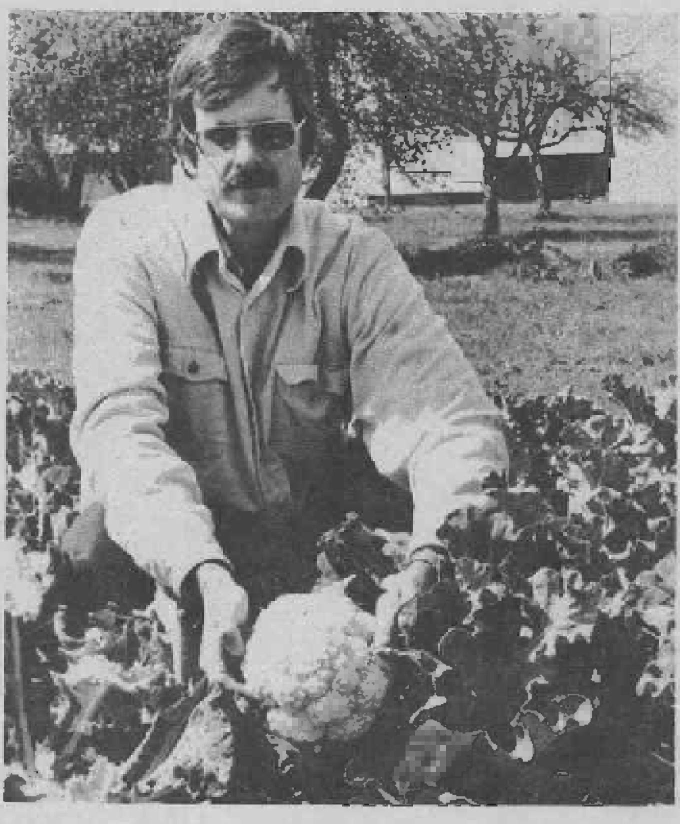
Overwintering Cole Crops and Spinach in the Willamette Valley



Special Report 769
April 1986

Agricultural Experiment Station
Oregon State University, Corvallis

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Cover: The author displays a head of overwintered cauliflower.

OVERWINTERING COLE CROPS AND SPINACH IN THE WILLAMETTE VALLEY

INTRODUCTION

Overwintered vegetable crops, planted in July through October and harvested the following spring, offer several advantages to both fresh market and traditional row crop growers.

The first is that these crops provide possible alternatives to winter grains and spring-seeded row crops. Market prices for vegetables are often higher in spring and early summer than later in the season. A second advantage is that these crops are often planted late enough and harvested sufficiently early to allow three crops in two growing seasons. A third advantage is the low irrigation requirement and the absence of foliar-feeding insects for much of the growing season.

Disadvantages include possibly increased costs for fertilizer and weed control, sometimes difficult conditions at harvest, and the risk of crop failure caused by freezes or flooding.

We have accumulated six years experience growing overwinter cauliflower at the North Willamette Station and have also looked at other possible crops, including onions, shallots, leeks, cabbage, spinach, and Brussels sprouts. This report deals with our experiences with cauliflower, other cole crops, and spinach. The approach has been to first find varieties suitable for our climate and markets, then to determine planting dates and probable harvest dates, and finally to work out cultural problems associated with each crop. The most common problems encountered are: 1. adequate plant growth in the spring, usually a soil fertility-temperature problem, 2. weed control, and 3. diseases related to high moisture, low-temperature conditions.

A full-time program of vegetable crop research has been conducted at the North Willamette Experiment Station since 1976. The Station, a branch of the Oregon State University Agricutural Experiment Station, 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 by the university. Major vegetable research emphasis is on the needs of fresh market growers in the Willamette River Valley, but research is also conducted on processed vegetable crops and home garden and small farm intensive vegetable culture.

Many of the trials reported here involved cooperation with research and Extension Service colleagues in the Oregon State University system and with area vegetable growers. The contributions of Drs. T.L. Jackson and N.S. Mansour, in particular, are gratefully acknowledged. The financial support of the Northern Willamette Valley Horticultural Society and the Plant Food Association was essential to completing these projects and is greatly appreciated.

General Methods

Experimental methods such as varieties used, planting dates, spring fertilizer applications, and plot size varied according to the nature of the trial and are reported below for the individual experiments. Certain methods were common for all experiments and are reported here. All trials were on a Willamette silt loam which was usually rototilled before planting. Pre-plant fertilizer application was 700 to 800 pounds/acre of 10-20-10 ($N-P_2O_5-K_2O$) and 1.0 pound boron/acre. Transplants were grown in soilless media on a greenhouse bench. Plant spacing for the cole crops (cauliflower, cabbage, Brussels sprouts) was usually 3 feet between rows and 1.5 feet in the row. Trifluralin at 0.75 pounds/acre was used for cole crop weed control and fonofos at 2.0 pounds/acre or chlorpyrifos at 1.3 pounds/acre was used for symphylan and cabbage maggot control. Foliar feeding pests were controlled with diazinon and carbaryl. Plots were always cultivated once or twice in early autumn. Cauliflower heads were not tied so self-blanching character could be evaluated. Heads of cauliflower and cabbage were always weighed and graded separately.

Overwinter Cauliflower Variety Trial, 1977-1978

Seven varieties were direct-seeded on July 13, 1977. All varieties except Pinnacle (Asmer Seed Co.) were from Elsoms, Ltd. Plot size was one 24-foot row with the stand thinned to approximately one foot between plants. An additional 225 pounds/acre of ammonium nitrate (34-0-0) was applied on February 2, 1978. Harvest commenced on March 16 and heads were harvested two or three times per week until May 8.

Armado April and Armado Quick were of highest overall quality with excellent head size, color, firmness, and flavor (Table 1). However, texture after freezing was somewhat poorer than most fall-harvested varieties, with a tendency toward mushiness (easy to overcook).

Armado April and Armado Quick also were least variable in head size with about 80 percent of heads falling within 25 percent of the mean. All other varieties produced smaller (average) center heads and one to several small side heads, greatly resembling sprouting broccoli in this respect. The high quality rating of April and Quick was attributable, in part, to their early harvest, before onset of warmer weather and insect and disease problems.

All varieties were adequately self-blanching, with Markanta superior in that respect. The winter of 1977-78 was generally mild, resulting in vigorous plants. However, the plants survived temperatures to 21°F and one severe ice storm in which a half-inch layer of ice destroyed the oldest leaves. Quality of June was totally unacceptable because of a tendency to riciness and formation of leaves in the heads.

This preliminary trial indicated that suitable varieties were available and provided encouragement for further variety trials.

Table 1. Yield of overwinter cauliflower varieties, 1978

Variety	Estimated yield (tons/acre)	Head size (pounds/head)	Mean grade[a]	Harvest span
Armado April	10.8	1.9	1.3	3/22 - 4/5
Armado May	9.1	1.1	1.5	3/31 - 4/12
Armado Quick	11.9	2.2	1.1	3/16 - 3/31
Armado Tardo	8.8	1.4	1.4	3/31 - 4/17
June	5.2	1.0	2.0	4/17 - 5/8
Markanta	9.6	1.3	1.6	3/31 - 4/12
Pinnacle	7.3	1.1	1.7	4/12 - 5/8

[a]Grade 1 = 1.0 pound minimum (4.5 inch diameter), tight, free of defects.
Grade 2 = less than 1 pound or overmature, ricey, discolored, etc.

Planting Dates and Rate of Nitrogen on Cauliflower, 1978-1979

The varieties Armado April and Armado Quick (Elsoms, Ltd.) were seeded in 2-inch pots in the greenhouse on August 1, August 16, and August 30, 1978, and were transplanted to the field on August 21, September 12, and September 26, respectively. Plots consisted of two 25-foot rows. Treatments were 1) 50 pounds N/acre as ammonium nitrate applied on December 22, 1978, and again on February 26, 1979, and 2) 100 pounds N on the same dates. Treatments were in randomized block design. Heads were harvested twice weekly from April 13 until May 9, 1979.

Table 2 presents the main effects of variety, transplant date, and nitrogen rate on yield, head size, and winterkill of cauliflower. Only main effects are presented since there were no significant 2-way or 3-way interactions among varieties, dates, or N rates.

Mean head weight decreased with later transplant dates and increased with the higher N rate. Armado April produced larger heads than did Armado Quick. Since the number of plants surviving the winter was lowest for the first planting date, part of the increased head weight for this planting could be caused by reduced competition between plants. However, the extra three weeks for plant growth probably accounted for most of the increase.

Planting date had little effect on timing of curd production. Peak maturity differed by no more than one week with more than a month difference in transplant dates.

Total yield on an area basis did not vary significantly with planting date because of greater winterkill of the earliest planting. The higher rate of N increased total yield and, in contrast to 1978, Armado April outyielded Armado Quick.

Winterkill was not affected by variety or by the winter-applied nitrogen. The larger plants from the earliest planting were most susceptible to winterkill. The winter of 1978-79 was colder than average. The plants were subjected to several days of minimum temperatures below 20°F and one night of 13°F in January, 1979. Plants appeared to be most susceptible after onset of curd formation. The greater incidence of early curd formation in the first planting may explain the greater winterkill.

Observations of the variety Ferry Morse April were made on several off-station locations with grower cooperators. In a field 4 miles southwest of the Station and transplanted on October 1, winterkill was approximately 25% with a minimum recorded temperature of 9°F. Yield was excellent but quality was poor because of poor cover of the curd.

