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Vegetable Research at the North Willamette Research and Extension Center (NWREC), 1991-1992

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AUTHOR: Dr. Delbert D. Hemphill, Jr., Professor of Horticulture, has conducted research on vegetable crops culture and management since 1976 at Oregon State University's North Willamette Research and Extension Center, 15210 NE Miley Rd., Aurora, OR 97002-9543.

COOPERATORS:

Dr. N.S. Mansour is Extension Vegetable Specialist and Professor, Department of Horticulture, Oregon State University, Corvallis, OR 97331

Dr. John Hart is Extension Soil Scientist and Associate Professor, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331

Dr. Richard Dick is Associate Professor of Soil Science, Department of Crop and Soil Science, Oregon State University, Corvallis, OR 97331

Dr. Richard O. Hampton is Research Virologist, USDA-ARS and Department of Botany and Plant Pathology, Oregon State University, Corvallis, OR 97331

Dr. James R. Baggett is Professor of Horticulture, Department of Horticulture, Oregon State University, Corvallis, OR 97331

Mr. Robert B. McReynolds is District Extension Agent for vegetable crops and Assistant Professor, North Willamette Research and Extension Center, 15210 NE Miley Rd., Aurora, OR 97002-9543

VEGETABLE RESEARCH AT THE NORTH WILLAMETTE RESEARCH AND EXTENSION CENTER (NWREC), 1991-1992

INTRODUCTION

A full-time program of vegetable crop research has been conducted at the North Willamette Research and Extension Center (formerly the North Willamette Experiment Station) since 1976. The Center, a branch of the Oregon State University Agricultural Experiment Station and Cooperative Extension Service, is just north of Aurora, a historic farming community 20 miles south of Portland, Oregon. The land is provided by Clackamas County, with facilities owned and maintained by OSU. The Center serves the vegetable, small fruit, and ornamentals industries and is located in an area noted for the diversity of its agriculture. Our vegetable research emphasizes the needs of both the fresh market and processed vegetable growers in the Willamette Valley. We also conduct research on home garden and small farm-intensive vegetable culture.

Many of the research projects reported here involved cooperation with Research and Extension Service colleagues at Oregon State University and their contributions are gratefully acknowledged. The financial support of the Oregon Processed Vegetable Commission, Nalley Fine Foods, UNOCAL, the Center for Applied Agricultural Research, and the Agricultural Research Foundation was essential to completing these projects and is greatly appreciated.

This report is the eighth in a series of biennial reports initiated in 1979.

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MUSKMELON RESPONSE TO COMBINATIONS OF WAVELENGTH-SELECTIVE MULCHES AND ROW TUNNELS

Introduction

Muskmelon production in the Willamette Valley is usually limited by cool springs, a short growing season, and relatively cool nights, even during midsummer. Cultural techniques to increase air and soil temperature around plants, such as black plastic mulch and row covers, have hastened development and increased yield of muskmelon in the valley.

A new development in mulch technology is the wavelength-selective film. It provides much of the weed control benefit of black plastic mulch, but warms the soil more than does black mulch. Thermic films, such as the IR-303 Thermofilm, were originally developed as greenhouse covers. They are reputed to reduce maximum and increase minimum temperatures slightly more than standard polyethylene films. These thermic films may have a role as hoop-supported row covers (tunnels). In a preliminary trial in 1990, the combination of black mulch and tunnels of either Lutrasil or IR-303 Thermofilm produced greater early yield than either black film or wavelength-selective mulch films alone. Thermofilm appeared promising for promoting greater total yield. Trials in 1991 and 1992 compared combinations of four mulch films with two different covering materials in enhancing earliness and yield of muskmelon.

Methods

In 1991, Superstar muskmelon was seeded in 5-cm pots in an unheated greenhouse on 15 April. The plot area of Willamette silt loam was prepared by rotary tillage, following a broadcast application of 10N-8.7P-16.6K fertilizer at 400 pounds/acre. Mulches and drip irrigation tubing were applied on 22 May. Melons were transplanted and hoop-supported covers (tunnels) were applied on 23 May. Treatments consisted of a factorial combination of four mulches and three hoop-supported tunnels, with mulches as main plots and tunnels as subplots. Main plots were replicated four times in randomized complete block design. Subplot size was 4 meters with five plants per subplot. The mulches were a standard 1.25-mil black polyethylene, a 0.8-mil brown wavelength-selective poly (AL-OR) from Polyon-Barkai, a 1.25-mil green wavelength-selective poly (IRT-76) from AEP Industries, and a standard 1.25-mil clear polyethylene. The tunnel treatments included a non-covered check, a spunbonded polypropylene (Typar, 60 grams per square meter), and a 2-mil perforated IR-303 Thermofilm (Polyon-Barkai).

Replicated soil temperature measurements were made at 5-cm depth from 23 May until 3 June with copper-constantan thermocouples and a Speedomax 150 recorder. Replicated air temperature measurements were made at 5 cm above ground from 3 June until 11 June. Covers were removed on 19 June. Plots were harvested at least weekly from first fruit ripening in mid-August until the end of September. Early yield was defined as that obtained during the first 10 days of harvest. Only marketable fruit were included in the yield.

In 1992, methods were the same except as follows. Superstar and Passport muskmelon were seeded on 13 April. Mulches were applied on 11 May. Melons were transplanted on 12 May and tunnels were applied on 13 May. Treatments consisted of a factorial combination of two cultivars, four mulches, and three tunnels with cultivars as main plots, mulches as subplots, and tunnels as sub/subplots. Mulches were as in 1991 except that a 0.6-mil clear (Polydak, Polyon-Barkai) replaced the 1.25-mil clear mulch. Among tunnel treatments, the polypropylene material was replaced with a 1.1-mil perforated polyethylene (Ken-Bar, Inc.).

Replicated soil temperature measurements were made 19 May until 26 May. Covers were removed on 2 June. Harvest was from mid-July until early September.

Results and Discussion

1991

Transplants that did not survive were replaced on 29 May or 6 June. Treatment affected plant survival (Table 1). Type of mulch had no effect, but among tunnel treatments, the IR-Thermofilm tunnel resulted in greater mortality than did the non-covered checks or the Typar. The soil was colder than normal at transplanting and saturated with moisture. The plants under the Thermofilm wilted rapidly and did not recover. Mean maximum air temperatures were greater under Thermofilm than under Typar or over mulch alone (Table 2). This could explain the observed differences in wilting and survival, as the root system could not deliver enough water to satisfy the transpiration demands of the shoots in the Thermofilm tunnel environment. The greatest mean minimum air temperature also occurred in the Thermofilm tunnel. The greatest mean maximum soil temperature occurred with the combination of IRT-76 mulch and the Thermofilm tunnel (Table 2). Averaged over all mulches, the IR-Thermolfilm also produced the highest mean maximum soil temperatures. Among mulches, the clear mulch produced the greatest mean minimum soil temperature. Soil maximum temperatures tended to be greatest with the IRT-76 mulch, but the differences were not statistically significant. Air minimum temperature was not affected by mulch type, but mean maximum air temperature was highest above the black mulch. Tunnels hastened flower development but mulch type had no significant effect on the number of flowers that reached anthesis within five weeks after transplanting (Table 1).

Early yield was affected by tunnels but not by type of mulch (Table 1). Early yield with either Typar or Thermofilm was nearly tripled compared to plots without tunnels. The greatest early yield of 1.5 marketable melons per plant was on plots with the combination of clear mulch and Thermofilm tunnel.

For the entire growing season, melon yield was affected by both mulch and tunnel (Table 1). Plants on clear mulch and the two wavelength-selective mulches produced significantly greater numbers of marketable fruit than did those on black mulch. Tunnel-covered plants outyielded those without a cover. Type of cover did not significantly affect yield. The greatest number of fruit per plant (4.5) was produced with the combination of clear mulch and the Thermofilm tunnel. Both mulch type and tunnels affected mean fruit weight (Table 3). Fruit weight was slightly lower with clear mulch as compared to the other mulches, and lower with tunnels as compared to non-covered plants. In each case, this may be due to competition for carbohydrates or nutrients since the treatments producing smaller mean fruit size were also those producing the greatest number of marketable fruit per plant.

These results are consistent with those obtained in 1990 and indicate that during a typical spring and summer, wavelength-selective mulches are best for melon production in the Willamette Valley. However, the best mulch is still inferior to the combination of a mulch and a tunnel. Weed growth was not a problem under the black or the wavelength-selective mulches. Weeds grew readily under the clear mulch but did not impair muskmelon growth and the number of fruit produced. However, the decrease in mean fruit weight with clear mulch might have been caused by weed competition.

1992

A substantial number of transplants did not survive and were replaced on 2 June. In contrast to 1991, the type of mulch affected survival, with greater mortality on black plastic than with the other materials. Among tunnel treatments, the two tunnels resulted in greater mortality than did the non-covered checks (Table 3). Although soil temperature was greater than normal in the two weeks after planting, the greater soil temperature under the wavelength-selective and clear mulches may have favored root development and plant survival. Air temperatures could not be measured while tunnels were in place. However, excessively high air temperatures under the tunnels may have contributed to plant wilting and death. This is consistent with results obtained in 1991. The greatest mean maximum soil temperature occurred with the combination of AL-OR mulch and the IR-Thermofilm (Table 4).

Early yield was not affected by tunnels or type of mulch (Table 3). Mean temperatures in May and June set new 40-year records for NWREC. This may have prevented any response to treatment. In contrast, in 1991, both mulch and tunnels greatly increased early yield during a cold, wet season. In agreement with 1991, neither mulch nor tunnel affected mean fruit weight of the early fruit. However, the trend was for greater mean fruit weight on the clear and wavelength-selective mulches and in the presence of tunnels.

For the entire growing season, melon yield was significantly affected by tunnel but not by mulch (Table 3). Tunnel-covered plants outyielded those without a cover, and the plants covered with the Ken-Bar tunnel outyielded those covered with the Thermofilm tunnel. The greatest number of Passport fruit per plant (4.8) was produced with the combination of clear mulch and the Ken-Bar tunnel; the greatest number of Superstar fruit (3.6 per plant) was produced with the combination of IRT-76 mulch and the Ken-Bar tunnel. In contrast to 1991, neither mulch type nor tunnels affected mean fruit weight. However, as in 1991, the trend was for tunnels to reduce mean fruit weight for the entire growing season.

Weed growth was, again, not a problem under the black or the wavelength-selective mulches. Some weeds grew under the clear mulch, but not to the degree in 1991. The weed growth was not sufficient to impair muskmelon growth and the number of fruit produced.

In conclusion, even in an unusually warm year, row tunnels are a desirable addition to wavelength-selective mulches for muskmelon production in the Willamette Valley.

Table 1. Main effects of mulch and tunnel on transplant survival[z], flowering[y], early and total yield, and fruit weight of muskmelon, NWREC, 1991

	Transplant survival (%)	Open blossoms/ plant	Early season Fruit/ plant	Early season Fruit wt. (g)	Total season Fruit/ plant	Total season Fruit wt. (g)
Mulch						
Black	78	0.8	0.8	1565	2.2	1466
AL-OR	90	1.3	0.9	1631	2.9	1405
IRT-76	85	1.2	1.0	1546	3.0	1464
Clear	93	1.3	1.0	1374	3.3	1290
LSD (0.05)	NS[x]	NS	NS	NS	0.6	150
Cover						
None	99	0.5	0.4	1648	1.9	1537
Typar	93	1.7	1.1	1526	3.2	1364
Thermofilm	69	1.3	1.2	1413	3.5	1318
LSD (0.05)	12	0.5	0.5	NS	0.5	131

[z]Survival five days after transplanting.
[y]Total number of flowers reaching anthesis before 26 June.
[x]NS: No significant differences, p=0.05.

Table 2. Interaction of mulch and tunnel on mean maximum and mean minimum air and soil temperatures (degrees F), NWREC, 1991

Mulch	Cover	Soil min.	Soil max.	Air min.	Air max.
None	None	50.0	74.0	47.7	83.7
Black	None	54.9	72.6	47.6	90.1
	Typar	53.8	89.1	49.2	103.1
	Thermofilm	59.3	90.1	52.4	119.3
AL-OR	None	54.0	77.8	47.6	93.2
	Typar	57.8	81.4	49.8	97.3
	Thermofilm	61.0	95.6	51.8	117.0
IRT-76	None	56.3	84.2	47.8	90.4
	Typar	60.0	82.5	50.6	105.1
	Thermofilm	59.8	101.5	51.4	112.3
Clear	None	58.1	81.0	48.2	86.1
	Typar	60.9	79.8	51.3	99.5
	Thermofilm	62.4	98.2	52.5	112.6
	LSD (0.05)	1.7	11.7	1.6	4.4
Main effects:					
Black		56.6	83.9	49.7	104.2
AL-OR		59.4	84.9	49.7	102.5
IRT-76		59.9	89.4	49.9	102.6
Clear		61.7	86.3	50.7	99.4
	LSD (0.05)	1.0	NS[z]	NS	2.5
	None	55.8	78.9	47.8	90.0
	Typar	58.1	83.2	50.2	101.3
	Thermofilm	60.6	96.4	52.0	115.3
	LSD (0.05)	0.8	5.8	0.8	2.1

[z]NS: No significant differences, p=0.05.

Table 3. Main effects of mulch and tunnel on transplant survival and on early and total yield and mean fruit weight of muskmelon, NWREC, 1992

	Transplant survival (%)	Early season Fruit/ plant	Early season Fruit wt. (g)	Total season Fruit/ plant	Total season Fruit wt. (g)
Cultivar					
Passport	94	1.9	869	3.8	889
Superstar	91	0.4	1270	2.3	1021
Significance	NS[z]	*	*	*	*
Mulch					
Black	80	1.1	883	2.9	923
AL-OR	95	1.1	1114	3.1	993
IRT-76	95	1.2	1276	2.8	948
Clear	100	1.4	1004	3.2	955
LSD (0.05)	10	NS	NS	NS	NS
Cover					
None	100	1.4	1004	2.6	1019
Ken-Bar	89	1.0	1090	3.4	891
Thermofilm	89	1.2	1114	3.1	955
LSD (0.05)	9	NS	NS	0.3	NS

[z]NS,*: No significant differences and significant differences between means, p=0.05, respectively.

Table 4. Interaction of mulch and tunnel on soil temperature (F), NWREC, 1992

Mulch	Cover	Soil min.	Soil max.
None	None	57.3	90.6
Black	None	61.4	86.8
	Ken-Bar	67.4	101.3
	Thermofilm	67.5	103.4
AL-OR	None	61.0	105.6
	Ken-Bar	67.0	109.3
	Thermofilm	68.9	114.6
IRT-76	None	61.0	98.4
	Ken-Bar	68.4	106.0
	Thermofilm	65.8	109.1
Clear	None	63.0	104.3
	Ken-Bar	67.3	112.0
	Thermofilm	68.6	110.8
	LSD (0.05)	2.1	13.7
Main effects:			
Black		65.5	97.2
AL-OR		65.6	109.8
IRT-76		65.1	104.5
Clear		66.3	109.0
	LSD (0.05)	1.1	9.2
	None	61.6	98.8
	Ken-Bar	67.3	107.2
	Thermofilm	67.7	109.5
	LSD (0.05)	1.3	8.5

EFFECT OF RATE, TIMING OF APPLICATION, AND PLACEMENT OF NITROGEN FERTILIZER ON BROCCOLI YIELD AND NITROGEN UPTAKE

Cooperator: John Hart, Dept. of Crop and Soil Science

Introduction

Broccoli growers in the Willamette Valley use high rates of nitrogen fertilizers, often exceeding 250 to 300 pounds actual N/acre per season. While the common experience has been that these rates are necessary to achieve maximum yields and quality, a considerable portion of the applied fertilizer may not be taken up by the crop. This has raised concerns that the remaining N may be contributing to nitrate pollution of groundwater. Improved efficiency of nitrogen management in broccoli may be possible if the fertilizer could be applied at the time of maximum crop need and placed for maximum contact with the root system. Trials conducted in 1989 and 1990 indicated that 250 pounds N/acre are needed for maximum yields, and that N source (potassium nitrate, sodium nitrate, calcium nitrate, urea, ammonium nitrate, ammonium sulfate) has very little effect on crop yield and nitrogen uptake. The purpose of the 1991 and 1992 trials was to study the response of broccoli yield to a wide range of rates of nitrogen as well as different methods of fertilizer placement and timing of the sidedressed applications. In addition, plots fertilized at 250 pounds per acre were used to determine the course of nitrogen uptake over time.

