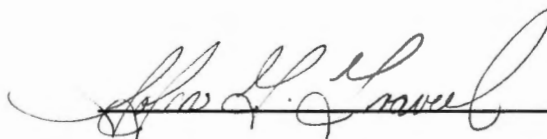


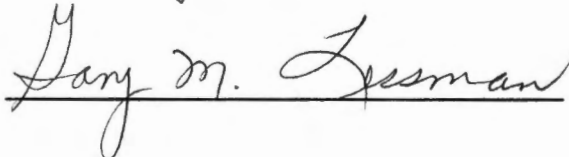
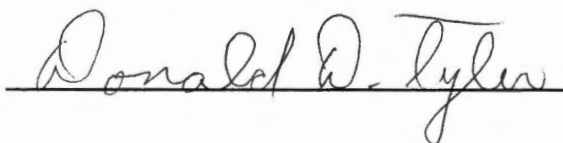
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GRASS AND LEGUME COVER CROP DECOMPOSITION
RATES IN NO-TILLAGE

A Thesis
Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

John Frederick Bowen

December 1990

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DEDICATION

I dedicate this thesis to my parents, Frank and Elloween Bowen. I will always be grateful for their love, faith, and support. They have always found the time for their children.

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ABSTRACT

Legume cover crops used as no-tillage mulches can reduce soil erosion and potentially contribute supplemental nitrogen to a subsequent crop. The decomposition rate of a chemically-killed legume may affect the availability of this additional nitrogen. Three legumes: hairy vetch (Vicia villosa), crimson clover (Trifolium incarnatum), Austrian winter pea (Pisum sativum), and wheat (Triticum aestivum) were compared as winter cover crops with no-tillage corn receiving 0, 56, 112, 168, or 224 kg N ha⁻¹. Nylon bags containing each cover type were placed on the soil surface and decomposition rates determined from weight, carbon, and nitrogen loss from the bags over a 16-week period. The experiment consisted of a main plot of five N rates and sub-plot of each winter cover crop. Nitrogen and carbon contents of the cover crops and rate of N fertilization affected mulch decomposition. Mulch decomposition was distinctly different for both years. Carbon and weight losses were greater for wheat residues than the legume residues in 1985, while in 1986 all cover crop residues had similar carbon and weight losses. Hairy vetch vetch had greater N losses over time at all N rates when compared to the other residues. Analysis of yield response curves indicated that legume mulches contributed up to 154 kg N ha⁻¹.

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CHAPTER I

INTRODUCTION

Historically, farmers used animal manure and legumes to build-up fertility levels of soil for crop production (Power, 1987). Legumes as green manure and cover crops were frequently used to add organic matter and supply nitrogen to improve the productivity of the soil (Pieters and McKee, 1938). Farmers relied on legumes to symbiotically fix atmospheric nitrogen which upon decay recycled its N to a following crop.

The benefits of legumes in crop rotations were known as early as 1915 in the Southern U.S (Hargrove, 1982). Prior to the production of nitrogen fertilizers, the Southern states relied mainly on hairy vetch (Vicia villosa) and Austrian winter pea (Pisum sativum) for cover crops and green-manure. Sweetclover (Melilotus) was the standard crop in the Corn Belt for supplying nitrogen for corn (Pieters and McKee, 1938). Duggar (1899) found that hairy vetch could produce 224 kg N ha⁻¹. Penney (1905) also observed that crimson clover (Trifolium incarnatum) could supply 155 to 210 kg N ha⁻¹.

Following World War II, the use of legumes declined with the development of inorganic nitrogen fertilizers which were a cheap and abundant source of nitrogen

(Hargrove and Frye, 1987). Currently, the widespread use of commercial N fertilizers has largely replaced N-fixing legumes as a source of nitrogen for crop production. From 1960 to 1980, N fertilizer usage quadrupled to 8.6 million Mtons yr^{-1} , while legume seed production declined by more than half to 63,500 Mtons yr^{-1} (Power, 1987).

In recent years there has been a renewed interest in legumes because of the rising cost of N fertilizers. During the 1970s, the rising cost of energy resulted in increased production costs for N fertilizers. Hargrove (1982) reported that N fertilizer represents the largest energy input in non-leguminous crop production.

Using legumes in no-tillage systems may offer greater fossil fuel energy savings and lower input expenses. The ability of legumes to fix nitrogen may reduce fertilizer inputs for non-leguminous crops. When used as winter cover crops, legumes may contribute a significant amount of N to a succeeding crop and replace a portion of the crops N requirement that would otherwise be supplied by N fertilizers.

Legume winter cover crops may have additional benefits, such as increasing soil organic matter, improving soil tilth, conserving soil moisture, cycling nutrients, and reducing soil erosion and off-site sedimentation (Schulte and Peterson, 1988). A vigorous cover crop may also aid in weed control.

CHAPTER II

LITERATURE REVIEW

Utilizing Legume N

To efficiently utilize fixed nitrogen from a legume, an effective residue management system must be developed (Wilson and Hargrove, 1986). It is necessary to know the pattern of N release from a chemically killed cover crop to properly manage its residue N. Ideally, the nutrient demand of the crop should coincide with the decomposition of the mulch and release of residue N. Therefore, the decomposition of the legume mulch needs to be understood to determine the amount and rate at which N is released during the growing season. It is also important to understand the influence of fertilizer nitrogen on microbial activity and subsequent decomposition of a chemically killed cover crop.

Benefits of Legume Cover Crops

Numerous studies have shown that adapting legume winter cover crops to row crop systems can reduce N fertilizer inputs while maintaining adequate production levels (Kamprath et al., 1958; Moschler et al., 1967; Touchton et al., 1982; and Hargrove et al., 1984). Much of this research indicates that crop yields are generally

higher following legume winter cover crops than grasses or fallow.

No-tillage corn (Zea mays L.) yields in Kentucky following hairy vetch averaged about 2.5 Mg ha⁻¹ more than corn yields after rye (Secale cereale) or previous corn stubble (Ebelhar et al., 1984). Hairy vetch was estimated to contribute 90 to 100 kg N ha⁻¹ to no-till corn. In Maryland, Decker et al. (1987) found that no-till corn yields were greater when planted into hairy vetch, Austrian winter pea, and crimson clover cover crops than wheat (Triticum aestivum), barley (Hordeum vulgare), or no cover. Their results on Piedmont soils showed yields following legumes averaged 10.9 Mg ha⁻¹ when no fertilizer N was applied. At 90 kg N ha⁻¹, corn yields after small grains or no cover were 9.3 and 10.3 Mg ha⁻¹, respectively. Mitchell and Teel (1977) observed in Delaware that corn grown without N fertilizer following hairy vetch and crimson clover produced similar yields as rye or oats with 112 kg N ha⁻¹.

Hargrove (1986) found crimson clover to be well adapted to Georgia, where it replaced up to 120 kg fertilizer N ha⁻¹. Touchton et al. (1982) reported that the N supplied by crimson clover was sufficient to produce maximum grain yields without additional fertilizer. Also in Georgia, Neely et al. (1987) observed similar results where a well adapted legume replaced all the fertilizer N

requirement for grain sorghum (Sorghum bicolor) and 110 kg N ha⁻¹ for corn production.

N Content: N Concentration and Dry Matter Production

The amount of N that chemically killed winter cover crops can supply a succeeding crop depends, in part, on cover crop type and N content. Total N content is a product of both initial N concentration and dry matter production (Ebelhar et al., 1984; Hargrove, 1986). Other factors affecting N contribution by cover crops include inherent soil fertility, crop management practices, such as N fertilizer additions and timing of cover crop burndown, and rate of decomposition and N release (Heichel, 1987; Wagger, 1987)

Total N concentration of cover crops is commonly measured as that present in aboveground plant tissues. It has been observed in several cover crops that over 80% of the total N present was contained in the aboveground tissues (Mitchell and Teel, 1977; Jensen and Frith, 1984). It has been well documented that legume cover crops generally have higher N concentrations compared to non-legumes (Miller, 1984; Hargrove, 1986; Wagger, 1987; Neely et al., 1987).

Pieters and McKee (1938) found hairy vetch supplied 150 to 225 kg N ha⁻¹, depending on the amount of top growth produced. Over three years, Hargrove (1986)

observed crimson clover and hairy vetch mulch contained the greatest amount of N. Their findings were related to greater dry matter production and higher N concentration of crimson clover and hairy vetch. Ebelhar and others (1984) at Kentucky studied N concentration and dry matter production of rye and three legume cover crops and found legumes supplied more N than rye. Hairy vetch produced the largest amount of dry matter and contained the highest N concentration; therefore, it supplied the greatest amount of N (209 kg N ha^{-1}). Rye produced more dry matter than crimson clover and bigflower vetch (Vicia grandiflora), but because of low N concentration, rye residue did not supply as much N as the legumes. Average N content of rye and three legume covers was 36 and 106 kg N ha^{-1} , respectively.

At two locations in Georgia, crimson clover produced more dry matter than hairy vetch (Neely et al., 1987). However, total N content was similar because hairy vetch had higher N concentrations. N content for wheat was much lower than hairy vetch and crimson clover because of lower N concentration and dry matter production. Averaged over two years, N supplied by wheat was 32 kg ha^{-1} , while the legumes averaged 120 kg N ha^{-1} . In North Carolina, Waggoner (1987) observed similar trends when comparing N content of legume and small grain cover crops. Rye produced more dry matter than crimson clover and hairy vetch, but N

contribution of wheat was about 40% lower than the legumes. In Maryland, Decker et al. (1987) reported that the most important factor affecting N contribution of legumes to no-till corn production was dry matter production. Using a cover crop adapted to environmental conditions may result in greater dry matter production, therefore contributing more N to a succeeding crop (Hargrove, 1986).

Residue Decomposition

The amount and pattern of residue decomposition largely determines the degree to which a succeeding crop may utilize nutrients released from residues. The pattern of N release is of special interest when evaluating legumes as winter cover crops (Wilson and Hargrove, 1986).

Soil bacteria are largely responsible for decomposition of organic materials (Albrecht, 1938). Residue decomposition appears to be controlled mainly by the C:N ratio and N concentration of the residue under various environmental conditions (Brady, 1974; Smith and Douglas, 1986; Waggoner, 1987). Bacteria use carbon for energy and nitrogen as building material for their bodies and production of complex organic compounds. Plant residues generally contain a large amount of C in relation to N. Residues, such as wheat straw, have a wide C:N ratio and decompose slowly. Residues with narrow ratios

decompose more rapidly because soil bacteria use C rapidly as an energy source while N is incorporated without appreciable loss.

Harmsen and VanSchreven (1955) reported no mineralization of N occurs when the N concentration of residues is less than 2.0%. This corresponds to a C:N ratio of 25. Studies by Parbery and Swaby (1942) showed mineralization of N to occur when residues contained at least 2.5% N. Barnes (1953) reported that the influence of N concentration on residue C:N ratio plays an important role in N mineralization and subsequent accumulation of nitrate for plant uptake. Leguminous residues with high N levels, such as vetch, showed complete mineralization within 10 weeks. However, grain straw with low N levels suppressed N mineralization up to 89 weeks. Lower C:N ratios of legume residues enable faster decomposition than other crop residues (Harmsen and VanSchreven, 1955).

Waggoner (1987) reported that legume cover crops which had lower C:N ratios than rye released significantly more residue N over a 16-week period in a no-till corn growing season. Hairy vetch and crimson clover C:N ratios averaged 11:1 and 15:1, respectively, while rye had a C:N ratio of 35:1. The release of residue N was in the order of hairy vetch>crimson clover>rye. According to Waggoner, the legume mulches released about 20-40% more of its residue N over a 16-week decomposition period as compared

to rye. The pattern of N release exhibited by legume cover crops may be beneficial to a succeeding crop. Many studies have shown improved N nutrition and increased yields of non-leguminous crops following legumes (Smith and Mabbitt, 1953; Ebelhar et al., 1984; Hargrove, 1986).

N Fertilizer Effects on Residue Decomposition

Some researchers have reported that application of inorganic N fertilizers may affect decomposition and N mineralization of plant residues. Groffman and others (1987) found that N fertilizer may enhance decomposition of rye cover crop residues in no-till systems. It was observed that rye cover crops fertilized with 95 kg N ha⁻¹ decomposed faster than crimson clover residues receiving no N fertilizer. Release of nitrogen from residues corresponded with the rate of decomposition. Surface residues from rye-N fertilized plots released more N (111 kg N ha⁻¹) than crimson clover (87 kg N ha⁻¹) from May to July. Interestingly, the total N released from the legume was nearly equal to that applied as inorganic fertilizer in the rye systems (95 kg N ha⁻¹).

In contrast, free ammonia released by N fertilizers may react with organic matter to form compounds that resist decomposition (Brady, 1974). Investigations by Harmsen and VanSchreven (1955) found that high levels of mineral N in soil may account for considerable immobili-

zation of N by microorganisms, and consequently a reduction in readily available N. Immobilization of mineral N is most apparent when large amounts of ammoniacal-N fertilizer is used (Bartholemew and Hiltbolt, 1952; Norman and Kampitz, 1945).

The nitrification process occurs by enzymatic oxidation which is microbially mediated. The conversion of NH_4^+ to NO_3^- is a two-step reaction in which NO_2^- (nitrite) is the intermediate. There is evidence that large applications of ammoniacal-N fertilizer may delay the reaction by inhibiting nitrobacter resulting in a toxic accumulation of NO_2^- (Brady, 1974). Sufficient quantities of nitrite may adversely affect plant growth and soil microbial activity. Reduced microbial activity in soils can reduce the rate of decomposition of organic residues.

During a three-month period, Smith and Douglas (1968) showed that wheat straw decomposition was not influenced by residual soil N, although C:N ratios narrowed with increasing N fertilization. A significant release of nitrogen from wheat straw residues was observed without N fertilization and in some cases at low N fertilizer rates. Appreciable gains in residue N occurred when high N rates were applied to a preceding crop, resulting in N immobilization. They concluded that carryover of fertilizer N or mineralization from organic sources increased by heavy

fertilization minimizes the effect of N content on decomposition of straw or other plant residues applied to the soil.

The potential benefits of legumes to reduce fertilizer N inputs and increase yields of a succeeding crop enhances the economic incentives to incorporate legumes into no-tillage systems. Therefore, the objectives of this study were to: i) determine decomposition rates of three legumes and wheat winter cover crops when used as mulches in no-tillage corn; ii) estimate the N contribution of legume cover crops; iii) evaluate the influence of N fertilization on decomposition and release of residue N from winter cover crops; and iv) determine the influence of cover crop type and N fertilization on grain yields of no-tillage corn.

CHAPTER III

MATERIALS AND METHODS

Field research was conducted on the intensely row-cropped, highly erodible, loessial soils of West Tennessee at the Milan Agricultural Experiment Station. The soils on the experimental area were mapped Memphis (fine-silty, mixed, thermic Typic Hapludalfs) and Loring (fine-silty, mixed, thermic Typic Fragiudalfs). Decomposition rates and release of nitrogen from one grass and three legume cover crop mulches, and their subsequent influence on no-tillage corn production, were measured during a two-year study (1985-86). The winter cover crops consisted of hairy vetch (Vicia villosa), crimson clover (Trifolium incarnatum), Austrian winter pea (Pisum sativum), and wheat (Triticum aestivum). Cover crops were established in mid-October on fallow plots in 1984 and in previous corn stubble in 1985. In early May of each production cycle, cover treatments were chemically killed with paraquat, and corn was planted no-till on or near May 10. Five nitrogen (N) fertilizer treatments (0, 56, 112, 168, and 224 kg N ha⁻¹ as NH₄NO₃) were surface broadcast following no-tillage corn planting. Phosphorus, potassium, and lime were applied to meet recommendations established by the University of Tennessee Soil Testing

Laboratory. Recommended herbicides were used for residual weed control.

The experimental design was a split-plot arranged as a randomized complete block. Main plots consisted of nitrogen fertilizer rates and were replicated four times. Split-plots consisted of five cover crop treatments which included the three legumes, wheat, and no cover.

Residue decomposition was determined using a nylon bag technique. Several researchers have used the residue bag technique to monitor residue decomposition under field conditions (Smith and Douglas, 1968; Brown and Dickey, 1970; Douglas et al., 1980; Wilson and Hargrove, 1986). Random samples of each cover crop were harvested prior to chemical burndown from 168 kg N ha⁻¹ plots using a 1 x 1 m quadrat. Residues were dried and appropriate proportions of stems and leaves were separated for placement into bags. Cover crop residues, 8g in 1985 and 10g in 1986, were placed in fine mesh nylon bags which were then placed on the soil surface of plots. The effect of N fertilization on decomposition of residues was determined by placing NH₄NO₃ into the nylon bags. The amount of NH₄NO₃ placed in the bag corresponded to the quantity of fertilizer that would normally come into contact with the surface residues, based on dimensions of the bag. Decomposition rates were determined from residue weight, carbon (C), and N lost from the bags as compared to

initial values over a 16-week period of the growing season. The bags were collected from plots at 1, 2, 4, 6, 8, and 16 weeks after placement on the soil surface.

The residues were removed from bags, oven dried at 70°C, and weighed. Residues were passed through a Wiley mill having a 30-mesh screen. Residues, at later sampling dates, often contained small amounts of soil; therefore, 0.5 g samples of ground residues were ashed at 600°C to determine the percent contamination due to soil. This permitted data to be expressed on an ash-free weight basis, therefore minimizing effects of soil contamination.

Carbon contents of the residues analyzed by a dry combustion method (Leco Model CR-12). Nitrogen was determined using a semi-automated (Tecator Kjeltac System 1004 Distilling Unit), modified micro-Kjeldahl method (Nelson and Sommers, 1973). Residue components remaining after decomposition for the various sampling periods were compared to the initial weight, and C and N contents. The C:N ratios of cover crop residues were determined initially for the whole sample and then for subsamples of stems and leaves. Corn was harvested on or near October 1 and grain yields were measured.

The decomposition and yield data were subjected to analysis of variance, regression analysis, and appropriate mean comparisons (SAS Users Guide, 1985).

CHAPTER IV

RESULTS

Winter Cover Crop Residue C:N Ratios in 1985 and 1986

Carbon to nitrogen ratios have often been used to estimate the rate of decomposition of plant residues (Brady, 1974; Smith and Douglas, 1986; Waggoner, 1987). In 1985 and 1986, legume residues had much narrower C:N ratios than wheat (Table 1). Carbon:nitrogen ratios for residues of each cover crop did not differ much over the two-year period. Legume residues ranged from 10:1 to 18:1 over two years. Hairy vetch had the lowest C:N ratios, averaging 10.5:1, while Austrian winter pea and crimson clover residues averaged 14:1 and 17.5:1, respectively. Based on C:N ratios, the narrow range of carbon to nitrogen for legume residues would result in faster decomposition over time and more rapid release of residual nitrogen as compared to wheat residues with wide C:N ratios. Legume residues should also release residual carbon faster than wheat, if the rate of decomposition is more rapid. It may be expected that the high C:N ratio of wheat may result in immobilization of nitrogen, since microorganisms utilize soil nitrogen as they decompose the highly carbonaceous wheat residues. A succeeding crop, such as corn, may exhibit nitrogen

Table 1. Winter Cover Crop Residue C:N Ratios
in 1985 and 1986.

Cover Crop	1985	1986		
Residue	Whole	Whole	Leaves	Stems
-----C:N ratios-----				
Wheat	34:1	32:1	36:1	49:1
Hairy vetch	11:1	10:1	7:1	12:1
Crimson clover	18:1	17:1	12:1	25:1
Austrian winter pea	15:1	13:1	9:1	18:1

deficiency symptoms as a result of N immobilization where wheat cover crops are used. Immobilization of N may be counteracted by applying larger quantities of N fertilizer at planting time.

As shown in Table 1, C:N ratios were determined for the whole sample, leaves, and stems for the residues in 1986. The C:N ratios of about 30 to 35:1 for wheat were not high enough to have resulted in substantial immobilization or slowed decomposition. The C:N ratios were lower for leaves than stems for all residues. The whole sample C:N ratios for the legumes were usually between those of the leaves and stems; however, for wheat the C:N ratio for the whole sample was less than the leaves and stems. Hairy vetch had the lowest C:N ratios for leaves, stems, and the whole sample as compared to the other residues.

The C:N ratios for the whole sample were hairy vetch < Austrian winter pea < crimson clover < wheat. Based on C:N ratios, decomposition of leaves should occur faster than stems. Observations in the plots showed that stems from the residues remained at later sampling times, while leaves had decomposed.

Weight Loss from Winter Cover Crop Residues in 1985

In 1985 where 0 kg ha⁻¹ N fertilizer was applied, rapid weight loss occurred for all residues during the

period 1 to 8 weeks after no-till corn planting (Figure 1). The rate of weight loss slowed from 8 to 16 weeks. Residual weight loss was significantly greater for wheat at 1, 2, and 16 weeks compared to the other residues. Austrian winter pea, hairy vetch, and crimson clover weight losses were similar from 1 to 16 weeks. At 2 weeks after planting, weight losses from wheat and the other residues were 41% and 24%, respectively. At 16 weeks, residue weight loss for wheat was 83%, while Austrian winter pea, crimson clover, and hairy vetch averaged 68.5%. In general, wheat residues appeared to decompose faster than the other residues over time.

At 56 kg N fertilizer ha⁻¹, rapid weight loss occurred for all residues from 1 to 8 weeks after planting no-till corn (Figure 2). The rate of weight loss slowed between 8 and 16 weeks. Residue weight loss was significantly greater for wheat compared to the other residues at all sampling dates. Austrian winter pea, crimson clover, and hairy vetch had similar weight losses at 1, 2, 4, and 8 weeks. At 2 and 8 weeks, weight loss for wheat was 36% and 71%, respectively. The legume residues averaged about 24% and 53% at 2 and 8 weeks, respectively. Sixteen weeks after planting, residue weight loss for wheat was 79% while the legumes averaged 60%. Wheat residues decomposed faster than the legumes over time.

