PROJECT REPORT TO THE OREGON PROCESSED VEGETABLE COMMISSION

TITLE: Effect of Nitrogen Rate, Timing, Placement, and Catch Crops on Yield and Nitrogen Utilization in Vegetable Crops.

PROJECT LEADERS: Delbert D. Hemphill, North Willamette R&E Center
John Hart, Dept. of Crop and Soil Science, OSU

PROJECT STATUS: Continuing, expect completion of broccoli subproject in 1992.

FUNDING: $5645 in 1991-92 from OPVC. Other funding from CAAR and OSU. Funds expended for fertilizer, ^{15}N-urea, pesticides, soil and tissue analysis, labor for plot establishement, maintenance, and harvest.

OBJECTIVES:

1. To evaluate the effect of several rates of applied N, as affected by timing and method of placement, on the yield of broccoli.
2. To determine the time of maximum broccoli uptake of applied N.
3. To determine how much of the applied N remains in the soil as nitrate at harvest and following winter rainfall.
4. To evaluate the efficiency of a winter cover/catch crop in capturing residual nitrate N.

PROGRESS REPORT:

Nitrogen Rates and Placement (Seeded Planting)

'Gem' broccoli was direct-seeded into fallowed ground on June 12. This planting compared several rates and methods of application of urea (Table 1). Spacing between rows alternated between 12 and 28 inches. The seedlings were thinned to about 10 inches between plants. Following harvest, the plots were split, with half of each plot containing cereal rye seeded into the standing broccoli stalks.

When all 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 application was shanked-in rather than broadcast. However, the trends in yield response to increasing rate of nitrogen were similar to that 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 with the same rate of N with a single sidedressing.

Method of N placement did not significantly affect yield. 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 two inches to the side and beneath the seed line did not increase 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 with all-broadcast N at 100 pounds (141 g) or the shanked-broadcast combination at 100 pounds (136 g).

Irrigation in this trial was controlled to prevent movement of nitrate out of the root zone. A total of 10 inches of irrigation 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 two foot depth. A comparison of pre-plant and post-harvest soil samples taken to 40-inch depth indicated no movement of nitrate-N or ammonium N below 20 inches depth during the growing season. Only at the highest rate of applied N was there any evidence of 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 1991 ^{15}N uptake studies are not available yet. Results from the 1990 uptake studies indicate that about two-thirds of N taken up by broccoli fertilized at the optimal 250 lb/A N rate comes from applied fertilizer. Total N uptake was 310 lb/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.

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

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 ^{15}N
13	250	50 broadcast ^{15}N	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, 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, 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, 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 before planting and after broccoli harvest, 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

Cover Crop N Recovery

Broccoli was also grown in the NWREC long-term crop rotation study in 1991. These plots had been in sweet corn or red clover in the summer of 1990 and in cereal rye or cereal rye plus Austrian pea cover crops, or in a red clover seed crop, or fallowed, during the winter of 1990-91. Nitrogen added to the sweet corn crop in the summer of 1990 significantly affected the growth of the cover crops. Both the cover crop biomass (Figure 1) 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 per acre applied N. This difference of about 80 pounds per acre suggests that, without a cover crop, 80 pounds per 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 per acre, but there was a synergistic effect on the companion rye crop, which accumulated additional N in the presence of the legume. Pea 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 per acre. Thus, legumes in a cover crop mix to fix N may be effective only following low rates of N on the preceding crop.

Broccoli Response to the Preceding Cover Crop or Seed Crop (Transplants)

'Gem' was transplanted into the rotation plots on June 4. The plots which had been in a winter cover crop were split by a herbicide variable, with half the plots receiving no herbicide and the other half receiving Treflan at planting. Three rates of urea were applied to the fallow and cover-crop plots and two rates to the clover plots. Plant spacing was 12 inches in the row with paired rows on 20-inch centers and a 40-inch wheel track. After harvest, the rotation plots were seeded back into the same cover crops which had been seeded in 1989 and 1990.

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 6). 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 6). 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 which had been in red clover, yields were generally higher than for the fallowed plots or the cover crop plots (Table 7). Plots receiving urea 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 nitrogen, than for broccoli following fallow or winter cover crops. The greatest yield in this experiment (4.6 tons/acre) was with the combination of spring-plowed cover and 200 pounds N/acre (interaction data not shown).

The disorder hollow stem is, at least in part, related to high rates of nitrogen 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 6. 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 7. 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.

SUMMARY:

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 fertilizer application did not significantly affect yield. Thus, it appears that at high plant populations and small between-row spacings, broadcast applications are as effective as any other means of application.

With the surprisingly high N uptake efficiency observed in these trials and the ability of a winter cover crop to catch most of the un-utilized N, it appears that a combination of avoiding excessive N application, careful irrigation management to keep N in the root zone, and catch-cropping to trap excess nitrate in organic manner, is promising as a means of avoiding leaching of nitrogen fertilizers from broccoli fields.

Objective 1 has been completed for broccoli except for obtaining more information on the effect of timing of N application on uptake efficiency. It would be very valuable to have more information on the comparative efficiency of N utilization by broccoli at a wide range of rates of applied N. This could be measured more precisely using ^{15}N-enriched fertilizer at all rates of applied N. Objective 2 should be satisfied when the results of measurements of total plant N uptake at various growth stages is completed. These samples are now being analyzed. Objective 3 will be completed at the end of the winter-spring rainy season. Objective 4 has been met, in part, as the 1990 and 1991 experiments have generated considerable information on the amount of N recovered by catch crops as a function of the rate of N applied to the previous crop. However, more work is needed to determine what factors affect crop response to the N contained in catch crops. We should introduce broccoli into the rotation plots again in the near future.