Methods

In 1991, 'Gem' broccoli was direct-seeded in a Willamette silt loam, pH 5.7, at the NWREC on 12 June. Plot preparation included a broadcast and incorporated application of triple superphosphate at 200 pounds/acre, potassium sulfate at 240 pounds/acre, boron at 2.0 pounds/acre, trifluralin at 0.75 pounds/acre, and chlorpyrifos at 1.3 pounds/acre. Fifty pounds N/acre as urea were shanked in at 2 inches beneath and 2 inches to the side of the seed row on the appropriate plots. All other plots except a zero-nitrogen check received a broadcast application of 50 pounds N/acre on 13 June, followed immediately by an irrigation of 0.5 inches. Plot size was 15 feet with four rows on an 80-inch bed. Spacing between rows alternated between 12 and 28 inches. The seedlings were thinned to approximately 10 inches between plants in the row on 26 June. The plots were sprinkler-irrigated as necessary and harvested on 21 and 28 August, and 4 September. Only main shoots were cut.

Urea was the sole nitrogen source. Of the total of 13 treatments that received N fertilizer, the remainder of the nitrogen was applied on 16 July for 12 treatments. For the remaining treatment, half the remaining N was applied on 9 July, the other half on 29 July. Treatments consisted of various combinations of fertilizer rates, and methods and timing of fertilizer placement (Table 1). In addition, two sets of plots were reserved for application of ^{15}N-enriched urea to monitor N uptake and movement of applied nitrogen through the soil profile. Treatments were in randomized complete block design with four replications.

Following completion of the last harvest and soil sampling for residual N, the four blocks were split and half of each block seeded to 'Wheeler' cereal rye on 17 Sept. Broccoli residue was left standing.

In 1992, methods were similar except as follows. The seeding date was 9 June. Plot size was 20 feet with four rows on an 80-inch bed. Spacing between rows was 16 inches. The initial application of nitrogen was broadcast immediately after seeding and irrigated in. Depending on treatment, all N was applied at planting; 40 pounds per acre were applied at planting and the remainder on 14 July; or 40 pounds were applied at planting, half the remainder on 7 July, and the final application on 27 July (Table 8). The plots were harvested on 18 and 25 August.

The cereal rye cover crop was seeded on 3 Sept. after mowing the broccoli and lightly disking the soil surface.

Results and Discussion

1991

When all N fertilizer was broadcast, yield increased with increasing rate of N to a maximum at 250 pounds N/acre (Table 2). Not all N rates were included when the second N application was banded between the paired 12-inch rows or when the first N application was shanked-in rather than broadcast. However, the trend in yield response to increasing rate of N was similar to the yield response when all N was broadcast (Tables 3 and 4). The greatest yield was obtained when the sidedressed N was split between two applications at four and seven weeks after planting rather than a single application at five weeks (Trt. 11, Table 2). However, the yield with the split application was not significantly greater than the yield with a single sidedressing of N at the same rate. These results are consistent with those obtained in 1990, when maximum yield occurred at 250 pounds N, regardless of source of the applied N. Rates of N in excess of 250 pounds do not appear to increase potential return to the grower.

Method of N placement did not significantly affect yield in this trial. Banding the sidedressed N between the closely-spaced paired rows was no more efficent than spinning the N over the entire area at this plant population (31,360/acre) and row spacing (Table 3). Apparently, fertilizer landing in the 28-inch space between paired rows was effectively utilized. Alternatively, concentrating the N between the paired rows may have resulted in excessive N in the band or exposure of too small a fraction of the root system to the available N. Likewise, shanking the initial fertilizer application in a band 2 inches to the side and 2 inches beneath the seed line did not increase efficiency of utilization as reflected in mean head weight (Table 4). Also, there was a single comparison of shanked at-planting fertilizer and banded sidedressed fertilizer at a total N rate of 100 pounds/acre (Treatment 4). This treatment produced an average head weight for the season of 133 g, less than that obtained for all-broadcast N at 100 pounds (141 g) or the shanked-broadcast combination at 100 pounds N/acre (136 g).

Thus, it appears that at high plant populations and small between-row spacings, broadcast applications are as effective as any other means of application. Irrigation in this trial was controlled to prevent movement of nitrogen out of the root zone. A total of 10 inches of water was applied and there was no significant rainfall. Wells (vacuum lysimeters) were installed in the ^{15}N plots. There was no movement of water below the two-foot depth. A comparison of pre-plant and post-harvest soil samples taken down to the 40-inch depth indicated no movement of nitrate or ammonium below a depth of 20 inches during the growing season. Only at the highest rate of applied N was there any evidence of residual nitrate or N movement to a depth greater than 10 inches (Table 5). With greater irrigation amounts or significant precipitation, band placement might still keep more of the applied N in the root zone.

Results from the ^{15}N uptake studies indicate that about two-thirds of N taken up by broccoli fertilized at the optimal 250 pounds/A N rate comes from applied fertilizer. Total N uptake was 310 pounds/A and essentially all the ^{15}N was taken up. This indicates that an optimally-fertilized and irrigated broccoli crop leaves almost no unutilized N in the soil. However, non-uniform plant stand and growth in these plots caution against extrapolating the results to commercial fields.

The cereal rye cover crop planted in 1991 was very effective in removing residual nitrate and ammonium from the soil profile on plots fertilized with 250 pounds N/acre (Table 6). The plots without cover show an increase in nitrate, but not ammonium, concentration with depth. The plots with a cover crop show a much lower level of nitrate and ammonium at all depths and less tendency for higher levels of nitrate in the 20 to 40-inch depth. The cover crop did not accumulate a great amount of dry matter. However, up to 33 pounds N/acre were trapped in the cover crop biomass at the highest rate of N application to the broccoli crop (Table 7). When there was no broccoli left standing, more than 40 pounds N/acre were taken up by the rye following broccoli fertilized with 250 pounds N/acre. The amount of nitrogen in the standing broccoli crop, which was not killed by the mild winter, was not determined.

Table 1. List of N application treatments, 1991 broccoli N utilization trial, NWREC

No.	Total N applied	N applied at planting	N applied at five weeks
	---lb/A---		
1	0	0	0
2	100	50 broadcast	50 broadcast
3	100	50 shanked	50 broadcast
4	100	50 shanked	50 banded
5	100	50 broadcast	50 banded
6	175	50 broadcast	125 broadcast
7	175	50 broadcast	125 banded
8	250	50 broadcast	200 broadcast
9	250	50 broadcast	200 banded
10	250	50 shanked	200 broadcast
11	250	50 broadcast	0[z]
12	250	50 broadcast	200 broadcast N-15
13	250	50 broadcast N-15	200 broadcast
14	325	50 broadcast	275 broadcast

[z]100 broadcast at 4 weeks; 100 broadcast at 7 weeks.

Table 2. Effect of N rate on yield and mean head weight of broccoli when all fertilizer is broadcast, NWREC, 1991

		Mean head weight (g)		
Trt. No.	N rate (lb/A)	First harvest	All harvests	Total yield (T/A)
1	0	95	91	2.9
2	100	137	141	5.5
6	175	145	153	5.4
8	250	154	158	5.9
11	250	159	162	6.0
14	325	123	140	4.1
	LSD (0.05)	48	40	1.8

Table 3. Comparison of N rate on mean head weight of broccoli when all fertilizer is broadcast versus band placement of the second nitrogen application, NWREC, 1991

Broadcast-broadcast			Broadcast-band		
Trt. No.	N rate (lb/A)	Mean wt. (g)	Trt. no.	N rate (lb/A)	Mean wt. (g)
2	100	141	5	100	129
6	175	153	7	175	145
8	250	158	9	250	161
	Mean[z]	151			145

[z]No significant difference between means (P=0.05).

Table 4. Comparison of N rate on mean head weight of broccoli when all fertilizer is broadcast versus shanked-in placement of the at-planting nitrogen application, NWREC, 1991

Broadcast-broadcast			Shank-broadcast		
Trt. No.	N rate (lb/A)	Mean wt. (g)	Trt. no.	N rate (lb/A)	Mean wt. (g)
2	100	141	3	100	136
8	250	158	10	250	151
	Mean[z]	150			144

[z]No significant difference between means (P=0.05).

Table 5. Soil nitrate and ammonium concentrations (ppm) before planting and after broccoli harvest, NWREC, 1991

		N rate, lb/A				
		0	100	175	250	325
Depth of sample (inches)	Pre-plant	Post-harvest				
Nitrate						
0-10	6.3	0.1	0.4	3.4	9.0	23.3
10-20	3.3	0.8	0.1	0.7	2.4	4.2
20-30	2.0	0.6	0.1	0.3	1.2	2.0
30-40	2.4	0.8	0.3	0.4	1.0	1.7
Ammonium						
0-10	3.2	3.7	4.0	7.6	12.9	30.8
10-20	3.7	2.4	2.7	2.3	4.2	12.1
20-30	6.7	3.7	4.9	2.8	4.8	5.2
30-40	8.2	3.0	3.1	2.3	2.7	4.0

Table 6. Effect of a cereal rye cover crop on soil nitrate and ammonium concentrations (ppm) in broccoli plots fertilizer with 250 pounds/acre nitrogen, NWREC, 15 April, 1992

Depth of sample (inches)	With cover	Without cover	Significance[z]
Nitrate			
0-10	0.07	0.41	*
10-20	0.09	0.57	**
20-30	0.12	3.17	**
30-40	0.18	5.38	**
Ammonium			
0-10	1.05	2.36	*
10-20	1.23	2.04	*
20-30	1.27	2.20	*
30-40	1.25	1.96	NS

[z]*,**,NS: Differences significant at the 5% and 1% levels and no significant difference, respectively.

Table 7. Nitrogen content, yield, and nitrogen uptake by a cereal rye cover crop in April, 1992, following various rates of nitrogen applied to a broccoli crop in 1991, NWREC

N rate, lb/acre	N content (%)	Dry matter yield, lb/acre	N uptake, lb/acre
0	1.55	430	6.2
100	1.48	580	7.6
175	1.29	1840	23.0
250	1.63	1510	24.4
250[z]	1.27	3530	42.5
325	1.45	2330	33.5
Significance	NS	**	**

[z]Broccoli plants removed from this plot but were left standing after harvest in all other plots.

1992

Averaged over timing of N application, yield increased with increasing rate of N to 180 pounds N/acre (Table 9). Rates of N application beyond this level had little effect on yield. In the previous experiments, yield peaked at 250 pounds N/acre, with a definite decrease at 325 pounds/acre.

Splitting the N application to provide most of the N nearer the time that the plants experience greatest uptake did not increase yield (Table 10). Even at less than optimal rates of N, yield was greatest when all N was applied at planting. This was a late-spring planting in a very dry year and with carefully controlled irrigation. Thus, N loss to leaching was probably not a factor. Results may have differed for a planting early in the season when leaching of the early N application would be more likely.

It is critical to have an adequate supply of N at planting. Even after a dry winter and with significant available N in the soil at planting (5.6 ppm nitrate in the surface six inches of soil), yield was increased by applying N at planting. Delaying the first N application to four weeks after planting reduced mean head weight from 163 g to 148 g for plants receiving a total of 180 pounds N/acre. In the comparison of the single application versus a 2-way or 3-way split, perhaps the split applications would have been more favorable if a greater proportion of the nitrogen had been applied at planting.

The broccoli crop effectively depleted soil mineral nitrogen at rates of applied nitrogen up to 180 pounds/acre (Table 11). At higher rates the soil nitrate, but not ammonium, concentration was elevated slightly. The results obtained at 240 pounds N/acre are almost identical to those obtained with the optimal rate of 250 pounds in 1991.

Four years of results indicate that the optimum nitrogen rate for broccoli grown on a Willamette silt loam at a plant density of 30,000 to 40,000 per acre is near 250 pounds/acre. Rates in excess of 300 pounds/acre leave significant amounts of residual nitrate available for leaching, whereas rates of 250 pounds/acre or less are efficiently utilized by the crop. Winter cover crops can catch a large proportion of the residual nitrate. Neither method of placement of N nor the timing of N application appear to have much effect on the efficiency of N utilization by broccoli.

Table 8. List of N application treatments, 1992 broccoli N utilization trial, NWREC

No.	Total N applied	At planting	At five weeks	At seven weeks
	-----	-----	lb/A -----	-----
1	0	0	0	0
2	60	40	20	0
3	120	40	80	0
4	180	40	140	0
5	240	40	200	0
6	300	40	260	0
7	60	60	0	0
8	120	120	0	0
9	180	180	0	0
10	240	240	0	0
11	300	300	0	0
12	120	40	40[z]	40
13	180	40	70[z]	70
14	240	40	100[z]	100
15	300	40	130[z]	130
16	180	0	90[z]	90

[z]At 4 weeks rather than 5 weeks.

Table 9. Main effect of nitrogen rate on yield and head size of broccoli, NWREC, 1992

N rate (lb/acre)	Mean head wt., first harvest (g)	Mean head wt., total of two harvests (g)	Total yield (tons/acre)
0	76	52	1.6
60	112	95	3.9
120	167	142	5.5
180	195	167	6.8
240	196	169	6.7
300	205	170	7.4
LSD (0.05)	41	31	1.0

Table 10. Effect of splitting nitrogen application on broccoli head size at several rates of applied nitrogen, NWREC, 1992

N rate (lb/acre)	Single applic.	Two applics.	Three applics.
	-----	g/head -----	-----
60	101	88	--
120	159	137	129
180	177	163	162
240	170	169	168
300	171	164	176
Mean (120-300 lb)	169	158	159

Table 11. Effect of rate of broadcast nitrogen on soil nitrate and ammonium concentrations (ppm) following final broccoli harvest, NWREC, September, 1992

		N rate, lb/A						
		0	60	120	180	240	300	LSD(.05)
Depth of sample (inches)	Pre-plant	Post-harvest						
Nitrate								
0-10	5.6	0.9	0.4	3.1	3.4	9.8	12.1	4.2
10-20	3.8	0.2	0.2	0.9	1.1	4.7	3.6	3.2
20-30	3.1	0.6	0.4	0.3	0.6	1.4	0.9	NSD
30-40	3.8	1.2	0.7	1.2	1.0	1.9	1.4	NSD
Ammonium								
0-10	4.8	2.0	1.1	1.8	2.0	2.0	2.3	NSD
10-20	2.8	1.8	1.6	2.2	2.7	1.3	1.5	NSD
20-30	5.1	1.5	2.0	1.1	0.9	0.8	1.3	NSD
30-40	4.4	1.5	0.8	1.2	1.1	0.9	1.4	NSD

BROCCOLI AND SWEET CORN RESPONSE TO WINTER COVER CROPS AND RATES OF NITROGEN FERTILIZER

Cooperator: Richard Dick, Dept. of Crop and Soil Science, OSU

Introduction

Nitrate pollution of groundwater resulting from application of high rates of N (up to 300 pounds per acre) to vegetable crops is an increasing concern in the Willamette Valley. These high rates of application exceed crop uptake and leave significant amounts of residual mineral N to be leached during the winter period of high rainfall. Little information is available on N cycling as related to crop rotations or on the ability of winter annual cover crops to capture residual N following the crop.

Partly in response to these concerns, a long-term crop rotation study was established at NWREC in 1988. The planned rotations included grass seed only, grass seed/clover, vegetable/small grains, vegetable/small grains/clover, and vegetable/winter cover crop. The vegetable rotations started with winter wheat, followed by either winter fallow, cereal rye, or cereal rye plus Austrian winter pea cover crop, followed by sweet corn at three N rates in 1990. Following the sweet corn crop, the plots were again fallowed or planted to the same cover crops as in the previous winter. In 1991, these plots were transplanted to broccoli. In addition, plots that had been in red clover since 1989 were also transplanted to broccoli. The primary objectives were to determine how much nitrogen was trapped in the winter cover crops and made available to the broccoli crop (as a function of applied fertilizer N) and to determine the potential of a winter cover legume, or a legume in the crop rotation, to provide N for the broccoli crop. A secondary objective was to determine the effect of weed control by cultivation alone, in the production of transplanted broccoli.

The same plots that had been in winter cover crops in 1990-91 and planted to broccoli in 1991 were replanted to the same cover crops following the broccoli crop. These cover crops were followed in 1992 with a planting of sweet corn. As with the broccoli, the primary objective was to determine the cover crop contribution to the yield of the sweet corn.