Rapid weight loss generally occurred for all residues

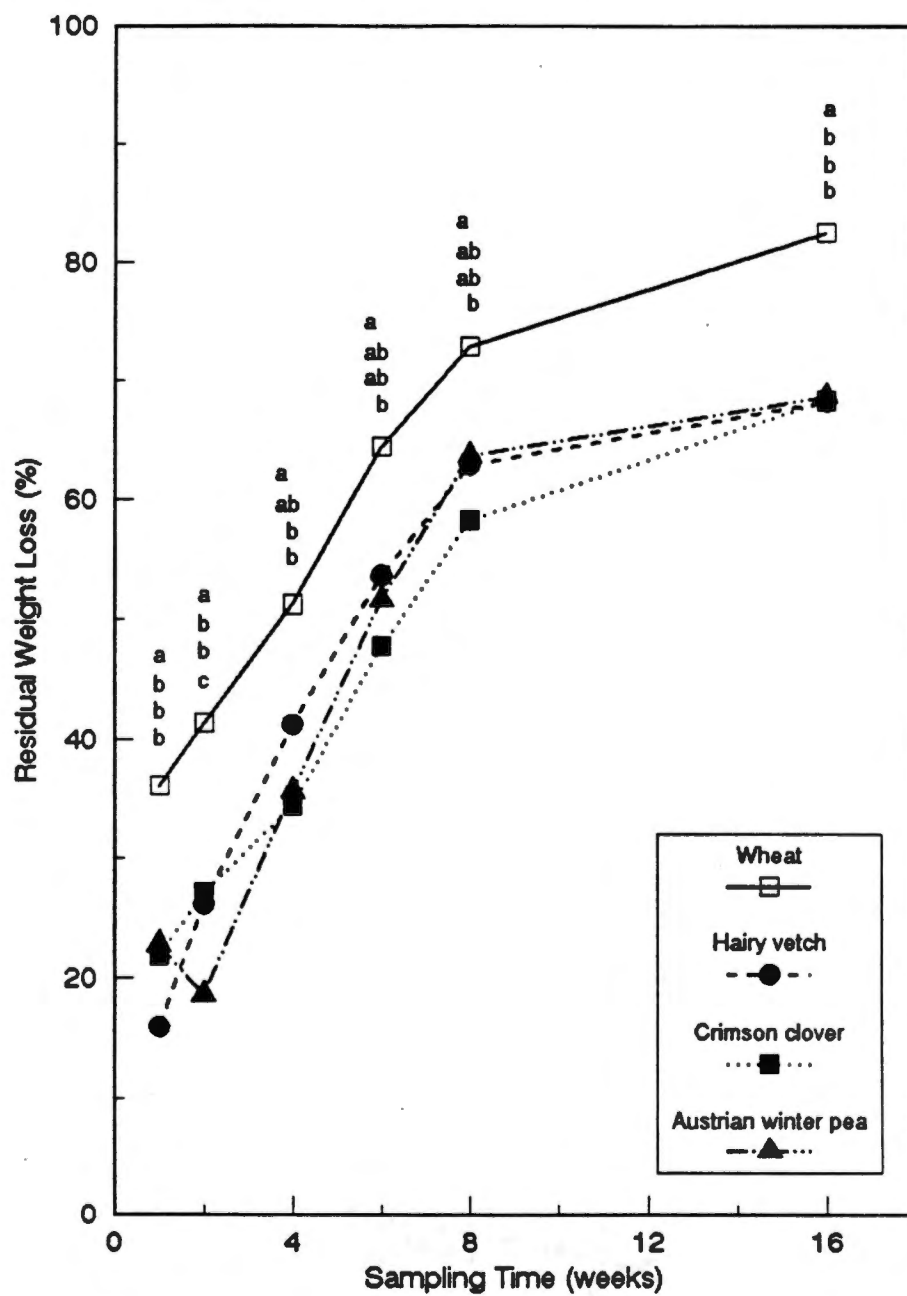


Figure 1. Residual weight loss over time at 0 kg N ha⁻¹ rate of fertilizer in 1985.

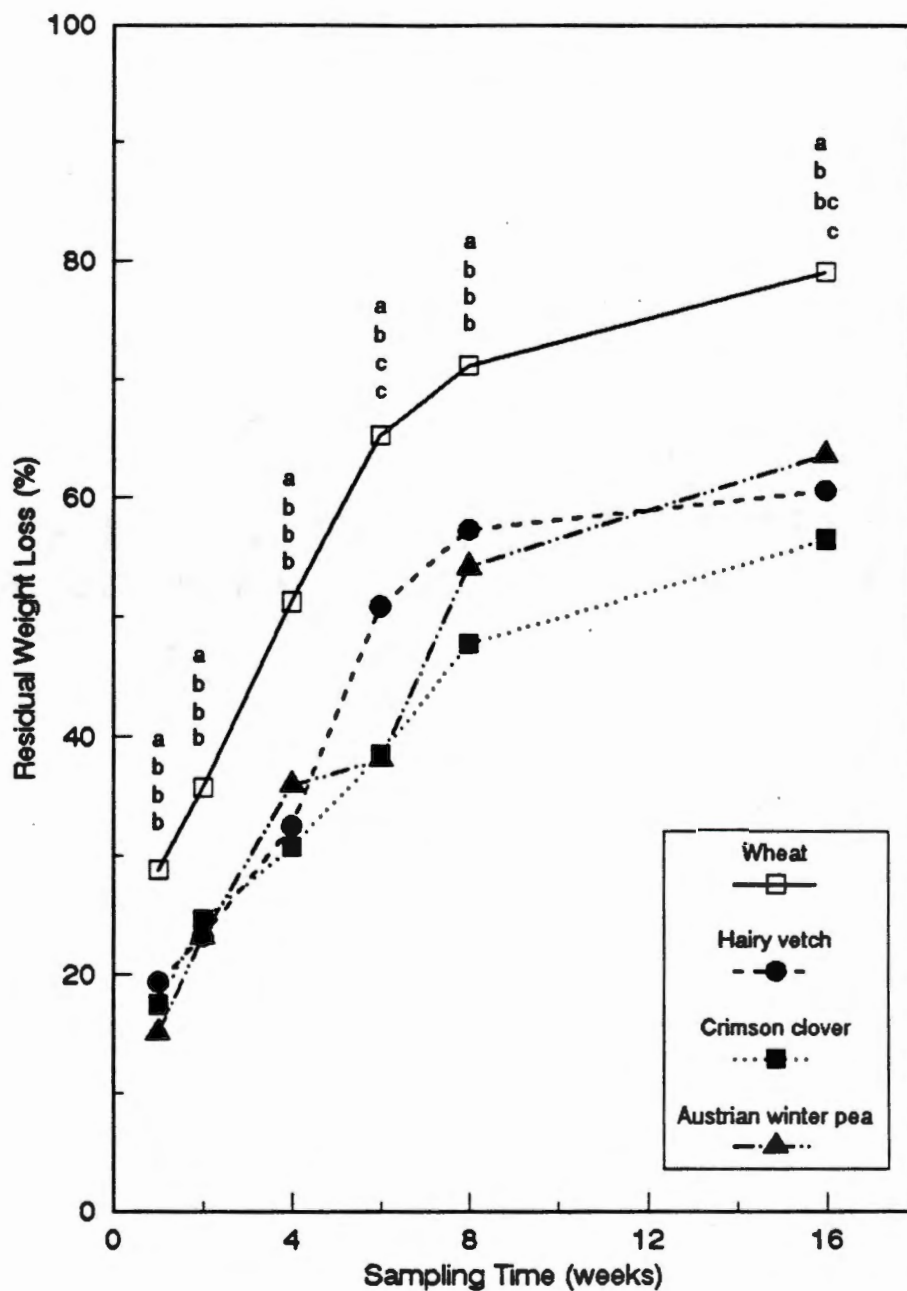


Figure 2. Residual weight loss over time at 56 kg N ha⁻¹ rate of fertilizer in 1985.

from 1 to 6 weeks after no-till corn planting at 112 kg N fertilizer ha⁻¹ (Figure 3). The rate of weight loss slowed from 6 to 16 weeks. Residue weight losses were generally greater for wheat and crimson clover at all 6 sampling dates as compared to hairy vetch and Austrian winter pea which had similar weight losses. Weight losses for wheat and crimson clover averaged 28% and 66% at 1 and 8 weeks, respectively. Austrian winter pea and hairy vetch averaged 17.5% and 52% at 1 and 8 weeks, respectively. Sixteen weeks after planting, weight loss for wheat (77%) was significantly greater than Austrian winter pea and hairy vetch (64%) and similar to crimson clover (71%). At several sampling times, wheat and crimson clover decomposed faster than hairy vetch and Austrian winter pea.

As shown in Figure 4, rapid weight loss occurred for all residues from 1 to 8 weeks after no-till corn planting at 168 kg N fertilizer ha⁻¹. The rate of weight loss slowed from 8 to 16 weeks. Residual weight loss was significantly greater for wheat at 1 and 2 weeks compared to the legume residues. Weight losses were generally similar for all residues from 4 to 16 weeks. At 2 weeks, weight losses for wheat and legume residues were 42% and 28%, respectively. Weight losses were generally similar for all residues at 8 and 16 weeks and averaged 66% and 75%, respectively. Wheat appeared to decompose faster at

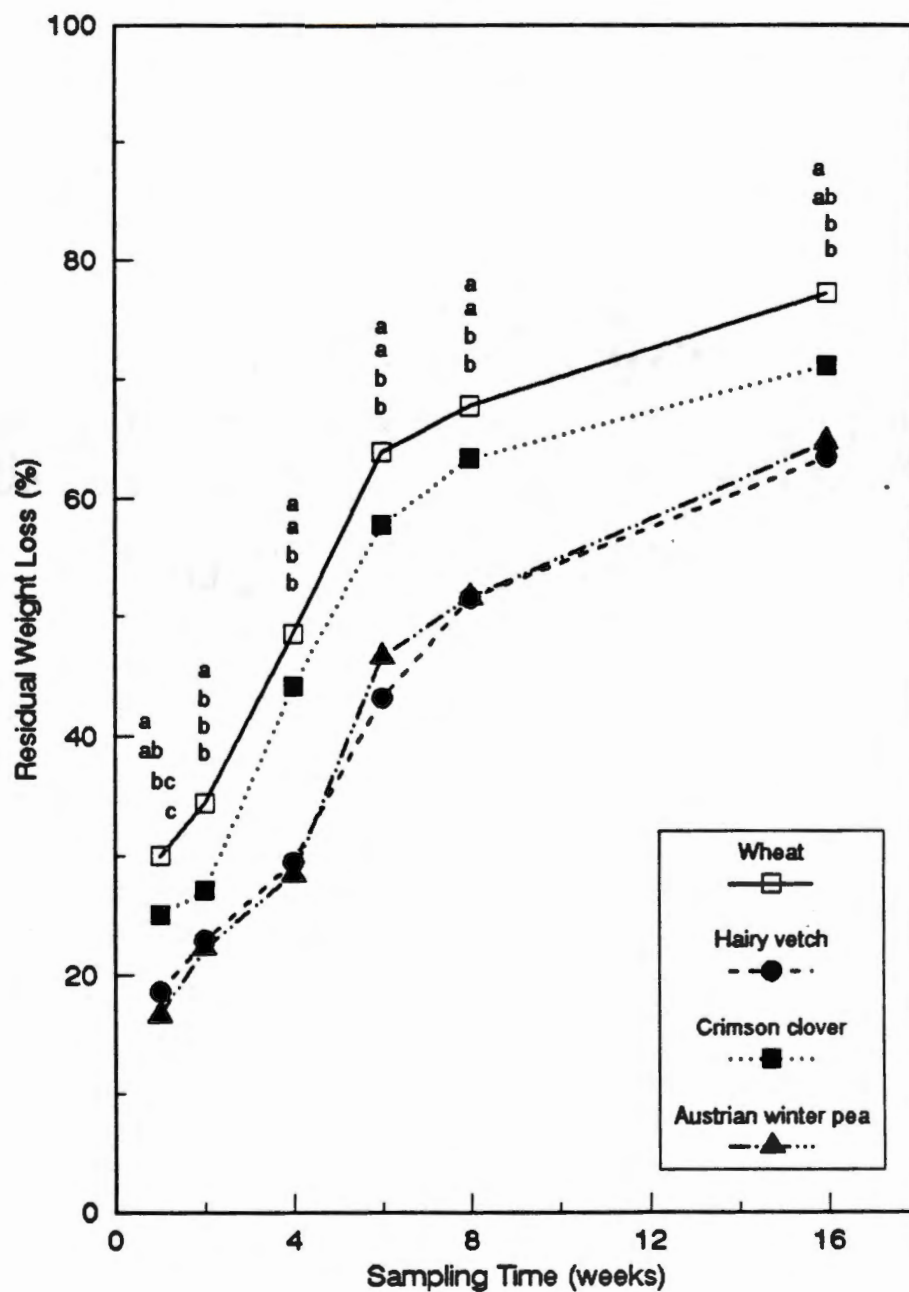


Figure 3. Residual weight loss over time at 112 kg N ha⁻¹ rate of fertilizer in 1985.

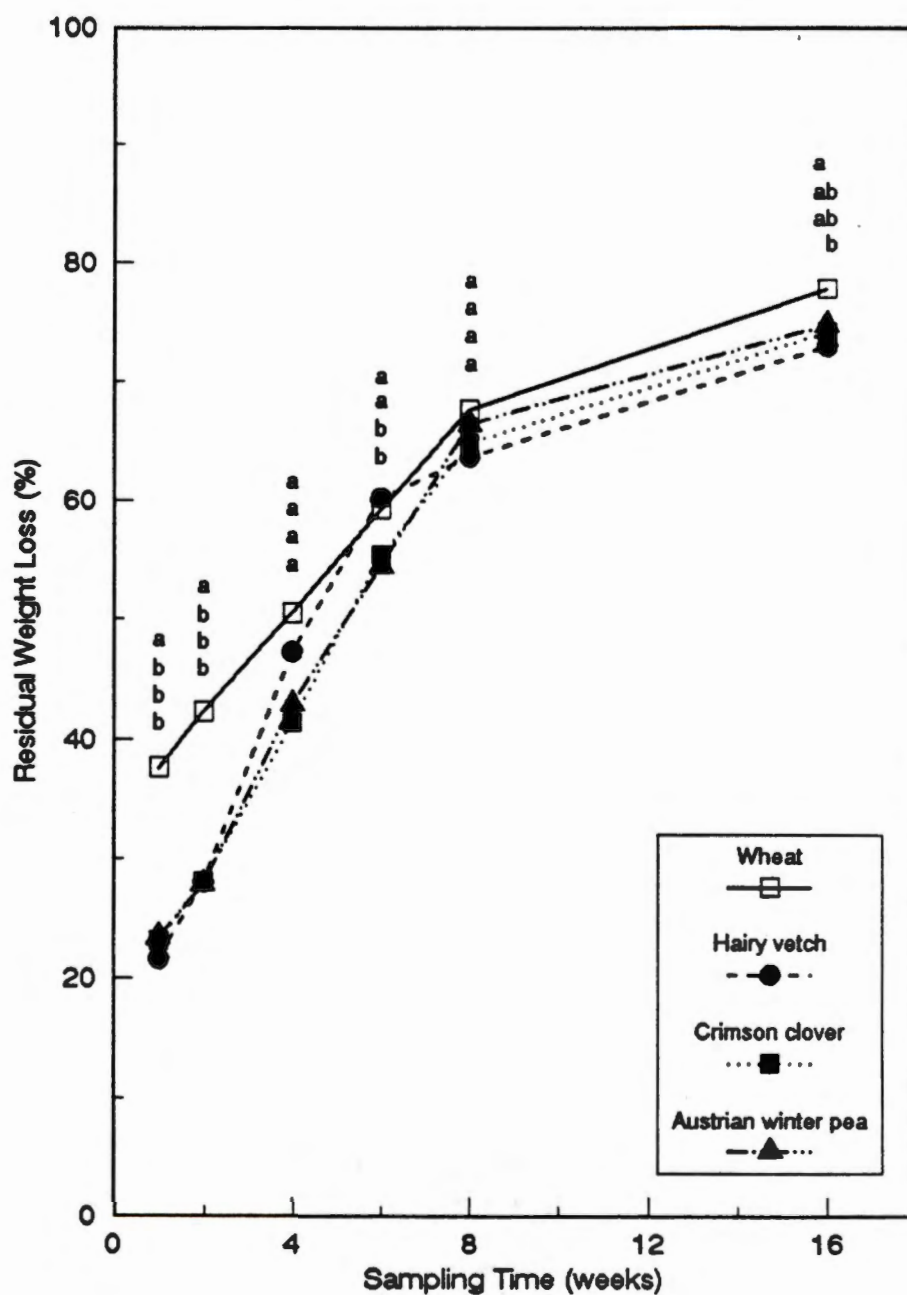


Figure 4. Residual weight loss over time at 168 kg N ha⁻¹ rate of fertilizer in 1985.

early sampling times, but was similar to the legumes at later times.

At 224 kg N fertilizer ha⁻¹, rapid weight loss occurred for all residues from 1 to 8 weeks after planting no-till corn (Figure 5). The rate of weight loss slowed from 8 to 16 weeks. Residual weight loss was significantly greater for wheat at 1, 2, and 4 weeks compared to the other residues. Weight losses were generally similar for all residues from 6 to 16 weeks. At 1 and 4 weeks, weight loss for wheat was 38% and 56%, respectively. Legume residues averaged 24% and 42% at 1 and 4 weeks, respectively. At 8 weeks all residues had similar weight losses and averaged 67%. Sixteen weeks after planting, weight loss for wheat was 79%, while the legume residues averaged 72%. Wheat decomposed faster than legumes at early sampling dates, but was similar to legumes at later dates.

Weight loss for cover crop residues in 1985 were rapid for all residues from 1 to 8 weeks at 0 to 224 kg N fertilizer ha⁻¹. The rate of weight loss slowed from 8 to 16 weeks at all N rates. Weight loss was significantly greater for wheat at 1 to 2 weeks after planting compared to the legume residues when averaged across all N rates; wheat weight loss averaged 39%, while the legumes averaged 25%. At 16 weeks wheat weight loss was significantly greater at 0 and 56 kg N fertilizer than

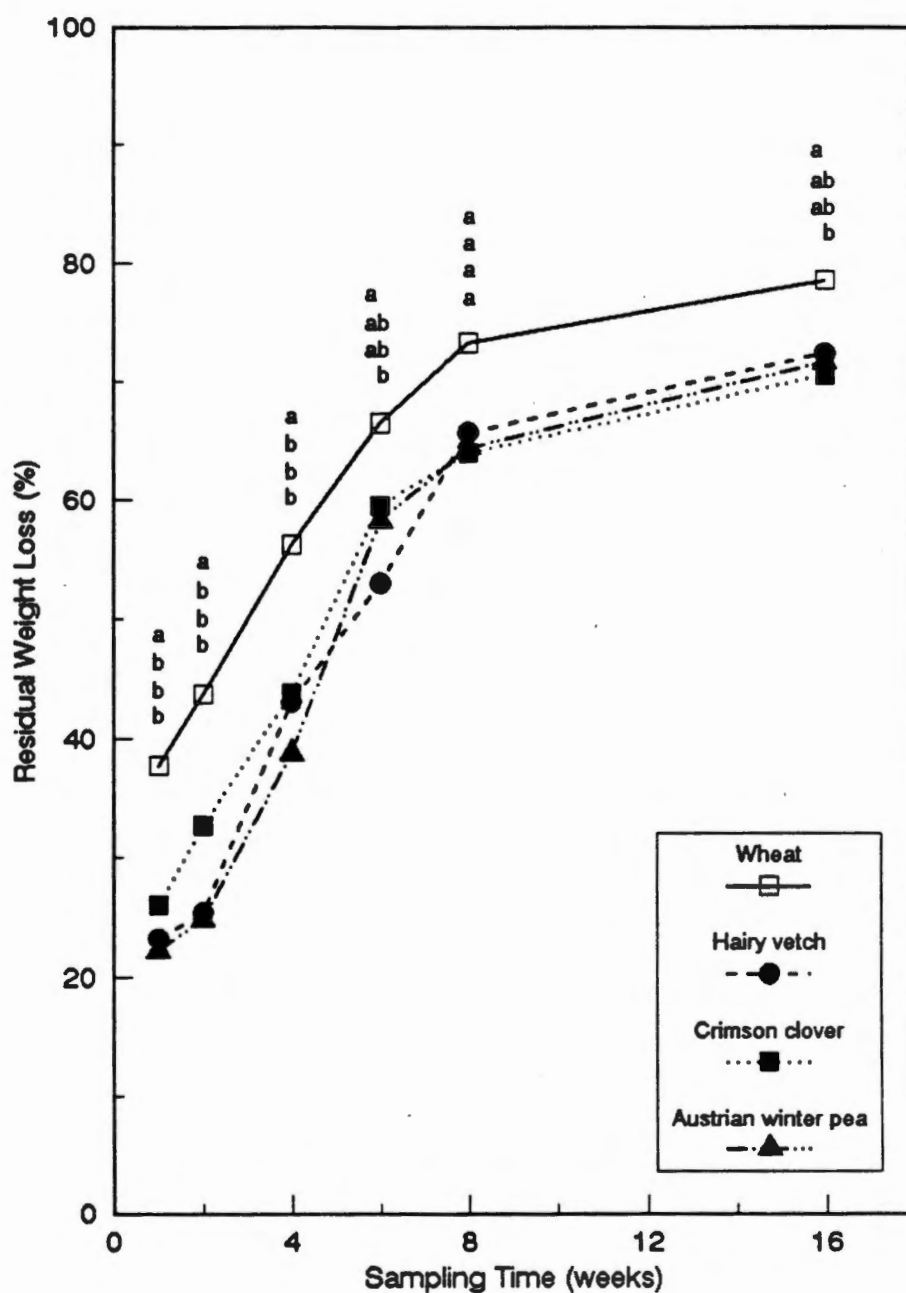


Figure 5. Residual weight loss over time at 224 kg N ha⁻¹ rate of fertilizer in 1985.

the legume residues. At the 168 and 224 kg N ha⁻¹ there were little differences in weight loss among residues. Nitrogen fertilizer did not appear to consistently influence weight loss of residues over time.

Carbon Loss From Winter Cover Crop Residues in 1985

In 1985 where 0 kg ha⁻¹ N fertilizer was applied, rapid loss of residual carbon from all covers occurred up to 8 weeks after planting no-till corn (Figure 6). The rate of C loss slowed between 8 and 16 weeks. Carbon loss was greater from wheat residues at 1, 2, and 16 weeks as compared to legume residues. Wheat residues lost about 10-20% more C over time than legume residues. Carbon loss was similar for legume residues at all sampling times. One week after corn planting, 35% of residual C was lost from wheat, while the legume C loss ranged from 14 to 22%. After 16 weeks 82% of wheat residue C was lost, while legumes lost nearly 70% of residual C.

At 56 kg N fertilizer ha⁻¹, rapid loss of residual carbon from wheat residues occurred up to 6 weeks after no-till corn planting (Figure 7). The rapid C loss from the legume residues occurred during the first 8 weeks where about 55% of residual C was released. The loss of residual C was significantly greater for wheat residues at all sampling times as compared to legumes; 10 to 15% more C was released from wheat than legume residues over time.

