Cover Crop Nitrogen for Summer Vegetable Crops

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Nitrogen (N) is an important nutrient for crop growth. Winter cover crops planted after a commercial crop is harvested, or relay planted before harvest, can provide N for subsequent crops, thus saving money and improving soil quality. Furthermore, cover crops can recover N remaining in the soil following summer crops, which otherwise could be leached into the groundwater.

Cover crops can provide N to subsequent crops in two ways: (1) nonlegume cover crops recover and recycle residual fertilizer N, and (2) legume cover crops fix atmospheric N for the later crops. This publication provides results and recommendations from a 5-year research project on the availability of cover crop N to subsequent summer vegetable crops.

Cover crops (also known as green manures) have been used for thousands of years, but as the use of inorganic fertilizer increased during the past 60 years, cover crop use declined. Over this period, crop yields increased steadily. However, soil erosion (Figure 1) still is a serious problem on sloping land, and groundwater nitrate concentrations are increasing in some regions. (See Oregon State University (OSU) Extension publication EM 8728 for details on how cover crops reduce nitrate leaching.)

Research in Oregon has shown that nonlegume and legume cover crops can take up from 45 to 70 and 50 to 140 lb N/acre, respectively. Legumes also have the potential to fix atmospheric N (Figure 2). Some of the N in the cover crop is available for the subsequent summer crop.

Figure 1.—Soil erosion on soils that have no vegetative cover during the winter in western Oregon.

Figure 2.—Legumes such as crimson clover have the potential to fix atmospheric nitrogen.

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Growers therefore can substitute some or all of the cover crop N for fertilizer N.

The N in cover crop residue is not directly available to plants; it first must be mineralized in the soil. Green manure residues can supply most or all of a crop's N needs if mineralization occurs when the crop requires the N.

Previous research in Oregon provided information on how much above-ground N can be produced with a wide range of cover crops (OSU Extension publication EM 8704). However, there is little information in Oregon about how much N from a winter cover crop can become available to a subsequent summer vegetable crop. This study was conducted to determine how much N a cover crop can capture after the vegetables are harvested and to determine how much of that N is available to the following vegetable crop. The goal of this research was to determine the effect of cover crops on sweet corn and broccoli yields and the amount of fertilizer N that could be replaced by cereal and legume cover crops.

Cover crop results

Winter cover crops in this study were Wheeler cereal rye, Wheeler cereal rye/Austrian winter pea mix, and Kenland red clover. Some plots were left fallow over the winter. Cover crops were planted in mid-September to early October of each year (see box on page 3). Wheeler cereal rye was drilled at a rate of 84 lb/acre. In the Wheeler cereal rye/Austrian winter pea mix, the Wheeler cereal rye rate was 45 lb/acre, and the Austrian winter pea rate was 125 lb/acre. Fall-seeded Kenland red clover was drilled at a rate of 23 lb/acre. Cover crops utilized N remaining in the soil from the previous summer crop, but received no other fertilizer. Rates of N applied to the summer crops were zero, intermediate, or recommended (see details on page 5 under "Summer vegetable crop results").

In the summer of 1992, the Kenland red clover treatment was changed to a relay cover crop system; i.e., the winter cover crop was established in the standing vegetable crop prior to harvest (Figure 3). The Kenland red clover was broadcast in the relay plots at a rate of 28 lb/acre. Fall-seeded Kenland red clover was harvested for seed in late July and then regrown as a winter cover crop.

Also in 1992, Wheeler cereal rye was relay-planted by broadcasting at the rate of 95 lb/acre into the plots that previously had been fall-planted Wheeler cereal rye. See OSU Extension publication EM 8704 for information on relay planting.

Factors affecting N uptake

A sample of each cover crop from each treatment was cut at ground level in the spring and weighed. Plant material was analyzed for total N content. In April of each year, cover crops were mowed and plowed into the soil. The seedbed was prepared for the summer crop by disking and rototilling.

The amount of N taken up was affected by the type of cover crop and the N application rate for the summer crop. Fall rains and wet, cold winter weather conditions also affected cover crop N recovery. Over the 5 years of this study, September and October rainfall varied from less than 1.5 inches to more than 8 inches. Cover crop growth was severely reduced following a dry fall, excessive rainfall, and/or a cold period (less than 32°F for several days).

Early and extensive growth in the fall is necessary to reliably recover fertilizer N and reduce the potential for nitrate leaching. If there is poor growth, cover crops are ineffective in capturing soil N for subsequent crops.

Figure 3.—Cover crops relay-planted between vegetable rows become established before the onset of cool late-fall weather.