In a second field 12 miles south of the Station, also transplanted on October 1, winterkill averaged 80% with a low temperature near 0°F. An interesting pattern of plant survival was noted. Where the transplanter press wheel made an extra deep furrow, survival was about 60%. Survival of more exposed plants was close to zero.

In a third field 30 miles northeast of the Station in an area where overwinter cauliflower has been grown for decades, the winterkill was nearly 70% with a low temperature of 15°F. This exposed hillside location appeared to suffer more wind and ice storm damage than did the valley floor sites.

Table 2. Effects of transplant date, variety, and nitrogen rate on overwinter cauliflower, 1979

Treatment	Mean head wt. (pounds)	Gross yield (tons/acre)	Winterkill (%)	Harvest span
Transplant date				
8/21	1.3	6.8	24	4/14 - 4/25
9/12	1.1	7.2	6	4/17 - 4/27
9/26	1.0	6.6	11	4/19 - 5/5
LSD(0.05)	0.2	NS[a]	11	
Variety				
Armado April	1.3	7.8	22	4/18 - 4/31
Armado Quick	1.0	5.9	19	4/15 - 4/28
LSD(0.05)	0.2	1.5	NS	
Sidedressed N rate				
100 pounds	1.07	6.3	12	4/16 - 4/29
200 pounds	1.21	7.5	15	4/16 - 4/30
	*	*	NS	

[a]NS, *: no significant difference, differences significant at 5% level, respectively.

Planting dates and Rate of Nitrogen on Cauliflower, 1979-1980

In an attempt to confirm results obtained in 1979, the cultivars Armado April and Preminda (Royal Sluis Co.) were seeded on August 1, 16, and 30, 1979, and were transplanted on August 28, September 10, and October 8, respectively. Nitrogen rates, in addition to the base fertilizer at planting, were 1) 50 pounds N/acre sidedressed as ammonium nitrate on February 12 and again on March 7, 1980, and 2) 100 pounds N/acre on the same dates. Plots were 4 rows x 25 feet and treatments were in randomized block design.

Results are presented for the first two transplant dates (Table 3). The third planting made insufficient foliar growth before head formation. Yield and quality were judged too low to justify harvesting the plots. In contrast to 1979, there were significant interactions between variety and transplant date and between N rate and transplant date. Armado April significantly outyielded Preminda for the first planting date, but not at the second date. Increasing the N rate increased head size and yield of both varieties for the first, but not for the second, transplant date.

The first planting produced the highest yields, regardless of cultivar or N rate. Quality was also higher for the first planting. Nearly 80% of the heads of both varieties were judged acceptable for fresh market while only 65% of the heads from the second planting were marketable. In general, heads from the second planting were smaller, looser, and had more yellow pigmentation.

Rate of N again had no effect on quality or date of maturity, increasing head size only. Plants were not noticeably larger, nor the curd better protected, at the higher N rate.

Winterkill was not a factor in this trial, averaging less than 1 percent, and did not vary significantly with treatment.

Table 3. Effect of transplant date, variety, and nitrogen rate on overwinter cauliflower, 1980

Transplant date	Variety	N rate (pounds/acre)	Total yield (tons/acre)	Mean head wt. (pounds)	Harvest span		
					First	Peak	Last
Aug. 28	A. April	100	6.9	1.77	4/7	4/14	4/21
		200	9.6	2.06	4/1	4/14	4/21
	Preminda	100	6.6	1.45	4/1	4/7	4/21
		200	8.5	1.88	4/1	4/7	4/21
Sept. 10	A. April	100	5.5	1.15	4/14	4/14	4/21
		200	5.9	1.21	4/7	4/14	4/21
	Preminda	100	5.2	1.13	4/7	4/14	4/21
		200	5.4	1.23	4/7	4/14	4/21
		LSD(0.05)	0.9	0.34			
Mean, first planting			7.9	1.79	4/4	4/11	4/21
second planting			5.5	1.18	4/8	4/14	4/21
			**[a]	**			
Mean, A. April			7.0	1.55	4/7	4/14	4/21
Preminda			6.4	1.42	4/4	4/11	4/21
			NS	NS			
Mean, 100 pounds N			6.1	1.38	4/7	4/12	4/21
200 pounds N			7.4	1.60	4/6	4/12	4/21
			*	*			

[a]**, *, NS: means differ significantly at 1% level (**), 5% level (*), or do not differ significantly (NS).

Cauliflower Variety Trials, 1980-1981 and 1981-1982

The two 1980-81 trials were seeded on August 5 and 15, and transplanted on September 11 and 17, respectively. In addition to fertilizer applied before planting, 100 pounds N/acre was sidedressed on March 2, 1981. In 1981-82, the trial was seeded on July 30 and transplanted on September 2, 1981. Calcium nitrate was applied at 50 pounds N/acre on January 25, 1982. Ammonium nitrate was applied at 60 pounds N/acre on March 11 and at 50 pounds N/acre on April 5, 1982.

In 1980-81, Armado April was the best of the early to mid-early varieties in yield and quality (Table 4). Armado May and Maya were the superior mid-to-late lines. Because of the very mild winter, there was no winterkill and all varieties made some growth throughout the winter. Early maturing varieties such as March and Superb Early White were exposed to night temperatures as low as 20°F after curd formation had started. However, damage was slight. Cold weather in February and March retarded development of foliage; plant size was smaller than normal for all but the latest cultivars. Nearly all cultivars had a russeting of the leaves and curd, perhaps because of crane fly or Hylemya fugax larvae, mildew (Peronospora), or black rot (Xanthomonas). Quality was significantly reduced. These problems had not occurred in previous trials.

Twenty varieties, with more than a two-month spread in maturity, were included in the 1981-82 trial. The 1981-82 winter was cold; on several nights, temperatures in the low teens (°F) were recorded. Plants made essentially no growth during the winter, and a cold, dry spring further retarded plant development. Peak harvests averaged two weeks later in 1982 than in 1981. The earliest varieties, such as Superb Early White, March Early, Morse's March, Armado Quick, and Preminda, did not size sufficiently to produce acceptable yields (Table 5), although each produced some heads with adequate curd quality. The mid-early variety Armado April also had low yields, although curd quality was good. The best combination of yield and quality occurred with mid-maturity varieties such as Maya, Arminda, and Inca. Inca was included in the trials for the first time and looked promising for a mid-early to middle maturity line. Late cultivars such as Midsummer, June, and Vision had excellent gross yields but poor curd quality. In general, the earliest varieties suffered the greatest degree of winterkill. Disease pressure was low in 1982 and no fly larvae were found in the heads.

Table 6 presents a summary of relative maturity of all varieties included in trials through 1982. Averages are for two or more years except as noted. The span of peak harvests from the earliest (Morse's March) to the latest cultivar (Vision) is nearly 60 days. Armado April was used as a standard for comparison, with other cultivars given in terms of days earlier or later maturity than Armado April. Descriptions of the varieties included in these two trials are found in Table 7.

Table 4. Overwinter cauliflower variety trial, 1980-81

Variety	Source	Mean head wt.(pounds)	Harvest range First	Peak	Last	Est. gross yield (tons/acre)
A. First planting (transplanted 9/11)						
April	3[a]	0.84	4/01	4/13	4/21	4.0
Armado April	4	1.43	3/16	4/01	4/10	6.9
Armado May	2	1.90	4/01	4/16	5/01	9.2
Armado Quick	4	1.20	3/19	3/23	4/01	5.8
Armado Tardo	2	NM[b]	4/10	NM	NM	NM
Arminda	4	NM	4/01	NM	NM	NM
Heralda	2	1.04	3/16	4/01	4/01	5.0
March Early	3	0.98	3/09	3/16	3/27	4.8
Markanta	2	NM	4/10	NM	NM	NM
Preminda	2	1.15	3/16	4/01	4/10	5.6
B. Second planting (transplanted 9/17)						
Aprilex	2	1.61	4/06	4/21	5/01	7.8
Armado Clio	4	1.71	4/21	5/01	5/14	8.3
March	2	0.85	3/09	3/09	4/01	4.1
Marchpast	2	1.36	3/23	4/01	4/16	6.7
Maya	1	1.52	4/24	4/27	5/11	7.4
Maystar	2	1.55	4/10	4/27	5/11	7.5
Midsummer	2	1.84	4/27	5/14	5/18	8.9
Mirado	4	1.06	4/21	5/01	5/05	5.1
Superb Early White	2	0.74	3/09	3/16	3/23	3.6
Vision	2	1.44	5/01	5/14	5/22	7.0

[a] 1=Bejo Zaden, 2=Elsoms, 3-Ferry Morse, 4=Royal Sluis.
[b] NM: not measured.