Methods

In 1991, all cover crop plots were sampled for biomass and N accumulation on 15 April. Samples were oven-dried, weighed, and subsamples taken for determination of total N. The 30 x 60-foot plots were mowed and disked on 19 April and then plowed, disked, and harrowed in May. On 31 May, all plots received a broadcast, incorporated application of chlorpyrifos at 1.0 pounds/acre and boron at 2.0 pounds/acre. Appropriate "high input" plots also received trifluralin herbicide at 0.75 pounds/acre. On 4 and 5 June, the plots were transplanted to Gem broccoli. Spacing was 12 inches in the row with paired rows on 20-inch centers and a 40-inch wheel track. For plots that had been winter-fallowed or in rye, or rye plus pea cover crops, urea was applied at 125 pounds N/acre to the appropriate subplots on 7 June. An additional 125 pounds N/acre was applied to the appropriate subplots on 1 July.

Four additional plots had been in 'Kenland' red clover. These were split with half of each plot plowed after seed harvest in the fall of 1990 and the remaining half plowed in April, 1991, permitting substantial shoot regrowth. These subplots were further split by application of either 0 or 200 pounds N/acre as urea. The N application was split, with half the total applied on 7 June, and the remainder on 1 July.

All plots were sprinkler-irrigated for four weeks, after which drip irrigation tubing was installed between the paired rows. The tubing had emitters at 9-inch intervals and a flow rate of 0.5 gallons/minute/100 feet. All plots were tractor-cultivated on 24 June and hand-hoed in July. Leaves were sampled for N content determination on 17 July. All plots were harvested on 30 July and 7 August. Yields were determined from a 40 row-foot section near the center of each subplot.

After disking and harrowing, cover crops were seeded on 20 September. Eight of the 16 plots were planted to 'Wheeler' cereal rye at 65 pounds/acre. The other eight plots were planted to a mixture of 'Wheeler' rye at 35 pounds/acre and Austrian winter pea at 100 pounds/acre. No fertilizers or pesticides were applied to the cover crops. Nitrogen rate subplots of 600 square feet each were determined by the N rate applied to the broccoli crop.

On 7 April, 1992, samples were taken from all subplots for determination of shoot dry weight and N uptake. The shoots were clipped about 1 inch above ground. The rye and pea plants were counted, weighed, and analyzed separately. The cover crops were mowed down on 17 April, disked on 27 April, and plowed under on 28 April, 1992. The plots were disked and harrowed in early May.

On 19 May, 1992, 2.0 pounds EPTC/acre was applied to one rye and one rye-pea mixture plot in each of the four blocks ("low input" or reduced herbicide main plots). The EPTC was rototilled into the surface 3 inches of soil. 'Jubilee' sweet corn was seeded in 20-inch paired rows on 20 May. The distance between pairs of rows was 40 inches. Triple superphosphate was banded 2 inches to the side and 2 inches beneath the seed row at a rate of 80 pounds/acre. Immediately after planting, the remaining rye and rye-pea plot in each block was sprayed with 2.0 pounds atrazine and 3.0 pounds alachlor/acre ("high input" or high herbicide main plots).

On 21 May, one-half of the total N was applied as urea in a surface band between the paired rows at rates of 0, 50, and 200 pounds/acre. These N rate subplots were in the same location as the corresponding N treatments on the previous vegetable crops. Drip irrigation tubing was then installed between each pair of rows. Two weeks after emergence, the corn was thinned to a stand of 7 inches between plants in the row. The remainder of the urea was sidedressed on 3 July.

On 3 July, the "low input" main plots that had been in cereal rye were overseeded with 'Wheeler' cereal rye at 50 pounds/acre. The "low input" main plots that had been in rye plus pea were overseeded with 'Kenland' red clover. In each case, the seed was broadcast with a spinner-type fertilizer spreader and scratched in with a garden rake. The overseeding was in preparation for the 1992-1993 experiments, in which one of the objectives will be to determine the value and feasibility of overseeding a cover crop into the standing vegetable crop.

On August 16, the stalks from 15 feet of two inner rows of each suplot were harvested. Ears were counted, measured for length, and rated for tipfill. Subsamples of ears and stalks were taken for determination of dry weight and total nitrogen content.

Results and Discussion

Cover Crop N Recovery, 1991

Nitrogen added to the sweet corn crop in the summer of 1990 significantly affected the growth of the cover crops in the winter of 1990-91 (Figure 1). Both the cover crop biomass and N uptake (Figure 2) increased as the rate of N applied increased. To estimate the amount of N recovered from the fertilizer applied to the sweet corn, the amount of N recovered in the cereal rye without applied N can be subtracted from the amount recovered with 200 pounds/acre applied N. This difference of about 80 pounds N/acre suggests that, without a cover crop, 80 pounds/acre would have been available for leaching.

Adding Austrian pea to the cover crop increased N content of the total cover crop at the 0 and 50 pound N rates, but not at the 200 pound rate. The legume contributed only about 10 pounds N/acre, but there was a synergistic effect on the companion rye crop, which accumulated additional N in the presence of the legume. Legume growth was suppressed at the high rate of N, probably by competition with the vigorously growing rye. The number of pea plants per unit area decreased from 30-35 per square meter at 0 or 50 pounds applied N per acre to 11 per square meter at 200 pounds N/acre. Thus, adding legumes to a cover crop mix in order to fix N may be effective only following low rates of N application to the preceding crop.

Broccoli Response to the Preceding Cover Crop, 1991

With transplanting allowing the crop a head start on weed growth, and with the subsequent cultivation of all plots, herbicide application had no effect on yield (Table 1). This suggests that it is practical to grow transplanted broccoli with only mechanical tillage and obtain satisfactory yields.

The cereal rye cover crop failed to increase broccoli yield, even though it trapped a significant amount of nitrogen from the previous corn crop (Table 1). The yield of plots with a cereal rye cover and no herbicide was actually reduced significantly compared to the fallow plots. The rye plus pea cover crop also failed to significantly increase broccoli yield. This is in contrast to the 1990 sweet corn crop, where the combination of rye and Austrian winter pea increased yield, particularly at low rates of applied nitrogen. One can speculate that the cereal rye had an allelopathic effect on the growth of the broccoli root system or that decomposition of the cover crop took applied N from the broccoli crop rather than acting as a source of readily available N.

For the plots that had been in red clover, yields were generally higher than for the fallowed plots or the winter-cover crop plots (Table 2). Plots receiving applied N produced greater broccoli yields than those not receiving applied N, regardless of whether the cover was plowed in the spring or fall. Spring-plowing was definitely advantageous, as yields exceeded those with fall-plowing. The yield of broccoli following clover was greater, with no applied N, than for broccoli following winter fallow or winter cover crops. The

Figure 1. Shoot biomass (dry weight) of cover crops just before plowdown in April, 1991, as affected by the rate of N applied to the previous sweet corn crop.

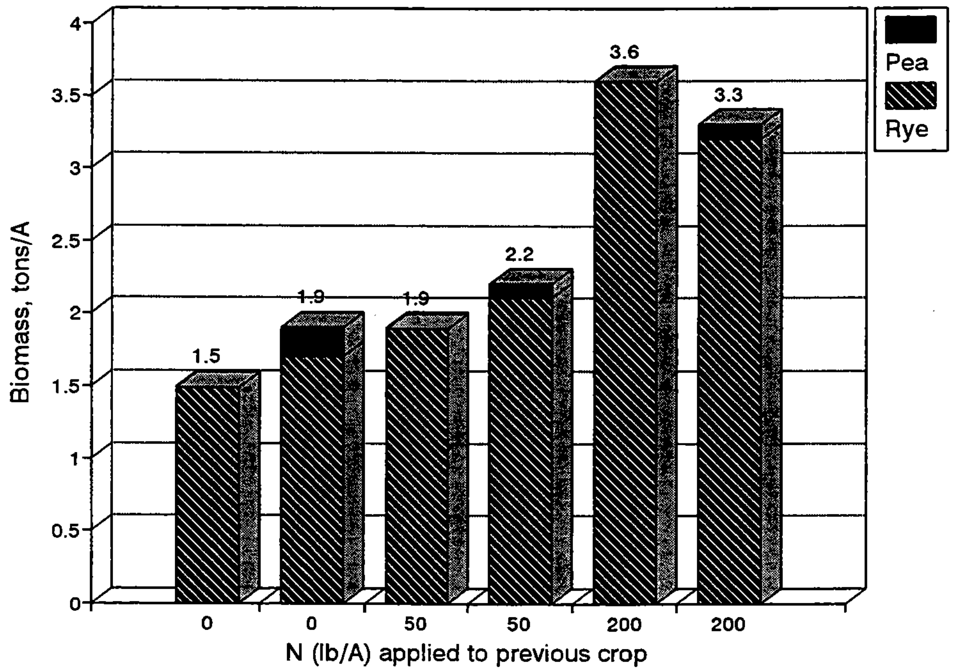
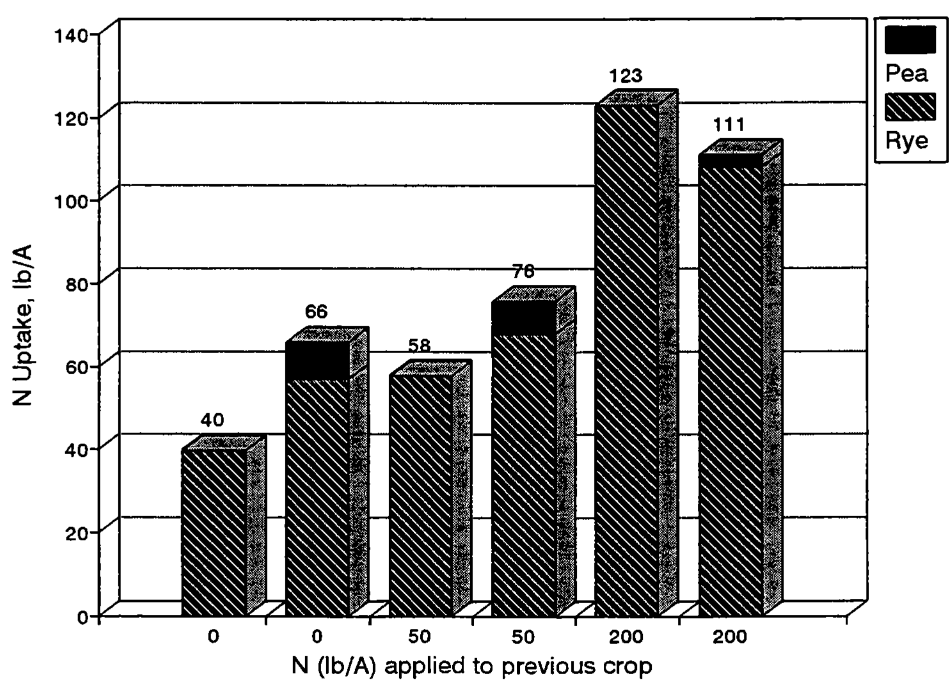


Figure 2. Nitrogen uptake by cover crops just before plowdown in April, 1991, as affected by the rate of N applied to the previous sweet corn crop. The black portion of the second bar for each N rate represents the portion of the total pea-rye uptake contributed by the pea plants.



greatest yield in this experiment (4.6 tons/acre) was with the combination of spring-plowed cover and 200 pounds N/acre.

The disorder hollow stem is, at least in part, related to high rates of N and rapid growth. In this trial, the incidence of hollow stem increased with applied N compared to no applied N, with pea plus rye compared to rye only as cover crop, and with spring rather than fall plowing of the preceding clover crop. In each case, this is consistent with hollow stem being related to high rates of available N.

Table 1. Main effects of winter cover crop and N rate on yield, head size, and incidence of hollow stem of transplanted 'Gem' broccoli, NWREC crop rotation study, 1991

	First harvest			Sum of two harvests		
	Yield (T/A)	Head wt. (g)	Hollow stem (%)	Yield (T/A)	Head wt. (g)	Hollow stem (%)
Cover crop						
Fallow	2.1	160	40.7	2.8	151	34.4
rye, - herb.	1.2	123	14.9	2.2	122	11.7
rye+pea, -herb.	2.1	156	35.0	3.1	155	28.5
rye, +herb.	1.8	136	19.8	2.7	134	16.3
rye+pea, +herb.	1.9	143	44.4	2.8	143	33.0
LSD (0.05)	0.4	18	16.9	0.4	20	12.3
Contrasts:						
Fallow vs. others	NS	*	*	NS	NS	*
-herb. vs. +herb	NS	NS	NS	NS	NS	NS
rye vs. rye+pea	*	**	**	*	**	**
N rate (lb/A)						
0	1.1	110	14.6	2.1	109	11.4
125	2.7	170	66.5	3.1	160	48.0
250	2.9	197	58.4	3.8	196	49.7
Significance	Q**	Q**	Q**	L**	Q**	Q**

NS,*,**,L,Q: No significant differences, differences significant at 5%, 1% levels, respectively, linear, quadratic.

Table 2. Main effects of fall versus spring plowing of an established red clover seed crop and nitrogen rate on yield, head size, and incidence of hollow stem of transplanted 'Gem' broccoli, NWREC crop rotation study, 1991

	First harvest			Sum of two harvests		
	Yield (T/A)	Head wt. (g)	Hollow stem (%)	Yield (T/A)	Head wt. (g)	Hollow stem (%)
Plowing season						
Fall	2.3	180	47.7	3.3	176	37.5
Spring	3.5	193	65.3	3.9	186	58.4
Significance	**	*	*	*	*	*
N rate (lb/A)						
0	2.0	143	43.0	2.8	140	33.4
200	3.6	224	70.0	4.2	222	62.6
Significance	**	**	**	**	**	**

*,**: Significant at 5% and 1% levels, respectively.

Cover Crop N Recovery, 1992

Both increasing the fertilizer rate on the preceding broccoli crop and the presence of peas in the cover crop increased total cover crop yield and N uptake (Figures 3 and 4). The high or reduced herbicide inputs on the broccoli had no effect on cover crop yield or N uptake, so the results are averaged over herbicide treatment. The rye produced greater biomass in the presence of peas at the low and intermediate rates of residual N. Pea biomass was somewhat reduced at the highest rate of N. The peas did not have as much effect on N uptake by the rye. Pea N uptake was nearly constant over N rates.

A rough estimate of the amount of residual fertilizer N left over from the broccoli crop and recovered by the rye cover crop can be obtained by examining the rye-only uptake at the three fertilizer rates shown in Fig. 2. Subtracting the amount of N taken up by the rye grown on non-fertilized subplots from the N taken up at the other two N rates suggests that about 9 pounds N/acre were taken up from the intermediate rate of N, and 22 pounds from the high rate of N. This N would have been available for leaching. Of course, an undetermined amount of N may have leached before the cover crops were well established.

For the high N rate subplots, the N uptake by the cover crop increases from 41 pounds/acre for rye alone to 76 pounds/acre for rye plus pea. A large part of the extra N taken up by the rye plus pea may come from N fixation, but the peas may also have taken up some residual N that escaped the rye.

The population density of Austrian winter pea plants in the rye plus pea plots was significantly lower in the high herbicide treatment than in the reduced herbicide treatment (Figure 5). Interestingly, the herbicide used for the "high input" treatment is registered for use on dry peas and is generally considered safe for the crop.

At corn harvest, pickers were instructed to pick all ears that they judged to have any mature kernels. The herbicide program (or overseeding to rye or clover) had no effect on the number of ears harvested (Table 3). However, both increasing rate of applied N and the presence of Austrian peas in the preceding cover crop increased the number of ears judged harvestable. Likewise, ear yield (tons/acre) did not vary with the herbicide program but did increase with increasing N rate and pea in the cover crop. There were no significant interactions among herbicide program, cover crop, and N rate affecting any component of yield or tipfill; thus, only main effects are given in Table 3. The highest yield of 11.0 tons/acre was for plots with the combination of atrazine-alachlor as herbicide (no overseeding), the highest N rate, and the mixture of rye and pea as cover crop.

Ear length was not affected by cover crop or herbicide program, but mean ear weight was affected by both cover crop and herbicide, as well as N rate. Kernel moisture content was not affected by treatment, while stover (stalk) weight increased with increasing rate of N. Tipfill, a measure of kernel development at the silk end of the ear, was increased by the atrazine-alachlor herbicide program as well as by increasing the rate of applied N.

The most striking feature of these results is the contribution of the cover crop peas to the sweet corn yield, even at a high rate of applied N. It is interesting to note that the 10 tons/acre yield achieved with 50 pounds N/acre following a rye plus pea cover crop is equivalent to the yield with 200 pounds

Figure 3. Shoot biomass (dry weight) of cover crops just before plowdown in April, 1992, as affected by the rate of N applied to the previous broccoli crop. Averaged over the high and low rates of herbicide application to the broccoli crop.