SIGNATURES:

Project Leader Redacted for Privacy

Project Leader Redacted for Privacy

Department Head Redacted for Privacy

Department Head Redacted for Privacy

Fig. 1. Cover Crop Biomass
NWREC, 1991

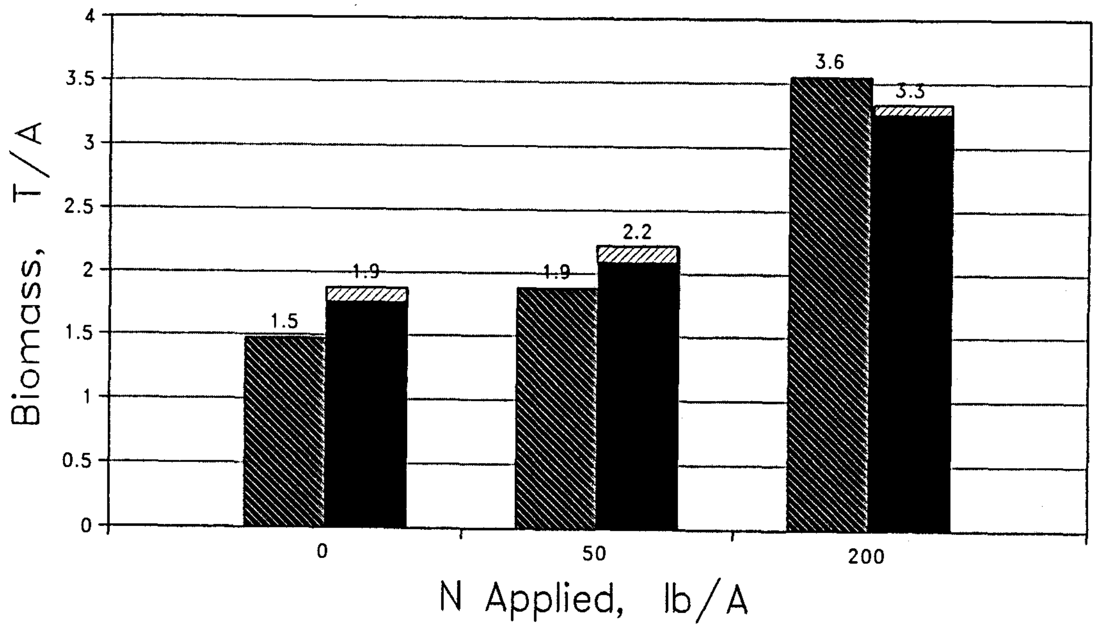
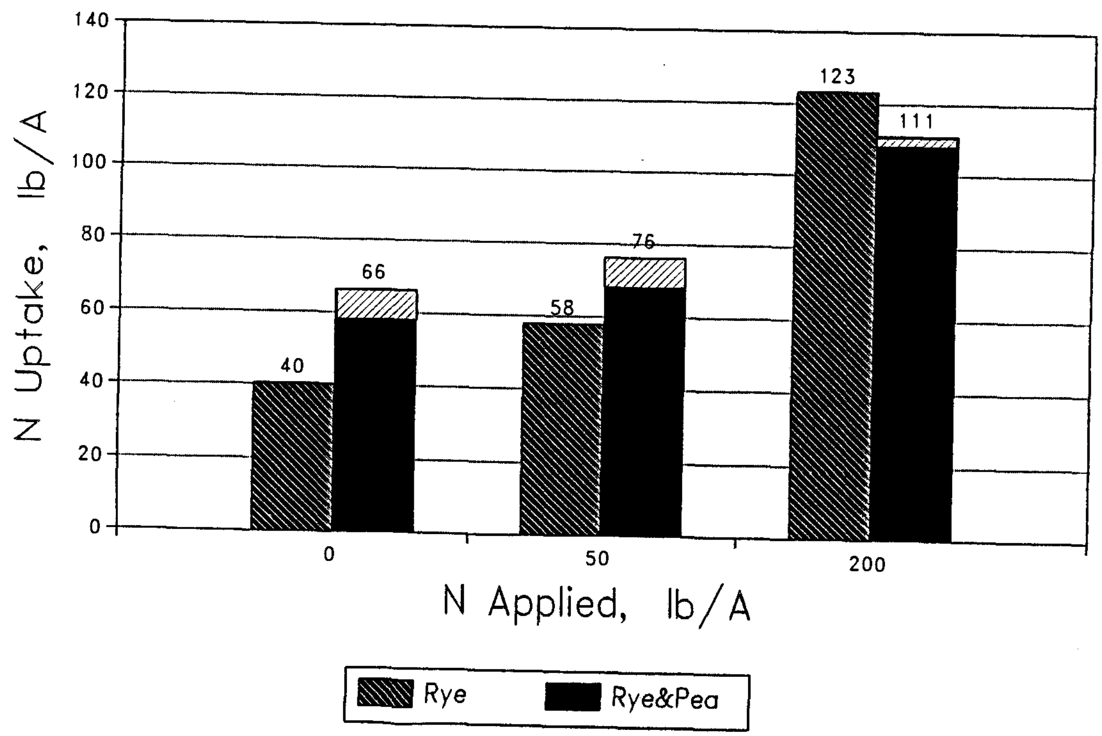


Fig. 2. Cover Crop N Uptake
NWREC, 1991



Note: The diagonally cross-hatched area at the top of the Rye&Pea bars represents the contribution of the Austrian pea to the biomass (or uptake) of the cereal rye-Austrian pea mixture.