Table 5. Overwinter cauliflower variety trial, 1981-82

Variety	Source[a]	Harvest range First	Peak	Last	Mean head wt. (pounds)	Est. gross yield (tons/acre)	Yield of #1 heads (tons/acre)	Mean grade[b]
April	3	4/23	4/30	5/07	1.22	5.2	3.5	1.4
Aprilex	2	4/30	5/03	5/17	1.24	6.1	3.8	1.4
Armado April	2, 4	4/01	4/13	4/23	1.08	4.6	2.9	1.4
Armado Clio	2, 4	5/03	5/14	5/17	1.47	8.5	4.4	1.6
Armado May	2, 4	4/16	4/30	5/11	1.35	7.0	4.1	1.6
Armado Quick	2, 4	3/16	4/13	4/26	0.72	3.1	1.8	1.5
Armado Tardo	2, 4	4/26	5/07	5/14	1.07	6.2	3.6	1.5
Arminda	4	4/30	5/07	5/14	1.89	6.9	5.0	1.3
Inca	1	4/16	4/23	5/07	1.65	8.0	6.4	1.4
June	2	5/15	5/17	5/28	2.23	10.2	0.8	1.9
March Early	3	3/29	3/29	4/13	0.32	0.9	0.2	1.8
Marchpast	2	4/13	4/23	4/26	1.57	5.2	4.6	1.2
Markanta	2, 1	4/23	5/03	5/07	1.30	5.1	2.6	1.7
Maya	1, 2	4/30	5/07	5/17	1.86	7.9	5.5	1.4
Maystar	2	4/26	5/07	5/14	1.54	8.4	4.4	1.6
Midsummer	2	5/11	5/21	5/28	2.03	7.4	0.0	2.0
Morse's March	2	3/16	3/16	4/02	0.52	1.6	0.4	1.8
Preminda	2, 4	3/19	4/20	4/23	0.84	4.1	2.2	1.5
Superb Early White	2	3/16	3/29	4/23	0.46	1.4	0.4	1.8
Vision	2	5/25	5/25	5/28	1.98	11.1	2.6	1.8

[a]1 = Bejo Zaden, 2 = Elsoms Seeds Ltd. 3 = Ferry Morse 4 = Royal Sluis. When two sources are listed, the seed lot from the first source listed was used in the trial.
[b]Grade 1.0 = all heads free of defects; tight, white curd. All heads given a score of either 1 or 2. Grade 2.0; all unacceptable.

Table 6. Relative maturity of overwinter cauliflower varieties compared to Armado April

Days earlier or later than A. April[a]	Varieties
-20 to -11	Morse's March, March Early, Superb Early White
-10 to -3	Armado Quick, Preminda
-2 to +2	Heralda[b], Armado April
+3 to +10	Marchpast, Barrier Reef[b], Inca[b]
+11 to +20	April, Armado May, Aprilex, Markanta
+21 to +30	Arminda[b], Armado Tardo, Maystar, Maya, Mirado[b], Armado Clio, Pinnacle[b]
Over +30	June[b], Midsummer, Vision

[a]Within each category, varieties listed in order of maturity.
[b]Based on one year of observations.

Table 7. Description of varieties in 1981 and 1982 trials

April:	Few leaves, poor cover. Small heads but better than average curd quality when protected. Usually no leaves or bracts in head.
Aprilex:	Fair to good cover. Good curd quality. Yield only fair for mid-maturing cultivar.
Armado April:	Good cover on larger plants. Excellent curd quality on well-sized plants. Fair yield. Best of early cultivars.
Armado May:	Good cover. Fair to good yield. Tendency to leaves in head but good curd quality.
Armado Quick:	Poor cover, small size. Too early for cold winter/spring. Heads small but curd quality usually better than average.
Armado Tardo:	Good cover, but yield and head size small for mid-maturing variety. Multiple stems.
Arminda:	Good cover, yield, head size. Very good curd quality.
Heralda:	Fair cover. Poor protection from wrapper leaves but older leaves form stovepipe. Poor yield, fair quality.
Inca:	Good cover, good plant size for early to mid-maturity range. Good yield, head size, quality.
June:	Good cover and plant size. Late maturing. Poor curd quality. "Fuzzy" curds, leaves and bracts in head.
March Early:	Too early to size sufficiently. Poor yield, curd quality. Thirty percent winterkill.
Marchpast:	Good cover, but small to medium size plants. Good head size for mid-early variety. Fifteen percent winterkill. Very good curd quality.
Markanta:	Good plant size but only fair cover. Low yield for mid-maturity variety. Very prone to green stems. Fifteen percent winterkill.
Maya:	Good cover, yield, head size. Good curd quality. Best of mid-maturing varieties.
Maystar:	Good cover and yield, but only fair curd quality. Low density heads.
Midsummer:	Good cover, large plants. Late maturing. Multiple stems. Large heads but very poor curd quality: "fuzzy", bracts in head.
Mirado:	Good cover, medium size plants. Fair yield, Conical, knobby curds.
Morse's March:	Poor cover, small plants. Too early to size sufficiently. Poor curd quality. Average of 35 percent winterkill.
Preminda (Armado Primo):	Poor cover and plant size. Too early to size sufficiently. Average curd quality.
Superb Early White:	Poor cover and plant size. Too early to size sufficiently. Poor curd quality. Thirty percent winterkill.
Vision:	Good cover, large plants. Late maturing. Excellent gross yields but curd quality poor. "Fuzzy" curds, bracts in head. Multiple stems. Superior to other late varieties.

Cauliflower Planting Date Trials, 1980-81 and 1981-82

The 1980-81 planting date trial involved the variety Armado April. The trials were seeded on July 25, August 2, and August 15 and transplanted on September 5, 11, and 17, 1980, respectively. In the 1981-82 planting date trial, Morse's March, Armado April, and Vision were seeded on July 15, July 30, and August 14, and transplanted on August 21, September 2, and September 21, 1981, respectively. Spring N applications were the same as for the variety trials (above).

In 1980-81, a 12-day range in transplant date had no significant effect on yield or harvest date (Table 8). The previous planting date trials had indicated a greater effect of planting date on mean head weight.

The effect of transplant date on yield and quality of three varieties in 1981-82 is seen in Table 9. In contrast to 1980-81, but in agreement with earlier trials, mean head weight and gross yield of all three varieties declined with later dates. However, winterkill of the very early variety Morse's March was greater with the earlier plantings, confirming results obtained in 1979. Curd of Morse's March suffered freeze damage, particularly with the first planting. A one-month spread in seeding and transplant dates led to a 19-day spread in peak harvest for Morse's March, but had little or no influence on peak harvest of Armado April or Vision. However, planting date did affect first harvest of Armado April.

These trials support the previous conclusion that a range of cultivars is a more effective means of spreading the harvest period than is a succession of plantings of one variety.

Table 8. Effect of planting date on yield and harvest period of Armado April, 1980-81

Transplant date	Mean head weight (pounds)	Harvest range			Est. gross yield (tons/acre)
		First	Peak	Last	
9/05/80	1.46	3/23	4/01	4/13	7.1
9/11	1.44	3/16	4/06	4/10	7.0
9/17	1.37	3/16	4/01	4/10	6.6

Table 9. Effect of planting date on yield, grade, and winter mortality of three winter cauliflower varieties, 1981-82

Variety	Transplant date	Harvest range			Mean head weight	Est. gross yield	Yield of #1 heads	Winter-kill	Mean grade
		First	Peak	Last					
					pounds	-tons/acre--		%	
Morse's March	8/21	8/21	3/10	3/29	1.22	1.5	0.0	50	2.0[a]
	9/12	3/16	3/16	4/02	0.52	1.6	0.4	31	1.8
	9/21	3/19	3/29	3/29	0.35	1.0	0.2	13	1.9
Armado April	8/21	3/19	4/13	4/16	1.35	5.7	5.4	13	1.1
	9/12	4/02	4/13	4/23	1.08	4.6	2.9	0	1.4
	9/21	4/13	4/16	4/26	0.85	2.6	1.2	19	1.6
Vision	8/21	5/21	5/25	5/25	2.01	15.2	5.8	6	1.7
	9/12	5/25	5/25	5/28	1.98	11.1	2.6	0	1.8
	9/21	5/21	5/25	5/28	1.52	5.5	1.9	0	1.7

[a]Freeze-damaged curds on early maturing heads.

Overwinter Cauliflower Variety Trial, 1982-83

This was the fourth and last of the series of variety trials and focused on mid-maturity varieties to determine those with the best combination of yield and quality. The previous trials had established that the best quality is obtained with varieties maturing in April and early May.

The trial was seeded on July 27, and transplanted on September 3, 1982. On February 16, 1983, 35 pounds N/acre as ammonium sulfate, 40 pounds N/acre as calcium nitrate, and 100 pounds/acre of 0-45-0 was sidedressed. An additional 75 pounds N/acre as ammonium nitrate was applied on March 14.

The 1982-83 winter was unusually mild. Plants made good growth but curd tended to form before plants achieved maximum size. Winterkill was insignificant. Peak harvests averaged one to two weeks earlier than the average for the previous five years and three weeks earlier than in 1982.

The earliest variety was Tolteca. Harvest was very concentrated and the percentage of grade #1 heads (no defects) was low because of yellow, fuzzy curds and green stems.

Of the remaining eight varieties, highest gross yields were obtained with Arminda, Armado May, and Maya; highest yield of #1 heads was obtained with Markanta; the highest percentage of #1 heads was obtained with Markanta, Armado April, and Inca (Table 10). In all trials to date, this was by far the best performance of the variety Markanta. This variety often has leaves in the curd but this was not a problem in 1983. Averaged over four trials, the most consistent varieties have been Armado April (early), Inca (early), Maya (late) and Arminda (late). Curd quality of some varieties was below average because of slug damage and a higher than normal incidence of diseases. Notes on causes of poor curd quality are found in Table 11.