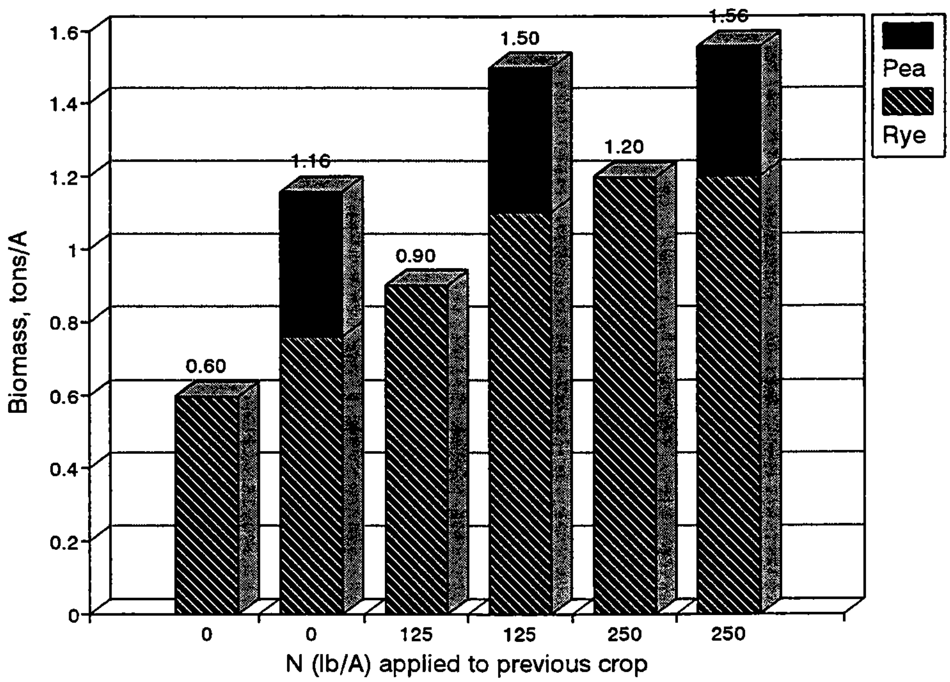


Figure 4. Nitrogen uptake by cover crops just before plowdown in April, 1992, as affected by the rate of N applied to the previous broccoli crop. Averaged over the high and low rates of herbicide application to the previous crop.

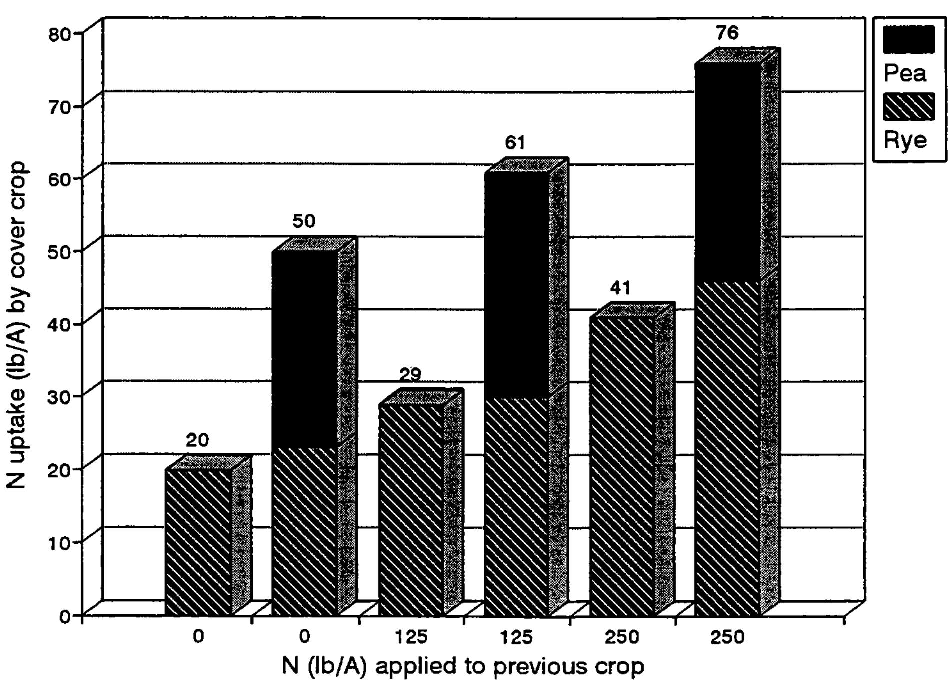


Figure 5. Effect of nitrogen rate and herbicide input level applied to the previous broccoli crop on the population density of Austrian winter pea plants in a rye plus pea cover crop.

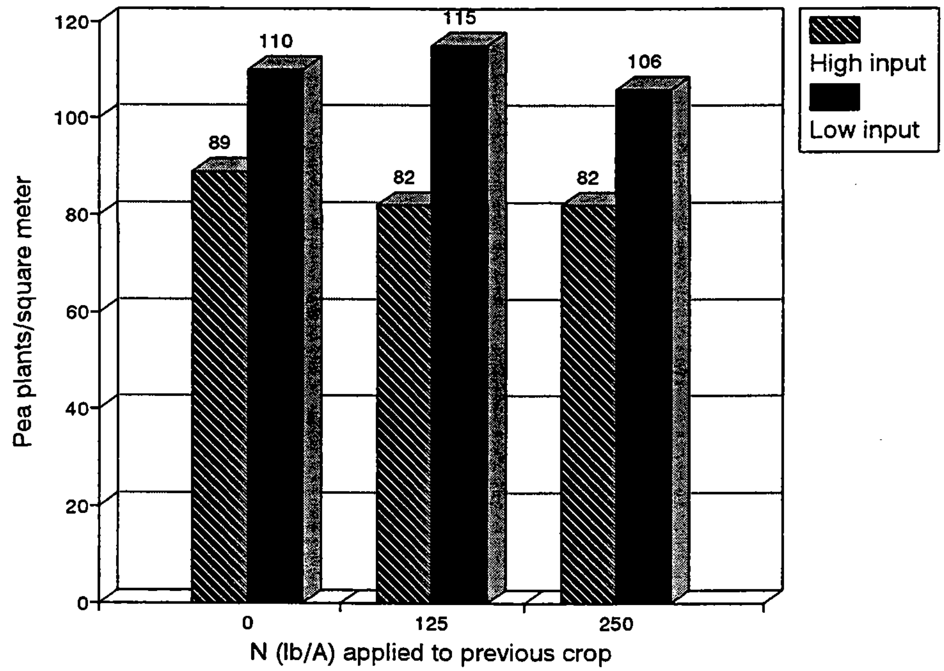
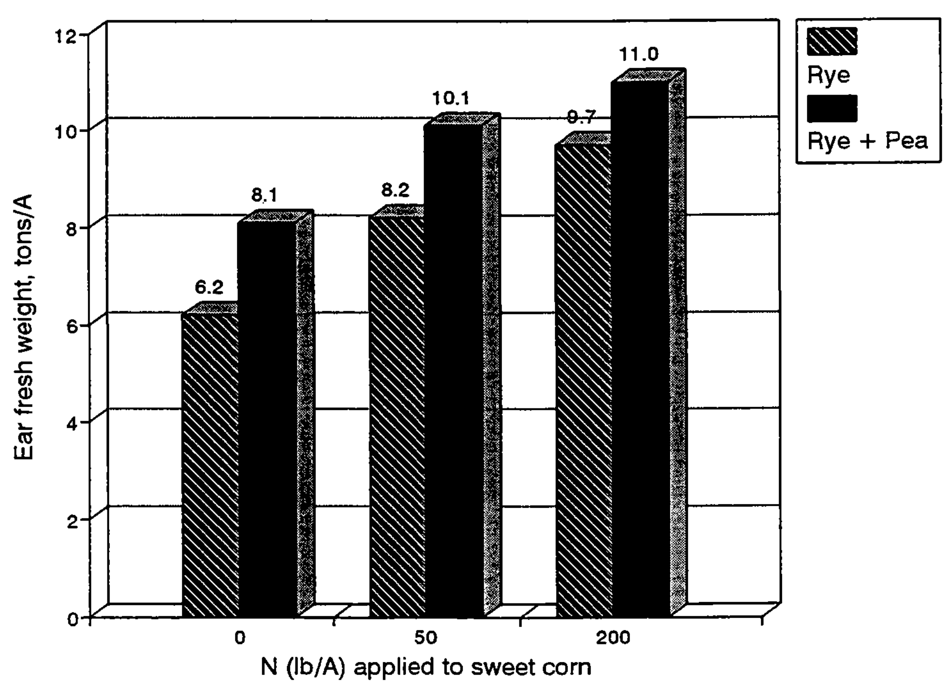


Figure 6. Effect of nitrogen rate and winter cover crop on the fresh weight ear yield of sweet corn, NWREC, 1992.



applied N/acre when the cover crop was rye only (Figure 6). In this experiment it was not possible to measure the contribution of the rye-only cover crop to sweet corn yield, as the program of crop rotations did not allow for sweet corn following a winter fallow.

Table 3. Main effects of herbicide and overseeding, preceding cover crop, and rate of applied nitrogen on ear yield and quality of sweet corn, NWREC, 1992

Treatment	No. harvested/ acre	Yield (Tons/ acre)	Length (inches)	Mean wt. (g)	Tipfill[z]	Kernel moisture content (%)	Stover yield (T/A)
Herbicide, overseeding							
EPTC, overseeded	30,100	8.7	11.1	260	2.8	77.8	14.6
Atrazine, not overseeded	29,210	9.1	11.2	279	3.1	75.7	14.7
Significance	NS	NS	NS	*	*	NS	NS
Cover crop							
Rye	27,780	8.1	11.2	258	2.9	77.2	14.0
Rye + pea	31,530	9.7	11.2	281	3.0	76.3	15.3
Significance	*	*	NS	*	NS	NS	NS
N rate (lb/A)							
0	25,110	7.2	10.9	251	2.6	77.7	12.8
50	30,200	9.2	11.2	276	3.1	76.4	14.6
200	33,650	10.3	11.4	280	3.3	76.2	16.6
Significance	**	**	**	**	**	NS	**

[z]Rated on a 5-point scale with 5 = perfect kernel development to the tip of the ear; 1 = at least two inches of undeveloped or shriveled kernels.

NITROGEN RATE, FORM, AND PLACEMENT ON SWEET CORN YIELD AND NITROGEN UPTAKE

Cooperator: John Hart, Dept. of Crop and Soil Science, OSU

Introduction

The rationale for this trial was similar to that of the previously described broccoli and sweet corn experiments. Sweet corn is planted at smaller populations and wider row spacings than is broccoli and may be less effective at taking up applied N. The purpose of this trial was to determine if yield of sweet corn would be affected by placement or source of N fertilizer at several rates of applied N.

Methods

'Jubilee' sweet corn was seeded in a Willamette silt loam, pH 5.9, at the NWREC on 19 May, 1992. Plot preparation included a broadcast and incorporated application of triple superphosphate at 250 pounds/acre and potassium sulfate at 250 pounds/acre, disking and cultimulching. Another 60 pounds/acre of triple superphosphate was banded 2 inches to the side and 2 inches beneath the seed row on all plots. Forty pounds N/acre as urea, ammonium nitrate, calcium-ammonium nitrate (CAN-17), or urea-ammonium nitrate (UAN-32) were also shanked in at 2 inches beneath and 2 inches to the side of the seed row on all but the zero N and zero N at planting treatments (Table 1). The pelleted urea and ammonium nitrate were mixed with the superphosphate. The liquid CAN-17 and UAN-32 were applied with separate shanks mounted behind the superphosphate shanks. Plot size was 15 feet wide (six rows) by 30 feet long. Spacing between rows was 30 inches. Immediately after planting, atrazine was applied at 2.0 pounds/acre and alachlor at 3.0 pounds/acre. The seedlings were thinned to approximately 7 inches between plants in the row on 9 June. The remaining nitrogen was shanked in or broadcast to the appropriate plots on 29 June. Treatments consisting of various rates, sources, and sidedress application methods were in randomized complete block design with four replications. The plots were sprinkler-irrigated as necessary and harvested on 17 August.

Following completion of harvest, the stover was mowed and left in place on the plots. The plots were sampled for residual soil nitrate and ammonium concentration on 26 August and their identity was maintained over the winter so that samples could be taken in the spring of 1993.

Results and Discussion

When all the sidedressed nitrogen fertilizer was banded as urea, yield increased with increasing rate of N to a maximum at 180 pounds N/acre (Table 2). However, the yields at 120 and 240 pounds N/acre were not significantly different than at 180 pounds/acre. Mean ear weight and length tended to be greatest at 120 pounds N per acre.

All other combinations of N source and application method were at 60 and 180 pounds total N/acre. Comparisons of N utilization are based on banded urea as the standard. Mean yield per unit area of corn fertilized at 60 and 180 pounds N/acre did not vary significantly with N source (Table 3). However, the plants fertilized with UAN-32 were consistently poorest in terms of number of ears harvested, mean ear weight and length, and degree of tipfill of the ear. Although not statistically significant, yield also tended to be lowest with UAN-

32. The greatest number of ears harvested and the greatest yield were with CAN-17 as N source, but the greatest mean ear weight, length, and tipfill were with ammonium nitrate.

When comparing only sweet corn fertilized with urea or ammonium nitrate and averaged over method of placement of the sidedressed fertilizer, ammonium nitrate appeared slightly superior to urea, but the difference was significant only for mean ear weight (Table 4). Past research at NWREC with urea, ammonium nitrate, and other solid N sources indicated no consistent differences among nitrogen sources in effects on corn yields. When comparing a broadcast versus a banded application of sidedressed fertilizer (Table 4), there were no significant effects on yield or quality.

Sweet corn production with zero or 60 pounds/acre of applied N reduced nitrate concentration in the top 30 inches of the soil profile during the growing season (Table 5). Soil ammonium concentration was not greatly affected by sweet corn fertilized with these same rates. However, at 120 or more pounds N/acre, soil nitrate and ammonium concentrations were greatly elevated in the surface 10 inches of soil. This is in contrast to soil cropped with broccoli where in 1991, rates of nitrogen up to 250 pounds/acre did not increase nitrate and ammonium levels beyond those present at planting. There is very little indication in this experiment of movement of applied nitrogen beyond the root zone. Increased nitrate and ammonium levels were generally confined to the surface 10 inches. Although not statistically significant, there was one apparent exception. Both nitrate and ammonium levels tended to increase at the 10 to 20-inch depth at the 120 pound/acre rate of urea. In each case, only two of the four replicates of the samples showed unusually high levels of nitrate and ammonium.

The high levels of residual fertilizer present at rates of N needed for acceptable sweet corn yields is in contrast to the situation for broccoli and is a cause for concern. Apparently sweet corn is less efficient at taking up applied N than is broccoli. This indicates the need for more research on improving N uptake efficiency in sweet corn.

Table 1. List of N application treatments, 1992 sweet corn nitrogen utilization trial, NWREC

No.	Total N rate (lb/A)	N source	Rate at planting (lb/A)	Sidedress rate and method (lb/A)
1	0	None	0	0
2	60	Urea	40	20 banded
3	120	Urea	40	80 banded
4	180	Urea	40	140 banded
5	240	Urea	40	200 banded
6	60	NH_4NO_3	40	20 banded
7	180	NH_4NO_3	40	140 banded
8	60	CAN-17	40	20 banded
9	180	CAN-17	40	140 banded
10	60	UAN-32	40	20 banded
11	180	UAN-32	40	140 banded
12	60	Urea	40	20 broadcast
13	180	Urea	40	140 broadcast
14	60	NH_4NO_3	40	20 broadcast
15	180	NH_4NO_3	40	140 broadcast
16	180	Urea	0	180 banded

Table 2. Yield, ear size, and tipfill of sweet corn as affected by rate of banded urea, NWREC, 1992

N rate (lb/acre)	No. ears/ acre	Yield (T/acre)	Mean ear wt. (g)	Mean ear length (cm)	Tipfill[z]
0	13,830	3.4	214	22.3	2.3
60	24,070	7.6	278	22.9	2.6
120	27,880	9.3	292	23.8	2.5
180	32,230	10.1	274	22.7	2.6
240	30,060	9.7	287	23.6	2.6
LSD(0.05)	5,920	1.7	29	1.0	NS

[z]A measure of the degree of kernel formation at the silk end of the ear. Five point scale with 5 = kernels filled out to tip of ear, 1 = at least 5 cm of ear without filled kernels.