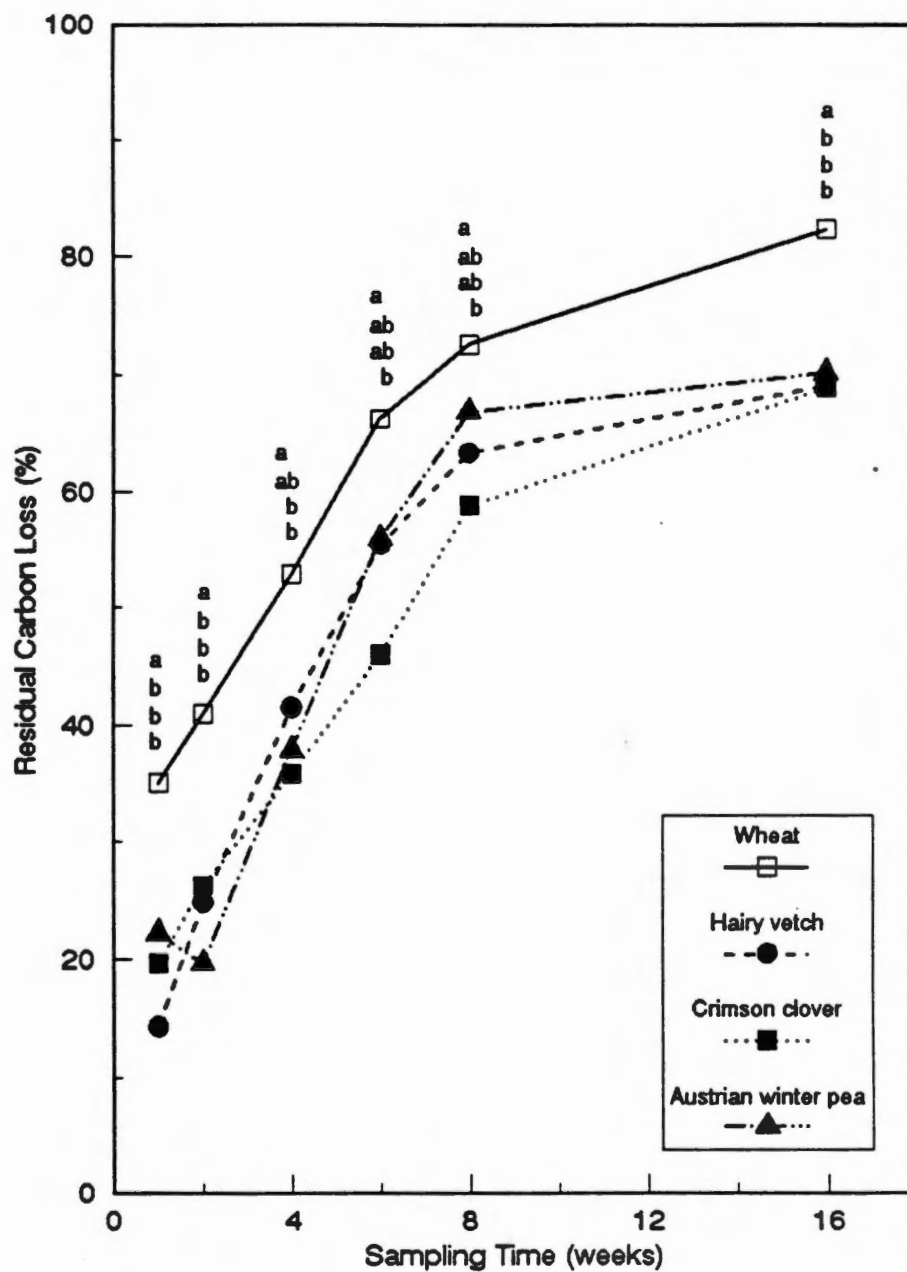


Figure 6. Residual carbon loss over time at 0 kg N ha⁻¹ rate of fertilizer in 1985.

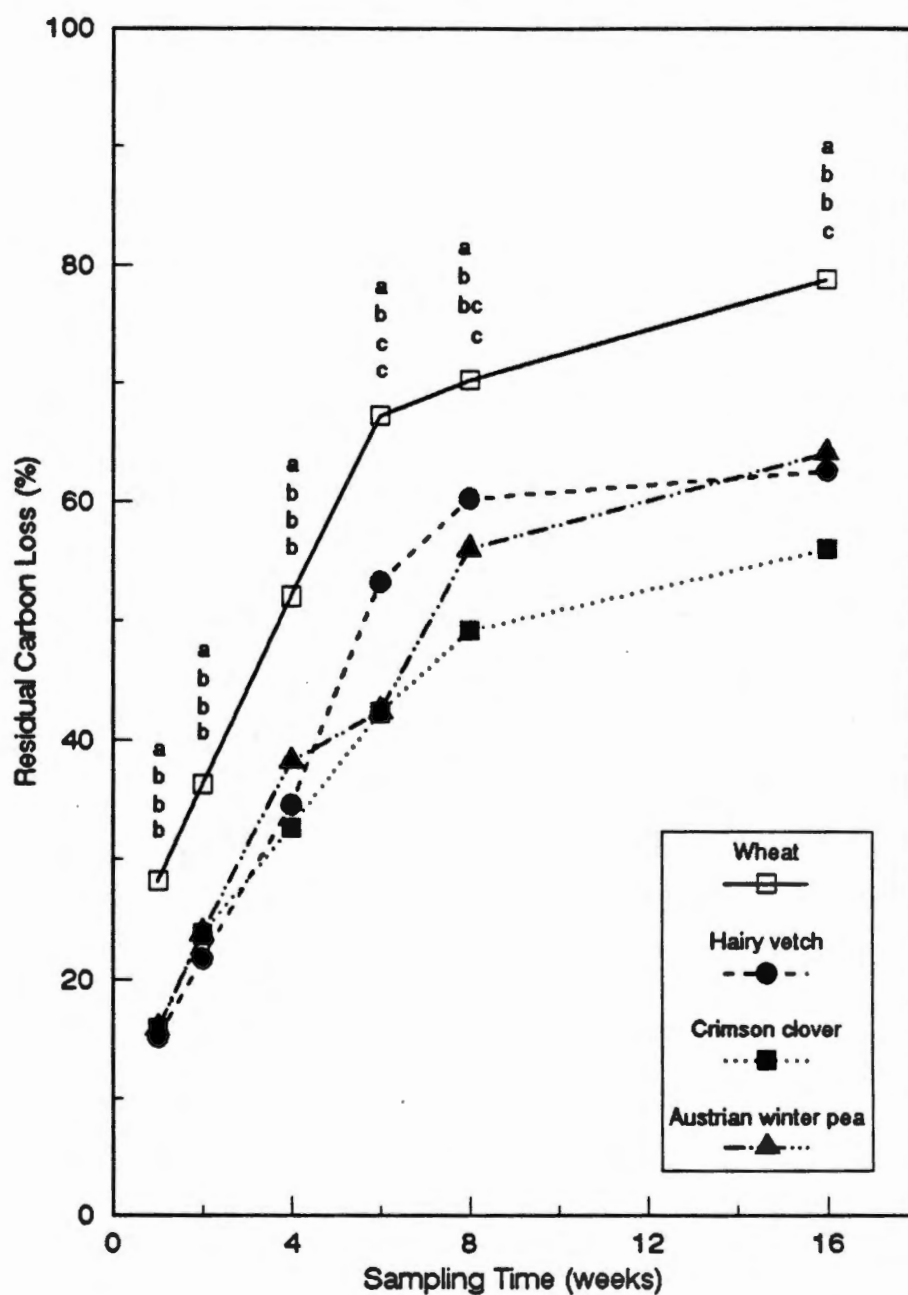


Figure 7. Residual carbon loss over time at 56 kg N ha⁻¹ rate of fertilizer in 1985.

Over the 16 week period, 79% of residual C was lost from wheat while the legumes averaged about 60% loss of residual C.

As shown in Figure 8, a rapid rate of C loss from all cover crop residues occurred up to 8 weeks after planting no-till corn at 112 kg N fertilizer ha⁻¹. At 8 weeks, the average C loss from wheat and crimson clover was about 68.5%, while hairy vetch and Austrian winter pea averaged about 51.5% C loss. The rate of C loss from all residues slowed between 8 and 16 weeks. From 1 to 4 weeks, C loss from wheat was significantly greater than legume residues. The loss of C for wheat and crimson clover was greater from 6 to 16 weeks than hairy vetch and Austrian winter pea. At 6 weeks after planting, wheat and crimson clover lost 62% of residual C, while Austrian winter pea and hairy vetch lost 43% carbon. At 16 weeks, wheat and crimson clover lost about 75% C and hairy vetch and Austrian winter pea lost about 64%.

A rapid rate of residual C loss for cover crop residues occurred between 1 and 8 weeks after planting no-till corn at 168 kg N fertilizer ha⁻¹ (Figure 9). The rate of C loss slowed dramatically after 8 weeks. The loss of C from wheat was significantly greater than the legume residues up to 2 weeks; the amounts of C released from wheat and legumes residues were 41% and 27.5%, respectively. From 4 to 16 weeks, all residues were

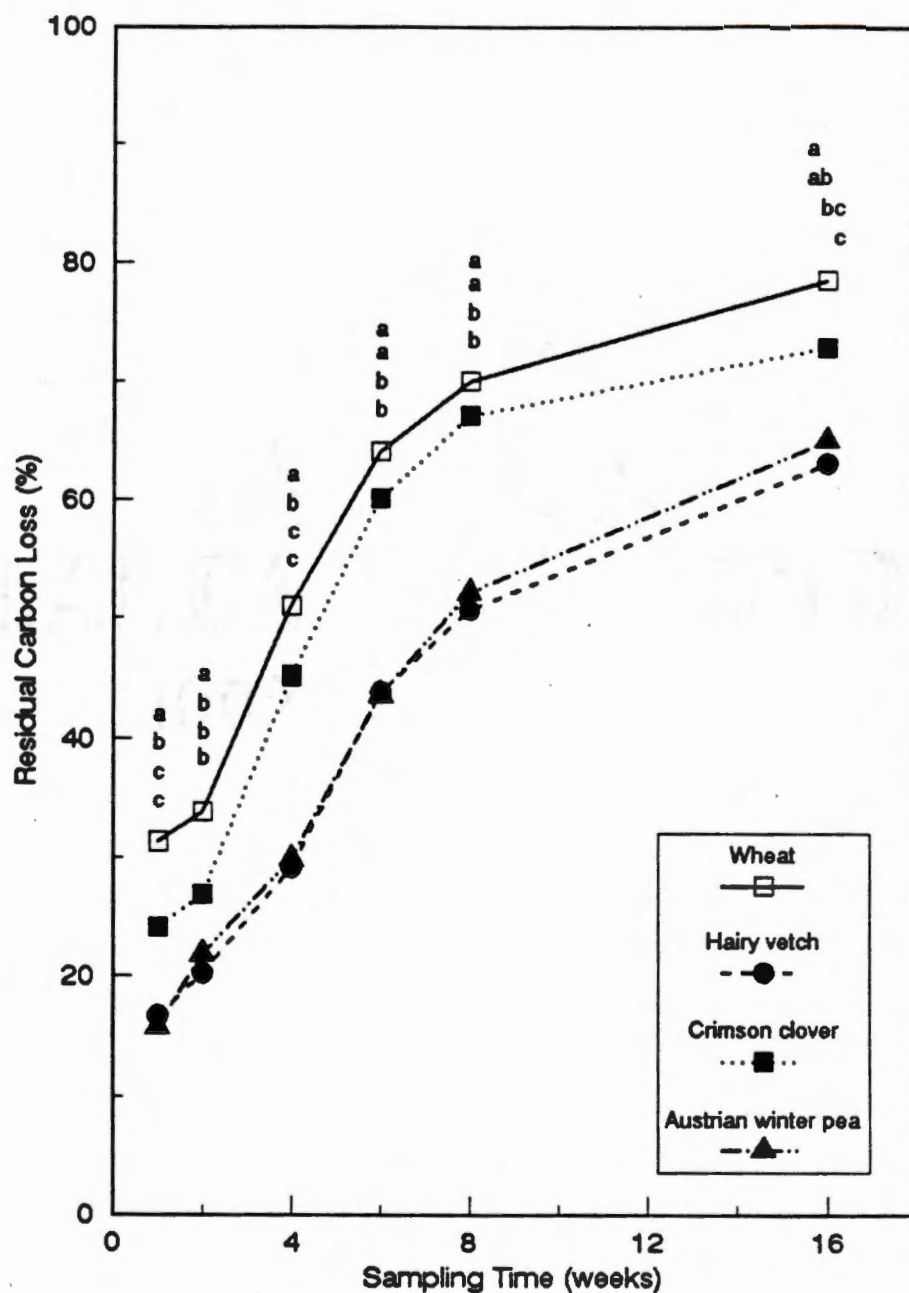


Figure 8. Residual carbon loss over time at 112 kg N ha⁻¹ rate of fertilizer in 1985.

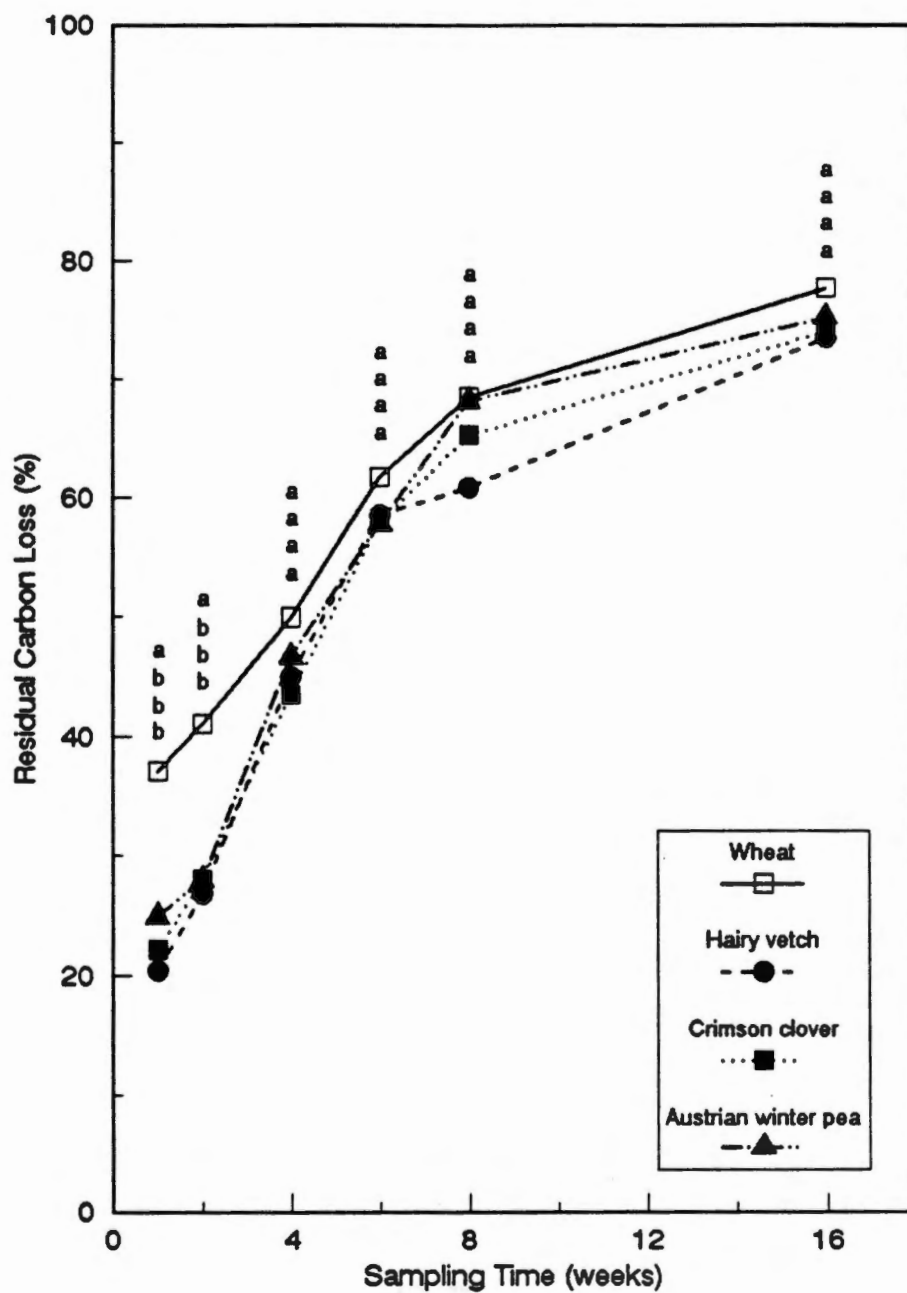


Figure 9. Residual carbon loss over time at 168 kg N ha⁻¹ rate of fertilizer in 1985.

similar in C loss. At 6 weeks after planting all cover residues had lost about 60% of the initial C; at 16 weeks all residues lost about 75% C.

At 224 kg N fertilizer ha⁻¹, the rate of residual C loss was greatest for all residues between 1 and 8 weeks after planting (Figure 10). At 8 weeks, the cover crop residues had released about 68% of the initial C. Carbon loss between 8 and 16 weeks for all cover crops accounted for only 6% of the residual C loss. The C loss was significantly greater for wheat residues up to 2 weeks as compared to legume residues. Beyond 2 weeks after planting, all cover crop residues generally had similar C losses. At 8 and 16 weeks, there were no significant differences in C losses for all covers.

The rate of carbon loss was similar over all fertilizer rates in 1985. The amount of residual C loss was greater for wheat residues over time at low N rates (0 and 56 kg N fertilizer ha⁻¹) as compared to legume residues. At 112 kg N fertilizer ha⁻¹ differences in carbon losses among wheat and legumes residues were less evident; C losses were wheat > or equal to crimson clover > hairy vetch and Austrian winter pea. At 168 and 224 kg fertilizer ha⁻¹ there were little differences among C losses of wheat and legume residues over time, except during the first 2 weeks. The residual C losses for the legume residues were similar over time across all five N

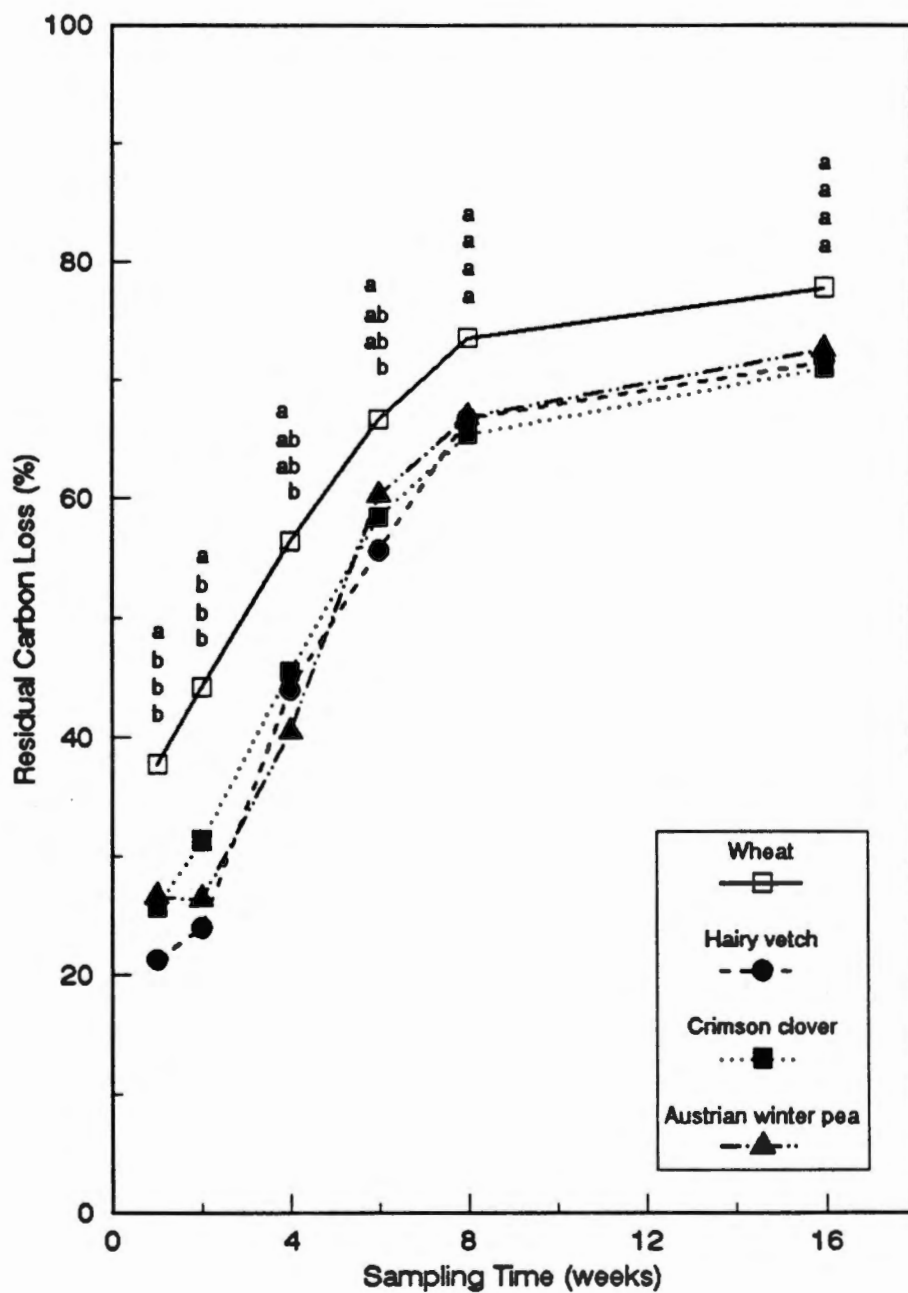


Figure 10. Residual carbon loss over time at 224 kg N ha⁻¹ rate of fertilizer in 1985.

fertilizer rates. The amount of C lost at 16 weeks for each cover crop changed little as N fertilizer rates increased.

Nitrogen Loss from Winter Cover Crop Residues in 1985

In 1985 where 0 kg ha⁻¹ N fertilizer was applied, the rate of N loss for all cover crop residues was irregular but appeared most rapid up to 8 weeks after no-till corn planting (Figure 11). Nitrogen loss was 69% for hairy vetch and averaged about 49% for Austrian winter pea, crimson clover, and wheat at 8 weeks. From 8 to 16 weeks, the rate of N release slowed. There were no significant differences in N lost by all residues at 1 and 2 weeks following corn planting. Residual N losses were significantly greater for hairy vetch residues than the other cover crop residues between 4 and 16 weeks. Nitrogen losses from Austrian winter pea, crimson clover, and wheat residues were similar during this period. At 4 weeks, hairy vetch and the other cover crops released 50% and 21% residual N, respectively. After 16 weeks, hairy vetch residues lost about 76% residual N, while the other residues averaged 61% N loss.

A rapid rate of residual N loss for hairy vetch occurred up to 6 weeks at the 56 kg N fertilizer ha⁻¹ rate (Figure 12). Austrian winter pea, crimson clover, and wheat showed rapid N losses up to 8 weeks and averaged 43%

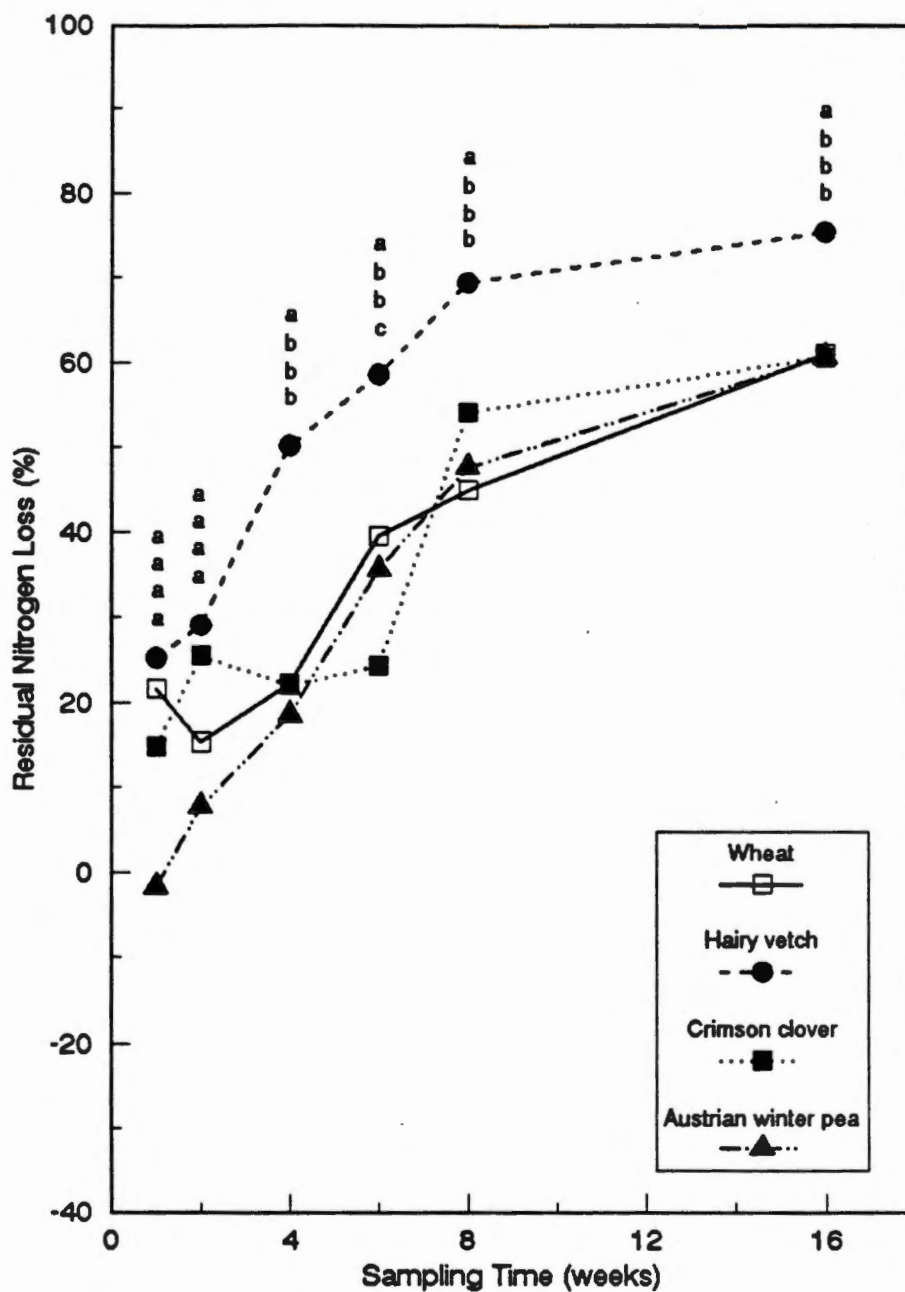


Figure 11. Residual nitrogen loss over time at 0 kg N ha⁻¹ rate of fertilizer in 1985.