Table 10. Yield and source of overwinter cauliflower varieties, 1983

Variety	Harvest range			Mean wt. of #1 heads (pounds)	Gross yield (tons/acre)	Yield of #1 heads (tons/acre)	% #1 heads
	First	Peak	Last				
Tolteca	3/11	3/11	3/14	2.2	6.2	3.0	46
Marchpast	3/21	3/24	4/1	1.5	7.9	3.7	53
Armado April	3/21	3/28	4/4	1.4	6.7	4.5	69
Inca	3/24	3/28	4/4	1.6	6.3	4.9	64
Armado May	4/1	4/8	4/19	2.0	7.8	4.5	47
Markanta	4/1	4/15	4/15	1.9	7.9	6.5	71
Aprilex	4/1	4/15	4/19	1.9	8.3	4.3	47
Armado Clio	4/12	4/19	4/22	1.2	5.6	3.6	60
Mirado	4/12	4/22	4/22	1.1	4.6	2.1	40
Arminda	4/15	4/22	4/22	2.6	12.9	4.9	38
Maya	4/19	4/19	4/26	1.8	8.3	3.9	44

Table 11. Comments on overwinter cauliflower varieties, 1983

Variety	Source[a]	Comments
Aprilex	3	Low to medium vigor, upright leaves, good cover; but half of heads had yellow curd.
Armado April	3	Medium vigor, upright leaves, good cover. Twenty-five percent of heads had yellow curd.
Armado Clio	1	Medium vigor, fairly good cover. One-third of heads with yellow curd.
Armado May	2	Variable plant growth: some tall and upright, others low and spreading. Some yellow curd, some bracts in curd.
Arminda	1	Medium to high vigor, upright leaves. Majority of heads yellow and/or brown spotting (disease or slug damage).
Inca	2	Low growing, lots of leaves, but only fair cover, tends to open. Some bracts in curd.
Marchpast	3	Sprawling, medium to high vigor, fairly good cover. Yellow curd on nearly half of heads.
Markanta	3	Low vigor, sprawling, but good cover. Some yellow curd and some leaves in curd.
Maya	2	Medium-low vigor, good cover, one-third of heads with yellow curd. Some leaves in curd.
Mirado	1	Tall, upright, sparse stovepipe. Conical curds and majority of plants had yellow curd.
Tolteca	2	Medium vigor. Fuzzy, yellow curd. Green stems.

[a] 1 = Royal Sluis, 2 = Bejo Zaden, 3 = Elsoms.

Lime and Fertilizer Effects on Overwintered Cauliflower, 1983-1985

Introduction

As a result of the variety and planting date trials described above, overwintered cauliflower is now considered a crop of proven potential in the Willamette Valley. Trials at the North Willamette Station and by growers have usually given acceptable yields and quality. However, yields of early varieties, and particularly in cold springs, have occasionally been disappointing. Since plant nutrient uptake is limited on cold soils, these low yields may have been caused by inadequate availability of P or other elements.

Past recommendations for overwintered cauliflower have called only for application of N in the spring. The effects of spring-applied P and the type of spring-applied N on cauliflower yield and quality had not been investigated. Likewise, the response of overwintered cauliflower to lime, which increases P availability, had not been studied. The purpose of these trials was to investigate the effects of lime, spring-applied P, banded P at planting, gypsum, and source and rate of N on the yield and grade of overwinter cauliflower.

Methods

1983

Agricultural limestone (95% $CaCO_3$ equivalent) at 0, 2, 4, and 6 tons/acre was applied in 1979 to 2,300 square foot plots with four replications of each treatment in randomized block design. Resulting soil pH in August 1982 averaged 5.5, 6.0, 6.2, and 6.6, respectively. 'Arminda' cauliflower was direct-seeded on approximately 3 feet x 4 inch spacing on August 4, 1982. Sprinkler irrigation was applied as necessary for stand establishment. In late September, the stand was thinned to 18 inches in the row. After a mechanical cultivation, napropamide was applied at 2.0 pounds/acre.

On February 15, 1983, the lime main plots were split into 5 subplots (2 rows x 24 feet) by banded surface application of the following: 1) ammonium nitrate at 50 pounds N/acre, 2) urea at 50 pounds N/acre, 3) ammonium nitrate at 50 pounds N/acre plus 100 pounds 0-45-0/A, 4) urea at 50 pounds N/acre plus 100 pounds 0-45-0, (5) no spring-applied fertilizer. Treatments 1-4 also received 30 pounds N/acre as ammonium sulfate. The ammonium nitrate and urea applications were repeated on March 25.

Leaf samples for plant tissue analysis were collected from plots receiving 0 and 4 tons lime/acre and all subplot treatments on March 24. The first harvest occurred on April 8, 1983, with additional harvests on April 15 and April 22. Heads were graded into #1 (free of any defect) and #2 (off color, mildew, slug damage, leaves or bracts in head, ricey etc.) before weighing.

1984

Methods for the lime x P x N rate experiment were essentially the same as in 1982-1983, except as follows: seeding date was August 3, 1983, and the variety was 'Inca'. Subplot treatments were surface banded on February 6, 1984, as follows: 1) ammonium nitrate at 50 pounds N/acre, 2) ammonium nitrate at 100 pounds N/acre, 3) ammonium nitrate at 50 pounds N/acre plus 0-45-0 at 150 pounds/acre, 4) ammonium nitrate at 100 pounds N/acre plus 0-45-0 at 150 pounds/acre. Gypsum, at 150 pounds/acre, and Solubor, at 2 pounds B/A were applied to all plots on the same date. Nitrogen treatments were reapplied on March 9. Leaf samples were taken on March 14. First harvest was on March 14 and plots were harvested weekly through April 20.

In a separate experiment, 'Inca' cauliflower was seeded on soil which had received a uniform application of lime at 3 tons/acre in 1980. Soil pH at planting was 6.1. All practices were as above, except that the following N sources were sidedressed at 100 pounds N/acre on February 6, 1984: ammonium nitrate, ammonium sulfate (21-0-0-24), calcium nitrate (15.5-0-0), and urea (46-0-0). The N sources were reapplied at 100 pounds N/acre on March 9. Leaf samples were taken on March 14.

1985

Methods for the lime experiment were similar to the above except as follows: 'Inca' was seeded on August 2, 1984. The lime main plots were split by a banded application of 0 or 90 pounds P_2O_5/acre, placed two inches to the side and two inches beneath the seed row at planting. On February 6, 1985, the plots were again split by a sidedressed application of gypsum at 0 or 150 pounds/acre. Resulting sub/subplot size was three rows x 24 feet. Treatments, harvest rows, and plants sampled for tissue analysis came from the center row of each plot. Additional N as ammonium nitrate was applied to all plots at 75 pounds N/acre on February 6, and again on March 6. Leaf samples were collected for tissue analysis on March 25. Plots were harvested on April 15 and on April 22.

In a separate experiment, 'Inca' cauliflower was seeded on August 2, 1984, in three-foot rows on a uniformly limed area, pH 6.1. The seedling stand was thinned to 18 inch in-row spacing in late September. Napropamide was applied at 2.0 pounds/acre in October, following hand-hoeing. On February 6, 1985, the following N sources were applied at 75 pounds N/acre in a randomized block design with four replications: ammonium nitrate, ammonium sulfate, calcium nitrate, and urea. The N sources were reapplied at the same rate on March 6. Leaf samples were collected for tissue analysis on March 25. Plots were harvested on April 15 and 22.

Results and Discussion

1983

Initial seedling stands increased slightly with increasing lime rate (data not shown) but, after thinning, stands were essentially equal on all plots. Application of lime tended to increase yield of grade #1 heads at the first harvest only (Table 12). In general, yield of #1 heads was lower at the highest rate of lime than at the intermediate rates. Lime had no effect on mean head weight of all heads but did increase weight of #1 heads at the first harvest. The number of grade

#1 heads harvested/plot also tended to be higher with lime at the first harvest, but the increase was not statistically significant. Both the increase in mean weight of #1 heads and the increased number of heads harvested appeared to contribute about equally to the increase in #1 yield with lime. Lime had no effect on total yield over three harvests. Thus, lime appeared primarily to hasten maturity, particularly of quality heads. No specific defect affecting grade was found to be related to lime rate.

Providing N in the spring increased total yield through increased head size and increased yield of #1 heads both through increased numbers and head size (Tables 12 and 13). The N effect was equally strong through all harvests. Form of spring-applied N affected yield of #1 heads, but not total yields; the number of grade #1 heads harvested was greater with ammonium nitrate than with an equal N rate with urea as N source. Mean head weight was not affected by N source. Greater foliar growth on ammonium nitrate-fertilized plants may have provided better curd cover and, thus, better color.

Spring-applied P application had no effect on yield or quality and there was no interaction of P and N source affecting yield or quality. There were also no significant lime x N or lime x P interactions. Highest yields of #1 heads were obtained with 4 tons/acre lime and spring-applied ammonium nitrate, either with or without P.

The lack of yield response to spring-applied P may have resulted from low solubility and poor access to the root mass of the surface-banded application. Alternatively, the lack of response to P might be attributed to an unusually mild winter and spring. Phosphorus availability on warmer-than-normal soils may not have limited yields. Results of plant tissue analysis tend to confirm that neither lime nor applied P increased P availability to the plants since neither affected tissue P concentration (Table 14). Applied P also did not affect levels of the other elements.

Application of lime increased leaf Ca concentration, and decreased leaf Mn and Cu levels. Since leaf Mn levels were low even on unlimed soil, Mn toxicity is apparently not a problem at pH 5.5. Spring application of N increased leaf P, K, Mg, Zn, and Mn levels. Form of spring-applied N had no effect on the levels of measured elements (Table 14).