Table 3. Yield, ear size, and tipfill of sweet corn as affected by rate and source of banded nitrogen fertilizer, NWREC, 1992

N source	N rate (lb/acre)	No. ears/ acre	Yield (T/acre)	Mean ear wt. (g)	Mean ear length (cm)	Tipfill
Urea	60	24,070	7.6	278	22.9	2.6
	180	32,230	10.1	274	22.7	2.6
Mean		28,150	8.9	276	22.8	2.6
NH_4NO_3	60	27,010	8.7	279	22.6	2.8
	180	28,530	9.8	298	23.9	2.7
Mean		27,770	9.2	288	23.2	2.7
CAN-17	60	29,510	8.6	253	22.7	2.7
	180	30,600	10.3	294	23.2	2.3
Mean		30,050	9.5	274	23.0	2.5
UAN-32	60	21,160	7.6	263	22.0	2.3
	180	28,210	9.6	265	22.9	2.1
Mean		24,690	8.6	264	22.5	2.2
LSD(0.05), means		4,890	NS	22	0.7	0.4

Table 4. Yield, ear size, and tipfill of sweet corn as affected by rate and method of placement of sidedressed nitrogen fertilizer, NWREC, 1992

Source	Placement	N rate (lb/acre)	No. ears/ acre	Yield (T/acre)	Mean ear wt. (g)	Mean ear length (cm)	Tipfill
Urea	Band	60	24,070	7.6	278	22.9	2.6
		180	32,230	10.1	274	22.7	2.6
	Mean		28,150	8.9	276	22.8	2.6
	Broadcast	60	27,990	8.0	246	22.1	2.5
		180	29,190	9.6	288	23.4	2.8
	Mean		28,590	8.8	267	22.8	2.6
NH_4NO_3	Band	60	27,010	8.7	279	22.6	2.8
		180	28,530	9.8	298	23.9	2.7
	Mean		27,770	9.2	288	23.2	2.7
	Broadcast	60	26,680	8.3	279	22.5	2.8
		180	30,710	9.9	282	23.2	2.7
	Mean		28,700	9.1	281	22.9	2.7
	Urea mean		28,370	8.8	272	22.8	2.6
	NH_4NO_3 mean		28,240	9.2	285	23.1	2.7
Significance, N source			NS	NS	*	NS	NS
	Banded mean		27,960	9.1	282	23.0	2.7
	Broadcast mean		28,650	9.0	274	22.8	2.7
Significance, placement			NS	NS	NS	NS	NS

Table 5. Effect of rate of banded urea on post-harvest soil nitrate and ammonium concentrations, NWREC, 26 August, 1992

Sample depth (inches)	Rate of applied urea, lb/acre 0	60	120	180	240	LSD (0.05)	Pre-plant
	ppm						
Nitrate							
0-10	0.5	1.1	22.6	27.1	48.2	24.6	5.6
10-20	0.1	0.9	20.0	2.9	4.8	NS	3.8
20-30	0.3	1.0	5.7	1.6	2.1	NS	3.1
30-40	2.5	2.2	2.2	3.0	3.7	NS	3.8
Ammonium							
0-10	2.9	2.5	30.2	106.7	56.2	49.0	4.8
10-20	2.8	2.5	8.4	6.5	6.0	NS	2.8
20-30	3.0	2.7	3.3	3.7	3.6	NS	5.1
30-40	2.7	2.8	3.3	7.0	3.1	NS	4.4

NITROGEN FERTILIZER RATE AND PLACEMENT ON CAULIFLOWER YIELD

Cooperator: John Hart, Dept. of Crop and Soil Science, OSU

Introduction

Cauliflower is also planted at lower populations and with greater between-row spacing than is the norm for broccoli. The purpose of this trial was to study the response of cauliflower to several rates of applied N fertilizer and combinations of banded versus broadcast placement of both the initial and sidedressed fertilizer applications. A second purpose was to study soil N accumulation as a function of rate of applied N and presence of a winter catch crop, and to monitor movement of nitrate through the soil profile in the winter following the crop.

Methods

'Snowball Y' cauliflower was direct-seeded in a Willamette silt loam, pH 5.9, at the NWREC on 3 June. Rows were 12 inches apart with a plant density of about two/inch in the row. Plot preparation included a broadcast and incorporated application of 10N-8.7P-16.7K fertilizer at 600 pounds/acre, boron at 2.0 pounds/acre, trifluralin at 0.75 pounds/acre, and chlorpyrifos at 1.3 pounds/acre. On 14 July, the seedlings were lifted with a shovel and transplanted bare-root into their final location. Soil preparation was the same as for the seed bed. Transplants were set in rows 2.5 feet apart with 18 inches between plants in the row. Plot size was three rows, 20 feet long. All three rows were harvested. The initial application of 40 pounds N/acre, as urea, was either broadcast or banded 3 inches to the side and 2 inches deep immediately after transplanting and irrigated in. The remaining urea was broadcast or banded on the appropriate plots on 20 August (Table 1). Treatments were in randomized complete block design with four replications. The plots were sprinkler-irrigated as necessary and harvested on 29 September and 5 and 15 October. In addition to the combination of nitrogen rates and methods of fertilizer placement, one set of plots (treatment 12) was reserved for sequential sampling of shoot dry matter accumulation and N uptake. Another set of plots (treatment 11) received its initial N application in the form of ^{15}N-enriched urea. These plots were harvested separately for refined determinations of N uptake. Two sets of plots (treatments 13 and 14) were interseeded with 'Wheeler' cereal rye on 3 September to determine the feasibility of overseeding in cauliflower as a means of establishing a winter N catch crop. Following the last harvest, soil in treatments 1, 2, 3, 4, 5, and 11 were sampled to 40-inch depth in 10-inch increments. The plots were maintained through the winter in order to resample for soil N content and cover crop biomass accumulation.

Results and Discussion

For the plots receiving only broadcast applications of urea, yield increased with increasing N rate to a maximum at 240 pounds/acre (Table 2). The same trend was true for mean head weight and the percentage of Grade No. 1 heads (defect-free). Previous work at the OSU vegetable farm suggested that the optimum rate of N application to cauliflower is in the range of 150 to 200 pounds/acre, somewhat lower than the results obtained in this trial.

Banded versus broadcast application of N at planting had no significant effect on yield or quality (Table 3), although there was a trend toward higher yield and head size with a banded application. Apparently, even with rows 30 inches apart, enough feeder roots establish in the soil between the rows that concentrating the fertilizer near the plant row is not a great advantage. This is in agreement with results obtained on broccoli grown on 16 or 20-inch row spacing.

Broadcast application of the sidedressed N resulted in significantly higher yield and mean head size than when the sidedressed N was banded. This was true at the 240 pounds/acre rate as well as the sub-optimal rate. The single greatest yield in this trial was with the combination of banded fertilizer at planting, broadcast sidedress fertilizer, and a rate of 240 pounds N/acre.

Overseeding cereal rye about four weeks before first harvest did not reduce cauliflower yield (Table 4). This is not surprising, as the stand of rye was sparse (approximately eight plants/square foot) and had not developed beyond the one-true leaf stage at harvest.

Results of soil tests for residual fertilizer after harvest, and for N uptake as a function of crop growth are not yet available. The soil and rye will be sampled in the spring as a function of rate of applied nitrogen to determine the amount of nitrogen leached versus that trapped in the rye shoots.

Table 1. List of treatments, 1992 cauliflower N utilization trial, NWREC

No.	Total N applied	Placement at planting	Placement at sidedress
	----------lb/A----------		
1	0	0	0
2	80	40 broadcast	40 broadcast
3	160	40 broadcast	120 broadcast
4	240	40 broadcast	200 broadcast
5	80	40 banded	40 broadcast
6	240	40 banded	200 broadcast
7	80	40 broadcast	40 banded
8	240	40 broadcast	200 banded
9	80	40 banded	40 banded
10	240	40 banded	200 banded
11	160	40 broadcast-^{15}N	120 broadcast-^{15}N
12	160	40 broadcast	120 broadcast
13	80	40 broadcast	40 broadcast, overseed
14	240	40 broadcast	200 broadcast, overseed

Table 2. Effect of rate of broadcast nitrogen on yield, head size, and quality of cauliflower, NWREC, 1992

N rate (lb/acre)	Mean head wt. (g)	Grade No. 1 heads (%)	Total yield (tons/acre)
0	430	68.3	4.8
80	678	82.4	7.4
160	751	88.0	7.8
240	815	89.5	8.6
LSD (0.05)	186	10.6	2.2

Table 3. Effect of broadcast versus banded application of initial and sidedressed N on yield, head size, and quality of cauliflower, NWREC, 1992

Placement at planting	Placement at sidedress	N rate (lb/acre)	Mean head wt. (g)	Grade No. 1 heads (%)	Total yield (tons/acre)
Broadcast	Broadcast	80	678	82.4	7.4
		240	815	89.5	8.6
		Mean	747	85.9	8.0
	Banded	80	633	80.6	6.6
		240	736	90.1	7.7
		Mean	684	85.4	7.2
Banded	Broadcast	80	727	86.2	7.0
		240	1051	90.7	10.9
		Mean	889	88.4	9.0
	Banded	80	549	88.7	6.2
		240	684	83.7	8.6
		Mean	617	86.2	7.4
	Broadcast at planting mean		716	85.7	7.6
	Banded at planting mean		753	87.3	8.2
	Significance, planting		NS	NS	NS
	Broadcast at sidedress mean		818	87.2	8.5
	Banded at sidedress mean		651	85.8	7.3
	Significance, sidedress		**	NS	*

Table 4. Effect of overseeding cereal rye on cauliflower yield, head size, and quality at two rates of nitrogen, NWREC, 1992

Treatment	N rate (lb/acre)	Mean head wt. (g)	Grade No. 1 heads (%)	Total yield (tons/acre)
Overseeded	80	649	81.0	6.4
	240	874	90.2	9.6
	Mean	762	85.6	8.0
Not overseeded	80	678	82.4	7.4
	240	815	89.5	8.6
	Mean	747	86.0	8.0
	Significance	NS	NS	NS

PICKLING CUCUMBER VARIETY AND WEED CONTROL TRIALS

Project Leaders and Co-Authors: Delbert D. Hemphill, Jr. and Robert B. McReynolds, NWREC, and N.S. Mansour, Dept. of Horticulture, OSU

Introduction

There has been a need to determine the best-adapted varieties and production practices for mechanically-harvested pickling cucumber production in the Willamette Valley. To do so, varieties with a good length:diameter ratio and processing quality should be grown in commercial-scale trials. Each variety should be harvested more than once to determine days or heat units to the optimum size distribution, and the rate at which size grade increases with time. Plant population, N fertilization, irrigation, and pollinator management are other production practices that affect variety performance.

Results of our 1990 trials indicated that nitrogen fertility is a major grower-controlled factor that may affect product quality and yield. Excessive vine growth caused by high rates of nitrogen fertilizer and irrigation appeared to be a major cause of poor fruit set and poor harvester recovery of fruit. Another factor in poor yields or harvester efficiency is weed control. High weed populations cause expensive downtime spent cleaning the harvester pickup head. Stocks of the herbicide chloramben (Amiben) are being rapidly exhausted and will not be replaced. Other herbicides have proven less effective, more expensive, or damaging to the crop. Testing of alternatives is needed to identify combinations of herbicides that are effective and non-phytotoxic to the crop.

Our 1990 trials focused on a number of varieties screened in earlier trials, nitrogen and harvest date variables, and plant population. The objective of the 1991 variety trial was to compare yields, size grades, and dollar return for five pickling cucumber varieties in commercial-size trials at two rates of fertilizer and over three harvest dates. The 1992 trial examined only varieties. The objectives of the herbicide trial were 1) to compare the weed control effectiveness of the currently registered herbicides naptalam and ethalfluralin, with that of clomazone, which has been registered for cucurbits in other states and 2) to determine whether the reported phytotoxicity of clomazone will reduce cucumber yields.

Methods

In 1991, the variety trial was established in a commercial planting just south of Woodburn, Oregon. The varieties Flurry-M, Napoleon, Cross Country, Sunseed 3509, and Calypso were direct-seeded on 5 June, following typical land preparation. The first four varieties were planted to an area of approximately 2.5 acres each, with Calypso planted to the remaining 10 acres in the field. The planter seeded six rows at a time on 30-inch centers. Planters were not adjusted for seed size, thus, the seeding rate varied with variety.

The fertilizer rate plots were located near the east end of the field, occupying an area 160 feet long and 62 feet wide (four planter beds) for each variety. The low fertilizer area received a banded application of 60 pounds N and 78 pounds P/acre. The high fertilizer area, as well as the rest of the field, received an additional broadcast pre-plant application of 40 pounds N and 42 pounds K/acre for a total N application of 100 pounds/acre. Irrigation, cultivation, and herbicide application (except in the weed control plots) was provided by the grower.

In the fertilizer portion of the trial, all varieties were hand-harvested on 1, 5, and 8 August using a once-over destructive harvest for each plot. The fruit was weighed and graded at NWREC on a mechanical grader provided by Nalley's Fine Foods. Harvest of each combination of harvest date, variety, and fertilizer rate was replicated three times. The commercial plots of all varieties were harvested by Nalley's personnel using a Byron harvester on 4 and 5 August.

The 1992 variety trial was established in the same field, immediately to the south of the 1991 trial. The previous crop was sugar beets. Methods were similar except as follows. The varieties Flurry-M, Lafayette, Regal, Quest, Vlaspik, and a mixture of equal weights of Flurry-M and Regal (blend) were direct-seeded on 3 June, following typical land preparation by the grower. Each variety was planted to an area of slightly less than 1.5 acres, except that the blend was planted to a total of three acres. The planted area for each variety was divided into two approximately equal replicates.

The entire area received a broadcast, pre-plant application of fertilizer equivalent to the high rate of 1991. The weed control plots were located near the northeast end of the field, in a replicate of Flurry-M. The herbicides Alanap, Prefar, Command, and Curbit were applied at various rates and combinations (Table 4).

Five treatments were preplant-incorporated with a hand-push rototiller on 27 May. Lorsban was incorporated into all treatments at the same time. Five other treatments were applied one day after planting and irrigated in. The Alanap-Curbit combination was lightly raked in following application.

An unreplicated observation trial which included Alanap (1.0 pound active/acre) and Prefar (2.5 pounds active/acre) preplant-incorporated, with Curbit surface-applied after planting at both 1.3 and 1.7 pounds active/acre, was located at one end of the replicated trial. These two plots were rated for weed control effectiveness and phytotoxicity but yield data were not collected.

The trial area was irrigated on the two days following planting and received approximately 0.5 to 0.75 inch of water. The cucumbers were fully emerged the week of 22 June. Weed control and phytotoxicity ratings were made on 30 June.

All varieties were hand-harvested by OSU personnel three to five times between 28 July and 3 August. Harvest of each combination of harvest date and variety was replicated three times in randomly chosen 150 square foot plots. The commercial plots of all varieties were harvested by Nalley's personnel using a Byron harvester on 29-31 July. Flurry-M, Quest, and Regal were machine-harvested once; Lafayette, Vlaspik, and the blend twice in the three-day period. The machine-harvested samples were weighed and graded at the Nalley receiving station. A 25-square foot section of each replicate of the weed control trial was hand-harvested once.

Results and Discussion

Commercial (Machine-harvested) Variety Trial, 1991

It is apparent that the field scouting efforts of Nalley's and OSU personnel were successful in scheduling the single once-over harvest at near optimal maturity (Table 1). The return per acre varied from $1,396 for Sunseed 3509 to $1,606 for CrossCountry, with mean grade between 2.40 and 2.59. The optimum date for harvest, either in terms of return to the grower or the desired size distribution, probably did not vary by more than a day from the actual harvest date.

In 1990 we concluded that the number of accumulated heat units (AHU; North Carolina State-Washington State formula; sum of T_{max}-15.5°C with a 32°C cutoff) required to reach maturity for a given variety increased with later plantings, indicating that maturity is not a simple linear function of heat unit accumulation in the Willamette Valley. This year's results are consistent with this conclusion. It took only 583 AHU to surpass optimal maturity for the variety Calypso (Table 2, 5 Aug. harvest date) with a 5 June planting date. However, in 1990, 690 AHU were required for Calypso to reach a mean grade of 2.5 from a 3 July planting date. Of course, difference in site and grower cultural techniques may also play a role. A highly complex model giving different required AHU for each planting date through the season may offer better predictive ability, but the experimentation required to generate the model may not be worth the investment.

There was an inverse relationship between plant stand and the number of usable fruit per plant at harvest-the greater the plant stand, the fewer the number of developed fruit per vine (Table 1). It is not possible to determine if the differences in fruit per plant are true varietal differences or were an effect of competition between plants. The end result is that the yield per acre for the five varieties varied by only a few percent. Unlike in the previous variety trials with a different grower and harvester, the maximum return to the grower (dollars per acre) occurred at the lowest mean grade. Thus, based on this year's results, the present pay scale appears to have the potential to provide a fair return to the grower, while encouraging harvest at a low mean size grade commensurate with processor product needs.

