a grower's field during the spring growing season. Hybrids generally showed an average performance compared to the commercial hybrid in that field.

Backcross program to CMS inbred: Backcross 3 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. Seeds will be produced in the 2003 – 2004 greenhouse to evaluate use in field production of hybrid seed in 2004.

7. Summary:

Eleven inbreds used for hybrid production were propagated in the greenhouse, selfed and intercrossed to produce 20 combinations for field-testing. Twelve of the best hybrids based on observation data were evaluated along with three commercial hybrids in a replicated yield trial. The consensus from four 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. Eight OSU hybrids 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. Backcrossing into a CMS background continued. New inbreds are being developed.

Table 1. Yield data from a hybrid broccoli trial, Corvallis, 2003.[z]

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
S387 x S446	82	24.0	1.3	1.5	0.0	21.3	0.71	5.50	5.40	4.8
S387 x S454	83	24.8	1.0	1.8	0.8	21.5	0.84	6.60	6.40	3.0
S396 x S446	82	26.0	1.5	2.0	0.3	23.0	0.64	5.00	4.90	2.9
S396 x S454	82	27.5	1.3	2.8	3.0	20.0	0.70	5.00	4.30	1.6
S398 x S446	82	24.3	1.5	3.5	1.5	18.8	0.78	5.65	5.20	3.1
S400 x S446	78	20.2	0.8	2.5	0.3	16.8	0.54	4.10	3.90	15.1
S400 x S454	78	24.0	2.0	2.0	0.0	20.5	0.51	3.90	3.80	9.5
S410 x S454	83	25.5	0.0	1.0	0.3	24.0	0.69	5.80	5.70	2.3
S411 x S446	85	18.5	1.0	0.3	0.8	16.8	0.68	5.60	5.30	3.9
S440 x S446	82	23.3	2.0	2.5	0.0	19.5	0.71	5.20	5.10	2.9
S445 x S454	83	24.3	1.5	2.5	0.0	21.8	0.78	6.20	6.10	2.8
S446 x S454	82	23.5	2.3	2.0	0.0	19.0	0.52	3.80	3.70	9.5
Emerald Pride	78	28.0	2.0	5.3	0.0	20.8	0.52	3.70	3.40	34.1
Excelsior	82	25.5	0.8	4.8	3.3	17.3	0.66	5.00	3.90	8.5
Regal	75	23.8	1.0	2.8	1.8	17.8	0.81	6.30	5.30	15.1
LSD @ 5%		3.0	NS	2.4	1.3	3.8	0.12	0.85	0.90	6.1

[z]Planted July 10 in 30' plots, rows 30" apart, thinned to 12" between plants. Mean of four replications.

Table 2. Broccoli yield trial observation data, Corvallis, 2003.[z]

Line	Maturity (days)	Plt 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 S446	82	62/68	18	6	7	M-C	7	8	7	7	3	7	
S387 x S454	83	72/78	19	6	7	C	7	7	6	5	3	7	
S396 x S446	82	67/74	17	7	6	M	5	6	5	7	1	8	
S396 x S454	82	74/79	18	7	7	M	7	8	6	5	1	5	
S398 x S446	82	76/79	14	6	7	F-M	7	8	5	4	2	6	quite variable for bead size
S400 x S446	78	67/73	13	7	7	M	5	7	5	7	3	8	
S400 x S454	78	58/70	14	7	7	M	5	6	7	5	5	7	
S410 x S454	83	60/68	16	5	7	F	7	7	7	8	3	9	
S411 x S446	85				7	F-M	7				3		
S440 x S446	82	63/73	17	7	8	M-C	7	7	7	8	3	7	
S445 x S454	83	76/71	17	5	8	F-M	7	9	7	7	3	7	variable floret size with small centers
S446 x S454	82	54/58	18	7	7	F-M	5	7	7	7	3	7	
Emerald Pride	78	49/63	13	6	3	F	3	4	1	5	1	5	
Excelsior	82	45/67	14	5	3	F	5	3	4	5	3	3	1 plant with head rot
Regal	75	41/55	13	4	5	C	7	3	3	3	3	3	variable maturity

[z]Planted July 10 in 30" rows, thinned to 12" apart.