Table 12. Main effects of lime, rate of spring-applied N, form of spring-applied N, and spring-applied P on yield of overwintered cauliflower at first harvest, April 8, 1983

Treatment	Yield of #1 heads	Total yield	Mean head wt.	Mean wt. of #1 heads	No. of grade #1 heads harvested/plot	No. of total heads harvested/plot
	-tons/acre-		---pounds---			
Lime (T/A)						
0	1.1	2.1	2.0	1.7	4.1	7.6
2	1.5	2.5	1.9	1.8	5.4	9.2
4	1.5	2.7	2.0	2.1	4.7	9.2
6	1.0	2.7	1.9	1.6	3.8	9.4
LSD(0.05)	0.5	0.5	NS	0.3	NS	NS
+N	1.4	2.6	2.1	1.9	4.7	8.6
-N	0.7	1.9	1.3	1.2	3.8	9.8
	**[a]	**	**	**	*	NS
Amm. nitrate	1.6	2.6	2.1	1.9	5.3	8.5
Urea	1.2	2.7	2.2	1.9	4.1	8.6
	*	NS	NS	NS	*	NS
+P	1.5	2.7	2.1	1.9	4.9	8.7
-P	1.3	2.6	2.2	1.9	4.4	8.4
	NS	NS	NS	NS	NS	NS

[a]**, *, NS: significant at 1% and 5% levels, and nonsignificant, respectively.

Table 13. Main effects of lime, rate of spring-applied N, form of spring-applied N, and spring-applied P on yield of overwintered cauliflower, sum of three 1983 harvests

Treatment	Yield of #1 heads	Total yield	Mean head wt.	Mean wt. of #1 heads	No. of grade #1 heads harvested/plot	No. of total heads harvested/plot
	--tons/acre--		---pounds---			
Lime(T/A)						
0	2.6	6.5	1.5	1.6	10.8	28.0
2	2.8	6.3	1.5	1.6	11.4	27.6
4	3.1	6.7	1.7	1.7	11.7	26.7
6	2.5	6.7	1.6	1.6	10.0	27.8
	NS[a]	NS	NS	NS	NS	NS
+N	3.1	7.0	1.7	1.7	16.8	27.5
-N	1.4	4.6	1.1	1.2	7.6	27.5
	**	**	**	**	**	NS
Amm. nitrate	3.4	6.8	1.7	1.8	12.9	27.4
Urea	2.7	7.1	1.7	1.7	10.8	27.7
	*	NS	NS	NS	*	NS
+P	3.0	7.0	1.7	1.7	11.7	27.3
-P	3.1	7.0	1.6	1.7	11.9	27.8
	NS	NS	NS	NS	NS	NS

[a]**, *, NS: significant at 1% and 5% levels, and non-significant, respectively.

Table 14. Main effects of lime, rate of spring-applied N, form of spring-applied N, and spring-applied P on leaf elemental concentrations of overwintered cauliflower

Treatment	P	K	Ca	Mg	Zn	Mn	Cu
	-----------%-----------				----ppm-----		
Lime(T/A), 0	0.49	3.32	1.38	0.19	32	48	7.4
4	0.48	3.29	1.84	0.18	24	29	7.3
	NS[a]	NS	*	NS	*	*	NS
+N	0.51	3.35	1.61	0.19	29	40	7.9
-N	0.41	3.13	1.63	0.17	24	34	5.2
	**	*	NS	*	*	*	NS
Am. nitrate	0.51	3.36	1.62	0.20	29	40	6.9
Urea	0.51	3.35	1.59	0.19	29	40	8.8
	NS	NS	NS	NS	NS	NS	NS
+P	0.52	3.40	1.65	0.19	28	42	7.5
-P	0.50	3.31	1.57	0.19	30	38	8.2
	NS	NS	NS	NS	NS	NS	NS

[a]**, *, NS: significant at 1% and 5% levels, and nonsignificant, respectively.

1984

The winter of 1983-84 was unusually severe. Low temperatures of 5°F combined with 20 mph winds to severely damage the crop. Most mature leaves were broken from the plants and approximately 20% of the plants were killed. The freeze damage appeared to be responsible for several crop responses observed in 1984: 1) reduced head size, probably related to reduced plant size, 2) early onset of head formation, perhaps stress-related, 3) extension of the normal three-week harvest to more than five weeks, and 4) greatly reduced head quality with a high percentage of loose curds, leaves in the curd, and early bolting.

For the lime x P x N rate experiment, no treatment significantly affected early yield (March harvests, data not shown). Total season yields tended to be increased by liming, and mean head weight was significantly increased by liming (Table 15). Lime had no significant effect, however, on production of #1 heads (Table 15). Lime slightly increased leaf Ca and decreased leaf Mn and Zn concentrations (Table 16).

Total yield and mean head weight were higher with 200 rather than 100 pounds/acre of spring-applied N. The higher N rate also increased the total yield and mean head weight of #1 heads (Table 15). Surface application of P in the spring tended to increase production of both total and #1 heads, but the increases were not significant. As in 1983, leaf tissue P was not affected by P application.

Lime and N significantly interacted in increasing total yield and #1 yield (Table 17): the higher N rate was much more effective in increasing yield at the 6 tons/acre lime rate than at the lower lime rates. Highest total yields were obtained with 6 tons lime/acre and 200 pounds/acre spring applied N. Highest yields of #1 heads, however, were obtained at 2 tons lime/acre and 200 pounds N.

Several interactions affected mean weight of #1 heads (Table 17). Averaged across lime rates, P increased mean head weight of #1 heads at the high N rate but not at the low N rate. The high rate of N increased mean #1 weight on limed, but not on unlimed, soil. The statistically significant lime x P interaction on #1 head weight does not appear to follow any biologically meaningful pattern.

In the N source experiment, early and total yield were highest with urea as N source. Mean head weight was not favored by urea, however. The yield increase was from a greater number of heads harvested (Table 18). The greater number of heads reflects a higher number of plants present on urea-treated plots. This was caused by non-random variability in plant stands; there was no evidence for increased plant survival resulting from urea application. Source of N had no effect on leaf tissue concentrations of any element analyzed (data not shown). No conclusions concerning relative effectiveness of different N sources could be drawn from this experiment.

Table 15. Response of 'Inca' cauliflower to lime, spring-applied P, and rate of spring-applied ammonium nitrate, main effects, 1984

Treatment	Total yield (tons/acre)	Mean head wt. (pounds)	Yield of #1 heads, (tons/acre)	Mean wt. of #1 heads (pounds)
Lime, 0 T/A	3.4	0.66	0.7	0.89
2 T/A	3.6	0.84	0.8	0.97
4 T/A	3.5	0.79	0.6	0.94
6 T/A	4.0	0.87	0.6	1.05
LSD(0.05)	NS[a]	0.10	NS	NS
N, 100 lb/A	3.3	0.75	0.5	0.88
200 lb/A	3.9	0.83	0.8	1.04
	**	*	*	**
P 0 lb/A	3.6	0.78	0.6	0.96
30 lb/A	3.7	0.80	0.7	0.96
	NS	NS	NS	NS

[a]**, *, NS: significant at 1% and 5% levels, and non-significant, respectively.

Table 16. Main effects of lime, N, and P on cauliflower leaf elemental concentrations, 1984

Treatment	N	P	K	Ca	Mg	Zn	Mn	Cu
	%					ppm		
No lime	5.15	0.57	5.0	1.61	0.23	46	46	5.1
Lime, 4 T/A	5.15	0.58	5.0	1.90	0.22	41	31	5.8
	NS[a]	NS	NS	*	NS	*	**	NS
-P	5.13	0.57	5.0	1.71	0.22	44	40	5.6
+P	5.18	0.58	5.1	1.80	0.23	43	37	5.3
	NS	NS	NS	NS	NS	NS	NS	NS
N, 100 lb/A	5.05	0.58	5.1	1.69	0.22	44	38	5.4
N, 200 lb/A	5.25	0.57	4.9	1.81	0.23	43	39	5.5
	NS	NS	NS	NS	NS	NS	NS	NS

[a]NS, *, **: no significant differences, and significant at 5% and 1% levels, respectively.

Table 17. Interaction of lime, P, and N rate on yield of 'Inca' cauliflower, 1984

Treatment Lime(T/A)	N(lb/A)	Total yield (tons/acre)	Yield of #1 heads (tons/acre)	Mean wt. of #1 heads (pounds)
0	100	3.3	0.8	0.90
	200	3.5	0.6	0.88
2	100	3.6	0.5	0.85
	200	3.6	1.2	1.09
4	100	3.3	0.5	0.82
	200	3.6	0.8	1.06
6	100	3.0	0.4	0.94
	200	4.9	0.7	1.15
	LSD(0.05)	0.4	0.3	0.11

Treatment Lime(T/A)	P(lb/A)	Mean wt. of #1 heads (pounds)
0	0	0.83
	30	0.95
2	0	1.01
	30	0.93
4	0	0.88
	30	1.00
6	0	1.14
	30	0.95
		0.07

Treatment N(lb/A)	P(lb/A)	Mean wt. of #1 heads (pounds)
100	0	0.89
100	30	0.86
200	0	1.03
200	30	1.06
	LSD(0.05)	0.03

Table 18. Effect of form of spring-applied N on yield of 'Inca' cauliflower, 1984

N source	Early yield (tons/acre)	Total yield (tons/acre)	No. of heads harvested/plot	Mean head wt. (pounds)	Mean wt. of No. 1 heads (pounds)
Ammonium nitrate	0.1	2.9	23.5	0.80	0.88
Ammonium sulfate	0.1	3.3	24.0	0.88	1.17
Calcium nitrate	0.1	3.1	24.5	0.84	1.19
Urea	0.2	4.4	35.0	0.81	1.00
LSD(0.05)	NS[a]	0.6	4.9	NS	NS

[a]NS: no significant differences.