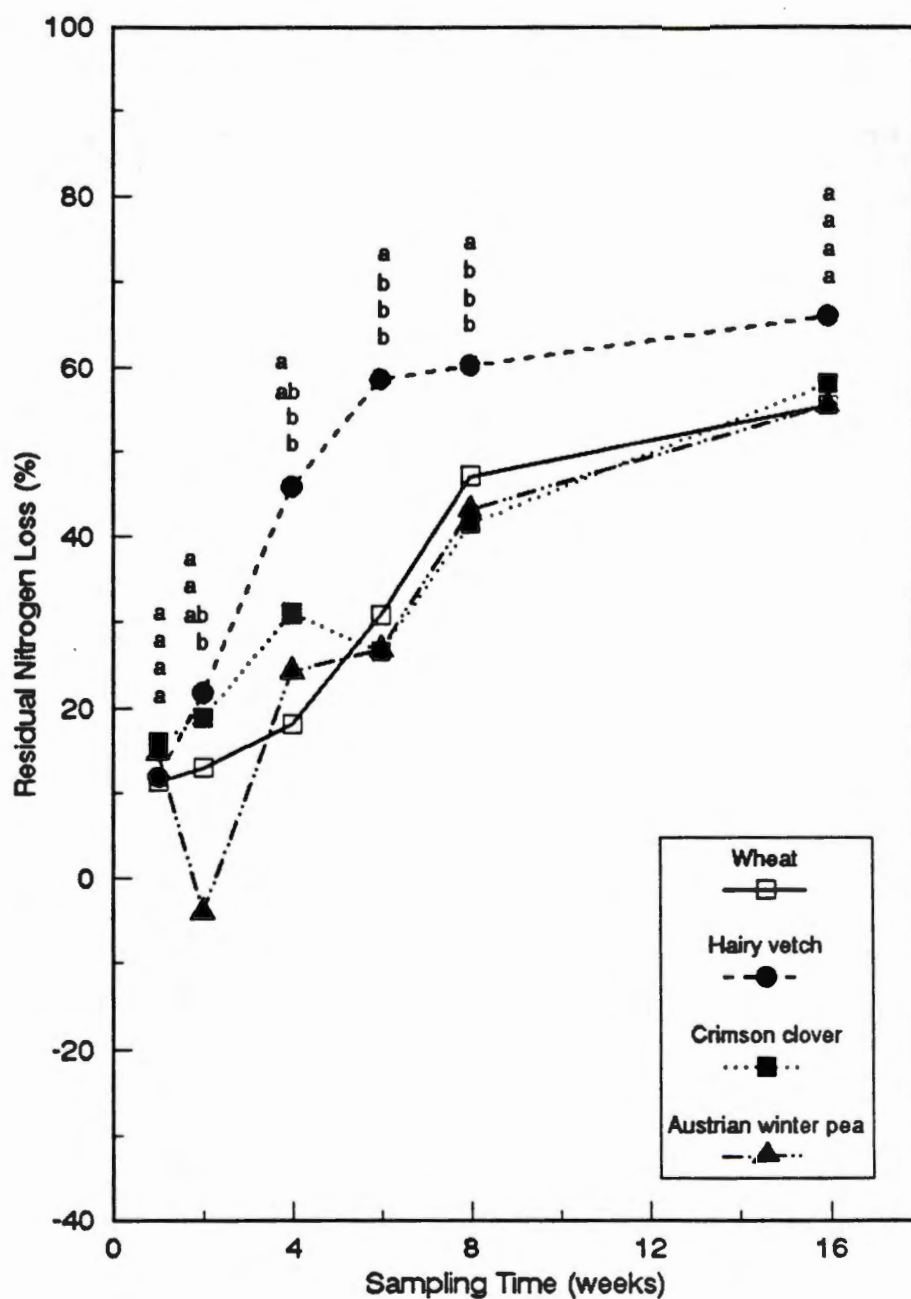


Figure 12. Residual nitrogen loss over time at 56 kg N ha⁻¹ rate of fertilizer in 1985.

N loss. Hairy vetch generally had significantly greater N losses between 4 and 8 weeks as compared to the other residues. Austrian winter pea, crimson clover, and wheat had similar N losses throughout the sampling period. Sixteen weeks after planting, there were no significant differences among N losses for all cover crop residues and averaged about 59%. At 2 weeks, Austrian winter pea had -3.9% N loss, which resulted from the N fertilizer which originally was placed in the nylon mesh bag.

At 112 kg N fertilizer ha⁻¹, N loss was rapid, but was variable among cover crop residues (Figure 13). Hairy vetch and wheat had a rapid rate of N loss between 4 and 8 weeks after corn planting; crimson clover and Austrian winter pea exhibited a rapid rate of N loss between 2 and 8 weeks. At 1 and 2 weeks after corn planting, hairy vetch had significantly greater N loss than the other 3 cover crop residues. About 38% of the N present in hairy vetch residue was released within two weeks, while the other residues released an average of 6% residual N at the 2 week sampling date. From 4 to 16 weeks, the legume residues had similar N losses. Hairy vetch residue lost significantly more N than wheat at 4 through 8 weeks, but they were not significantly different at 16 weeks. Crimson clover N losses were significantly greater than wheat at 6 and 16 weeks. Austrian winter pea and wheat had similar N losses at all 6 sampling dates. Nitrogen

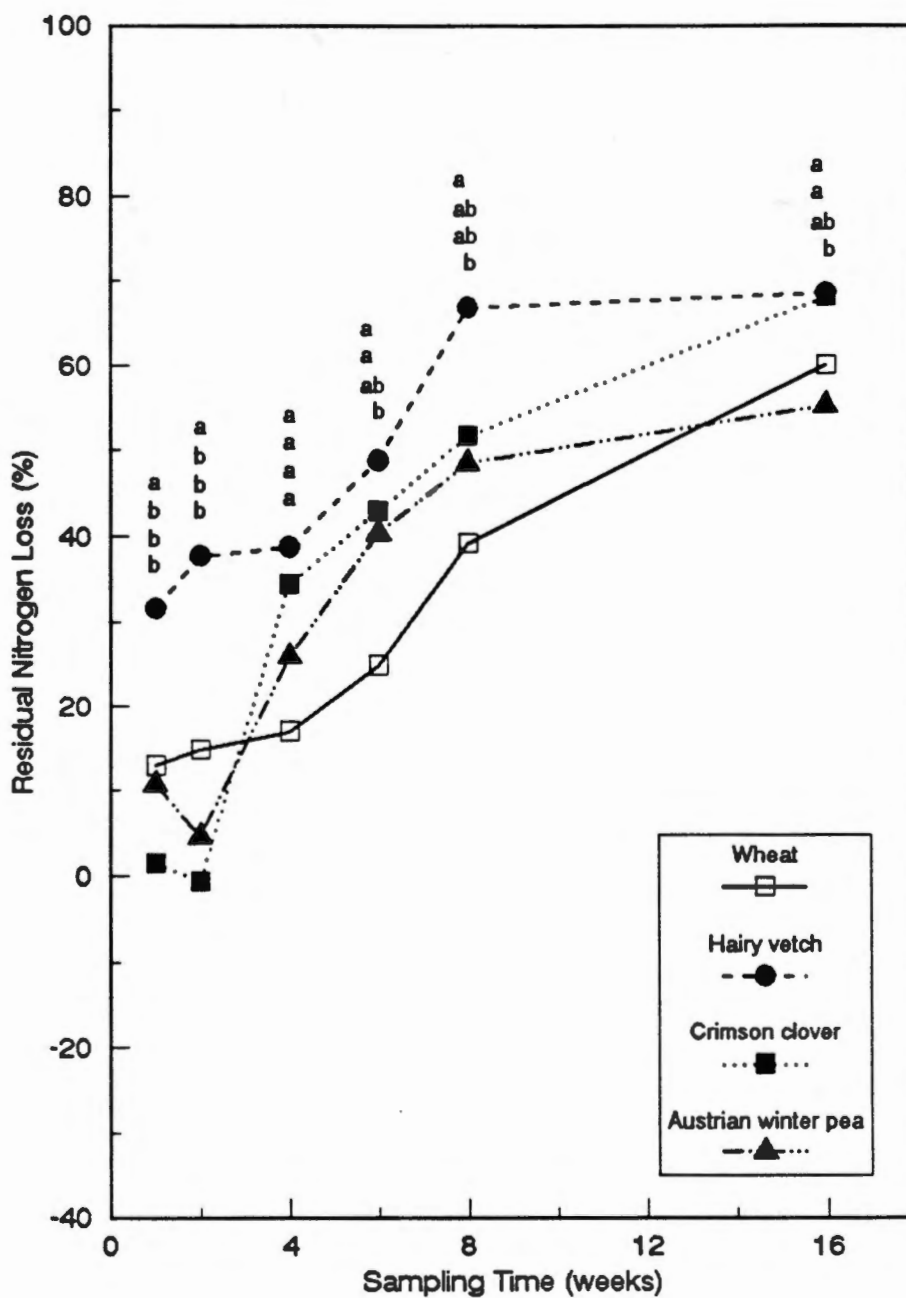


Figure 13. Residual nitrogen loss over time at 112 kg N ha⁻¹ rate of fertilizer in 1985.

losses decreased between 1 and 2 weeks after corn planting for Austrian winter pea and crimson clover which resulted from the N fertilizer which was placed in the nylon mesh bags.

Loss of N from residues varied among the cover crops at the 168 kg N ha⁻¹ rate (Figure 14). Legume residues exhibited rapid N loss up to 6 or 8 weeks after no-till corn planting. Wheat residues exhibited rapid N loss at 1 to 4 weeks. Between 4 and 6 weeks the residual N level of wheat residues increased, possibly due to immobilization of fertilizer N, but at 8 weeks values were reasonable. The rate of N loss slowed considerably for all residues after 8 weeks. At 6 weeks, residual N loss for hairy vetch was 59% and significantly greater than the other residues which averaged 28% N loss. There was no significant difference in N loss at 8 weeks among legume and wheat residues. At 16 weeks, the legumes had significantly higher N losses (68%) as compared to wheat (52%). Austrian winter pea and crimson clover had negative N loss values shortly after corn planting which may be a result of the N fertilizer added to the nylon mesh bags.

At 224 kg N fertilizer ha⁻¹, rapid rate of N loss occurred between 2 and 8 weeks for the legume residues (Figure 15). The rate of N loss was variable for wheat, but was rapid at 1 to 2 weeks and 6 to 8 weeks. Hairy vetch generally had greater N losses from 4 to 16 weeks

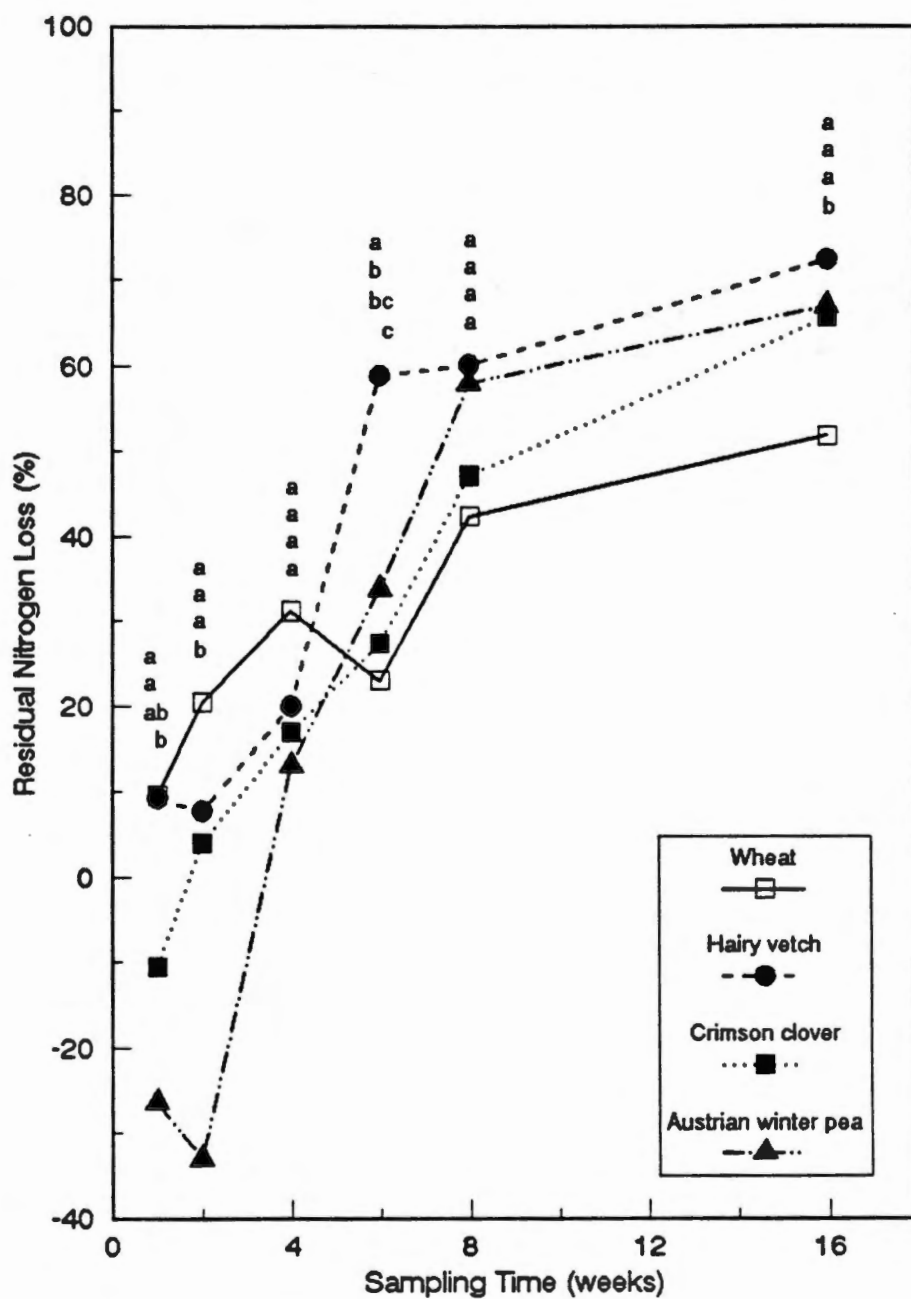


Figure 14. Residual nitrogen loss over time at 168 kg N ha⁻¹ rate of fertilizer in 1985.

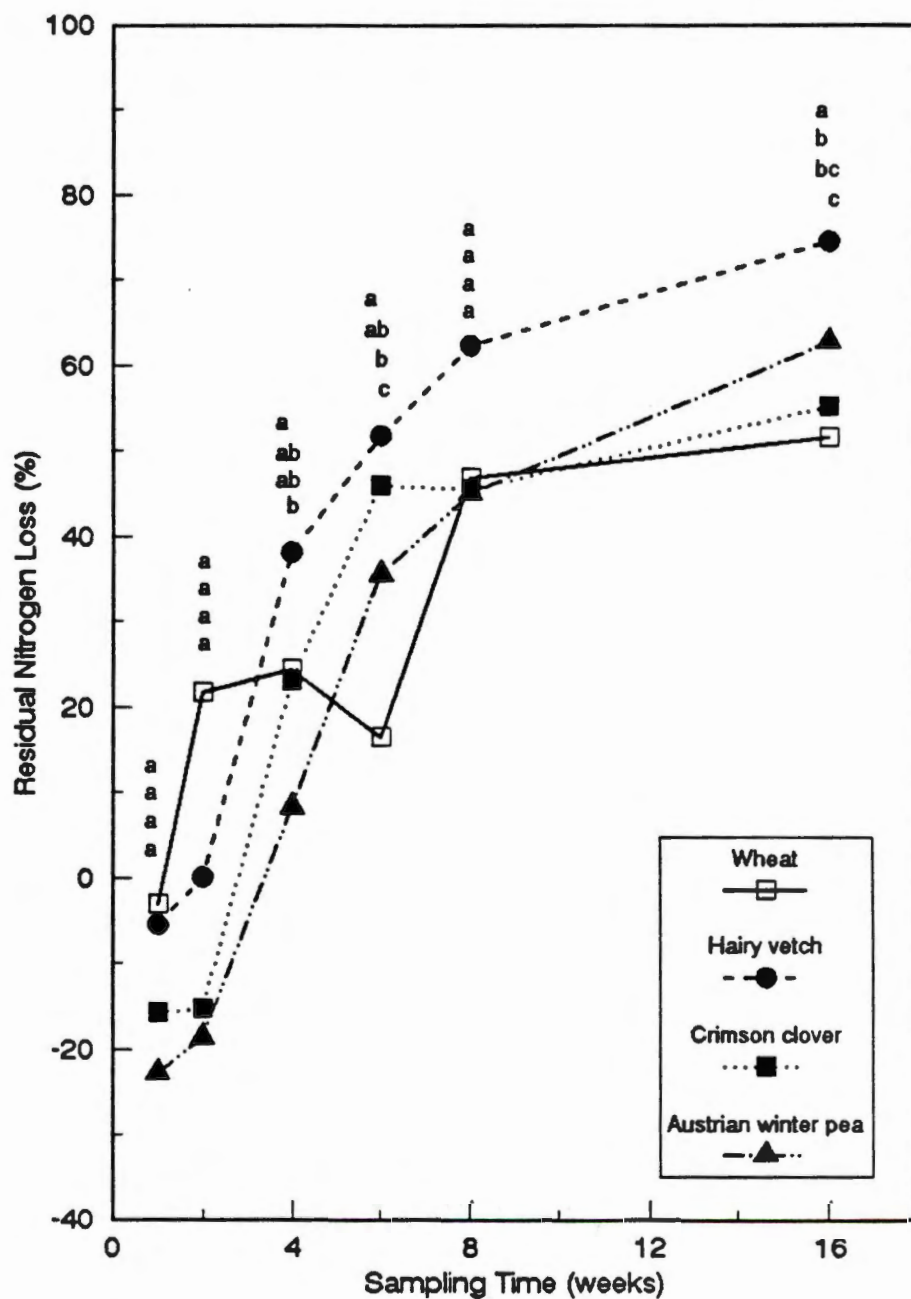


Figure 15. Residual nitrogen loss over time at 224 kg N ha⁻¹ rate of fertilizer in 1985.

compared to the other residues, but was significant only at 16 weeks after no-till corn planting. At 4 weeks, residual N losses for hairy vetch were similar to wheat and crimson clover, but significantly greater than Austrian winter pea. At 6 weeks, hairy vetch N losses (52%) were significantly greater than Austrian winter pea (37%) and wheat (17%), but similar to Crimson clover (46%). At 8 weeks, there were no significant differences in N losses among all cover crops. At 16 weeks, N released from hairy vetch residues was 75% and was significantly greater than the other residues which averaged about 57%. All cover crop residues had negative N losses at 1 or 2 weeks after planting corn which may be a result of the N fertilizer which was added to the bags. Wheat exhibited a gain in residual N between 4 and 6 weeks and this may be attributed to microbes immobilizing N from fertilizer.

Losses of N from residue in 1985 at 6 to 8 weeks after corn planting were rapid for all cover crops at the five N fertilizer rates. Hairy vetch residues generally had the greatest N loss over all N fertilizer rates as compared to the other cover crops. At 0 kg N fertilizer ha⁻¹, N loss from hairy vetch was significantly greater than the other residues between 4 and 16 weeks. At the 112, 168, and 224 kg N ha⁻¹ rates, the legume residues generally lost more residual N than wheat by the 16-week sampling date.

Sixteen weeks after corn planting there did not appear to be any influence from N fertilizer rates on total N loss from cover crop residues; N losses ranged from 55 to 75% loss for the legumes and 52 to 61% for wheat. As N fertilizer rates increased cover crop residues had greater negative values for N loss shortly after corn planting because of the N fertilizer which was placed in the nylon mesh bags.

Weight Loss from Winter Cover Crop Residues in 1986

In 1986, at all nitrogen rates, rapid weight losses comparable to those observed in 1985 between 1 and 8 weeks did not occur (Figures 16, 17, 18, 19, and 20). Few significant differences occurred in weight loss among all cover crops over the 16 week period at the 0, 56, and 112 kg N ha⁻¹ rates. At 1, 8, and 16 weeks, for the 0, 56 and 112 kg N ha⁻¹ rates, weight loss for residues averaged 18, 37, and 50%, respectively. However, at the 168 kg N ha⁻¹ rate of weight loss at 1 week was significantly greater for crimson clover (19%) than wheat (15%). Crimson clover had significantly greater weight loss than the other residues at 8 weeks. At 16 weeks, weight loss was significantly greater for hairy vetch (52%) than wheat (46%).