Cover crop treatments and planting time line

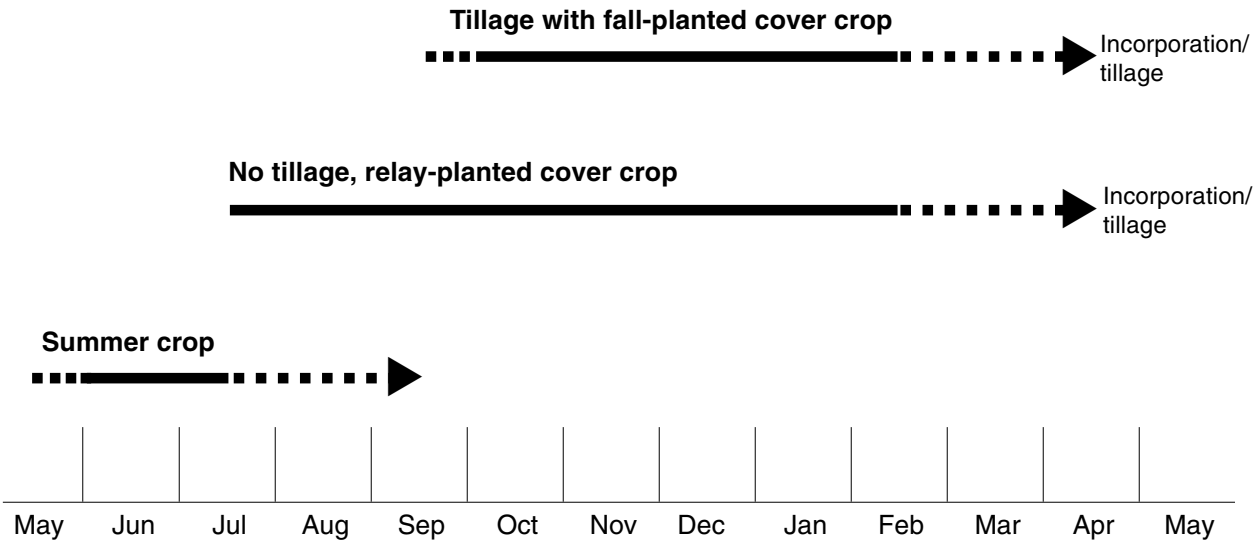
A field trial was begun in 1989 in the mid-Willamette Valley. There were five winter cover crop treatments (see table below) and three N fertilizer rates within each main plot.

Fall-planted cover crops were planted after the summer vegetable crop had been harvested. Relay cover crops were planted into the standing summer crop. Both fall and relay cover crops were incorporated in spring. See below.

Table 1.—Cover crop–vegetable rotations.

	Crop grown[a]									
	1989	1990		1991		1992		1993		1994
Cover crop treatment	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring	Fall	Spring
No winter cover	Fallow	Corn	Fallow	Broc	Wheat	Wheat	Fallow	Broc	Fallow	Corn
Red clover	Red clover	Red clover	Red clover	Broc	Red clover	Corn	Relay red clover	Broc	Relay red clover	Corn
Cereal	Rye	Corn	Rye	Broc	Rye	Corn	Relay rye	Broc	Relay rye	Corn
Cereal	Rye	Corn	Rye	Broc	Rye	Corn	Rye	Broc	Rye	Corn
Cereal/legume	Rye/ Pea	Corn	Rye/ Pea	Broc	Rye/ Pea	Corn	Rye/ Pea	Broc	Rye/ Pea	Corn

[a]Red clover = Kenland red clover; Rye = Wheeler cereal rye; Rye/Pea = Wheeler cereal rye/Austrian winter pea



Note: Dashed lines signify that dates for pre- or postseason activities may vary within these time ranges.

These results indicate it is important to plant cover crops that will grow during less-than-optimal winter weather conditions. Wheeler cereal rye and Kenland red clover seem to grow best during the late summer and early fall, especially if irrigation is available. To facilitate early planting, establishment of relay cover crops can be done using irrigation and cultural practices typical of the Willamette Valley.

Results from cereal rye/pea mix

Another important finding is that high rates of fertilizer N applied to summer crops reduced the number of legume plants in the cereal/legume cover crop system (Table 2). This might occur because the cereal crop takes up more N and is more competitive with the legume. Also, it is known that high fertilizer N rates suppress N fixation by legumes. These results suggest that to encourage legume growth and N fixation by legume cover crops, lower rates of N should be applied to summer crops.