1985

Lime tended to increase total yield slightly at the first harvest but had no effect on head quality (Table 19). Gypsum had no effect on head weight or quality but fewer heads were harvested on gypsum-treated plots. This appeared to be from chance, a non-random decrease in number of plants present on gypsum-treated plots. Banded P at planting also tended to reduce the number of heads harvested/plot, with no effect on head weights when averaged over lime and gypsum treatments. There were no significant interactions affecting the first harvest.

Neither lime, gypsum, nor banded P affected yield or quality for the sum of two harvests (Table 20), when averaged over the other treatments. However, lime and banded P significantly interacted in their effects on total weight harvested for the two harvests. Banded P tended to increase yield at low soil pH but not at high soil pH (Table 21).

Treatments had no effect on leaf tissue concentrations of N, P, Ca, Mg, Zn, and Cu (data not shown). Gypsum increased leaf K level from 2.86% to 3.13%, and S level from 1.07% to 1.16%, when averaged over all treatments. In contrast to previous effects of lime application on leaf Mn levels, leaf Mn was increased from the range of 35 to 37 ppm for the lower rates of lime, to 49 ppm at the highest rate. However, only one replicate showed high leaf Mn levels at the high rate of lime.

Three years of experiments on the effects of lime and P on overwinter cauliflower yield and quality indicate that the effect of lime is small but significant when averaged over the three years. Neither a subsurface-banded application of P at planting nor a sidedressed spring P application appreciably affected yield on this soil of high P content. A single year's work indicates no response to a spring application of gypsum.

Table 19. Main effects of lime, banded P, and gypsum on yield of overwintered cauliflower at the first harvest, 1985

	Yield		Mean head weight		Heads/plot		% #1
Treatment	#1 heads	all heads	#1 heads	all heads	# 1	Total	heads
	---- tons/acre ----		------pounds-------				
Lime (T/A)							
0	1.1	3.6	1.25	1.34	2.9	8.9	33
2	1.1	3.6	1.22	1.32	2.9	9.5	29
4	1.5	4.2	1.40	1.33	3.5	10.5	34
6	1.3	3.8	1.24	1.33	3.1	9.5	33
LSD(0.05)	NS[a]	0.5	NS	NS	NS	NS	NS
+ Gypsum	1.1	3.6	1.27	1.30	2.8	9.1	31
- Gypsum	1.3	4.1	1.29	1.35	3.3	10.1	33
	NS	NS	NS	NS	NS	*	NS
+ P	1.2	3.8	1.24	1.34	3.1	9.1	34
- P	1.2	3.9	1.31	1.31	3.1	10.1	30
	NS	NS	NS	NS	NS	*	NS

[a]NS; *: no significant differences; significant differences among means at 5% level.

Table 20. Main effects of lime, banded P, and gypsum on yield of overwintered cauliflower, total of two harvests, 1985

Treatment	Yield		Mean head weight		Heads/plot		% #1 heads
	#1 heads	all heads	#1 heads	all heads	# 1	Total	
	---- tons/acre ----		------pounds-------				
Lime (T/A)							
0	1.5	4.9	1.28	1.31	3.6	12.5	29
2	1.2	5.0	1.17	1.25	3.3	13.4	25
4	1.6	5.1	1.43	1.30	3.7	13.1	28
6	1.4	4.8	1.26	1.19	3.5	13.4	26
	NS[a]	NS	NS	NS	NS	NS	NS
+ Gypsum	1.4	4.8	1.30	1.26	3.4	12.8	27
- Gypsum	1.4	5.1	1.26	1.27	3.6	13.4	28
	NS	NS	NS	NS	NS	NS	NS
+ P	1.5	4.9	1.31	1.27	3.7	13.1	30
- P	1.3	4.9	1.26	1.25	3.3	13.2	26
	NS	NS	NS	NS	NS	NS	NS

[a]No significant differences.

Table 21. Interaction of lime and banded P on total yield of overwinter cauliflower, 1985

Lime Rate (tons/acre)	P rate (pounds/acre)	
	0	90
	---- tons/acre ----	
0	4.6	5.3
2	4.9	5.0
4	5.4	4.7
6	4.8	4.8

LSD(0.05) = 0.5

In the 1985 N source experiment, yield of grade #1 heads at the first harvest (Table 22) and for the season (Table 23) was higher with the strictly ammonium-N sources than with the strictly nitrate source, calcium nitrate. The mean weight of #1 heads was increased by ammonium-N at the first harvest but not for the sum of two harvests. Mean weight of all heads was not affected by N source.

For the sum of both harvests (Table 23), highest total yield but the lowest percentage of grade #1 heads was obtained with calcium nitrate. More foliar growth on ammonium N-fertilized plants may have provided more cover for the curd and improved curd color and quality.

Source of N had no effect on leaf tissue concentrations of N, P, K, Ca, Mg, S, Zn, and Mn (data not shown). Leaf Cu level was significantly higher with urea as N source (11.9 ppm) than with the other N sources (6.9-7.1 ppm).

While indicating a significant advantage to providing an ammonium-N source, these results do not agree entirely with results obtained in 1983 and 1984. Larger scale experiments will be needed to determine if there are significant advantages to use of a certain N source or if choice of N source should be determined only by price.

Table 22. Effect of N source on yield of overwinter cauliflower at first harvest, 1985

N source	No. of heads harvested/plot	Yield of #1 heads	Yield of all heads	Mean wt. #1 heads	Mean wt. all heads	% #1 heads
		---- tons/acre ----		----- pounds ------		
Amm. nit.	8.8	1.3	3.3	1.38	1.27	37
Amm. sul.	10.3	2.2	4.4	1.31	1.42	54
Cal. nit.	9.5	0.7	4.4	1.01	1.49	24
Urea	10.0	2.5	4.2	1.50	1.37	53
LSD(0.05)	NS[a]	1.3	NS	0.35	NS	18

[a]NS: no significant differences.

Table 23. Effect of N source on yield of overwinter cauliflower, total of two harvests, 1985

N source	No. of heads harvested/plot	Yield of #1 heads	Yield of all heads	Mean wt. #1 heads	Mean wt. all heads	% #1 heads
		---- tons/acre ----		------pounds ------		
Amm. nit.	14.8	2.0	5.5	1.50	1.23	31
Amm. nit.	13.5	2.3	5.1	1.28	1.33	44
Cal. nit.	17.0	1.2	7.3	1.46	1.42	16
Urea	13.5	2.5	5.5	1.50	1.31	39
LSD(0.05)	NS[a]	0.9	1.0	NS	NS	11

[a]NS: no significant differences.

Summary of Cauliflower Trials and Recommendations

1. Varieties. Winter cauliflower varieties require a cold period to induce head formation. The heads, or curd, of overwintering cauliflower are composed of true flower buds and are usually of lower density than for Snowball types in which the curd is floral primordia tissue. Stems often tend to be slightly green and flavor tends to be mild. Because of the low density and tendency to break up when the stem is removed, these varieties are considered more promising for fresh market than for processing.

Four variety trials were conducted over five years. Very early varieties which mature in March are not acceptable for commercial production in the Willamette Valley. They must be planted early to achieve acceptable head size. Early planting increases the risk of curd formation during winter warm spells, increasing the probability of winter damage, and reduces the time available for growing another crop in the season before planting the cauliflower. Early curd formation greatly increases the risk of crop loss since the curd cannot stand severe or extended freezing temperatures. The earliest variety which has consistently proven adapted to the Valley is Armado April, although Armado Quick and Preminda have produced well in mild winters.

Varieties which mature in late May or June have also not done well in these trials. The curd is often discolored and loose, and curd texture of the latest varieties often becomes fuzzy or ricey. Tieing heads might prevent discoloration, but even well-protected heads have had poor curd quality. Insect problems also increase with the warmer weather.

The best varieties have been those which mature in early April to mid-May in most years. A range of three or four varieties should cover this period. A list of recommended varieties is found in Table 24.

Table 24. Recommended overwinter cauliflower varieties for the Willamette Valley.

Variety	Maturity	Yield potential	Comments
Armado April	1 April	medium	good color, best early variety
Inca	7 April	medium	white curd, domed head, may need tieing
Marchpast	7 April	medium	high quality
Aprilex	20 April	med. high	good curd quality
Armado May	20 April	med. high	tends to have leaves in head
Markanta	20 April	medium	variable, excellent in some trials
Arminda	1 May	high	color good if tied
Armado Tardo	5 May	medium	may discolor in warm weather
Armado Clio	10 May	med. high	may discolor in warm weather
Maya	10 May	high	best late variety

2. Planting window. Except for the very early varieties, planting date has little effect on maturity. The latest practical direct-seeding and transplanting dates are August 10 and September 10, respectively. The recommended earliest dates are July 20 for direct-seeding and August 20 for transplanting. Both very early and very late plantings are more susceptible to winter injury. For late maturing varieties which do not form a curd until the danger

of hard freezes has passed, seeding in early July or transplanting in early August is feasible. In the mild winter climates of England and Holland, seeding is often in June. With the warmer summers of the Willamette Valley, such early seedings are unnecessary as adequate growth can occur before the onset of cold weather. Such early plantings eliminate double cropping in the year the crop is planted and increase risk of freeze damage to the cauliflower.