As shown in Figure 20, weight loss was significantly greater for crimson clover (21%) than for hairy vetch

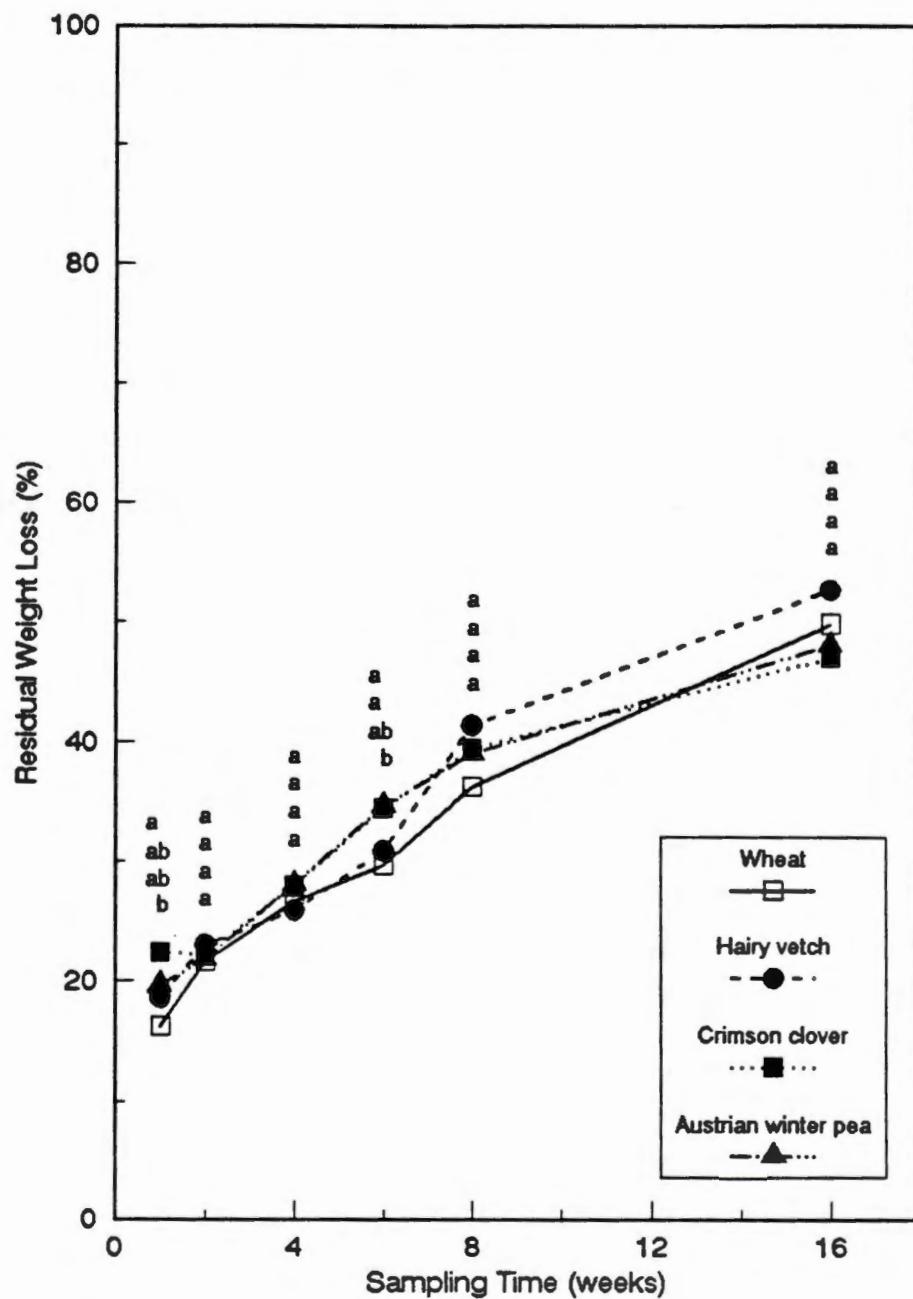


Figure 16. Residual weight loss over time at 0 kg N ha⁻¹ rate of fertilizer in 1986.

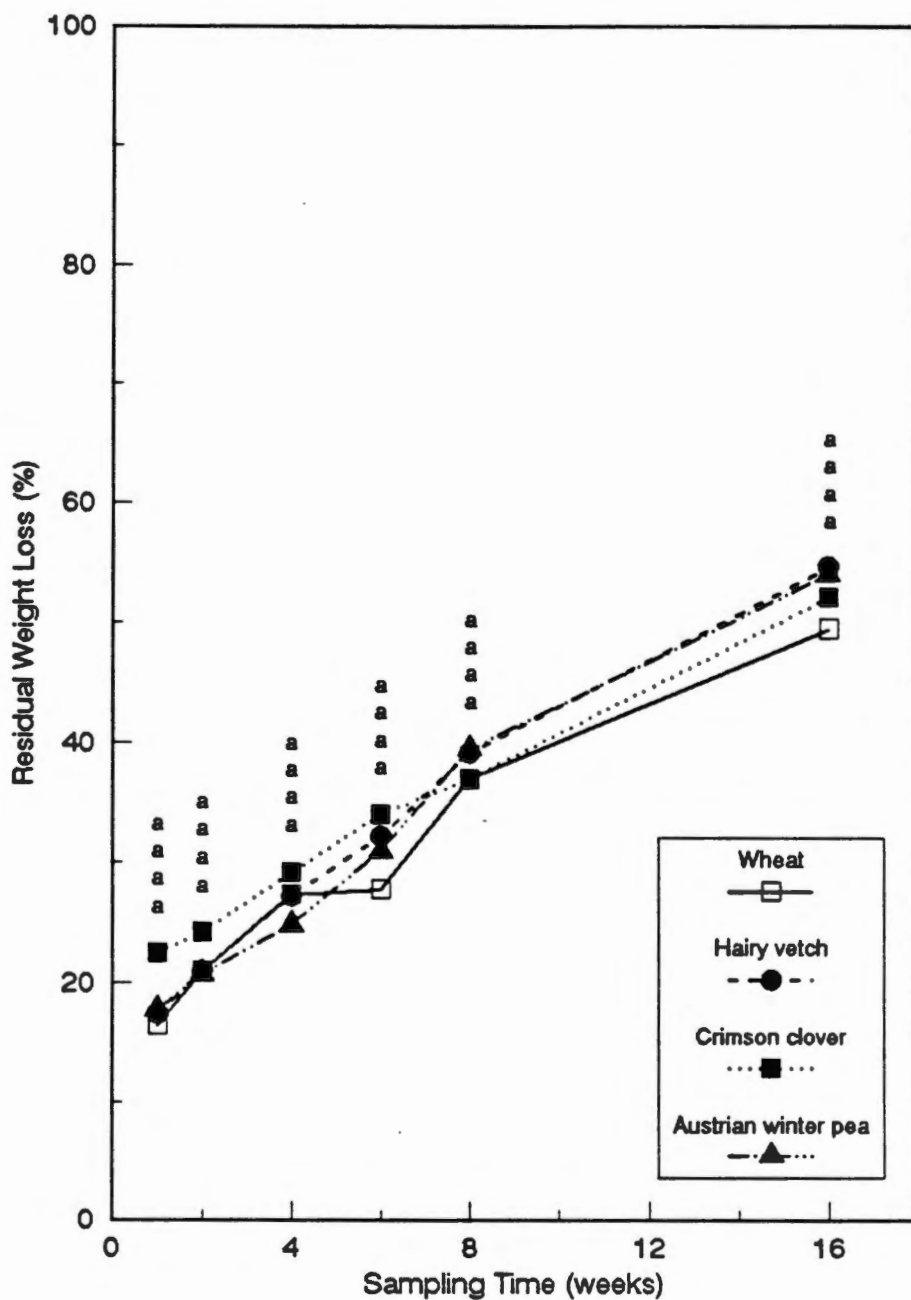


Figure 17. Residual weight loss over time at 56 kg N ha⁻¹ rate of fertilizer in 1986.

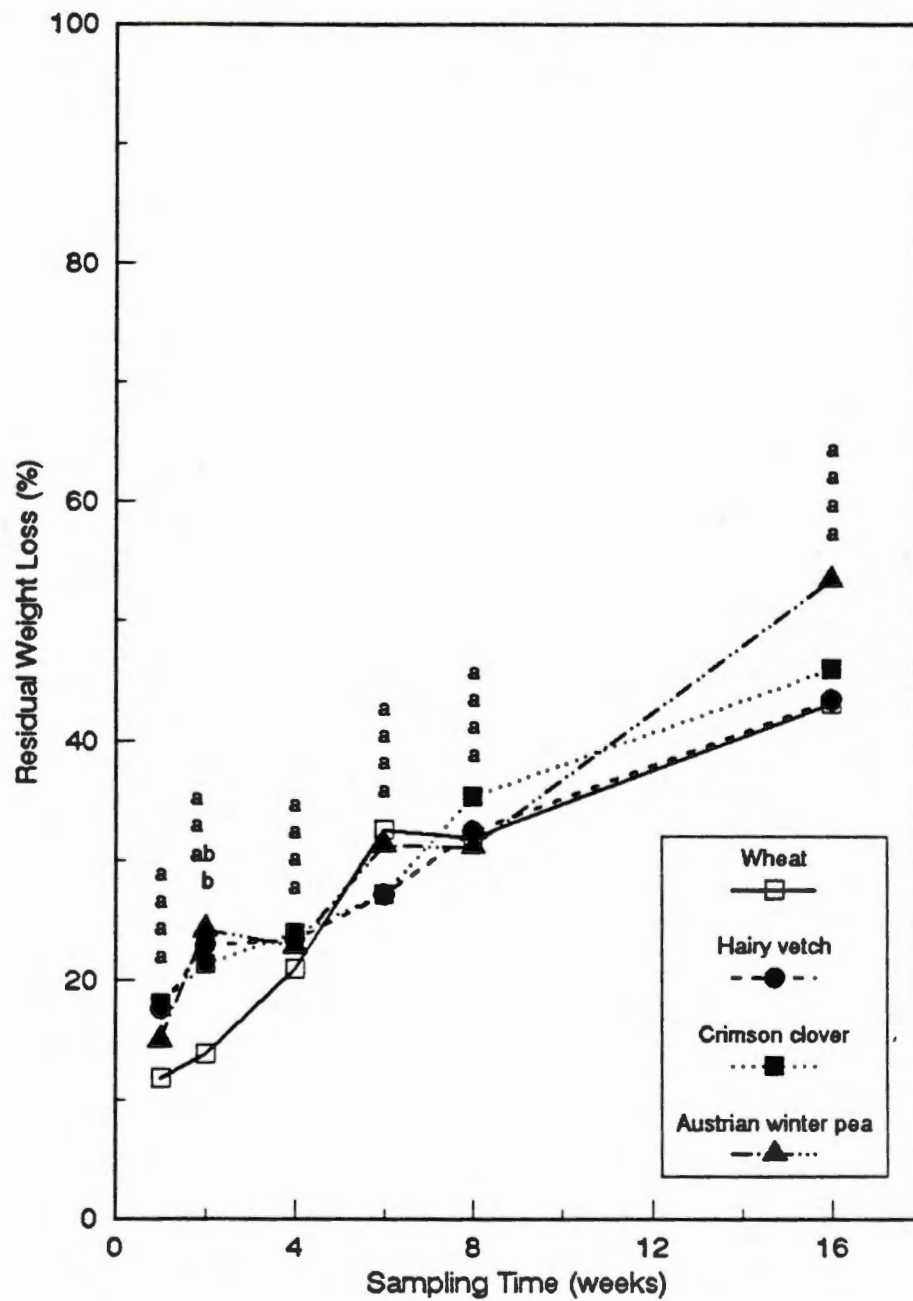


Figure 18. Residual weight loss over time at 112 kg N ha⁻¹ rate of fertilizer in 1986.

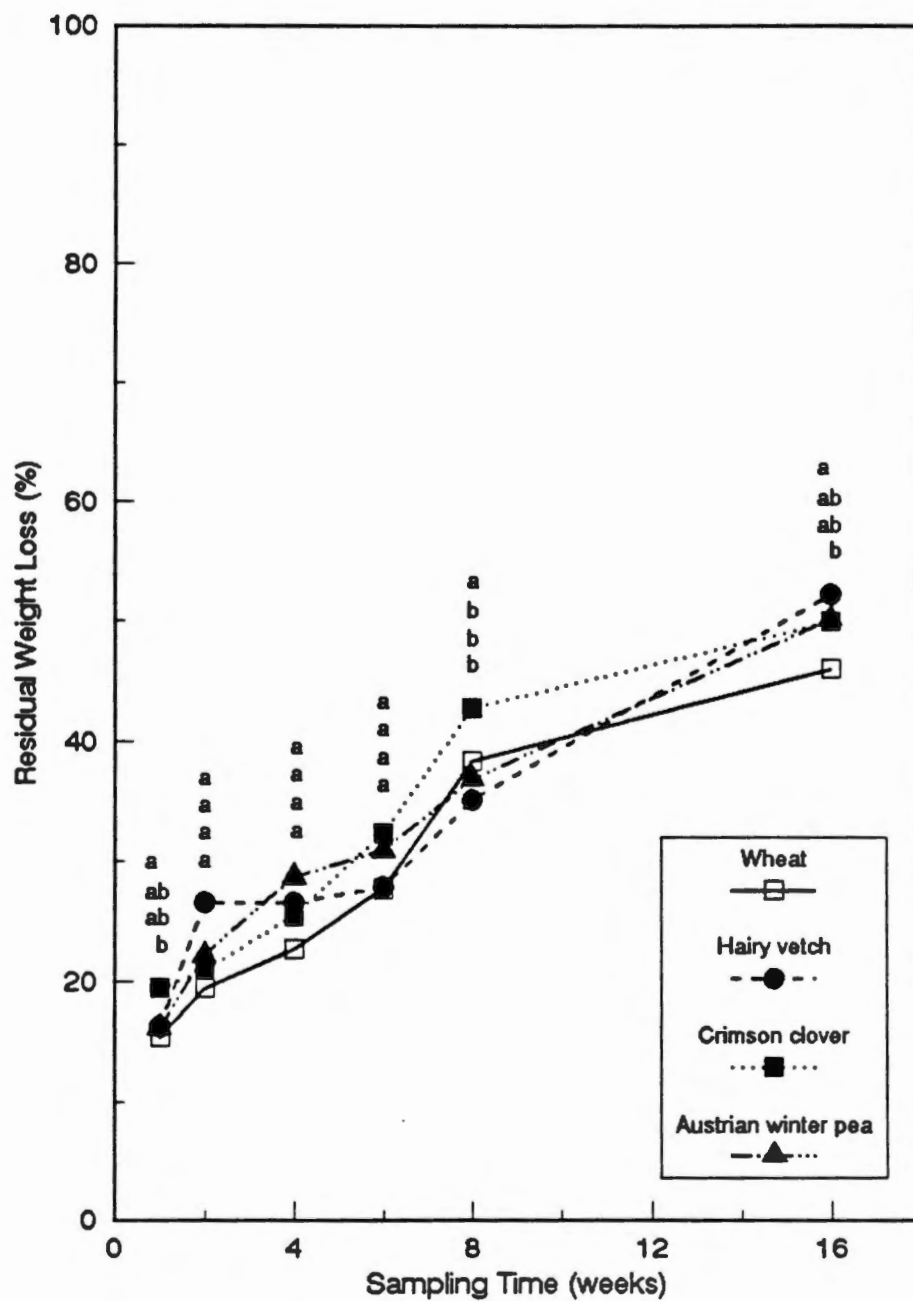


Figure 19. Residual weight loss over time at 168 kg N ha⁻¹ rate of fertilizer in 1986.

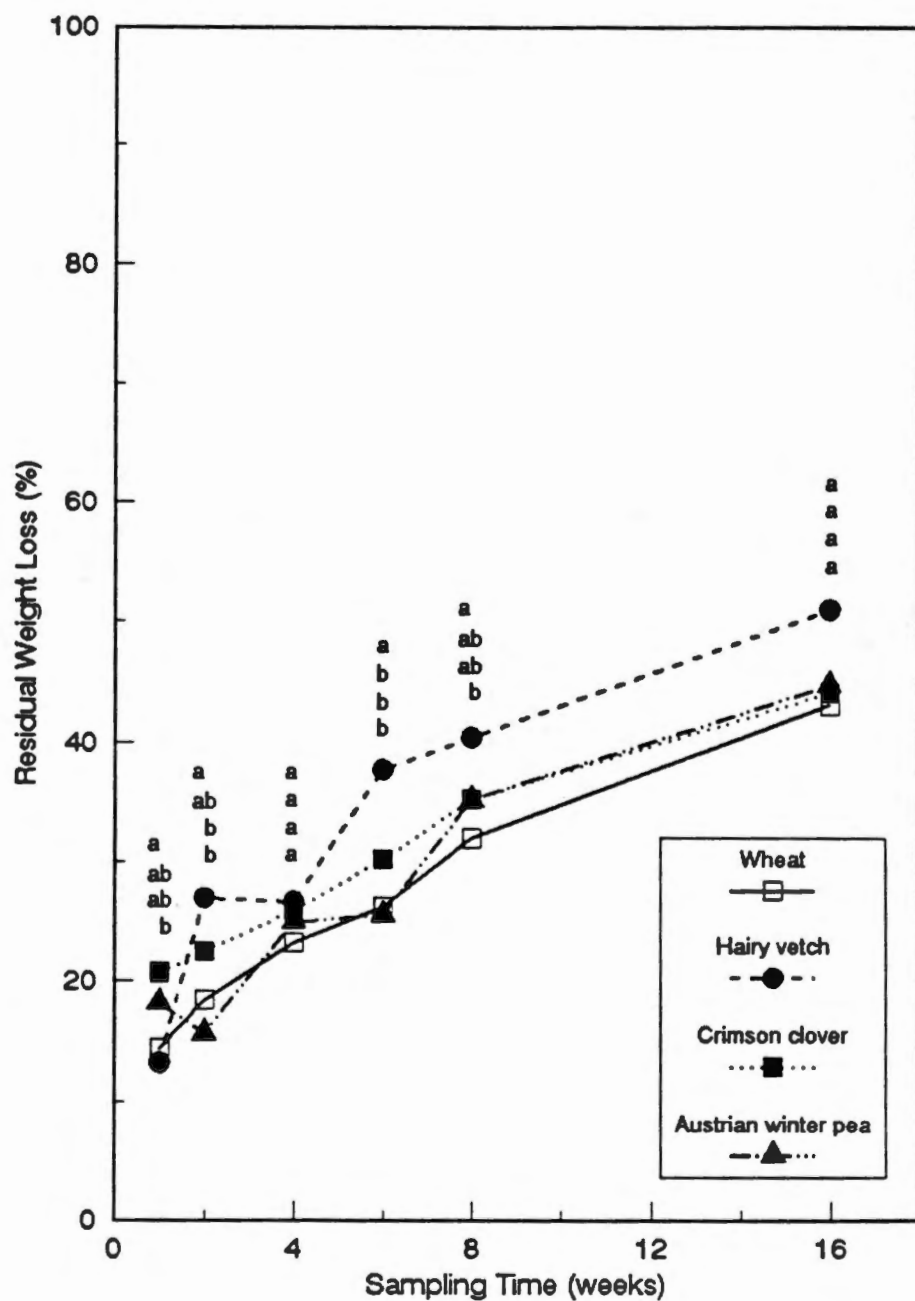


Figure 20. Residual weight loss over time at 224 kg N ha⁻¹ rate of fertilizer in 1986.

(13%), and similar to wheat and Austrian winter pea (16%) at the 224 kg N ha⁻¹ rate. At 2, 6, and 8 weeks, hairy vetch had greater weight loss than wheat residues. Weight loss at 16 weeks was not significantly different among residues and averaged 46%. Over time, the rate and amount of decomposition was similar for all residues, although hairy vetch had greater weight losses from 2 to 16 weeks.

In 1986 weight loss was similar for all residues over the 16 week sampling period across all N rates. The rate and amount of decomposition as determined by weight loss was not influenced by N fertilization.

Carbon Loss from Winter Cover Crop Residues in 1986

Loss of carbon from all cover crop residues at the 0, 56, 112, and 168 kg N ha⁻¹ rates occurred at similar rates over the 16 week period following no-till corn planting (Figures 21, 22, 23, and 24). However, at the 224 kg N ha⁻¹ rate, hairy vetch exhibited a rapid C loss which occurred at 1 to 2 weeks and 4 to 6 weeks after planting (Figure 25). There were no significant differences in C loss among the cover crop residues up to 8 weeks after corn planting at the 0, 56, and 112 kg N ha⁻¹ rates (Figures 21, 22, and 23). At the 0 kg N ha⁻¹ rate, the C loss from hairy vetch residue at 16 weeks (52%) was significantly greater than Austrian winter pea and crimson clover (46%) (Figure 21). At the 56 kg N ha⁻¹ rate C loss

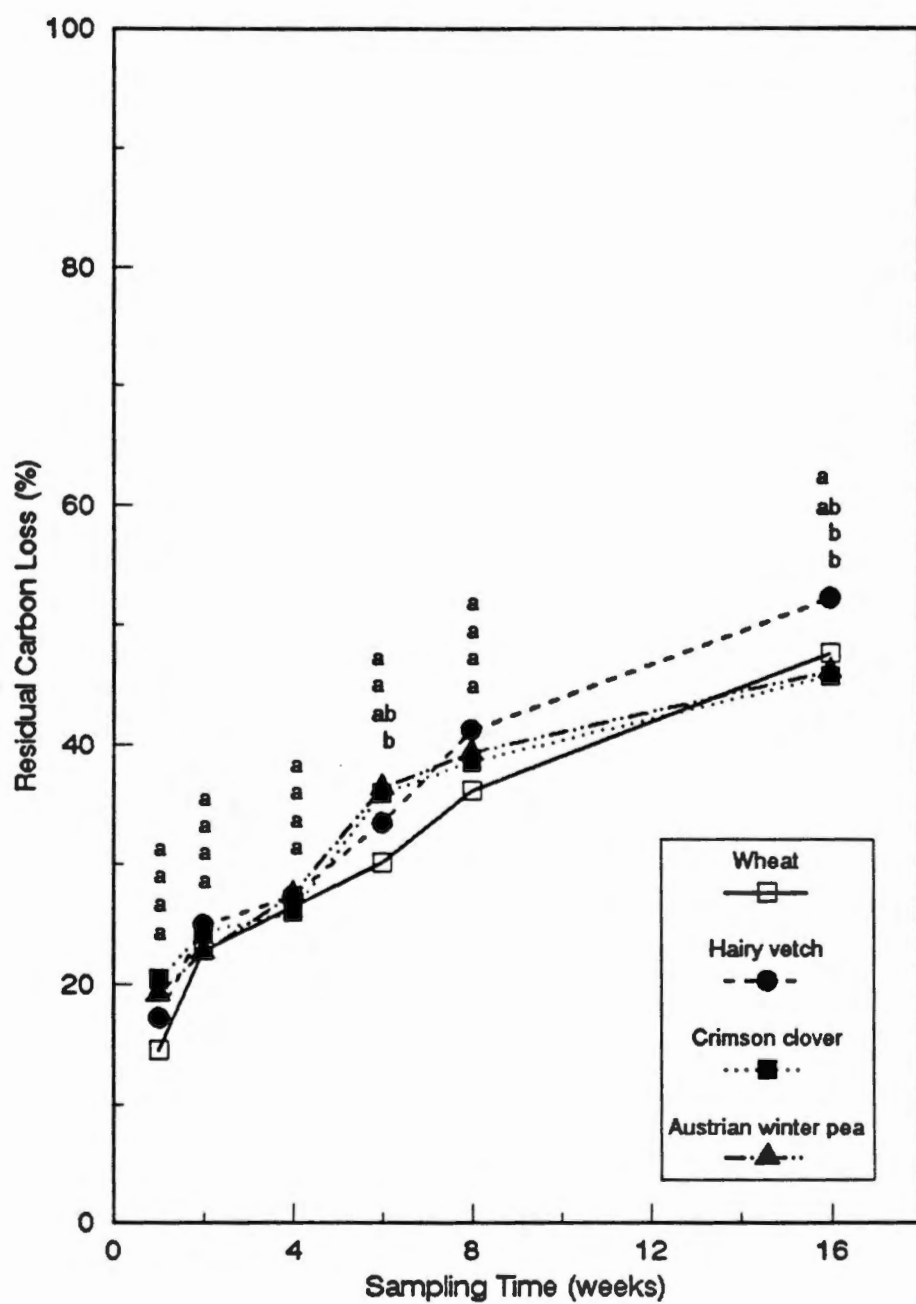


Figure 21. Residual carbon loss over time at 0 kg N ha⁻¹ rate of fertilizer in 1986.