Winter cover crop cereal/legume mixes contain more N than do cereal cover crops with no legume. The amount of above-ground N in sole Wheeler cereal rye cover crops averaged over 4 years was 63, 36, and 23 lb N/acre when the amount of N applied to the summer crop was at the recommended, intermediate, and zero rates, respectively. The Wheeler cereal rye/Austrian winter pea mix averaged 86, 63, and 53 lb of above-ground N/acre when the amount of N applied was at the recommended, intermediate, and zero rates, respectively (Table 2).

The N content of the cereal increased in a mixed cover crop, compared to a pure cereal cover crop, at all summer N rates (Table 2). The higher rate of N accumulation by cereal rye in a mix suggests that fixed N is somehow transferred from the legume to the cereal rye or that more N is mineralized from the soil when legumes are repeatedly planted and incorporated alongside a cereal.

Figure 4.—Broccoli is a common summer vegetable rotation crop.

Table 2.—Above-ground N content of Wheeler cereal rye and Austrian winter peas when grown together as a mixed winter cover crop, 1991–1994.

		N content (lb/a)		
N rate applied to previous crop	Pea plants (no./yd^2)	Pea plants	Cereal rye plants	Cereal rye/ pea cover crop
Zero	59	17	36	53
Intermediate	58	18	46	63
Recommended	48	14	71	86

N rates:

Intermediate—50 lb/acre for corn (1992) and 125 lb/acre for broccoli (1994). Intermediate rates for each summer crop are based on previous research experience and are suboptimal for these crops.

Recommended—200 lb/acre for corn (1991) and 250 lb/acre for broccoli (1993). Recommended rates are from the OSU Extension Service western Oregon fertilizer guides—FG 11 for sweet corn and FG 27 for broccoli.

Summer vegetable crop results

The summer vegetable crops included in this study were sweet corn and broccoli (Figure 4), planted in alternate years. The summer crops had three rates of urea-N treatment:

- No N
- Intermediate (suboptimal) N—50 lb N/acre for corn and 125 lb N/acre for broccoli
- Recommended N—200 lb N/acre for corn and 250 lb N/acre for broccoli

In 1992, plots that were fallow during the winter were planted in wheat for the summer to more closely follow conventional crop rotations in the Willamette Valley.

Summer crop yields

Unhusked ears of sweet corn were harvested and weighed (Figure 5). Broccoli heads were harvested as they matured, to simulate multiple commercial harvests. Samples of the summer crop were weighed and analyzed for total N content.

Winter cover crops and the fertilizer N rate for the summer crops were shown to be very important to the summer crop yields (Figure 6). Averaged over all years and N rates, the yields of the vegetable crops were 19 percent lower in the relay Wheeler cereal rye plots as compared to fallow plots (data not shown for corn). Cereal rye might cause microbial N immobilization and reduce the amount of available N for subsequent

Figure 5.—Sweet corn yields were determined following cover crop or fallow treatments.