[y]First value is height of the head, second value is height of the tallest leaves.

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

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

[v]F = fine, M = medium, C = coarse.

Table 3. Broccoli observation trial, OSU hybrids, Corvallis, 2003.[z]

Hybrid	Maturity (days)	Plt Ht (cm)[y]	Head Diam (cm)	Head Shape[x]	Head Color[w]	Bead Size[v]	Stem Color[w]	Head Ex-sertion[w]	Head Seg-ment-ation[w]	Plot Uni-form-ity[w]	Branch-ing[w]	Overall Score[w]	Notes
S410 x S446	85	61/66	16.0	5	7	F	7	8	7	7	3	8	heads hold quality well
S438 x S446	84	64/66	14.0	4	5	F	7	7	6	7	3	5	small heads
S438 x S454	84	67/69	17.0	4	5	M	7	6	7	5	3	5	
S442 x S446	91	81/70	18.0	5	8	F	7	9	9	7	3	7	variable floret size
S445 x S446	84	74/83	15.0	7	8	F	8	8	7	5	2	7	some small heads; very tall robust plants
S446 x S447	91	76/67	17.0	7	7	F	7	8	7	7	3	8	
S447 x S454	85	68/68	13.0	7	7	F	7	7	7	3	3	7	

[z]Planted July 10 in 30" rows, thinned to 12" apart.

[y]First value is height of the head, second value is height of the tallest leaves.

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

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

[v]F = fine, M = medium, C = coarse.

Table 4. Average inbred performance of broccoli hybrids, Corvallis, 2003.[z]

Source	Maturity (days)	Plt Ht (cm)[y]	Head Dia. (in)	Head Shape[x]	Head Color[w]	Bead Size[v]	Stem Color[w]	Head Exser-tion[w]	Head Seg-ment-ation[w]	Plot Uni-form-ity[w]	Branch-ing[w]	Overall Score[w]
S387 crosses	83	67/73	18.5	6.0	7.0	C	7.0	7.5	6.5	6.0	3.0	7.0
S396 crosses	82	69/76	17.5	6.8	6.8	M	6.7	7.5	6.0	5.3	1.7	5.8
S398 crosses	83	71/74	16.2	5.2	7.0	F-M	6.7	7.0	5.8	5.5	2.8	6.2
S400 crosses	78	78/63	13.5	7.0	7.0	M	5.0	6.5	6.0	6.0	4.0	7.5
S410 crosses	84	61/67	16.0	5.0	7.0	F	7.0	7.0	7.0	6.5	3.0	8.0
S438 crosses	84	66/68	16.0	4.0	5.0	F-M	7.0	6.5	6.5	6.0	3.0	5.0
S440 crosses	82	68/73	16.0	5.0	6.0	M-C	6.0	8.0	6.0	8.0	2.0	6.0
S442 crosses	91	81/70	18.0	5.0	8.0	F	7.0	9.0	9.0	7.0	3.0	7.0
S445 crosses	83	72/79	15.9	6.1	7.9	F-M	7.5	8.3	7.0	5.8	2.7	7.0
S446 crosses	85	69/71	16.2	5.8	6.8	F-C	6.5	7.7	6.6	6.4	2.5	6.6
S447 crosses	89	72/68	15.0	7.0	7.0	F	7.0	7.5	7.0	5.0	3.0	7.5
S454 crosses	83	66/71	16.4	6.0	6.9	F-M	6.6	7.1	6.8	5.5	3.4	6.8

[z]Planted July 10 in 30" rows, thinned to 12" apart. Number of crosses differed for each inbred.

[y]First value is height of the head, second value is height of the tallest leaves.

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

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

[v]F = fine, M = medium, C = coarse.

Figure 1. Broccoli Yield 2003