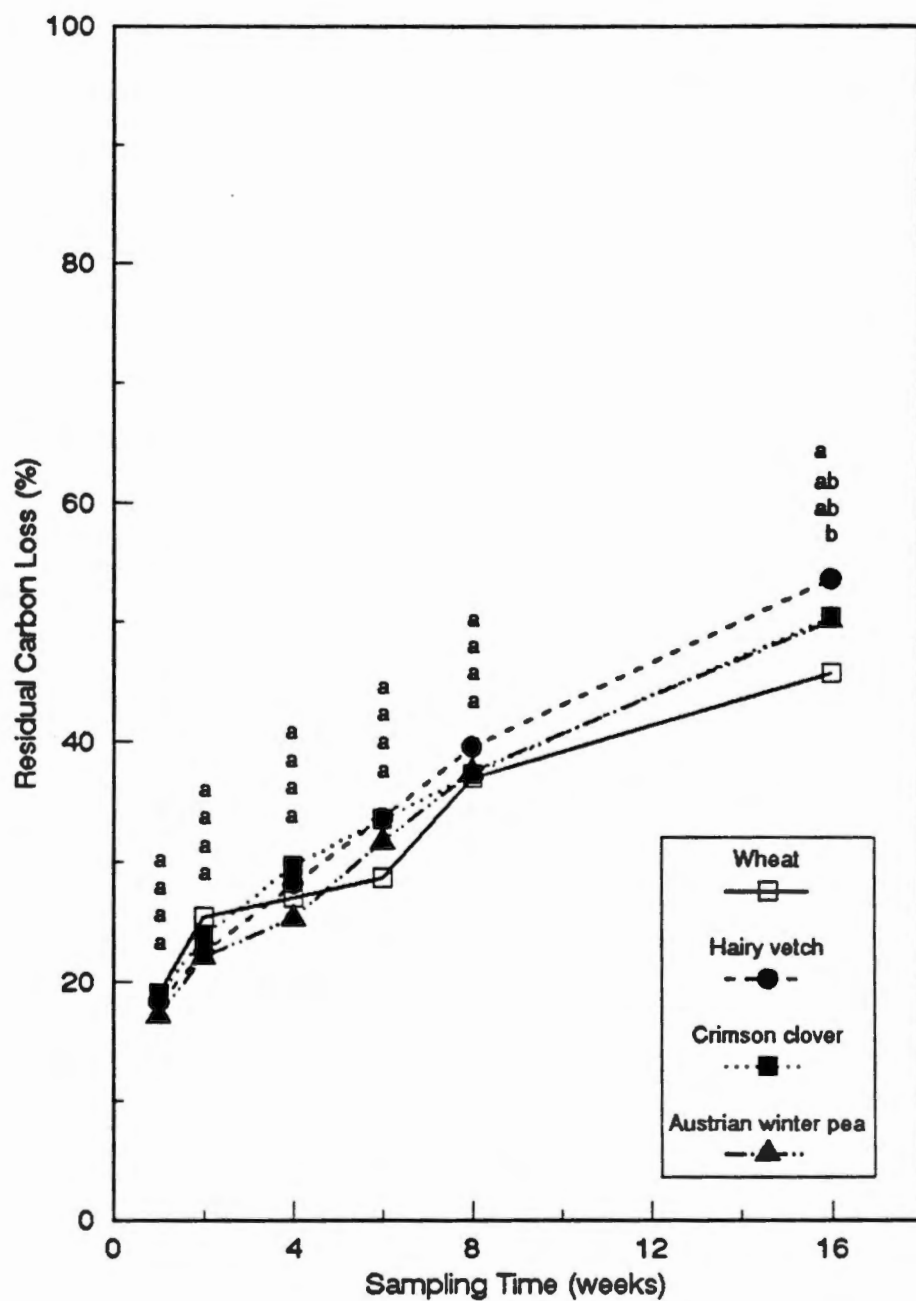


Figure 22. Residual carbon loss over time at 56 kg N ha⁻¹ rate of fertilizer in 1986.

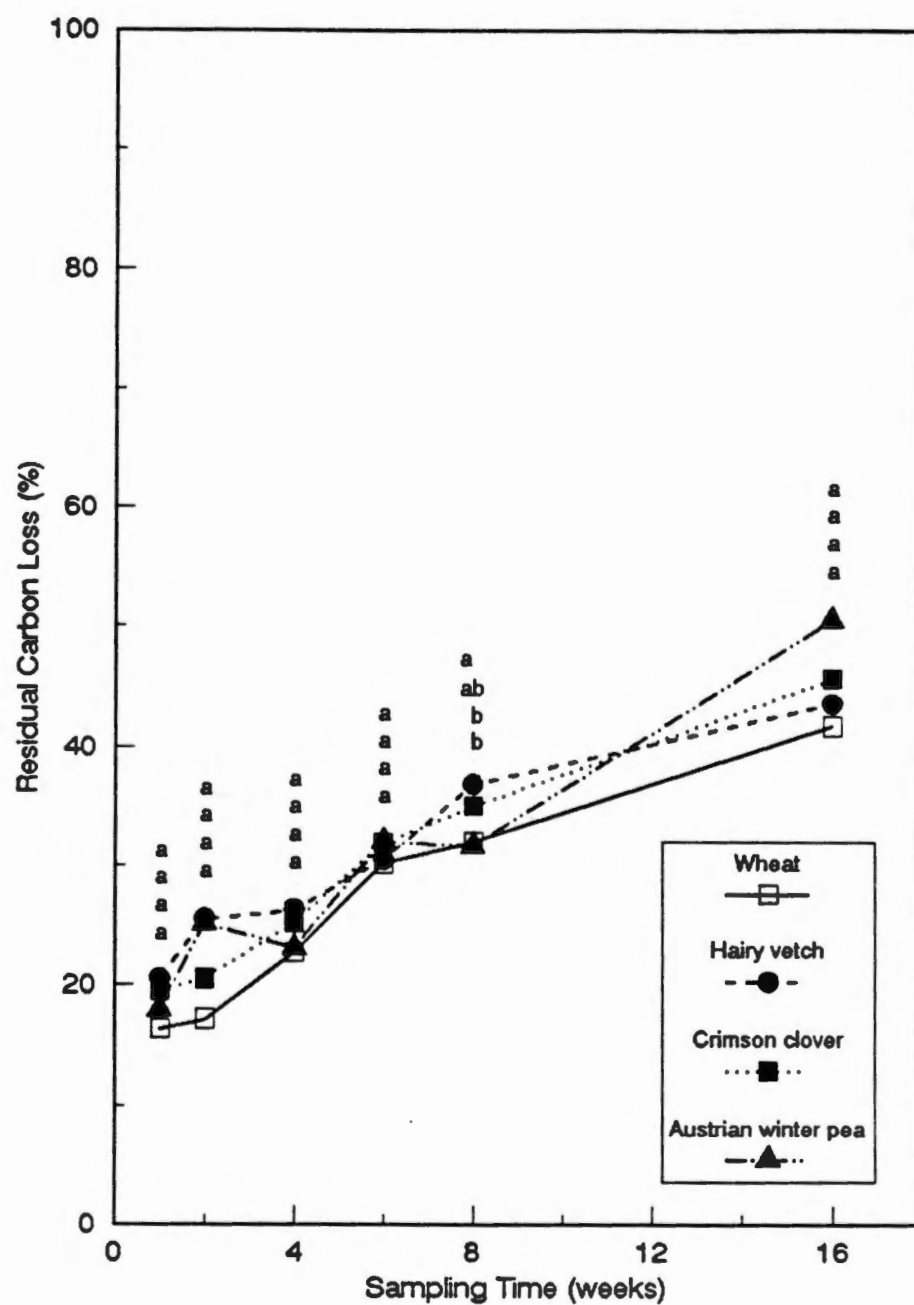


Figure 23. Residual carbon loss over time at 112 kg N ha⁻¹ rate of fertilizer in 1986.

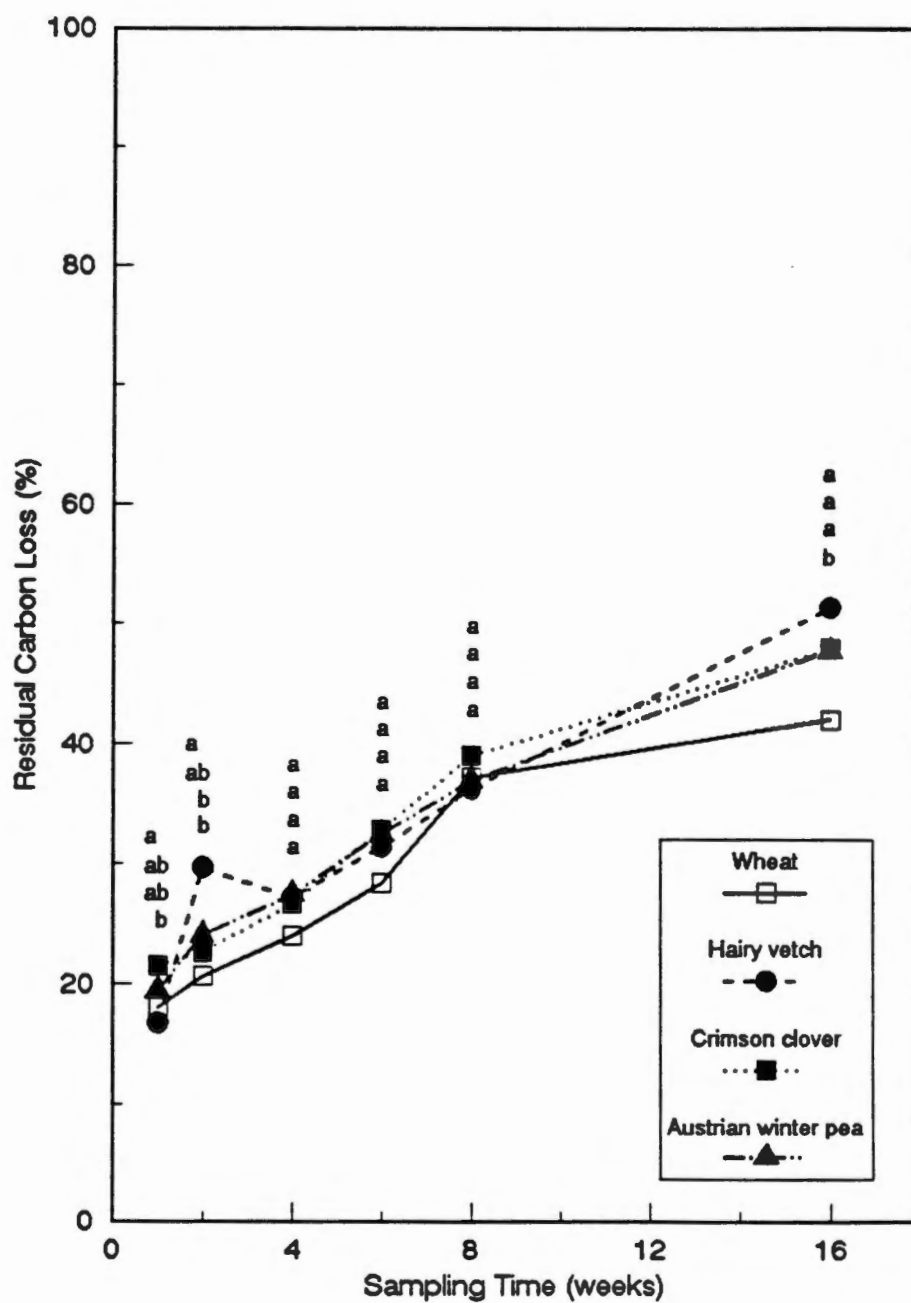


Figure 24. Residual carbon loss over time at 168 kg N ha⁻¹ rate of fertilizer in 1986.

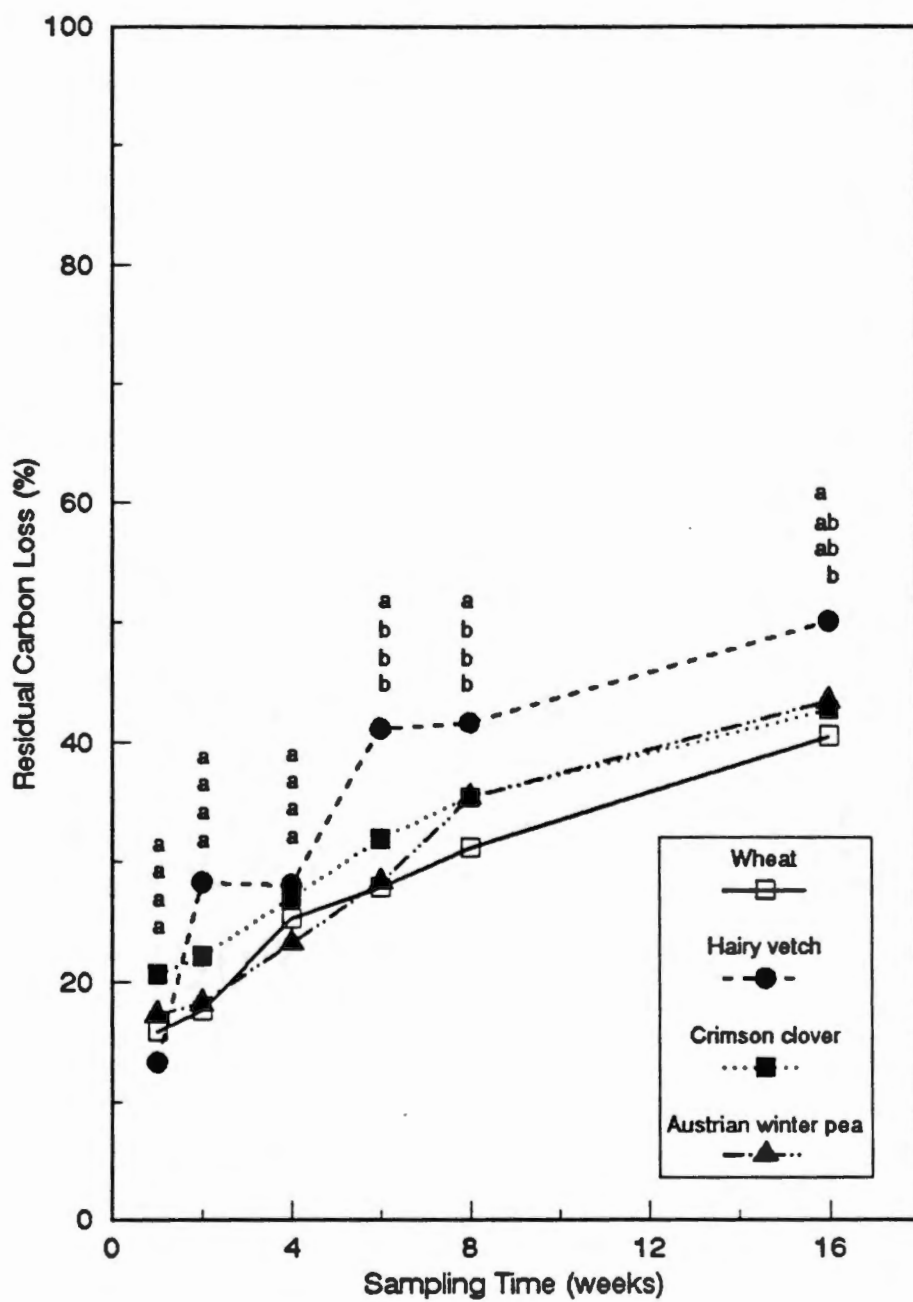


Figure 25. Residual carbon loss over time at 224 kg N ha⁻¹ rate of fertilizer in 1986.

from hairy vetch (54%) at 16 weeks was greater than wheat (46%), but similar to the other legumes at 16 weeks (Figure 22).

For the 112 kg N ha⁻¹ rate at 8 weeks, hairy vetch C loss was significantly greater than that of wheat and Austrian winter pea, but it was similar to crimson clover (Figure 23). Figure 24 shows that at 16 weeks legume residues had a significantly higher residual C loss than wheat at the 168 kg N ha⁻¹ rate.

At the 224 kg N ha⁻¹ rate C loss was similar for all covers up to 4 weeks (Figure 25). At 6 and 8 weeks, C loss was significantly greater for hairy vetch as compared to the other legumes and wheat. At 16 weeks, C loss was similar for the legumes, while hairy vetch had a significantly greater C loss than wheat.

For 1986, C loss from hairy vetch was usually greater than the other residues at all N fertilizer rates, but this difference was significant in only a few cases. At 16 weeks, hairy vetch had a significantly greater loss of residual C than wheat, except where 0 and 112 kg N fertilizer ha⁻¹ was applied. Nitrogen fertilizer did not appear to have an influence on total C loss for any of the cover crop residues. Average carbon loss ranged from approximately 18% at 1 week to 41 to 54% after 16 weeks at the five N fertilizer rates. In contrast to 1985, all cover crop residues decomposed at a more uniform rate over

time. In 1985 a two-phase decomposition rate of 1 to 8 versus 8 to 16 weeks was present.

Nitrogen Loss from Winter Cover Crop Residues in 1986

In 1986 where 0 kg ha⁻¹ N fertilizer was applied, the rate of N loss was erratic from crop residues between 1 and 4 weeks following no-till corn planting (Figure 26). Nitrogen loss was similar for cover crop residues up to 4 weeks. Rapid N loss generally occurred up to 6 to 8 weeks for all residues. At 8 weeks, hairy vetch residues had lost 65% of the initial N, while the other covers averaged about 40% residual N loss. Nitrogen loss slowed considerably for all residues between 8 and 16 weeks. From 6 to 16 weeks, residual N loss was generally greater for hairy vetch than the other residues. Nitrogen loss for wheat, crimson clover, and Austrian winter pea were similar from 6 to 16 weeks. At 16 weeks, N losses for hairy vetch and the other residues averaged 72% and 55%, respectively. At 2 weeks, Crimson clover had a small and unexplainable gain in measured N in the nylon bag.

As shown in Figure 27, a rapid rate of residual N loss for cover crop residues generally occurred between 4 and 8 weeks after corn planting at 56 kg N ha⁻¹. The rate of N loss was slower for residues up to 4 weeks and after 8 weeks. At 8 weeks, N loss for hairy vetch was 54%, while the other residues averaged 37% N loss. Wheat

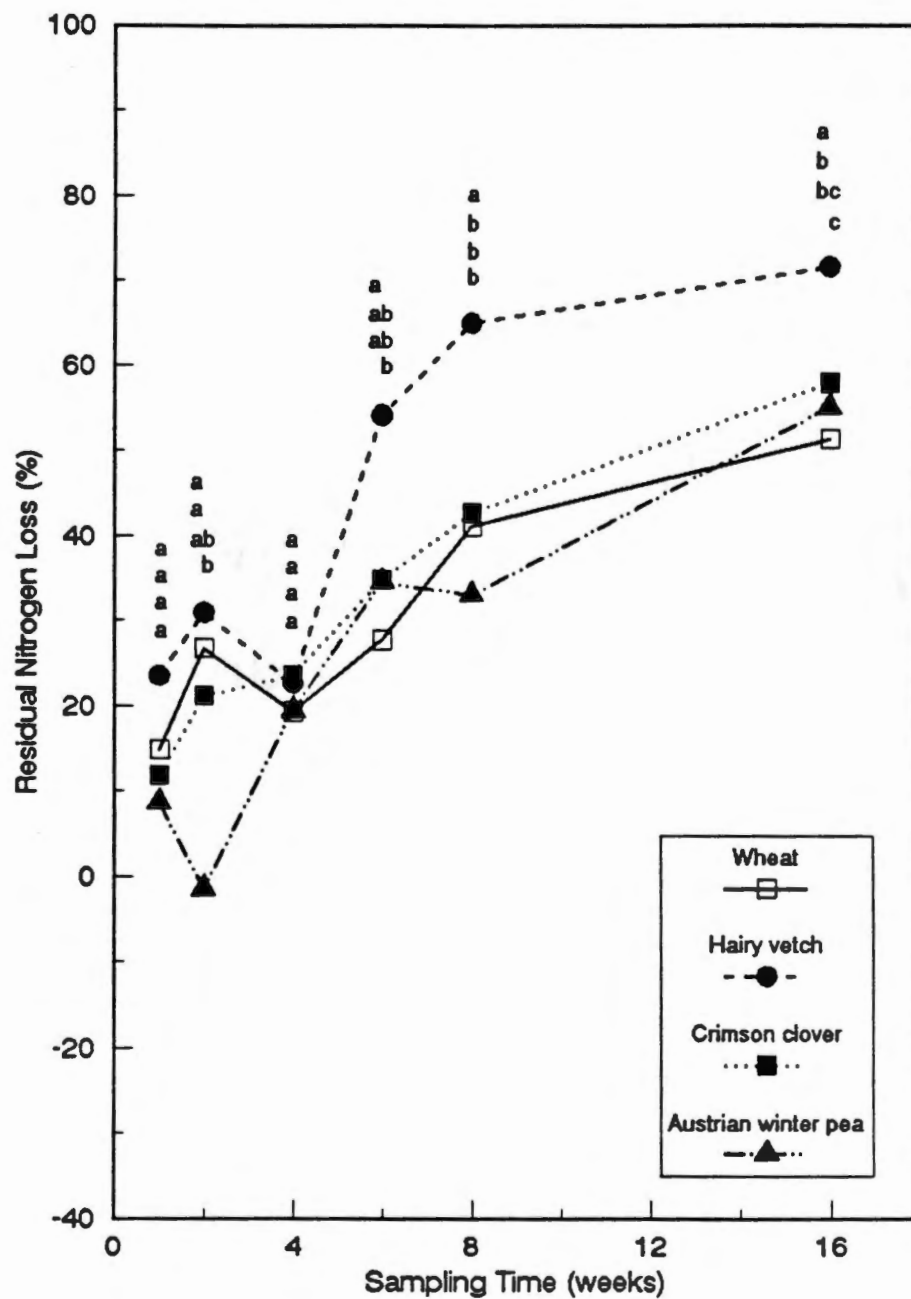


Figure 26. Residual nitrogen loss over time at 0 kg N ha⁻¹ rate of fertilizer in 1986.