3. Planting site. The soil type must be a well-drained sandy or silt loam without low spots which collect standing water in the winter. The site should be sheltered from the cold, desiccating winds which occasionally invade the Valley from the north and east. Frost pockets should be avoided; good air drainage is essential. Winterkill temperatures are from 0° to 15°F, depending on duration of the low temperature, soil moisture, wind velocity, relative humidity, variety, and stage of growth. Some loss of yield and quality can be expected when the temperature reaches the low teens.

4. Fertilization. Soil pH should be adjusted to at least 6.0 with a mixture of calcitic and dolomitic limes. The initial fertilizer application should include 60 to 80 pounds N/acre unless the cauliflower follows a heavily fertilized crop with residual soil nitrogen. Chicken manure is often used at a rate of 10 tons/acre for the initial N application. Phosphorus and potassium should be applied in accordance with soil test. Ranges for application of these nutrients are given in Table 25. Cauliflower has a high sulfur requirement and Willamette Valley soils are often S deficient. Sulfur should be applied before planting. A second application may be desirable after a very wet winter.

   The bulk of the N application should be made in late winter and spring, 150 to 200 pounds N/acre, split between two or three applications. Nitrogen source trials indicated a possible advantage to applying N in the NH_4 form; however, acid-forming fertilizers such as ammonium sulfate and ammonium nitrate should not be used if soil pH is below 6.0.

   Magnesium, calcium, boron, molybdenum, copper, and zinc are other elements likely to be limiting for cauliflower production. Magnesium is routinely applied to spring-seeded cauliflower as dolomite or Epsom salts and the same requirement exists for the overwinter crop. Rates of up to 20 pounds Mg/acre should be based on soil test. Calcium is not likely to be deficient on properly limed soils. Boron is usually deficient in Willamette Valley soils. Up to 5 pounds B/acre may be applied before planting or as a spring foliar spray, based on soil test. Molybdenum deficiency is common in cauliflower and may be prevented by application of 1 pound Mo/acre as ammonium or sodium molybdate, usually incorporated with the pre-plant fertilizer. The seed may also be treated by dissolving 0.5 ounces sodium molybdate in 1 ounce of water and mixing with enough seed to plant 1 acre. Copper and Zn should be applied only if a soil test indicates a deficiency.

Table 25. Overwintered cauliflower fertilizer requirements (pounds/acre)

	N	P_2O_5	K_2O	S	Mg	Mo	B
At planting:	0-80	70-150	30-150	30	0-20	0-1	2-4
In spring	150-200	0	0	0-30	0	0	0

Rates of K_2O, Mg, Mo, and B should be based on soil test.

5. Cultural practices. Seedbed or transplant bed preparation is the same for the summer crop and fall crop. If direct-seeding, 5-6 ounces of seed/acre are necessary to achieve a seedling density of about 3/foot. After thinning, plant spacing should be 18 inches in the row and 36 or 40 inches between rows. Seed should be planted 1/2 to 3/4-inch deep with a precision seeder. Transplanting offers several advantages, including more possibilities for the crop preceding the cauliflower, avoidance of seedling stand establishment problems, and less insect and weed problems. Cultivation, after thinning to control weeds and loosen the soil, is a good practice. Both direct-seeded and transplanted crops require irrigation until the start of the fall rains.

6. Pest control. The major pest problems include cabbage maggot, slugs, head maggots, cruciferous weeds (mustard family), and grasses. Chlorpyrifos and fonofos have provided acceptable control of cabbage maggot and symphilids and many slug baits are available. Local Cooperative Extension offices or licensed pesticide consultants should be contacted for current pesticide registrations. The weed control program includes an incorporated application of trifluralin before planting, followed by cultivation, and an application of napropamide after thinning. Consult the herbicide labels for appropriate rates. Good weed control is essential. Diseases commonly encountered include mildew, blackleg, black rot, and root rot. Control methods are the same for the summer crop and fall crop.

7. Rotations. Overwintered cauliflower can follow any crop which matures sufficiently early and which does not result in residues of herbicides or other pesticides not registered for cauliflower. Ideal candidates include peas, early beans, overwintered onions, leafy greens, early root crops, and winter wheat. Overwintered cauliflower should not follow a badly shattered grain crop, as thick stands of volunteer grain will seriously compete with the crop. Fields should not be in cole crops in successive years and those infested with cruciferous weeds or clubroot must be avoided.

   Most row crops can easily follow overwintered cauliflower because of the early harvest season and lack of herbicide residue problems. The cauliflower should not be followed with another cole crop. Fertilizer needs may be reduced as residual N should be available to the following crop.

8. Risks and rewards. The greatest risk is the possibility of losing the crop to a severe freeze. The recommended varieties have all

survived temperatures as low as 10°F, but head size and quality can be reduced at this temperature. Marketable crops should be produced in 4 of 5 years.

Markets are hard to predict. During April and May the major competition is from central and southern California growing areas that are able to produce quality fall-type varieties in the spring.

Fertilizer requirements are also higher for overwintered cauliflower than for spring-planted cauliflower since N and other elements leached by winter rainfall must be replaced in the spring. However, application of most of the N can be delayed until the extent of winterkill has been determined.

Among the advantages to the crop are reduced costs for irrigation, the lack of insect pests such as moth larvae and loopers, a cash flow during a period when crops are not usually harvested, and the potential for three crops in two years. Marketable yields of 500 cartons or 4,500 heads/acre are not uncommon.

Brussels Sprouts Variety Trials, 1980-81 and 1981-82

The objective of these trials was to evaluate several lines of Brussels sprouts for suitability for overwintered production. In 1980, the lines were seeded on April 23, transplanted on May 29, and harvested on March 13, 1981. In both 1980 and 1981, the same lines were seeded on July 25 and transplanted in early September. These late plantings did not produce marketable sprouts. All varieties went to seed in late winter and were not harvested. Cultural methods were similar to those described above for cauliflower.

Disease pressure and the tendency to blast (bolt) were greater in the April seeding than in earlier Brussels sprouts trials conducted in 1980. The variety Rasmunda stood out in resistance to both disease and bolting, but sprout size was small.

It is apparent that if Brussels sprouts are planted at the same time as overwintered cauliflower, the plants will bolt before producing marketable sprouts. When planted in spring, sprouts have formed by early autumn. These sprouts can be overwintered successfully for February-March harvest. The high incidence of mildew will reduce marketable yield and hand-trimming of sprouts will be necessary.

Table 26. Ratings[a] of Brussels sprouts quality characteristics, 1980

Variety	Mildew	Internal browning	Smoothness	Solidity	Color	Sprout spacing	Shape	Sprout-stem angle
Belfort	7	4	6	7	8	3	7	6
Fortress	2	4	4	4	4	3	7	7
Glentora	3	4	6	6	5	4	7	8
Ladora	3	4	7	7	3	6	7	5
Late Lime	4	5	4	4	4	4	6	5
Rasmunda	8	8	6	6	5	8	6	7
Roodnerf Gravendeel	4	5	7	6	5	7	6	5
Roodnerf Late Supreme	4	3	4	4	5	5	5	7
Sigmund	3	4	7	7	7	4	4	4
Ulysses	5	3	5	6	7	4	6	7
Zid (Fasolt)	4	6	6	6	4	6	7	5

[a]Explanation of ratings: mildew and internal browning, 10 = none; smoothness and solidity, 10 = smoothest or most solid; color: 1 = yellow, 10 = dark green; spacing, 1 = tight, 10 = wide; shape, 1 = round, 10 = elongated; angle, 1 = acute, 10 = right.

Table 27. Rating[a] of Brussels sprouts plant characteristics and sprout sizes

Variety	Deleafing ease	Picking ease	Uniformity among plants	% sprouts in category		
				less than 1"	1-1.5"	blasted[b]
Belfort	-	7	5	65	2	33
Fortress	-	4	6	50	1	49
Glentora	-	5	5	63	3	34
Ladora	7	8	7	33	0	67
Late Lime	4	6	6	20	0	80
Rasmunda	4	9	8	65	20	15
Roodnerf Gravendeel	-	7	3	50	0	50
Roodnerf Late Supreme	-	5	3	60	15	25
Sigmund	4	8	7	59	10	31
Ulysses	4	6	5	54	5	41
Zid (Fasolt)	6	-	4	48	2	50

[a]Explanation of ratings: defleafing and picking ease, 10 = easiest; uniformity, 10 = most uniform.

[b]blasted: sprout broken up, loose, bolting to flower.

Table 28. Sources and comments on Brussels sprouts varieties

Variety	Source[a]	Comments
Belfort	3	Fairly uniform, short plants. Fair sprout quality; little mildew. Low yield potential.
Fortress	5	Uniform type, short plants. Poor sprout quality.
Glentora	3	Fairly uniform type, short plants. Fair sprout quality. Low yield potential.
Ladora	2	Fairly uniform type, pale green leaves. Much mildew; blasts easily.
Late Line	1	Fairly uniform type; fair sprout quality but blasts easily.
Rasmunda	3	Uniform type; good sprout quality but low yield potential.
Roodnerf Gravendeel	3	Variable type; all quality characteristics non-uniform.
Roodnerf Late Supreme	4	Highly variable plant size and sprout characteristics. Many purple sprouts.
Sigmund	3	Fairly uniform type; fair sprout quality, outer leaves purplish.
Ulysses	1	Fairly uniform type; small plants. Fair yield potential.
Zid (Fasolt)	3	Fairly uniform type; fair sprout quality. Blasts easily.