In comparing the bulk of the field, as harvested by the Byron machine, with the small plots hand-harvested by OSU personnel, some surprises emerge. All varieties were hand-harvested on 5 August, comparable to the machine-harvest date for the same varieties. Almost without exception, the percentage of grade 1 fruit recovered in the hand-harvest was less than that with the Byron harvester. However, the percentage of oversize fruit recovered by hand-harvest was much greater than with the Byron. Apparently, most of the fruit dropped by the pickup device was in the oversize category. This is an advantage, as this fruit has no paid value to the grower, and is of little value to the processor. The lower percentage of grade 1 fruit in the hand-harvests may reflect the greatly increased recovery of large fruit with hand-harvesting. Alternatively, the ability of the harvester to recover small fruit may be greater than we expected.

The optimal maturity date for the varieties did not appear to vary by more than a day or two. A better estimate of the relative maturity of the varieties can be obtained from the hand-harvested plots (Table 2). Based on the relative size grade distribution at three harvests over a seven-day period, Flurry-M was the earliest maturing variety, Sunseed 3509 the latest, with the other three falling in between. This can be seen by comparing the percentage of grade 1 fruit obtained at the first harvest. The mean percentage 1s, averaged over fertilizer rates, was 7.2 for Flurry-M, 10.3 for Napoleon, 13.3 for CrossCountry, 16.9 for Calypso, and 23.0 for Sunseed 3509. Alternatively, one can compare the percentage of oversize fruit obtained on 5 August- 33.0 for Flurry-M, 20.8 for Calypso, 14.9 for Napoleon, 8.4 for CrossCountry, and 7.1 for Sunseed 3509. Again, the difference in optimal harvest date did not appear to vary by more than two days. Comparing the change in mean grade over the seven-day period (Table 2), it appears than Napoleon mean size grade changes a little less rapidly than that of the other varieties (about 0.15 per day rather than 0.18 to 0.20).

The presence of small differences in maturity dates between varieties, the subtle differences in rate of change of mean size grade between varieties, and the difficulty of scheduling harvest of a field on the optimal day, suggests the potential of mixed seeding of varieties of similar length:diameter ratio and processing quality, but slightly different maturity. Mixed seeding of varieties differing in maturity date by two to three days may allow the combination of satisfactory total tonnage and return to the grower, a good mix of size grades, insurance against the risk of poor performance of a seed lot, and slightly greater flexibility in harvest date.

Fertilizer Rate x Harvest Date (Hand-Picked) Trial, 1991

The five varieties were hand-harvested three times over an eight-day period. Mean grade varied over this period from a low of near 2.0 for all varieties at the 1 August harvest to a high of 3.2 to 3.7 at the 8 August harvest. The greatest return per acre occurred at the first harvest for Flurry-M and at the second harvest for the other varieties. Unlike the two previous years, the maximum return per acre occurred at a mean grade below 3.0. The greatest return per acre was with the variety Napoleon at the high rate of fertilizer (Table 2).

In every case, maturity was delayed slightly by the higher rate of fertilizer, perhaps because foliar growth was stimulated at the expense of flower formation. This can be seen in the higher percentage of grade 1 fruit at the first harvest for all five varieties. Also, the percentage of oversize fruit at the second harvest was always lower with the higher rate of fertilizer.

Both total yield and return per acre were higher with the high rate of fertilizer, except for Flurry-M. In contrast to our grower-cooperator trials in 1989 and 1990, application of about 100 pounds N per acre did not lead to excessive vine growth. Thus, the OSU recommendation for N application for machine-harvested pickling cucumbers should be about 100 pounds/acre, but the interaction of soil type, irrigation program, and other grower cultural practices cannot be ignored in making fertilizer recommendations.

Table 1. Summary of mechanical harvest of Nalley's-OSU pickling cucumber variety trial-1991[z]

	Variety				
	Flurry	Napoleon	CrossCountry	Sun3509	Calypso
Delivery date	8/4	8/5	8/6	8/5	8/4 & 8/5
Stand, seedlings/acre[y]	65300	94100	70600	108000	79300
No. paying fruit/plant	3.4	2.4	2.5	1.6	1.7
Gross wt. (lb)	51360	54760	50020	51860	103980
Acres harvested[x]	2.17	2.13	2.03	2.07	4.20
Tons/acre	11.83	12.85	12.32	12.53	12.38
Percent 1s[w]	6.86	4.43	4.84	2.46	4.30
Percent 2s	41.57	33.39	51.79	41.98	51.08
Percent 3s	31.69	40.98	25.30	31.28	26.69
Percent 4s	7.45	6.93	7.20	8.13	6.97
Percent nubs & crooks	3.77	3.15	3.45	3.53	2.10
Percent rejects	8.66	11.12	7.78	12.62	8.87
Mean grade[v]	2.45	2.59	2.40	2.54	2.41
$/acre	1495	1433	1606	1396	1600
$/ton	126.30	111.50	130.33	111.42	129.20
$ gross	3243.41	3052.83	3259.53	2889.01	6718.15

[z]Trial located on Boone's Ferry Road, south of Woodburn, Oregon. Harvester: Byron. Note: data taken only from pure loads of each variety.

[y]Estimated from the mean of five random samples of 20 row feet each per variety.

[x]Acres harvested calculating by subtracting N rate plot area and headlands delivered in mixed loads from the total area planted for each variety.

[w]Size grades: 1=0.5-1 inch diameter, 2=1-1.5 inch, 3=1.5-2 inch, 4=over 2 inch.

[v]Excluding nubs and crooks. For Calypso, assumes approx. 2.1 acres harvested for each pure load.

Table 2. Interaction of fertilizer rate and harvest date on yield and mean grade of five hand-harvested pickling cucumber varieties, Nalley's-OSU variety trial, 1991

			Percent in grade by wt.					Mean	Tons/	$/	$/
			1s	2s	3s	4s	N&C	grade	acre	ton	acre
Variety	Harvest[z]	Fertilizer									
Flurry M	Aug. 1[z]	1x	4.6	59.6	30.2	4.0	1.6	2.34	8.59	141	1216
		2x	9.8	77.5	11.0	0.4	1.2	2.02	8.63	181	1600
	Aug. 5	1x	1.3	20.8	39.3	38.2	0.4	3.15	14.82	76	1107
		2x	0.8	12.5	58.2	27.7	0.6	3.14	14.95	77	1126
	Aug. 8	1x	0.0	3.1	27.4	67.2	2.2	3.65	21.37	31	620
		2x	0.2	1.7	30.0	68.1	0.0	3.66	20.72	30	606
Napoleon	Aug. 1	1x	5.5	62.7	29.1	0.0	2.7	2.24	8.60	156	1335
		2x	16.0	60.7	22.1	0.0	1.2	2.06	10.10	182	1810
	Aug. 5	1x	1.9	33.8	46.3	17.0	1.0	2.79	15.99	107	1718
		2x	1.7	30.2	54.8	12.7	0.6	2.79	21.51	108	2327
	Aug. 8	1x	0.9	7.0	47.4	43.5	1.2	3.35	21.70	58	1248
		2x	0.8	7.3	49.6	41.2	1.1	3.33	23.26	60	1441
CrossCountry	Aug. 1	1x	8.0	82.9	4.7	1.9	2.5	2.00	6.78	179	1209
		2x	18.5	79.4	0.3	0.0	1.7	1.81	7.61	205	1559
	Aug. 5	1x	1.4	20.0	62.7	14.7	1.3	2.92	13.41	96	1279
		2x	2.0	50.1	44.0	2.0	1.8	2.47	16.36	135	2208
	Aug. 8	1x	0.7	9.0	46.1	43.9	0.3	3.33	18.53	59	1102
		2x	1.1	7.6	53.9	37.3	0.2	3.28	22.60	65	1445
Sun 3509	Aug. 1	1x	11.5	77.2	8.7	0.0	2.6	1.97	6.94	184	1285
		2x	34.4	63.8	4.8	0.0	1.8	1.65	7.30	232	1692
	Aug. 5	1x	1.0	19.5	67.4	11.1	1.0	2.90	14.62	98	1442
		2x	3.4	35.5	55.8	3.0	2.2	2.60	15.57	124	1959
	Aug. 8	1x	0.0	3.8	52.9	41.0	2.3	3.38	15.39	54	831
		2x	0.3	11.7	56.6	26.4	5.0	3.15	18.55	73	1364
Calypso	Aug. 1	1x	8.7	80.7	8.9	0.6	1.2	2.01	6.93	180	1250
		2x	25.0	72.1	1.4	0.0	1.6	1.76	7.14	215	1534
	Aug. 5	1x	0.5	21.6	45.3	31.4	1.2	3.09	12.54	80	996
		2x	2.4	24.1	61.8	10.2	1.5	2.81	16.26	106	1718
	Aug. 8	1x	0.0	2.9	34.3	59.0	3.8	3.58	14.17	37	518
		2x	1.6	5.3	52.4	39.3	1.4	3.31	19.75	62	1217

[z]Accumulated heat units were 523 on 1 Aug., 583 on 5 Aug., and 627 on 8 Aug.

Weed Control Trial, 1992

Weeds present in the trial consisted primarily of pigweed (*Amaranthus retroflexus*), lambsquarter (*Chenopodiaceae berlandieri*), shepherdspurse (*Capsella bursa-pastoris*), and field bindweed (*Convolvulus arvensis*). Shepherdspurse emerged first on the south side of the plots while pigweed and lambsquarter emerged on the north side.

Prefar-Alanap was effective initially in suppressing pigweed and lambsquarter in comparison to the untreated control, and phytotoxicity was not apparent (Table 3). However, without cultivation the weeds would have become a serious problem. When Command was included in the combination, weed control was improved and yield increased significantly. In the Prefar-Alanap-Curbit observation plot the soil surface remained weed-free throughout the trial period and phytotoxicity was not observed. The yields for Prefar-Command and Alanap-Command did not differ significantly, but Alanap-Command provided more effective weed control.

Both Curbit rates were ineffective on shepherdspurse, but were effective on both pigweed and lambsquarter. Weed control and yield were greater at the higher than at the lower rate. Cultivations would have been required to prevent late emerging weeds from becoming a problem. Yield from the Curbit and the Alanap-Prefar treatments did not differ. The Curbit-Alanap surface-raked treatment was the most phytotoxic and produced the lowest yield.

Treatments including Command showed a slight degree of phytotoxicity either as plant stunting or marginal leaf yellowing. However, the high yields of these treatments suggest that the phytotoxicity was inconsequential. Weed control for the treatments that included Command was consistently good. Of the treatments including Command, the poorest weed control and yields occurred with 0.25 pounds active/acre preplant-incorporated.

Although slightly phytotoxic, Command treatments do not reduce yield and are actually better than the standard Amiben treatment or the handweeded control. This is reassuring, but should be verified with further trials. Other concerns regarding the use of Command include its effect on the following crops and the potential for chemical drift or injury to neighboring crops. These concerns should be addressed before its widespread use in Oregon.

Growers currently can use Prefar, Alanap, Curbit, and remaining stocks of Amiben in cucumbers. The trial results indicate that a Prefar-Alanap combination would provide adequate weed control if combined with a cultivation. As shown in the observation plot, adding Curbit to the combination would extend the spectrum of weed control and its duration.

Curbit alone does not appear to provide a broad spectrum of weed control. In addition, injury under certain conditions, such as excess water, has been associated with Curbit. In the Curbit-Alanap treatment, disturbing the soil surface after application by raking lightly resulted in injury that was significant enough to reduce yields.

The cost of the various treatments is an important factor in choosing a control strategy. Table 3 lists the per acre costs based upon current product prices. The cost of Command is likely to increase following its registration in more crops. However, based upon the current cost and its effectiveness, it would be the primary choice. The Prefar-Alanap-Curbit combination, which performed well in the observation trial, would be the most expensive.

In addition to the concerns regarding the use of Command, future trials could help to refine the knowledge base for the use of these herbicides. More information on the conditions in which injury might occur with Curbit would help growers decide if the added control in combinations is worth the risk and cost. Determining if lower rates of Command in combination with Alanap or Prefar could still provide acceptable control might lessen the concern regarding drift and residue on subsequent crops.

Commercial (Machine-harvested) Variety Trial, 1992

All the data for the machine harvests are found in Table 4, including the two harvests each of Lafayette and the blend. Table 5 contains simplified yield data for the machine harvests, with data for Lafayette and the blend averaged over the two harvest dates.

The planting was seeded into dry soil and had to be irrigated up. The irrigation sets started at the north end of the field and it took two days to reach the south side. Thus, emergence was one to two days earlier on the north side. This difference in maturity appeared to carry through to harvest and influenced the dates of machine-harvest of the replicates of the varieties.

Hand-sampling by OSU personnel on 28 July indicated that the variety Lafayette was ready for harvest, about five days earlier than expected based on the number of days from planting. Nalley's and OSU personnel decided to mechanically harvest the first replicate of Lafayette, which seemed more mature (2.32 mean grade), on 29 July. Since the grower-cooperator was harvesting Flurry-M, and visual observation indicated that Flurry-M was maturing rapidly, we decided to mechanically harvest both replicates of Flurry-M on 29 July.

The machine-harvest data (Tables 4 and 5) indicated that the 29 July harvest was indeed optimal for both varieties. For the purpose of calculating mean grade and comparing results with the hand-picked trial, 90 percent of the reject grade material was assumed to be oversize (grade 4) cucumbers. This assumption was based on information provided by Nalley's grading personnel. One replicate of the blend was machine-harveted on 30 July and all other varieties were harvested on 31 July, including the second replicate of Lafayette.

Unfortunately, all varieties were somewhat past optimal maturity, ranging from a mean grade of 2.69 for Regal to 2.93 for the blend (Table 5). Two factors contributed to this. First, it is obvious from comparing the machine-harvest and hand-picked harvests of the same varieties on 29, 30, and 31 July, that machine-harvest led to higher mean grade, perhaps due to poorer recovery of small fruit. In six of eight cases, hand-picked samples led to lower mean grade for the same harvest date (Table 4). This is in contrast to 1991, when the hand-picked samples generally produced a higher mean grade than did the machine-harvested samples. Second, the extreme heat and high soil moisture produced very rapid fruit sizing for all varieties.

The return per acre varied from $421 for Flurry-M to $1,109 for the blend (Table 5). Yields were down compared to 1991. Averaged across all varieties and harvests, machine-harvested plots in 1991 yielded a gross of 10.4 tons/acre. In

1992, the average was 8.3 tons/acre, even with slightly greater maturity. The only variety in both trials was Flurry-M. In 1991 it yielded 11.8 tons/acre, in 1992 only 3.1 tons/acre at similar mean grade. The yields from the hand-picked plots were consistent with this trend. Average yield declined from 15.1 tons/acre in 1991 to 9.2 tons/acre in 1992. Hand-picked Flurry-M declined from 8.6 tons/acre to 5.7 tons/acre. Several factors may have contributed to the reduced yield. Stands were greater in 1991, ranging from 65,300 plants/acre for Flurry-M to 108,000/acre for Sun 3509, and averaging 83,500. In contrast, in 1992 stands ranged from 48,600/acre for the blend to 64,500 for Quest (Table 2), with an average of 56,700. The 1992 stand counts were made on 18 June, 15 days after seeding. This should have allowed more than ample time for all seedlings to emerge. Thus, the plant population was lower than the target of 80,000/acre. Heat stress may also have played a role, as it was difficult for the grower to irrigate optimally. Another factor may have been poor pollination. We considered the location and number of bee hives to be inadequate.

The blend of Regal and Flurry-M produced the greatest yield and dollar return at the 31 July harvest, even though it had the highest mean grade at this point.

Our observations of the machine-harvest operation indicated that an excessive number of cucumbers were being left on the ground. These were usually covered by the harvested vines. Since vines are normally deposited on the ground immediately after having been run through the pinch rollers, it was apparent that the harvester was failing to pick up this fruit, rather than it being lost in the pinch-roller mechanism or the conveyor system. We often observed that the pickup mechanism would roll vines ahead of the machine until there was a sufficiently large mass to be captured and pulled up the conveyor. This often resulted in excessive vine mass being carried into the holding tank but, more importantly, a loss of fruit from the vines that were rolling ahead of the pickup mechanism. Some of the variation in yield between the two replications of 'Lafayette' and the less-than-expected yield of Vlaspik (Table 4) may have been caused by harvester pickup problems.