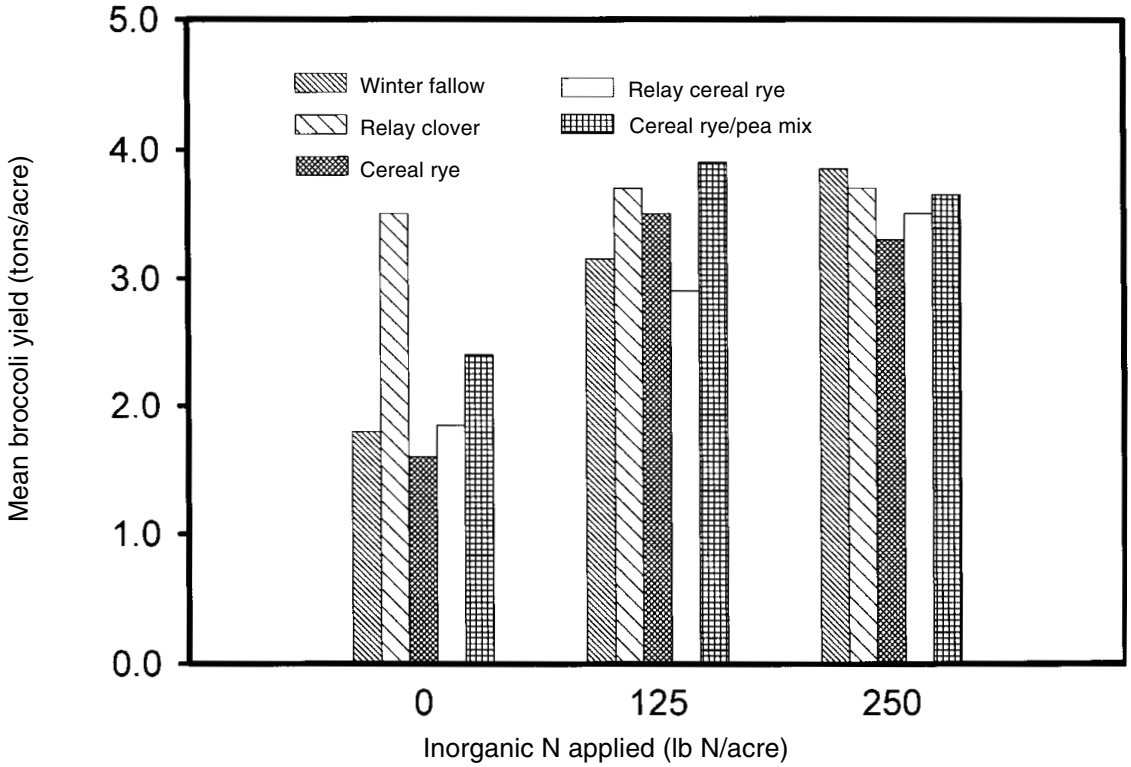


Figure 6.—Effect of cover cropping on yield of broccoli heads at three N rates averaged over 2 years (1991 and 1993).

crop use. It is unlikely that this effect caused the reduced yields, however, because yields were reduced even with high N application rates. It is more likely that decomposing rye might have a toxic effect (allelopathy) on subsequent row crops, which has been suggested by other researchers.

Broccoli yields in the Wheeler cereal rye/Austrian winter pea plots were statistically equal at fertilizer N rates of 125 or 250 lb/acre (Figure 6). For both 1991 and 1993, broccoli grown with no fertilizer N after a legume-containing winter cover crop had a 58 percent higher average yield than that of the fallow or cereal rye plots. In 1993, broccoli grown without fertilizer N after a relay Kenland red clover cover crop had a yield equal to that obtained with the recommended fertilizer rate. Yields following all winter cover crops, except for relay cereal rye, had maximum yields at the intermediate N rates. Thus, the use of legume cover crops showed that N fertilizer for broccoli can be reduced by 125 lb N/acre compared to winter fallow or nonlegume cover crop systems.

Sweet corn yields with 50 lb N/acre following a Wheeler cereal rye/Austrian winter pea mix or relay Kenland red clover (data not shown for red clover) statistically equaled yields with 200 lb N/acre following either fallow or Wheeler cereal rye cover crops (Figure 7). In 1994, sweet corn yields at all N rates were highest following relay Kenland red clover (data not shown). Nonfertilized sweet corn following relay Kenland red clover produced a yield equal to that of corn with 200 lb N/acre. Other studies using legume green manure crops have shown similar results. Thus, the use of legume cover crops showed that N fertilizer can be reduced by 150 lb N/acre for sweet corn compared to winter fallow or non-legume cover crop systems.