[a] 1 = Asmer Seeds, 2 = Bejo Zaden, 3 = Elsoms, 4 = Territorial Seed, 5 = Zenner Bros.

Overwintered Cabbage

Overwintering varieties of cabbage are available, particularly from European seed companies. Variety trials were conducted in 1980 and 1981, with planting dates the same as for the cauliflower, but quality was low and disease incidence high. The hardiest varieties had pointed or conical heads which are not desired in the local markets.

Overwintered Spinach Variety Trial 1981-82

In northern states, spinach is normally planted in early spring for late spring harvest or in late summer for autumn harvest. Spring plantings are often limited by the difficulty of working cold, wet soils and many varieties bolt in the long daylengths and increasing temperatures of late spring. Autumn crops must be established during periods of very high soil temperature and low soil moisture and require frequent irrigation.

Some Willamette Valley growers have successfully planted spinach in autumn for early spring harvest. Ideally, stands can be established during periods of relatively favorable soil temperature and moisture and plants harvested before long days induce bolting. This trial was undertaken to evaluate several spinach cultivars or lines for overwinter use and to obtain better knowledge of the cultural problems involved in maintaining the crop over a six- to seven-month period.

Twenty-four varieties or lines of spinach were seeded on 40-inch (furrow to furrow) raised beds of pH 6.0, on October 3, 1981. The plot area had received a broadcast, incorporated application of 750 pounds/acre of 10-20-10 and 4 pounds/acre of cycloate on October 2, before final bed shaping. Four replications of each variety were planted in randomized complete block design. Two rows were planted on each bed with a custom-built belt planter. Plot size was 20 row feet. Chlorpropham at 1.0 pound/acre was applied October 5. Fluid lime at approximately 1,000 pounds/acre $CaCO_3$ was applied on January 18, 1982. Sidedress applications of calcium nitrate at 50 pounds N/acre were made on January 25, March 11, and April 2, 1982. Quality characteristics of all varieties were rated on April 16, 1982, and all plots were harvested on April 28.

For the 22 varieties included in both the overwinter and an earlier autumn-harvest trial, 16 yielded more as an overwinter crop than as a fall crop, although harvest was at similar maturity. Some of this yield increase may have been because of better stands. However, overall yields and plant vigor were somewhat disappointing relative to yields obtained in some growing areas. Marginal soil pH probably contributed to low yields and marginal quality of some varieties. In particular, the varieties Big Leaf and Hybrid 424 have performed better at higher soil pH.

In addition to yield and plant height, several quality characteristics were evaluated on a five point scale (Table 29). Desirable characteristics include deep green color, upright growth habit, plant and leaf uniformity, large leaves, and lack of bolting.

The most outstanding variety in terms of yield, earliness, and upright character was XPH 1285 from Asgrow. However, color was not very dark and the variety tended to bolt early. Other promising varieties included 7R, Chinook, Emerald Queen (except for mediocre color), FM 18DX7 (except for color), Hybrid 424, and Symphony. Varieties exhibiting significant bolting at time of harvest included XPH 1285, 7R, Chinook, FM18DX44, FM18DX62, and Jake. Varieties performing well in both autumn and overwinter trials were XPH 1285, Hybrid 424, and 7R.

The cycloate-chlorpropham herbicide combination provided good weed control. One spring cultivation was needed. Insect problems were minimal. Disease problems were moderate, with downy mildew the major problem. No fungicides or insecticides were used.

Despite the intensive management which may be needed, overwinter spinach production on well-drained soils may be a feasible alternative to spring plantings. Major advantages are better planting conditions, earlier harvest, and reduced bolting. Disadvantages include the necessity to keep the field weed free and fertilized during periods when field operations are difficult. Harvest would likely occur under muddy conditions. Overwintered spinach suffers from most of the same nutritional and disease problems as the spring and fall crops and has greater problems in foliar diseases and weed control.

Table 29. Yield, plant height at harvest, and quality characteristics of overwintered spinach, 1981-82

Variety	Yield (tons/acre)	Height (inches)	Color[a]	Vigor[b]	Uniformity[b] Leaf	Uniformity[b] Plant	Leaf Size[b]	Growth Habit[c]
7R	8.8	6.7	4.0	4.0	3.8	3.5	4.0	4.0
ACX59	5.7	4.3	2.8	2.8	3.5	2.8	2.8	2.5
ACX61	3.3	4.7	3.3	2.8	3.8	2.8	3.8	3.0
Avon	5.5	5.0	4.0	2.5	3.5	2.3	3.0	2.8
Baker	5.3	4.7	3.8	3.0	3.3	3.0	3.3	2.5
Big Leaf	6.0	4.8	3.0	2.5	3.0	2.5	2.5	2.8
Chinook	7.5	6.7	3.0	3.8	4.0	3.0	3.8	3.5
Dynamo	4.2	4.5	1.3	2.8	3.3	3.0	3.5	2.3
Early Hybrid 7	6.4	4.7	3.5	2.5	3.5	2.5	2.5	3.3
Early Hybrid 424	6.5	6.7	2.8	3.5	3.5	3.8	3.3	4.0
Emerald Queen	8.4	6.5	2.8	3.3	3.8	3.5	3.3	3.3
FM 18DX7	8.1	7.3	2.8	3.8	3.8	3.0	3.8	3.0
FM 18DX44	6.9	6.9	2.0	3.5	3.8	2.8	3.3	3.8
FM 18DX56	4.9	4.7	3.0	2.8	2.8	2.8	3.0	2.8
FM 18DX59	6.5	5.5	3.3	3.0	3.8	3.0	3.3	3.3
FM 18DX61	6.1	4.5	3.8	2.3	2.8	2.3	2.3	2.3
FM 18DX62	5.8	5.5	2.8	3.3	3.3	2.5	3.3	3.3
High Pack	5.8	5.8	2.8	2.5	3.8	3.8	3.3	3.3
Jake	7.2	5.5	3.5	2.8	3.8	3.0	2.5	4.0
R 2578	5.0	5.3	2.8	2.8	3.0	2.0	2.8	3.3
St. Helens	4.3	5.5	3.5	2.5	4.0	2.8	3.0	3.5
Symphony	6.3	5.5	4.0	3.0	4.3	3.5	2.8	3.8
XPH 1285	16.9	12.5	3.5	5.0[d]	5.0	5.0	4.0	5.0
XP 3057	6.0	5.3	3.0	3.3	3.5	2.3	3.5	3.0
LSD (0.05)	1.4	4.0	1.1	1.3	0.8	1.0	0.9	1.1

[a] 1 = pale, yellow green; 5 = dark green.
[b] 1 = least vigorous, uniform etc., 5 = most vigorous, uniform, etc.
[c] 1 = prostrate, 5 = upright.
[d] bolting

Table 30. Source, leaf type, comments on overwintered spinach varieties, 1981-82

Variety	Source[a]	Leaf type	Comments
7R	1	semi-savoy	Variable color, good texture. Seed stalks just forming.
ACX59	1	smooth	Average variety.
ACX61	1	smooth	Poor stand; good size, uniform leaves.
Avon	1	semi-savoy	Variable color but usually good.
Baker	1	smooth	Poor yield but better than average quality.
Big Leaf	?	slight savoy	Small leaves, not impressive.
Chinook	1	semi-savoy	Highly variable color, seed stalks forming.
Dynamo	4	slight savoy	Poor color may be nutritional problem; poor yield.
Early Hybrid 7	1	savoy	Average variety.
Early Hybrid 424	1	smooth	Looks good except for mediocre color.
Emerald Queen	4	smooth	Variable color, otherwise above average.
FM 18DX7	3	slight savoy	Poor color, otherwise slightly better than average.
FM 18DX44	3	semi-savoy	Seed stalk formation just starting.
FM 18DX56	3	semi-savoy	Average variety.
FM 18DX59	3	smooth	Fair yield, above average quality.
FM 18DX61	3	semi-savoy	Fairly good color, otherwise poor.
FM 18DX62	3	semi-savoy	Just starting to bolt. Average.
High Pack	2	slight savoy	Broad, triangular leaf. Poor color, vigor.
Jake	1	slight savoy	Seed stalks forming, better than average color.
R 2578	4	semi-savoy	Variable leaf type and shape. Fair.
St. Helens	1	smooth	Low yield, vigor; average or better otherwise.
Symphony	4	slight savoy	Small leaves, otherwise above average.
XPH 1285	2	very smooth	Rank, soft growth; starting to bolt, bland flavor.
XP 3057	2	slight savoy	Average variety.

[a]1 = Alf Christianson, 2 = Asgrow, 3 = Ferry Morse, 4 = Rogers Bros.

Conclusion

Overwintered crops offer an opportunity for expanded production without increased acreage and can generate income when no other crops are being harvested. At the North Willamette Experiment Station research continues on overwintered production of onions and other alliums, and floating row covers will be evaluated for protection of overwintered cauliflower and spinach.