Our previous conclusion concerning the North Carolina State-Washington State heat unit formula is supported by results in 1992. From 1991 and 1992 data on Flurry-M, it can be concluded that the formula is not consistent between seasons with differing late spring weather patterns. In 1991, with a relatively cool, wet June, it took about 540 AHU to bring Flurry-M to optimal maturity. In 1992, however, with unusually high temperatures in June, it took 600. It is becoming apparent that, even with the high temperature cutoff of 32°C, the model gives too much weight to above-normal temperatures at the pre-bloom stage of plant development. Furthermore, the model cannot anticipate any delay in fruit set that may result from inadequate bee activity at first bloom.

Hand-Picked Variety Trial, 1992

Lafayette was much slower to increase in size grade over the harvest period than were the other varieties (Table 4). The single greatest return per acre was $1,369 with Lafayette. Flurry-M produced the lowest return at the early harvest due to a low yield. The performance of the variety Quest was unusual in that the return per acre stayed almost constant over seven days (Table 4). Gross yield tripled and nearly offset the doubling of mean grade and consequent rapid decline in value per ton.

The blend looked less promising in the hand-picked harvest than in the machine harvests. Due to the poor performance of Flurry-M in 1992, it is difficult to judge the benefits of blending varieties of differing maturity.

Table 3. Weed control and Flurry-M cucumber yield in response to herbicide treatments, Woodburn, Oregon, 1992

Herbicide	Rate lb active/A	Cost $/A	Method	Weed control rating[z]	Phytotoxicity rating[y]	Yield tons/A	Mean grade
Alanap+ Prefar+ Command	2.00 4.00 0.25	59.32	Preplant incorporated	8.1	<1	4.9 a[x]	2.6
Command	0.25	5.82	Postplant, irrigated	8.8	<1	4.6 ab	2.7
Prefar+ Command	4.00 0.25	40.82	Preplant incorporated	8.1	1.3	4.2 ab	2.6
Alanap+ Command	3.00 0.25	33.57	Postplant, irrigated	9.7	1.0	3.6 abc	2.6
Command	0.25	5.82	Preplant incorporated	6.0	<1	3.5 abc	2.4
Amiben	2.50	?	Preplant incorporated	9.4	1.8	3.3 bc	2.5
Hand-weed	--	?	--	8.0	0.0	3.2 bcd	2.3
Curbit	1.70	32.48	Postplant, irrigate	7.3	0.0	3.2 bcd	2.7
Alanap+ Prefar	3.00 5.00	71.50	Preplant incorporated	4.0	0.0	2.4 cd	2.2
Alanap+ Curbit	3.00 1.30	52.69	Postplant, raked in	9.5	2.3	1.8 d	2.5
Curbit	1.10	21.21	Postplant, irrigated	5.5	<1	--	--

[z]0=no control, 10=complete control.
[y]0=no phytotoxicity,10=seedling death.
[x]Mean separation by Duncan's MRT, 5% level.

Table 4. Yield, mean grade, and value of pickling cucumbers, OSU-Nalley's variety trial, Woodburn, Oregon, 1992

Date[z]	Variety	Percent in grade by wt.					Tons/	$/	$/	Size[y]
		1s	2s	3s	4s	N&C	acre	ton	acre	grade
Hand-harvested										
7/28	Flurry-M	18.1	51.4	22.2	6.3	2.0	5.3	175	935	2.16
	Lafayette	13.4	33.4	11.7	8.8	1.4	8.3	146	1205	2.49
	Quest	40.6	55.3	3.1	0.0	1.1	4.9	234	1180	1.62
	Regal	38.0	47.6	11.4	0.8	2.2	4.5	229	1025	1.75
	Vlaspik	25.4	61.6	9.6	1.6	1.8	5.5	207	1137	1.87
	Blend	16.4	55.2	21.5	5.0	2.0	5.6	176	982	2.17
7/29	Flurry-M	10.2	50.4	25.2	7.0	7.2	5.7	151	855	2.30
	Lafayette	17.9	35.9	35.7	7.1	3.2	8.5	160	1369	2.32
	Blend	14.6	65.4	11.7	1.3	7.0	6.2	184	1131	1.99
7/30	Vlaspik	7.5	42.7	42.1	3.5	4.2	9.4	141	1324	2.44
	Blend	5.7	28.8	50.1	12.1	3.3	9.2	118	1081	2.71
7/31	Lafayette	5.4	32.2	47.7	7.7	7.0	10.8	115	1247	2.63
	Quest	6.4	25.2	52.6	11.9	3.8	9.5	117	1111	2.78
	Regal	7.3	34.6	44.9	9.7	3.5	10.7	113	807	2.69
	Vlaspik	3.4	27.0	56.5	9.5	3.6	11.6	112	1307	2.75
	Blend	3.2	13.9	50.0	28.4	4.5	13.3	83	1106	3.07
8/03	Flurry-M	1.7	3.8	32.8	57.9	3.8	12.5	48	600	3.56
	Lafayette	2.9	8.2	65.5	16.6	6.9	11.3	87	990	3.03
	Quest	2.2	7.1	49.4	36.4	4.9	15.7	71	1110	3.26
	Regal	2.7	7.0	43.5	41.7	5.1	12.1	66	801	3.31
	Vlaspik	1.7	8.7	53.3	34.7	1.6	10.7	72	775	3.24
	Blend	3.2	6.9	51.8	33.5	4.6	8.0	76	604	3.21
Machine-harvested										
7/29	Flurry-M	7.3	47.2	29.4	11.8	4.3	3.1	157	421	2.47
	Lafayette	8.1	37.3	38.9	13.4	2.3	9.2	130	1195	2.57
7/30	Blend	2.7	28.2	39.2	28.4	1.6	13.3	94	1264	2.92
7/31	Lafayette	1.6	28.8	58.9	4.4	6.3	6.7	112	742	2.70
	Quest	1.6	23.5	62.8	10.6	1.6	8.7	104	902	2.83
	Regal	1.7	31.0	56.1	5.9	5.4	7.2	113	807	2.69
	Vlaspik	1.1	22.5	59.8	11.6	5.0	8.1	99	801	2.85
	Blend	1.0	16.8	63.6	15.4	3.2	10.4	92	953	2.95

[z] Accumulated heat units for each date as follows: 7/28, 584; 7/29, 600; 7/30, 616; 7/31, 633; 8/03, 674.

[y] Mean grade for machine-harvest calculated on the assumption that 90% of the rejects were grade 4 cucumbers.

Table 5. Yield, mean grade, and value of machine-harvested cucumbers, averaged over replicates, OSU-Nalley's trial, Woodburn, Oregon, 1992

	Variety					
	Flurry	Lafayette	Regal	Quest	Vlaspik	Blend
Harvest date	7/29	7/29&7/31	7/31	7/31	7/31	7/30&7/31
Heat units	600	616	633	633	633	624
Stand, seedlings/acre[z]	55,900	62,600	58,400	64,500	50,400	48,600
Gross weight (lb)	7,100	20,874	19,040	23,140	16,180	31,336
Acres harvested	1.15	1.33	1.33	1.33	1.00	1.33
Tons/acre	3.1	8.0	7.2	8.7	8.1	11.9
Percent 1s	7.3	4.8	1.7	1.6	1.1	1.8
Percent 2s	47.2	33.1	30.0	23.5	22.5	22.5
Percent 3s	29.4	48.9	56.1	62.8	59.8	51.4
Percent reject[y]	11.8	8.9	5.9	10.6	11.6	21.7
Percent nubs and crooks	4.3	4.3	5.4	1.6	5.0	2.4
Mean grade[x]	2.47	2.63	2.69	2.83	2.85	2.93
$/acre	421	969	807	902	801	1109
$/ton	157	121	113	104	99	93
$ gross	484	1289	1073	1200	801	1475

[z]Evaluated 15 days after seeding on four 30-foot sections of row per replicate.
[y]For purposes of calculating mean grade, 90 % of the rejects were assumed to be oversize cucumbers.
[x]Does not include nubs and crooks.

SCREENING LETTUCE AND SPINACH GERMPLASM FOR RESISTANCE TO BEET WESTERN YELLOWS VIRUS

Project Leaders and Co-Authors: Delbert D. Hemphill, Jr. and Robert B. McReynolds, NWREC; N. S. Mansour, Dept. of Horticulture, OSU

Cooperators: R. O. Hampton, Dept. of Botany and Plant Pathology, and J. R. Baggett, Dept. of Horticulture, OSU

Introduction

Beet western yellows virus (BWYV), an aphid-vectored luteovirus, causes a pronounced, bright yellow color to the leaf margin of lettuce, spinach, and other leafy greens. Interveinal chlorosis may also develop. The virus does not usually stunt growth and is not considered a problem in many susceptible crops. However, where the leaves are harvested or comprise the edible portion of the crop, such as with lettuce, spinach, Chinese cabbage, and root crops sold with the shoots attached, even a slight expression of symptoms can render the crop unmarketable.

This problem has increased dramatically in recent years, perhaps influenced by changing weather patterns that favor increased numbers of aphid vectors. Another factor is the prevalence of both weedy and cultivated host species. This makes control extremely difficult as even a grower who practices perfect phytosanitary practices cannot control the practices of neighbors, particularly in the mixed woodland-row crop-pasture land use patterns typical of the Willamette Valley.

The winged aphids that spread the disease are difficult to control with insecticides. New flights entering an area must be constantly monitored and eradicated immediately. Thus, the best solution may be to find varieties or breeding lines that are resistant to the disease or that do not strongly express the symptoms. Tolerant varieties of crisphead lettuce have been developed for the Salinas Valley of California and resistance has been found in some European lines, so the appropriate germplasm may be available to breeding programs. The purpose of this trial was to screen a wide number of spinach and lettuce varieties for tolerance to BWYV.

Methods

In 1991, seed companies known to produce lettuce and spinach were contacted for trial samples. In late April the NWREC plot area was treated with a broadcast, incorporated application of 1000 pounds/acre of 10N-8.7P-16.7K fertilizer. A mixture of Rainier spinach and Detroit Dark Red table beet seed was broadcast over the plot area and over a 50-foot wide buffer area around the plots in the variety trial. The spinach, beets, and weedy species were allowed to grow uncontrolled in this area as a potential reservoir for the virus and as a shelter for the aphid vectors.

On 17 June, 53 lettuce and 24 spinach varieties were seeded into a rototilled section in the middle of the plot area. Each variety was seeded twice in 10-foot long plots. Pronamide was applied to the lettuce area at 1.5 pounds per acre for weed control. No herbicide was used on the spinach. An additional 150 pounds ammonium nitrate/acre was applied three weeks after seeding. On 27 June, 58 lettuce and 25 spinach varieties were seeded on a bed in a commercial lettuce field near Aurora, Oregon. The bed was located at the edge of the field next to a weedy fence-row and pasture. Plot length was 15 feet with one replication. The plots were sidedressed twice with ammonium nitrate, with a total N application of 100 pounds/acre. One replication of the same varieties was also planted at the OSU Vegetable Crops Research Farm on 24 June. Fertilizer consisted of 12N-12.6P-8.3K-4S at 450 pounds/acre, banded at planting. No herbicide was used. Twenty-one varieties of spinach were seeded adjacent to the earlier trial at NWREC on 15 August. Plot length was 15 feet with two replications. The earlier trial, now heavily infected with BWYV, was left as a source of virus inoculum. In all trials, lettuce was thinned to 10-12 inches between plants. Spinach was not thinned. No insecticides were used at any site. Plots were sprinkler-irrigated as necessary.

Observations of virus symptoms and other quality characteristics were made periodically. The scores reported in the tables are for the final observation of each planting (5-7 August for the NWREC and grower plots for both lettuce and the early spinach planting, 19 August for the OSU Vegetable Crops Farm planting, and 26 September for the second spinach planting at NWREC). Data presented are averaged over all sites and replications. Quality characteristics were rated on a five-point scale with 1 equal to least intense and 5 equal to most intense. Thus, a low score is desirable for virus symptoms and tendency to bolt, while a high score is desirable for color and overall score. In addition to an intensity of symptoms score, the percentage of symptomatic plants was determined for the lettuce varieties. For all plantings, presence of the virus in symptomatic plants was confirmed by enzyme-linked immunosorbant assay.

The seed used in the 1992 trial was drawn primarily from material donated in 1991. Promising varieties were included along with several known to be highly sensitive to BWYV. Methods were similar except as follows. On 16 June, 34 lettuce and 18 spinach varieties were seeded in the middle of the plot area. Each variety was seeded four times in 10-foot long plots. Fifty pounds N/acre was applied as ammonium nitrate immediately after seeding and another 100 pounds N/acre were applied three weeks after seeding. Observations of virus symptoms and other quality characteristics were made on 27 August.

Results and Discussion

1991

Lettuce varieties differed greatly in expression of BWYV virus symptoms (Table 1). Many of the varieties with a low score for BWYV intensity were red-pigmented leaf or Romaine types and slow-growing. Late maturity is related to delayed BWYV expression. The red pigmentation may have masked the virus symptoms as a bronzing of the leaf margin could be normal for the variety, or might indicate virus infection.

Several green-leafed varieties also had low scores for BWYV intensity, including Alto, Balisto, Canasta, Cindy, Divina, Fanfare, Krizet, Loriol, Nancy, Royal Green, Slobolt, and Waldmann's Green. These varieties represent a wide range of leaf types. In the case of Alto, Cindy, and Slobolt, the pale to cream yellow color of the leaves may also have masked the expression of the virus.

Varieties with high (4.0 or higher) overall scores included Balisto (butterhead), Brunia and Raisa (red oakleaf), Canasta (French crisp), Krizet (oakleaf), Majestic Red (red romaine), New Red Fire and RedPrize (red leaf).

As no insecticides were used, many plants suffered from intense damage caused by diabrotica and other chewing insects. Varieties differed in susceptibility to insect damage. Insect damage was not scored, but the comments note those with severe damage. Most varieties were adapted to the climate and daylength of the Willamette Valley in early summer. However, several varieties did bolt (form an elongated seed stalk) before reaching market maturity, notably Etna and Musca. Varieties of particular interest in future trials include those green leaf, romaine, and butterhead types (listed above) with a low percentage and intensity of BWYV. Their market acceptance will also have to be determined.

In general, the spinach varieties showed much less diversity in type and in expression of BWYV than did the lettuce. The degree of virus expression was great for most varieties, although Bejo 1299 and NIZ 46-17 were the slowest to express it and appeared most promising (Table 2). Perhaps the most valuable observation from this trial is the large difference among varieties in tendency to bolt. Bejo 1299, Correnta, Bejo 1369 and 1370, Martine, Space, and Splendour appeared particularly resistant to bolting and may be well-adapted as a summer crop in the Willamette Valley. The color of Splendour, Correnta, 1369, and 1370 was particularly outstanding.

In the autumn spinach planting (Table 3), bolting was not observed in any variety. BWYV intensity was, again, very high with only Fall Green, 1370, NIZ 46-17, and Splendour showing promise when rated on 26 September. Observations were made again on 11 October. At this time, all varieties expressed intense BWYV symptoms (data not shown).

1992

As in 1991, lettuce varieties differed greatly in expression of BWYV virus symptoms (Table 4). Again, many of the varieties with a low score for BWYV intensity were red-pigmented leaf or Romaine types.

Several green-leafed varieties also had low scores for BWYV intensity, including Alto, Balisto, Canasta, Cindy, Divina, Enza 5879, Fanfare, Krizet, Royal Green, Soraya, and Waldmann's Green. Varieties showing consistently low scores (1.5 or less) for BWYV symptoms in both years included Alto, Balisto, Brunia, Canasta, Cindy, Deep Red, Garnet, Krizet, Majestic Red, Musca, New Red Fire, Prizehead, Raisa, RedPrize, Sierra, and Waldmann's Green.

Varieties with high (4.0 or higher) overall scores in 1992 included Balisto and Divina (butterhead); Brunia and Raisa (red oakleaf); Canasta and Sierra (French crisp); Majestic Red (red romaine); New Red Fire, Deep Red, Garnet, Prizehead, and RedPrize (red leaf). All but Divina, Sierra, Deep Red, Prizehead, and Garnet were also rated 4.0 or higher in 1991.

Several varieties bolted (formed an elongated seed stalk) just after reaching market maturity, notably Fanfare, Musca, and Royal Green.

Again, spinach varieties showed much less diversity in type and in expression of BWYV than did the lettuce (Table 5). The degree of virus expression was high for most varieties, although Ambassador, Hybrid #7, NIZ 46-17, Rainier, and Rhythm 9 expressed the symptoms to a lesser degree. These varieties also had a paler color, possibly obscuring symptoms. As in 1991, there were large differences among varieties in tendency to bolt. Bejo 1369, Martine, and Splendour appeared particularly resistant to bolting. The color of Martine was particularly outstanding.