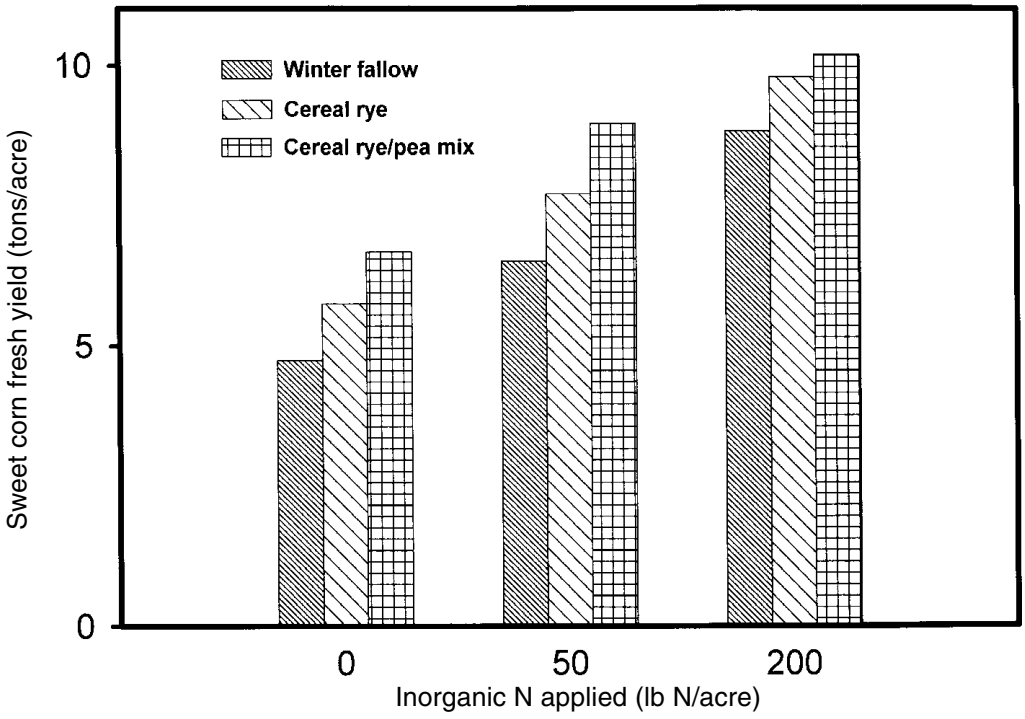


Figure 7.—Effect of cover cropping on the yield of sweet corn at three N rates averaged over 3 growing seasons (1990, 1992, and 1994).

Table 3.—Above-ground biomass N of winter cover crops, 1991–1994.

	Biomass N (lb/a) with zero N fertilizer		Biomass N (lb/a) with intermediate N fertilizer		Biomass N (lb/a) with recommended N fertilizer	
Winter cover crop	**Average**	**Range**	**Average**	**Range**	**Average**	**Range**
Clover	79	54–104	—	—	54	29–80
Cereal rye	23	15–40	36	21–58	63	40–123
Cereal rye/pea	53	39–66	63	52–76	86	59–111
Relay clover	50	34–65	43	31–54	51	37–65
Relay cereal rye	19	8–29	23	14–31	46	37–54

N rates:

Intermediate—50 lb/acre for corn (1992) and 125 lb/acre for broccoli (1994). Intermediate rates for each summer crop are based on previous research experience and are suboptimal for these crops.
Recommended—200 lb/acre for corn (1991) and 250 lb/acre for broccoli (1993). Recommended rates are from the OSU Extension Service western Oregon fertilizer guides—FG 11 for sweet corn and FG 27 for broccoli.

Above-ground N results

Table 3 shows that the difference in above-ground N between Wheeler cereal rye and the Wheeler cereal rye/Austrian winter pea mix was no more than 26 lb/acre. Yet, the results showed that N fertilizer could be reduced by 125 lb/acre for broccoli and 150 lb N/acre for sweet corn. We did not measure below-ground N in roots and nodules, which would provide additional N by the pea plants that would become available to summer crops.

It may be that there is more efficient uptake of N mineralized from plant material than the same amount added by fertilizer N. Lastly, 50 percent or more of fertilizer N generally is immobilized in soil organic matter and is unavailable for plant uptake. Thus, much more fertilizer N must be applied than is needed by the plant to ensure adequate N for plant growth.

Recommendations

Results from this study indicate that, in western Oregon, a legume is needed (alone or in a cover crop mix) in order to reduce N application rates below the recommended rate for subsequent vegetable crops. Sweet corn needed only 50 lb N/acre following a Wheeler cereal rye/Austrian winter pea or Kenland red clover crop to maintain the maximum yield achieved with 200 lb N/acre following fallow or cereal rye alone. For broccoli, the maximum yield was maintained with 125 lb N/acre following a Wheeler cereal rye/Austrian winter pea mix or Kenland red clover.

For Willamette Valley conditions, non-legumes should be used to capture residual N to reduce leaching of nitrate to groundwater. However, even after 4 years of incorporating cereal residue, there was no evidence that the captured N in cereals was replacing any fertilizer N for subsequent vegetable crops. Consequently, our results suggest that a vegetable crop following a cereal cover crop must be fertilized at the recommended N rates.

A cereal rye cover crop alone caused a small (about 10 percent on average) decrease in sweet corn and broccoli yields. This result is similar to findings in other regions of the United States and indicates it is best to mix cereal rye with a legume for use as a cover crop.

For more information

Columbia Root-Knot Nematode Control in Potato Using Crop Rotations and Cover Crops, EM 8740 (November 1999).

Cover Crop Dry Matter and Nitrogen Accumulation in Western Oregon, EM 8739 (October 1999).

Cover Crop Weed Suppression in Annual Rotations, EM 8725 (published March 1999, reprinted October 1999).

Nitrogen Scavenging: Using Cover Crops to Reduce Nitrate Leaching in Western Oregon, EM 8728 (October 1999).

Using Cover Crops in Oregon, EM 8704 (published January 1998, reprinted October 1998).

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