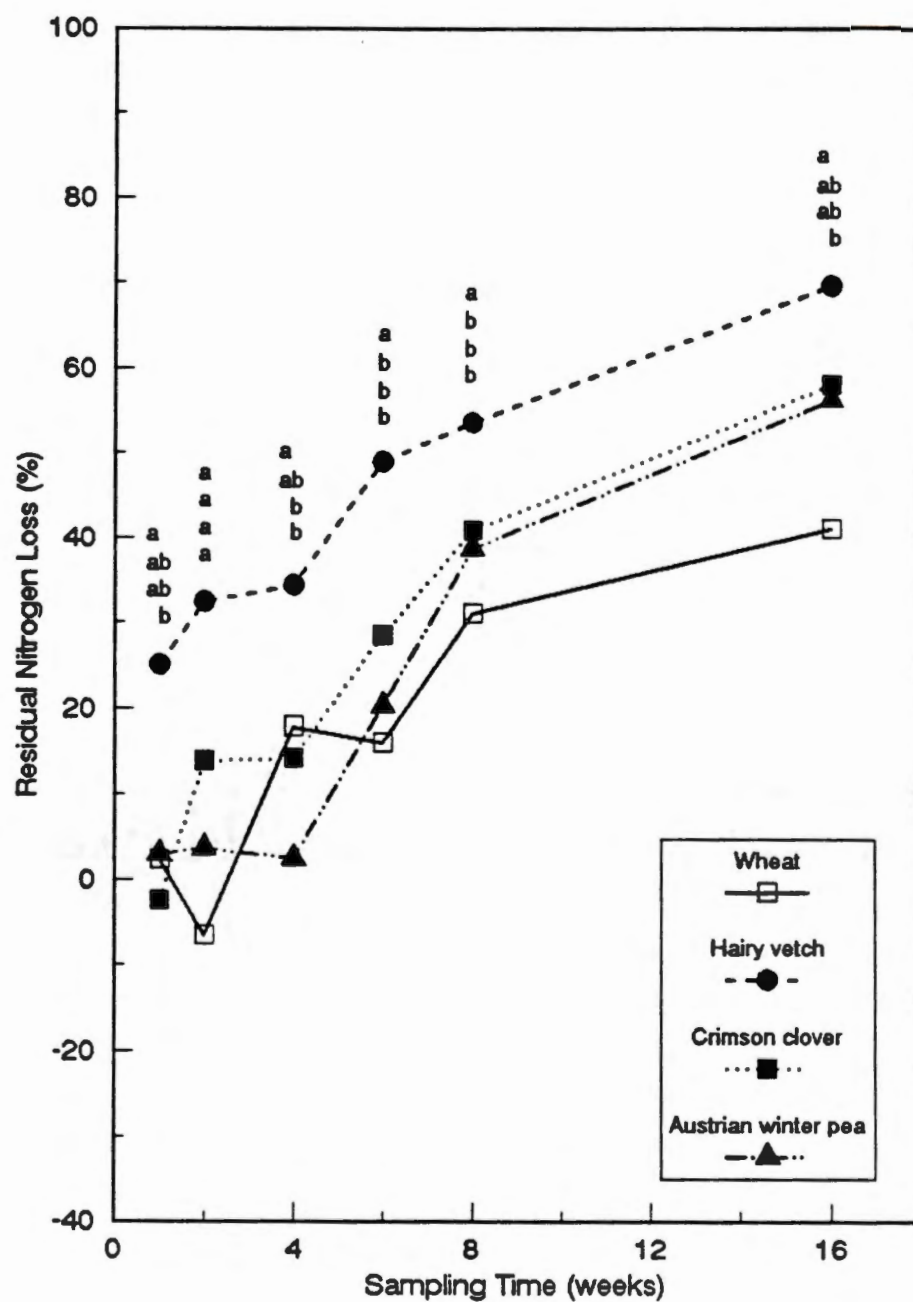


Figure 27. Residual nitrogen loss over time at 56 kg N ha⁻¹ rate of fertilizer in 1986.

showed erratic N loss up to 6 weeks. The loss of N was generally greater for hairy vetch over 16 weeks than for the other residues; Austrian winter pea, crimson clover, and wheat generally had similar N losses over time. After 16 weeks, N loss of hairy vetch residues at 70% was significantly greater than wheat (41%) but not significantly different from crimson clover and Austrian winter pea (57%). At early sampling dates, some cover crop residues showed gains in residual N which may be the result of the N fertilizer that was added to the nylon bags.

At 112 kg N fertilizer ha⁻¹ the rate of N loss for wheat, Austrian winter pea, and crimson clover residues was slow up to 4 weeks but was rapid between 4 and 8 weeks after no-till corn planting (Figure 28). Hairy vetch showed a rapid loss of N at 1 to 2 weeks and 6 to 8 weeks. At 4 weeks N losses for hairy vetch and the other residues were 45% and 2%, respectively. After 8 weeks hairy vetch N loss was 59%, while the other residues averaged 28%. Over the 16 week period, residual N loss for hairy vetch was significantly greater than for the other residues. Austrian winter pea, crimson clover, and wheat residues had similar N losses up to 8 weeks. At 16 weeks, residual N loss was hairy vetch (65%) > crimson clover and Austrian winter pea (54%) > wheat (34%). At early sampling dates, some residues had increases in total N content which may

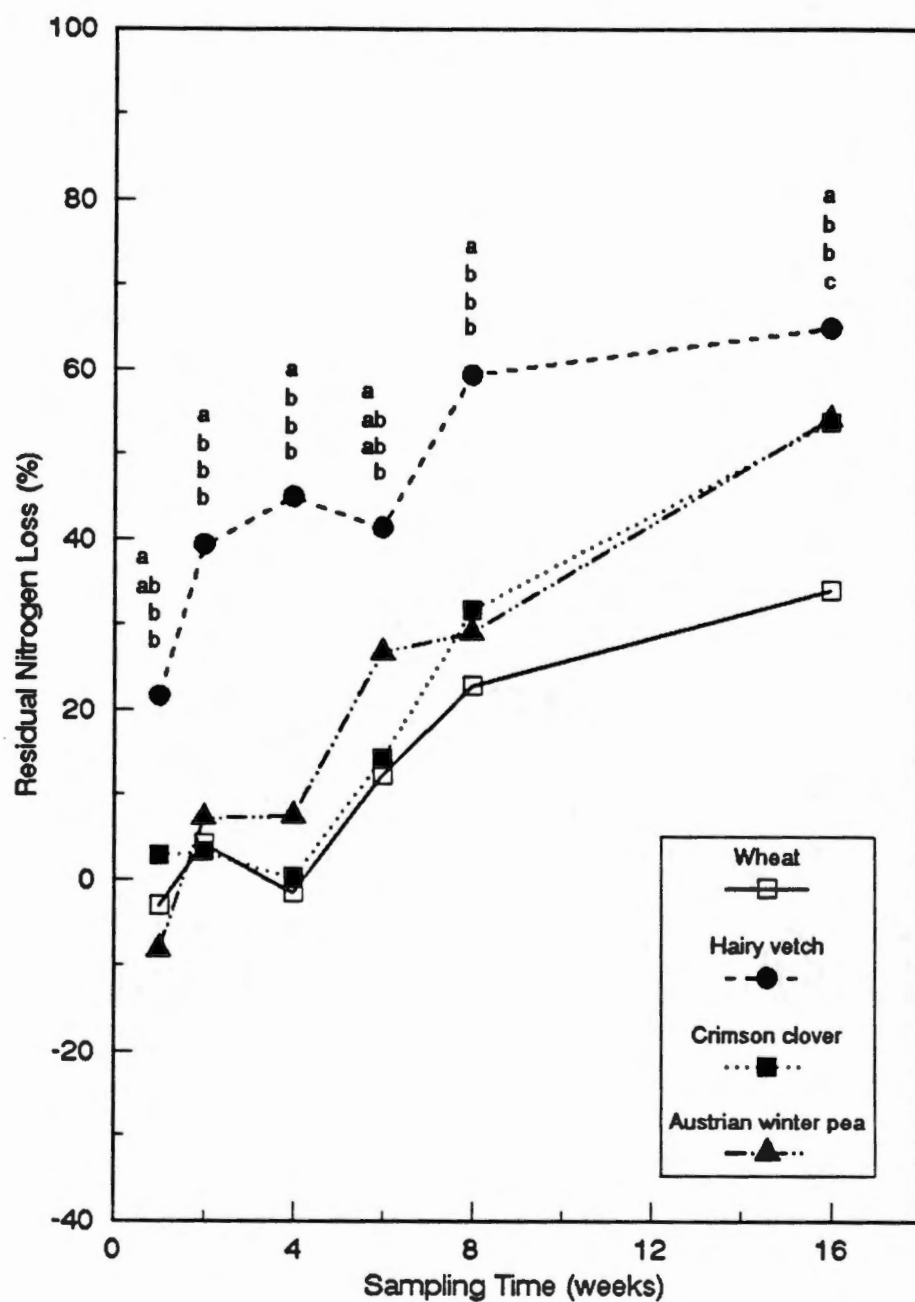


Figure 28. Residual nitrogen loss over time at 112 kg N ha⁻¹ rate of fertilizer in 1986.

have resulted from the N fertilizer added to the nylon bags.

Hairy vetch had a rapid rate of residual N loss from 1 to 2 weeks after planting no-till corn at 168 kg N fertilizer ha⁻¹ (Figure 29). A slower, steady rate of N loss occurred from 4 to 16 weeks. Rapid N loss for Austrian winter pea, crimson clover, and wheat generally occurred between 2 and 8 weeks. At 2 weeks hairy vetch residue had lost 42% of its initial N. Crimson clover residue lost 37% and wheat and Austrian winter pea lost 27% of initial N after 8 weeks. At 1, 2, 4, and 16 weeks, N loss was significantly greater for hairy vetch than the other residues. After 16 weeks, residual N loss was hairy vetch (67%) > Austrian winter pea and crimson clover (52%) > wheat (37%). Some residues showed gains in residual N at 1 to 4 weeks which may be the result of N fertilizer that was added to the nylon bags.

At 224 kg N fertilizer ha⁻¹ a rapid rate of residue N loss for hairy vetch occurred at 1 to 2 weeks and 4 to 6 weeks after no-till corn planting (Figure 30). Austrian winter pea, crimson clover, and wheat had a rapid N loss between 2 and 8 weeks. Hairy vetch residues lost 34% and 56% of initial N at 2 and 6 weeks, respectively. The other residues had an increase in initial N of 20% at 2 weeks and had lost 23% of initial N at 8 weeks. Residue N loss for hairy vetch was significantly greater than the

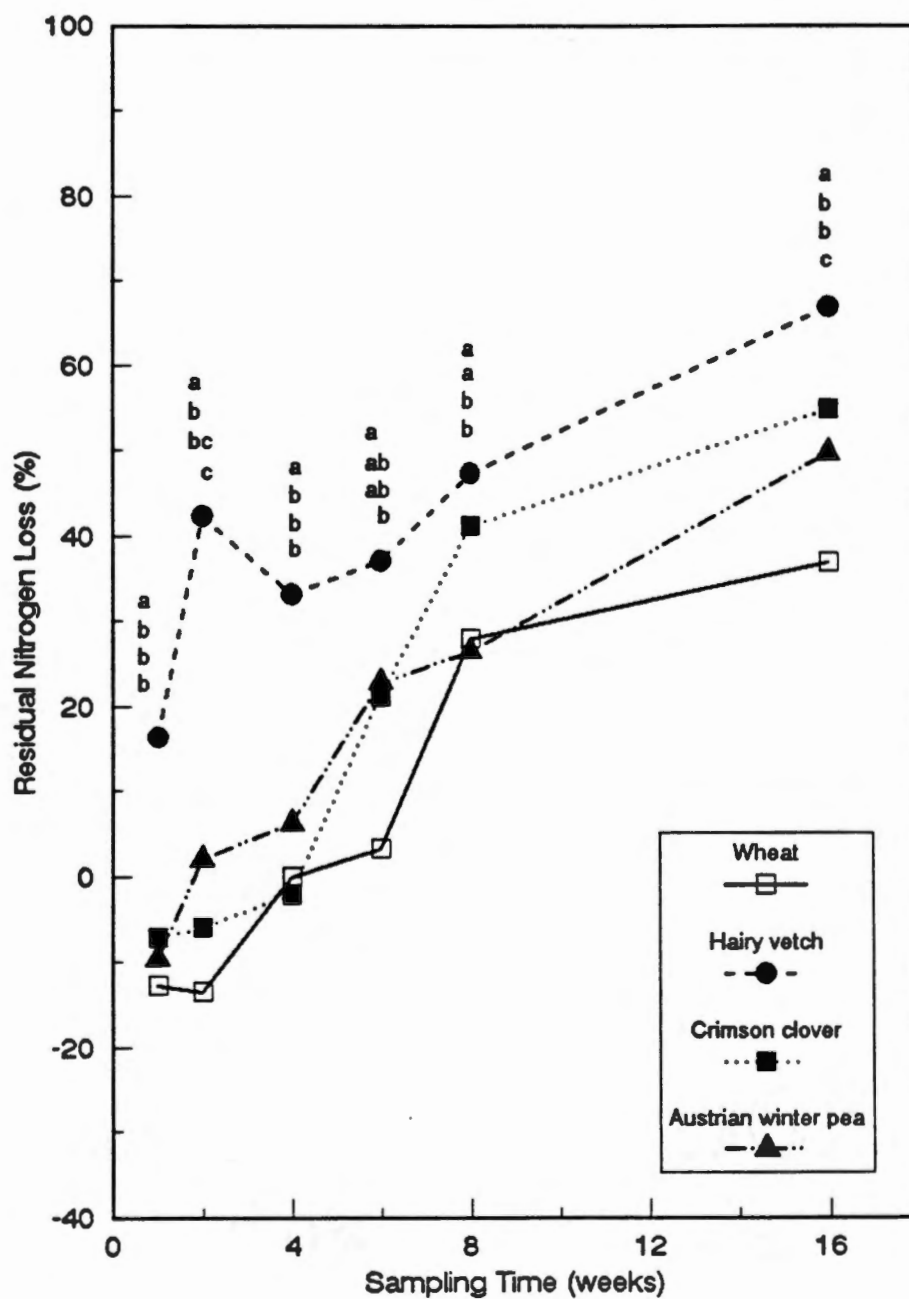


Figure 29. Residual nitrogen loss over time at 168 kg N ha⁻¹ rate of fertilizer in 1986.

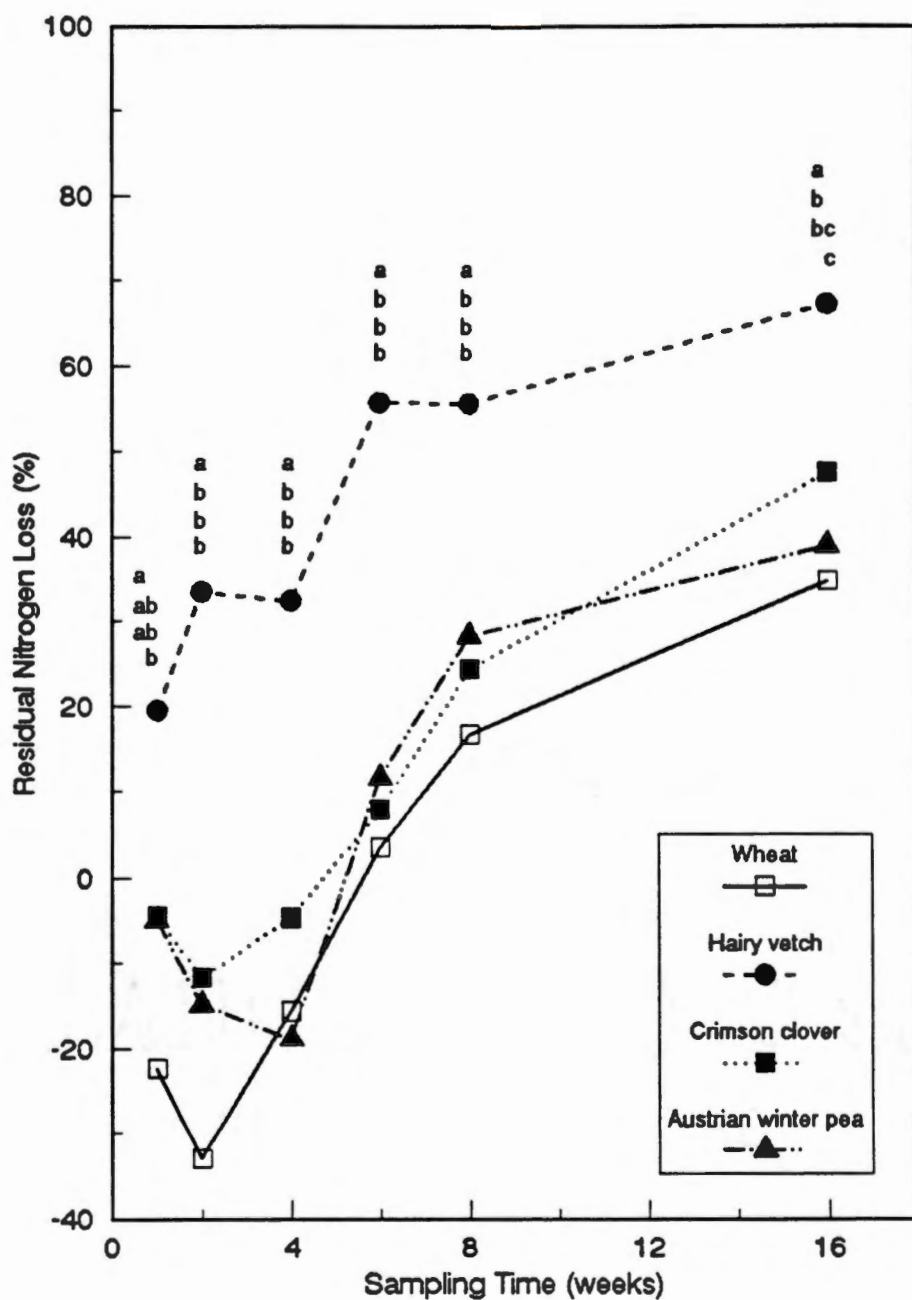


Figure 30. Residual nitrogen loss over time at 224 kg N ha⁻¹ rate of fertilizer in 1986.

other residues over 16 weeks. Austrian winter pea, crimson clover, and wheat had similar N losses over time. At 16 weeks, hairy vetch residues lost 67% of initial N, while the other residues lost an average of 41% N. Austrian winter pea, crimson clover, and wheat had gains in residual N up to 4 weeks, which may have resulted when N fertilizer was added to the nylon bags. Hairy vetch did not have appreciable gains in residual N, but rather a 20% N loss at 1 week. Hairy vetch residues may decompose faster than the other residues, thereby releasing residual N rapidly.

In 1986 N loss from hairy vetch residues occurred from 1 to 2 weeks after planting, then slowed from 2 to 4 weeks at all five N fertilizer rates. A rapid rate of N loss followed between 4 and 8 weeks with a slower but steady loss up to 16 weeks. Austrian winter pea, crimson clover, and wheat generally had slow release of residual N between 1 and 4 weeks after planting. Hairy vetch residues generally had greater N losses when compared to the other residues over the 16 week sampling period. Austrian winter pea, crimson clover, and wheat had similar N losses over time at all five fertilizer rates. Sixteen weeks after corn planting, hairy vetch had significantly greater N losses than the other residues at all N rates, except at 56 kg N ha⁻¹ where the other legume residues were similar. Hairy vetch N losses averaged 68% after 16

weeks over all N fertilizer rates. Wheat residues had significantly lower N losses than the other residues after 16 weeks at 112 and 168 kg N ha⁻¹. At 16 weeks across all N fertilizer rates, wheat averaged 40% N loss. Austrian winter pea and crimson clover residues had similar N losses over time at all N fertilizer rates and averaged 52% N loss after 16 weeks. As N fertilizer rates increased cover crop residues often had gains in residual N during the early sampling periods and this may be attributed to N fertilizer that was added to the nylon bags. Hairy vetch residues did not exhibit gains in residual N even at high N fertilizer rates which may be a result of its rapid decomposition and corresponding release of residual N.

Estimating Nitrogen Contributions of Cover Crops from Yield Response Curves in 1985

The nitrogen contributed by a legume cover crop may be estimated by comparing yield response curves at various N fertilizer rates with and without a legume (Tyler et al., 1987; Neely et al., 1987; Hargrove, 1986).

Figure 31 shows no-till corn yields from no cover treatments compared to corn planted in wheat and hairy vetch cover crop residues. Regression equations having R² values of 0.97, 0.99, and 0.98 for no cover, wheat, and hairy vetch, respectively, were used to derive yield

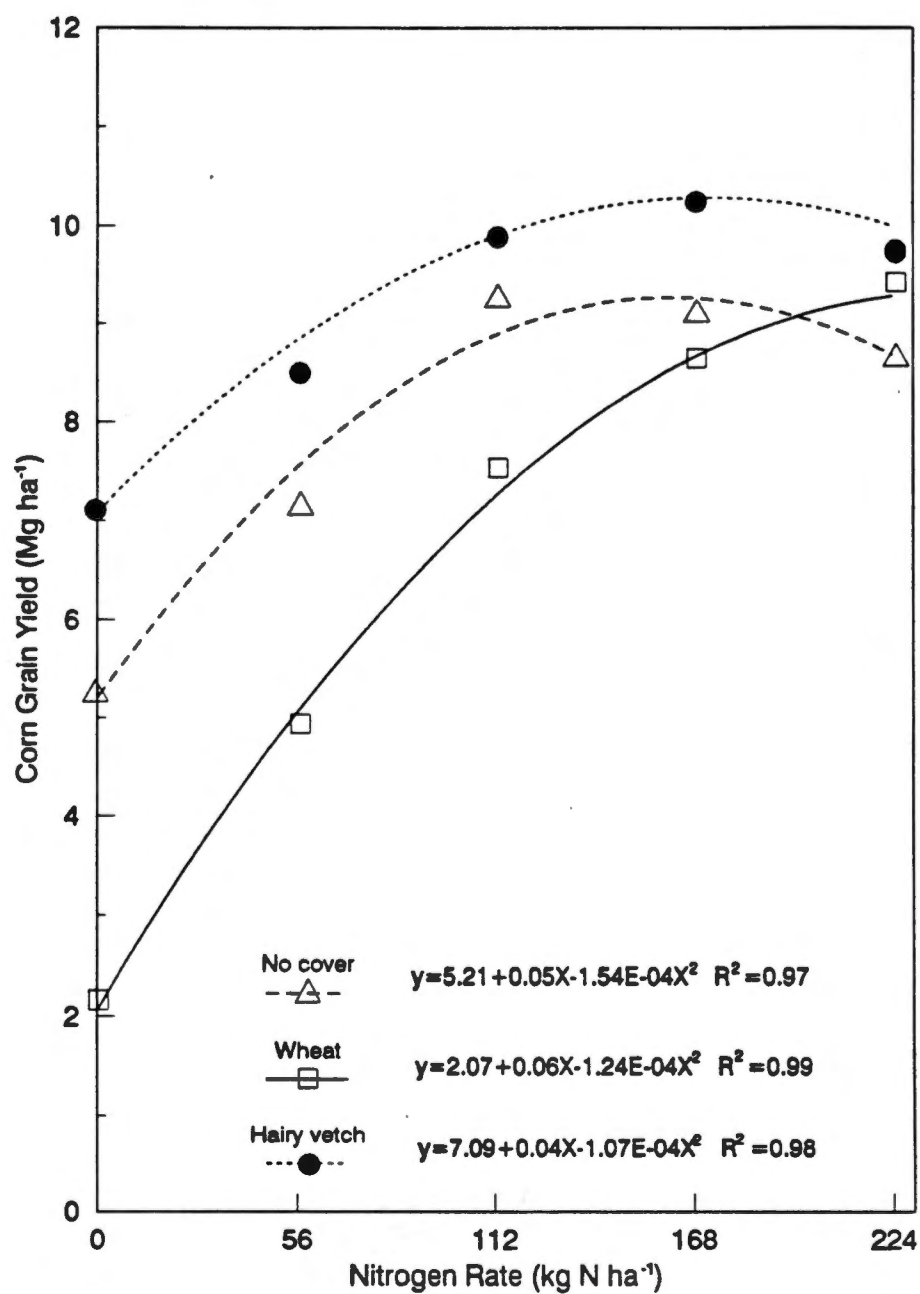


Figure 31. Regression response curves for corn yields versus nitrogen rates for three covers in 1985.

response curves. Corn planted into hairy vetch had higher yields at all N rates than the other two covers. Yields of corn following no cover and wheat treatments responded differently to N fertilizer rates. Yields were higher for corn planted into no cover crop as compared to corn when planted into wheat residues, up to about 195 kg N ha⁻¹. Corn yields for the no cover treatment peaked at about 160 kg N ha⁻¹ with about 9.2 Mg ha⁻¹ yield. Yields were similar when corn was planted into hairy vetch residues with 70 kg N fertilizer. When corn was planted into wheat residues, yields peaked at 224 kg N fertilizer ha⁻¹, while similar yields for corn planted into hairy vetch occurred at 70 kg N fertilizer ha⁻¹. Based on yield response comparisons, the estimated N contributions of hairy vetch were about 90 kg N ha⁻¹ when compared to no cover and 154 kg N ha⁻¹ when compared with a wheat cover crop.