Table 1. Lettuce beet western yellows virus variety trial, NWREC and OSU Vegetable Farm, 1991

Variety	Source	Type	Color	BWYV	%BWYV	Bolting	Overall	Comments
Alpi	Nun[z]	R[y]	3.5[x]	4.0	45[w]	1.0	3.0	Very little insect damage.
Alto	RZ	L	1.5	1.5	5	1.0	3.0	Pale.
Anuenue	Ter	FC	2.3	3.7	35	1.7	2.0	Severe insect damage.
Aquarius	Sak	B	3.8	3.3	21	1.0	3.0	
Augustus	Peto	R	2.8	2.5	38	1.0	3.0	Spreading habit.
Balisto	RZ	B	4.5	1.0	0	1.0	4.5	
Bellagreen	FM	B	3.8	3.0	33	1.0	3.0	
Brunia	Ter	RO	4.3	1.0	2	1.0	4.7	Attractive; very little insect damage.
Bubbles	Toz	BR	2.8	3.5	58	1.0	2.3	
Canasta	Ter	FC	2.8	1.3	21	1.0	4.0	Attractive; some insect damage.
Centennial	Joh	FC	3.3	2.8	40	1.0	2.0	
Cindy	Ter	B	2.3	1.3	28	1.8	3.0	Pale, cream-yellow; severe insect damage.
Corsair	Toz	R	3.3	3.8	39	1.0	2.0	Upright habit; severe insect damage.
Cosmic	Toz	R	3.5	4.0	46	1.0	2.0	Severe insect damage and virus expression.
Dark Green Boston	Asg	B	3.0	3.3	27	1.0	1.7	Severe virus expression.
Deep Red	HM	RL	4.0	1.0	21	2.0	3.3	
Density	Toz	BR	4.0	4.0	40	2.0	2.3	Spreading habit.
Divina	Vil	B	2.0	1.7	29	1.0	3.0	Severe insect damage; poor emergence.
E5879	Enza	B	2.8	2.5	27	1.0	3.0	Moderate insect damage; one lettuce mosaic.
Eline	Joh	B	2.8	2.3	47	1.0	2.3	Severe insect damage.
Etna	Vil	RL	4.0	1.0	7	4.3	1.3	Bolts too readily.
Fanfare	FM	L	3.0	1.8	34	2.3	2.7	Virus-infected leaves are trimmable.
Felicia	Enza	B	2.5	3.5	49	2.0	1.7	Severe insect damage.
Garnet	FM	RL	4.8	1.0	1	2.3	2.7	
Gento	Nun	B	3.3	3.8	39	1.0	2.0	Severe insect damage and virus expression.
Green Towers	HM	R	3.3	3.0	41	1.0	2.0	Spreading habit.
HMX 9561	HM	R	3.3	2.5	25	1.0	2.3	Spreading habit.
Kagran Summer	Joh	B	2.3	4.0	63	1.0	1.7	Severe insect damage and virus; poor color.
Krizet	RZ	O	2.0	1.0	0	1.0	4.0	
Lobjoits	Toz	R	4.0	3.5	40	1.0	2.0	Severe insect damage.
Loriol	Enza	B	2.3	1.3	39	1.0	3.7	Moderate insect damage; low vigor.
Majestic Red	Ter	RR	4.8	1.0	8	1.0	4.0	
Musca	Vil	RL	4.8	1.0	4	3.5	2.0	Low vigor; internal tipburn; poor germination.
NIZ 739	NZ	B	2.0	3.0	40	1.0	2.3	Severe insect damage; pale.
NIZ 740	NZ	B	2.3	2.3	34	1.0	2.3	Severe insect damage.
Nancy	Joh	B	2.0	1.5	35	1.0	3.0	Severe insect damage.

Table 1. Continued.

New Red Fire	Tak	RL	5.0	1.0	6	1.0	4.3	Very deep red.
Parris Island Cos	Joh	R	3.5	3.0	30	1.0	3.0	Spreading habit.
Prizehead	HM	RL	3.8	1.0	8	2.0	2.7	
Raisa	RZ	RO	5.0	1.0	0	1.0	5.0	Attractive; leathery leaf.
RedPrize	FM	RL	4.0	1.0	15	1.0	4.7	
Romea	Joh	R	3.0	4.0	58	1.0	2.0	
Romulus	Peto	R	3.3	3.0	39	1.0	2.3	
Royal Green	RS	L	3.8	1.8	25	1.3	3.7	
Salinas	HM	C	3.3	4.0	28	1.0	2.0	Poor emergence.
Sergio	Enza	R	3.3	4.0	50	1.3	1.3	Severe virus expression.
Sierra	Vil	RF	2.0	1.5	39	1.0	3.0	Moderate insect damage.
Slobolt	Joh	L	1.8	1.0	34	1.0	3.0	Very yellow leaf.
Soraya	RZ	B	2.5	2.0	14	1.0	3.0	
Sudia	Vil	B	4.3	2.5	40	1.0	1.7	Dark green; poor emergence.
Summertime	OSU	C	3.0	3.5	40	1.0	3.0	
Tania	HM	B	3.3	2.8	43	1.0	2.0	Poor emergence.
Vanity	Enza	FC	2.0	2.0	58	1.0	3.3	Rib blight, tipburn; yellow leaf masks virus.
Verte Mar	Vil	R	3.8	3.8	56	1.0	2.7	Severe virus; upright, self-blanching.
Victoria	Joh	FC	3.8	2.0	38	1.0	3.0	
Vista	Vil	B	2.5	2.5	49	1.0	2.3	Cream yellow; severe insect damage.
Waldmann's Green	Asg	L	4.3	1.5	28	2.3	2.3	
Winter Density	Ter	BR	4.3	3.0	41	1.0	2.3	

[z] Asg, Asgrow Seed Co.; Enza, Enza Zaden; FM, Ferry-Morse; HM, Harris-Moran; Joh, Johnny's Selected Seeds; NZ, Nickerson-Zwaan; Nun, Nunhem's; OSU, Oregon State University Dept. of Horticulture; Peto, PetoSeed; RS, Royal Sluis; RZ, Rijk Zwaan; Sak, Sakata; Ter, Territorial Seed Co.; Toz, Tozer Seeds; Vil, Vilmorin.

[y] R, Romaine; L, Leaf; C, Crisphead; O, Oak Leaf; B, Butterhead or Bibb; FC, French Crisp; RR, Red Romaine; RL, Red Leaf; RC, Red Crisphead; RF, Red French Crisp; RO, Red Oak Leaf; RB, Red Butter; BR, Butter-Romaine.

[x] Color, bolting, overall score, and beet western yellows symptom intensity rated on a 5-point scale with 1=least intense, 5=most intense expression of the characteristic.

[w] Percentage of plants expressing virus symptoms, regardless of intensity.

Table 2. Summer spinach beet western yellows virus variety trial, NWREC and OSU Vegetable Farm, 1991

Variety	Source	Type	Color	BWYV	Bolting	Comments
Ambassador	Asg[z]	SS[y]	3.0[x]	4.5	4.3	
Avon	AC	SS	3.3	4.8	4.0	
B1299	Bejo	SS	3.0	3.0	1.0	Resists bolting.
Chinook II	AC	SS	1.8	5.0	5.0	
Coho	AC	SS	3.3	4.8	4.5	
Correnta	RS	F	4.3	4.3	1.0	Resists bolting; some chlorotic mottle.
Fall Green	AC	SS	2.8	3.8	5.0	
Grandstand	Asg	SS	3.3	4.3	5.0	
Hybrid 1369	Bejo	SS	4.3	3.3	1.0	Resists bolting.
Hybrid 1370	Bejo	SS	4.5	4.5	1.0	
Hybrid 7	AC	SS	2.0	4.3	3.8	Some chlorotic mottle.
Hybrid CX5013	AC	SS	3.7	4.7	3.3	
Iron Prince	FM	F	3.0	4.8	3.5	Some chlorotic mottle.
Liberty	FM	F	2.8	4.0	4.0	
Martine	RZ	S	3.5	3.5	1.0	
Melody	Twi	S	3.3	3.5	3.0	
NIZ 46-17	NZ	S	1.5	2.8	4.8	Interveinal chlorosis.
Rainier	AC	F	2.7	3.3	5.0	
Rhythm 9	RS	SS	3.3	4.3	5.0	
Skookum	AC	SS	3.3	5.0	4.5	Some chlorotic mottle.
Space	Bejo	F	3.3	4.5	2.0	Some chlorotic mottle; stunted.
Splendour	Bejo	F	4.3	5.0	1.8	Resists bolting.
Tyee	AC	SS	3.3	5.0	4.3	
Vienna	AC	S	3.5	4.0	5.0	
Winter Bloomsdale	AC	S	4.0	3.5	4.7	

[z]AC, Alf Christianson; Asg, Asgrow; Bejo, Bejo Zaden; FM, Ferry-Morse; NZ, Nickerson-Zwaan; RS, Royal Sluis; RZ, Rijk Zwaan; Twi, Twilley.

[y]S, Savoy; SS, Semi-savoy; F, Flat or Smooth leaf.

[x]Color, bolting, and BWYV symptom intensity rated on 5-point scale with 1=least intense and 5=most intense expression of the characteristic.

Table 3. Autumn spinach beet western yellows virus variety trial, NWREC, 1991

Variety	Source	Type	Color	BWYV	Bolting	Overall	Comments
Avon	AC[z]	SS[y]	3.0[x]	4.0	1	2.5	
Chinook II	AC	SS	2.0	3.5	1	2.5	
Coho	AC	SS	2.5	4.5	1	2.5	
Correnta	RS	F	3.0	3.0	1	2.5	
Fall Green	AC	SS	2.5	2.0	1	3.0	Small leaves.
Hybrid 1369	Bejo	SS	3.0	3.5	1	3.5	Poor stand; prostrate habit.
Hybrid 1370	Bejo	SS	3.0	2.5	1	2.5	Poor stand.
Hybrid 7	Bejo	SS	3.0	4.0	1	2.5	Good vigor.
Hybrid CX5013	AC	SS	2.5	3.5	1	2.0	Small leaves; poor vigor.
Iron Prince	FM	F	2.0	4.5	1	2.0	Leaf dieback; mildew-like symptoms.
Liberty	FM	F	2.5	3.0	1	2.5	Good vigor; large leaf.
Martine	RZ	S	3.5	3.0	1	2.5	
Melody	Twi	S	3.0	3.0	1	2.5	
NIZ 46-17	NZ	S	2.5	2.5	1	3.0	
Rainier	AC	F	2.5	3.5	1	2.0	
Rhythm 9	RS	SS	3.0	3.0	1	3.0	
Skookum	AC	SS	2.0	5.0	1	1.5	
Splendour	Bejo	F	3.0	2.5	1	3.0	
Tyee	AC	SS	2.5	3.5	1	2.0	Small leaves; poor vigor.
Vienna	AC	S	2.0	3.5	1	2.5	
Winter Bloomsdale	AC	S	3.0	3.5	1	3.0	

[z] AC, Alf Christianson; Bejo, Bejo Zaden; FM, Ferry-Morse; NZ, Nickerson-Zwaan; RS, Royal Sluis; RZ, Rijk Zwaan; Twi, Twilley.

[y] S, Savoy; SS, Semi-savoy; F, Flat or Smooth leaf.

[x] Color, bolting, beet western yellows virus intensity, and overall score on a 5-point scale with 1=least intense and 5=most intense.

Table 4. Lettuce beet western yellows virus variety trial, NWREC, 1992

Variety	Source[z]	Type[y]	Color intensity	BWYV	%BWYV	Bolting	Overall
Alpi	Nun	R	3.0[x]	1.5	17[w]	1.0	3.5
Alto	RZ	L	2.0	1.5	25	1.0	2.5
Balisto	RZ	B	4.5	1.0	0	1.5	4.0
Brunia	Ter	RO	4.0	1.0	2	1.0	4.0
Canasta	Ter	FC	4.0	1.5	13	1.0	4.0
Cindy	Ter	B	2.5	1.5	50	1.0	3.0
Cosmic	Toz	R	3.7	2.7	23	1.0	3.0
Dark Green Boston	Asg	B	4.0	2.3	35	2.0	3.0
Deep Red	HM	RL	4.0	1.0	21	3.0	4.0
Density	Toz	BR	4.0	2.3	20	1.3	3.3
Divina	Vil	B	3.0	1.7	0	1.0	4.0
E5879	Enza	B	3.0	1.0	0	1.0	3.0
Fanfare	FM	L	3.3	1.0	0	2.3	3.0
Garnet	FM	RL	4.5	1.0	0	2.0	4.5
Green Towers	HM	R	3.0	2.7	33	1.3	3.0
HMX 9561	HM	R	4.0	2.0	16	1.0	3.5
Kagran Summer	Joh	B	3.5	4.0	67	1.5	2.0
Krizet	RZ	O	2.5	1.5	19	1.0	2.5
Loriol	Enza	B	3.3	2.3	17	1.0	2.7
Majestic Red	Ter	RR	5.0	1.0	0	1.0	5.0
Musca	Vil	RL	4.0	1.0	0	4.3	1.7
Nancy	Joh	B	2.0	2.0	42	1.0	3.0
Nevada	Vil	FC	2.8	2.3	25	2.0	2.8
New Red Fire	Tak	RL	5.0	1.0	0	1.3	4.8
Parris Island Cos	Joh	R	3.8	1.8	20	1.5	3.8
Plato	Peto	BR	3.8	2.3	19	1.0	2.5
Prizehead	HM	RL	3.8	1.0	0	1.3	4.0
Raisa	RZ	RO	5.0	1.0	0	1.0	5.0
RedPrize	FM	RL	4.3	1.0	0	1.3	4.0
Royal Green	RS	L	3.8	1.5	13	4.0	3.5
Sierra	Vil	RF	3.7	1.3	17	1.0	4.0
Slobolt	Joh	L	2.7	2.3	44	1.0	3.5
Soraya	RZ	B	3.3	1.0	0	1.0	3.7
Waldmann's Green	Asg	L	3.8	1.5	25	1.5	3.5

[z] Asg, Asgrow Seed Co.; Enza, Enza Zaden; FM, Ferry-Morse; HM, Harris-Moran; Joh, Johnny's Selected Seeds; Nun, Nunhem's; Peto, PetoSeed; RS, Royal Sluis; RZ, Rijk Zwaan; Ter, Territorial Seed Co.; Toz, Tozer Seeds; Vil, Vilmorin.

[y] R, Romaine; L, Leaf; C, Crisphead; O, Oak Leaf; B, Butterhead or Bibb; FC, French Crisp; RR, Red Romaine; RL, Red Leaf; RF, Red French Crisp; RO, Red Oak Leaf; RB, Red Butter; BR, Butter-Romaine.

[x] Color, bolting, overall score, and beet western yellows symptom intensity rated on a 5-point scale with 1=least intense, 5=most intense expression of the characteristic.

[w] Percentage of plants expressing virus symptoms, regardless of intensity.

Table 5. Spinach beet western yellows virus trial, NWREC, 1992

Variety	Source	Type	Color intensity	BWYV	Bolting	Overall
Ambassador	Asg[z]	SS[y]	4[x]	3	5	2
Avon	AC	SS	3	4	5	2
Coho	AC	SS	3	4	5	2
Correnta	RS	F	4	5	2	3
Hybrid 1369	Bejo	SS	4	5	1	3
Hybrid 1370	Bejo	SS	4	5	2	3
Hybrid 7	AC	SS	2	3	5	1
Hybrid CX5013	AC	SS	3	4	5	1
Liberty	FM	F	2	4	5	1
Martine	RZ	S	5	5	1	2
Melody	Twi	S	4	4	4	2
NIZ 46-17	NZ	S	3	3	5	2
Rainier	AC	F	2	3	5	1
Rhythm 9	RS	SS	2	3	5	1
Space	Bejo	F	4	5	3	2
Splendour	Bejo	F	4	5	1	3
Vienna	AC	S	3	5	5	2
Winter Bloomsdale	AC	S	3	4	5	2

[z] AC, Alf Christianson; Asg, Asgrow; Bejo, Bejo Zaden; FM, Ferry-Morse; NZ, Nickerson-Zwaan; RS, Royal Sluis; RZ, Rijk Zwaan; Twi, Twilley.

[y] S, Savoy; SS, Semi-savoy; F, Flat or Smooth leaf.

[x] Color, bolting, and BWYV symptom intensity rated on 5-point scale with 1=least intense and 5=most intense expression of the characteristic.