Figures 32 and 33 showed similar R² values and yield response curves when corn was planted into Austrian winter pea and crimson clover residues compared to wheat and no cover treatments at various N fertilizer rates. The estimated N contribution of Austrian winter pea and crimson clover was about 75 kg N ha⁻¹ using no cover and 140 kg N ha⁻¹ with a wheat cover crop. Corn yields were generally similar for all three legumes at each N fertilizer rate. However, at 112 to 224 kg N ha⁻¹, hairy vetch had higher yields than crimson clover and Austrian

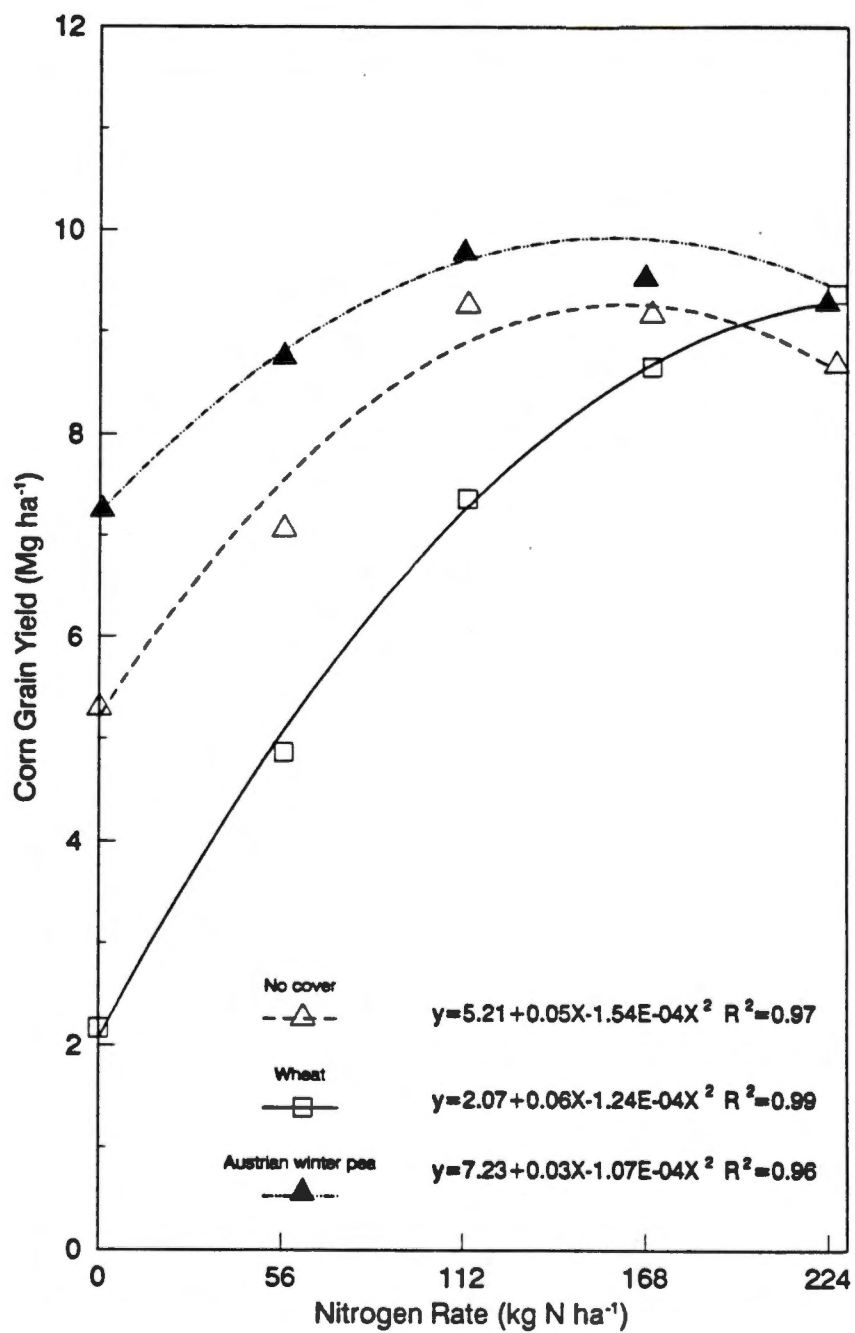


Figure 32. Regression response curves for corn yields versus nitrogen rates for three covers in 1985.

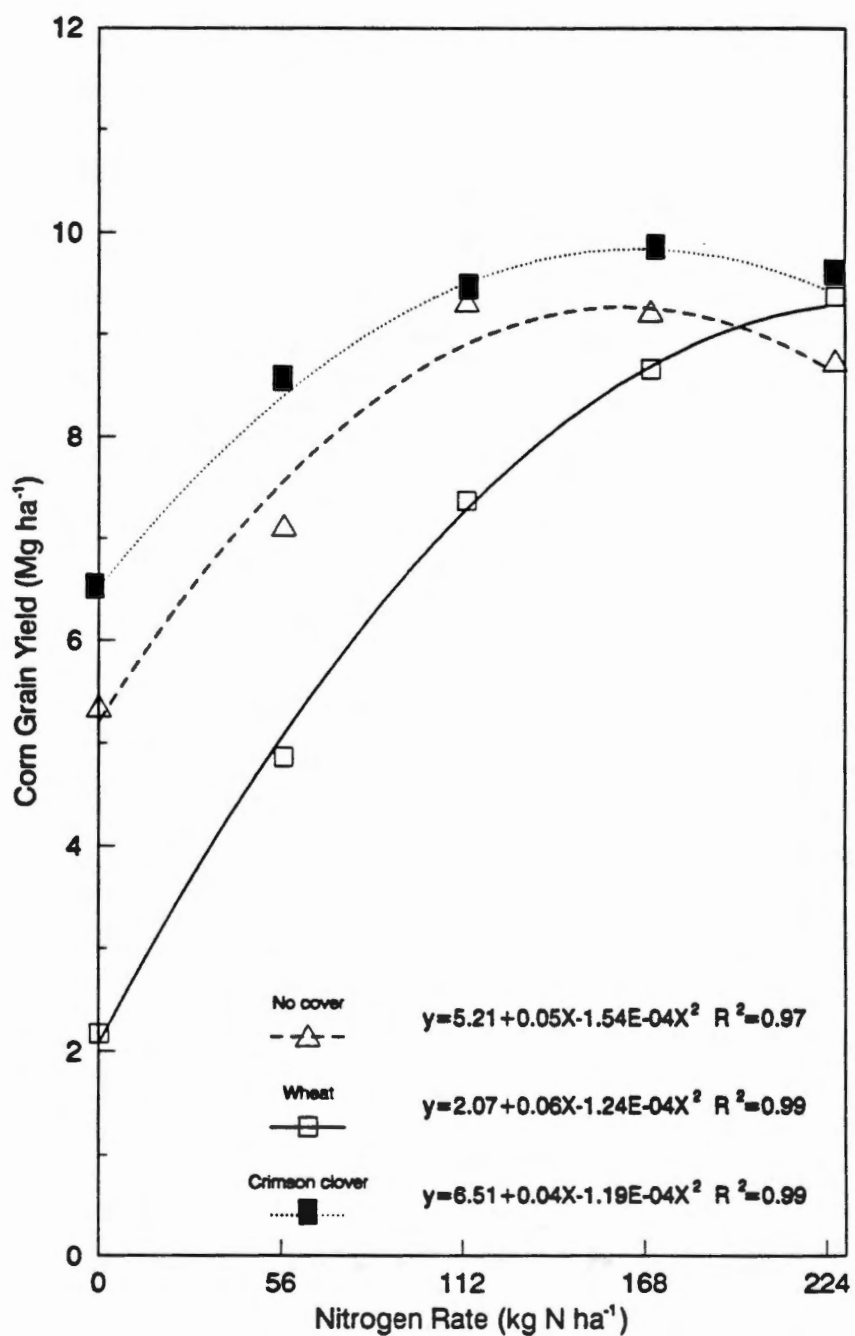


Figure 33. Regression response curves for corn yields versus nitrogen rates for three covers in 1985.

winter pea.

Estimating Nitrogen Contribution of Cover Crops from Yield Response Curves in 1986

Yield response curves were derived for wheat, hairy vetch, and no cover treatments from regression equations having R^2 values of 0.98, 0.99, and 0.95, respectively in 1986 (Figure 34). Corn planted into hairy vetch had higher yields than corn planted after wheat and no cover at all N rates, except at 224 kg N ha⁻¹ where yields were following vetch and wheat were similar. Yields of corn following no cover and wheat treatments responded differently to N fertilizer rates. For corn planted after no cover, yields peaked at about 4.3 Mg ha⁻¹ at 168 kg N ha⁻¹ fertilizer. Similar yields were obtained at 56 kg N ha⁻¹ fertilizer where corn was planted into hairy vetch residue. Yields peaked at the 224 kg N fertilizer rate for corn planted into wheat residues with yields of 4.8 Mg ha⁻¹, while similar yields occurred at about 100 kg N ha⁻¹ fertilizer for corn planted into hairy vetch. Based on yield response comparisons, estimated N contributions of a hairy vetch cover crop were about 112 kg N ha⁻¹ when compared with no cover and 124 kg N ha⁻¹ when compared with a wheat cover crop.

Figure 35 shows yield response curves for Austrian winter pea, wheat, and no cover crop with R^2 values of

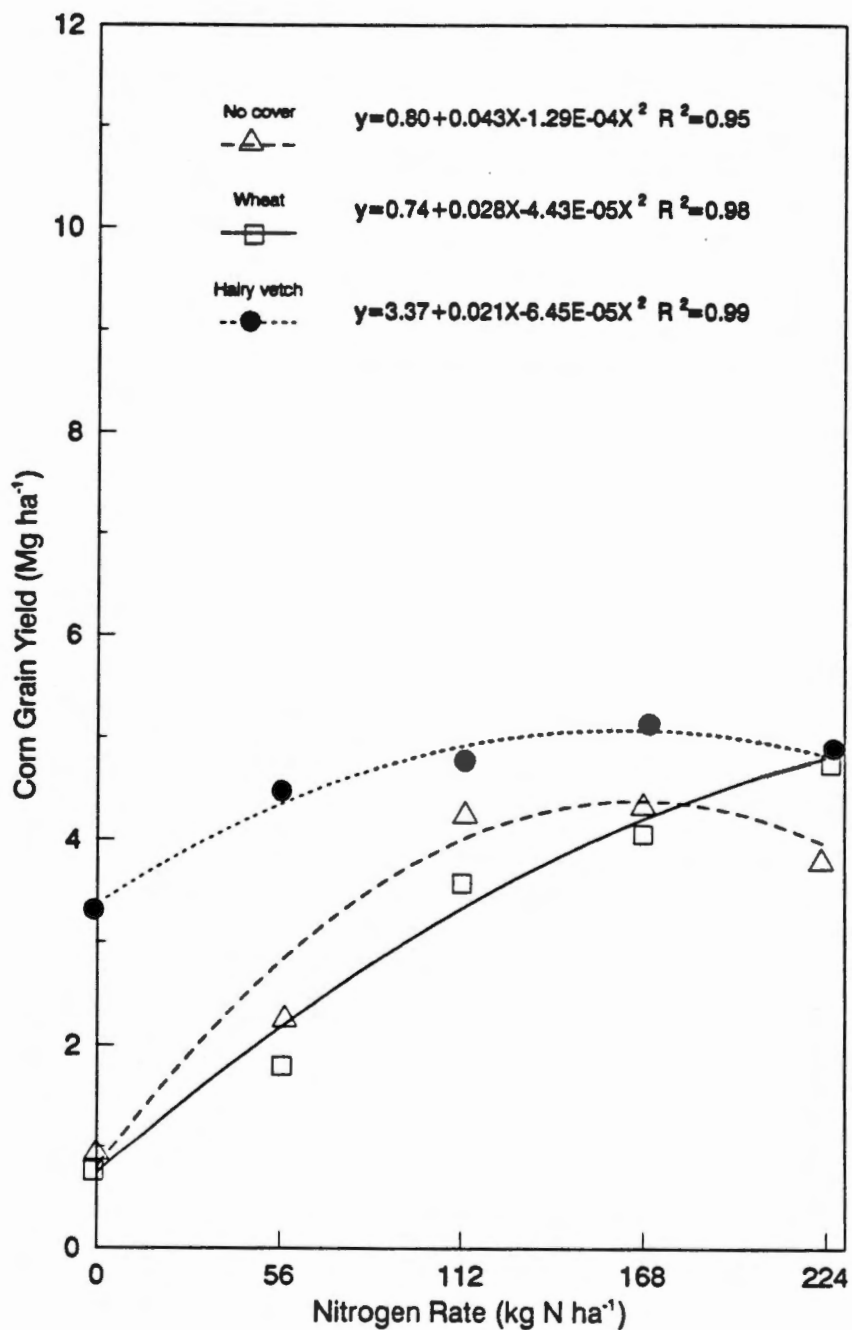


Figure 34. Regression response curves for corn yields versus nitrogen rates for three covers in 1986.

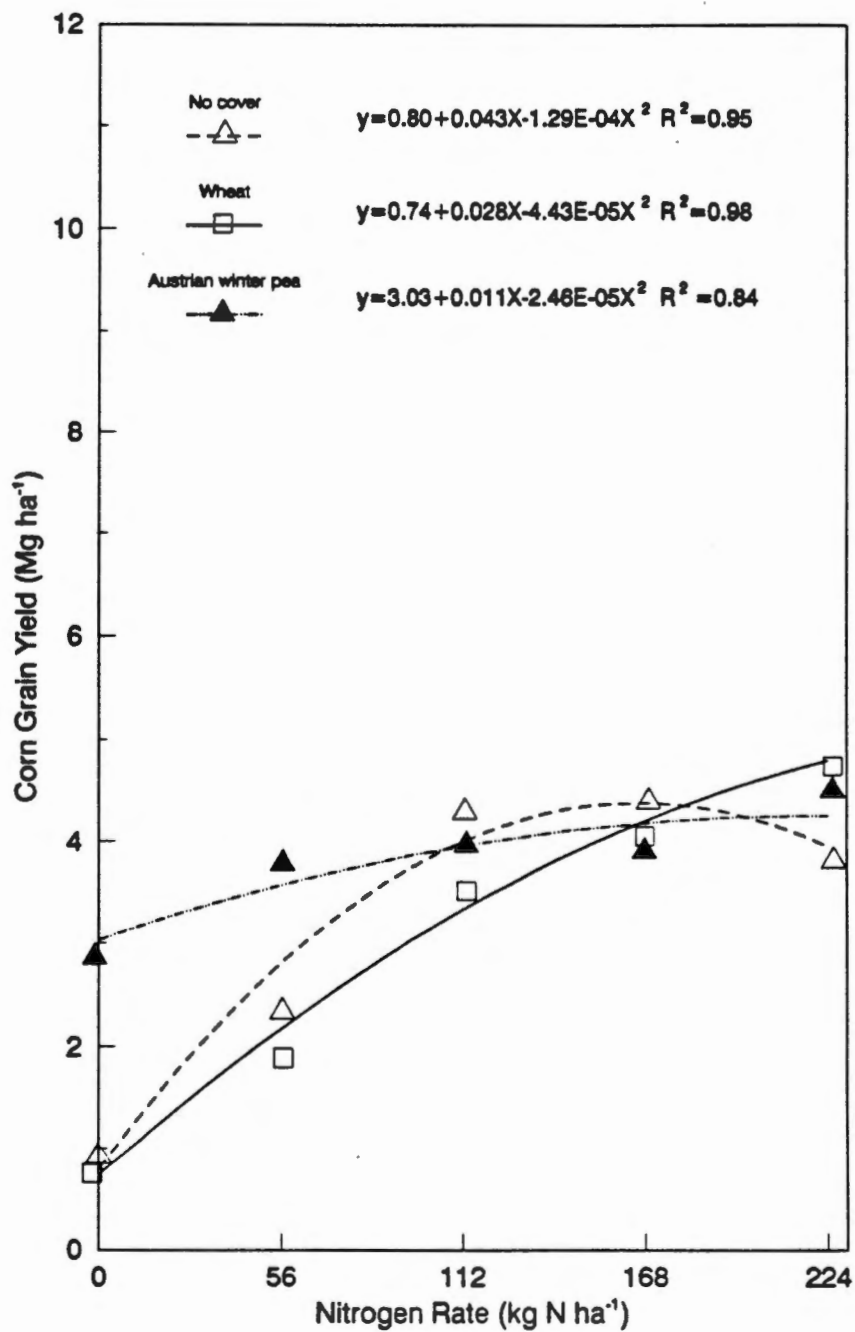


Figure 35. Regression response curves for corn yields versus nitrogen rates for three covers in 1986.

0.84, 0.98, and 0.95, respectively. Yields were higher for corn planted into Austrian winter pea residues at 0 and 56 kg N fertilizer ha⁻¹ than wheat or no cover treatments. At 112 to 224 kg N ha⁻¹ fertilizer, corn planted into Austrian winter pea had yields similar to yields for corn planted into wheat residues or no cover. Corn planted into wheat residues and no cover had maximum yields at 224 and 168 kg N fertilizer ha⁻¹, respectively. Yield response comparisons indicate that Austrian winter pea contributed little or no nitrogen to a no-till corn crop when compared to wheat and no cover treatments except at lower rates of N fertilization.

Regression curves in Figure 36 also show that crimson clover contributed little or no nitrogen to no-till corn except at lower rates of N fertilization. Corn yields following crimson clover were similar or less than those following wheat and no cover treatments at N rates where yields peaked.

The limited contribution of fixed nitrogen to the corn crop from Austrian winter pea and crimson clover in 1986 as compared to 1985 was due in part to winter kill of these legumes. Dry matter accumulations of crimson clover averaged about 4 Mg ha⁻¹ in 1985 but only 2 Mg ha⁻¹ in 1986. Austrian winter pea also accumulated less dry matter in 1986 as compared to 1985. Hairy vetch dry matter accumulation was about the same in both years.

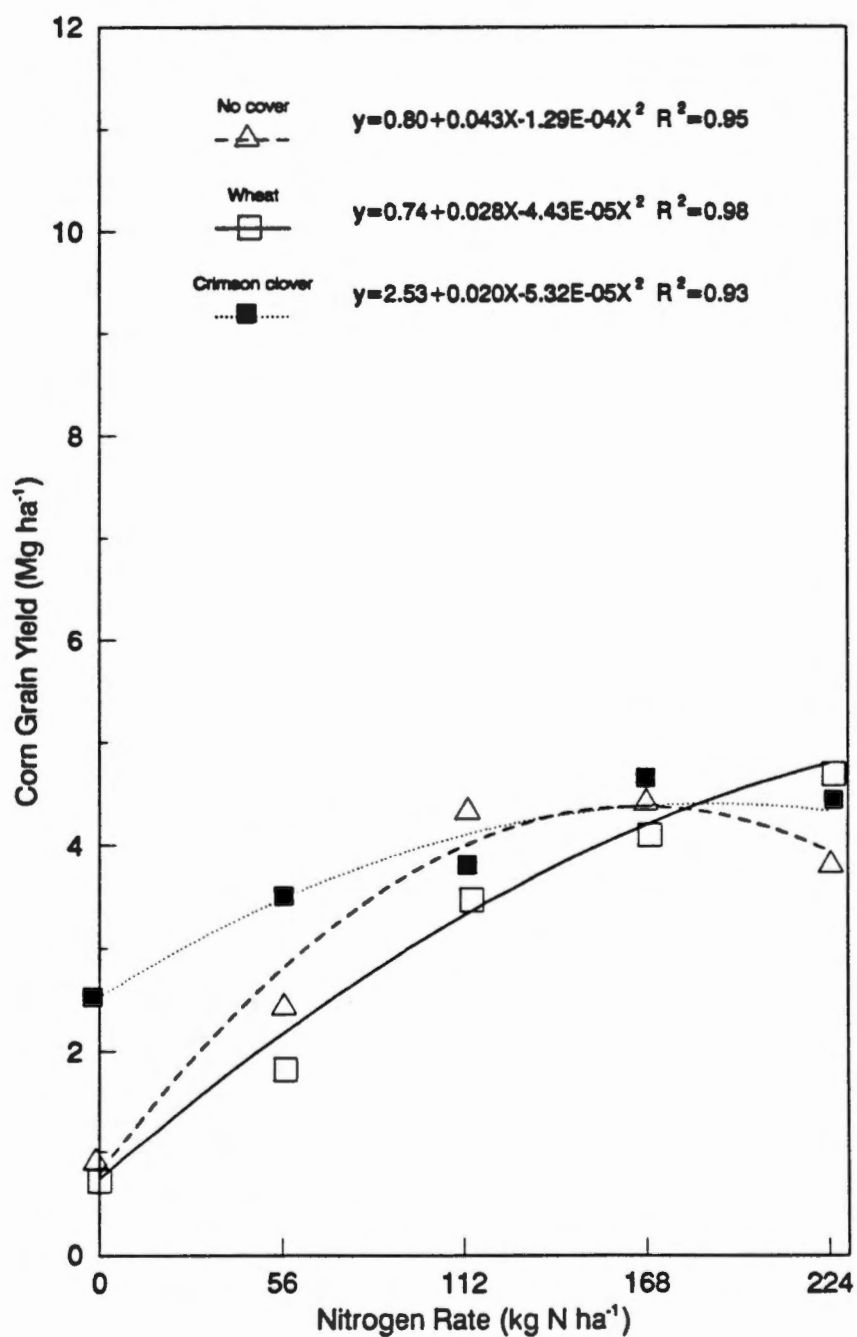


Figure 36. Regression response curves for corn yields versus nitrogen rates for three covers in 1986.

Chapter V

DISCUSSION

Weight losses from cover crop residues were different in 1985 and 1986 (Figures 1 to 5 and 16 to 20). The rate of weight loss was more rapid in 1985 than 1986. Rapid weight loss of residues in 1985 generally occurred between 1 and 8 weeks after no-till corn planting at all 5 N rates. In 1986, at all N rates, rapid weight loss between 1 and 8 weeks was not observed. Total weight loss over time was also much greater for all residues in 1985 than 1986. After 16 weeks weight losses were about 25 to 30% greater for 1985 residues at all N fertilizer rates as compared to residue weight losses in 1986. In 1985, wheat residues generally had greater weight losses as compared to the other residues at all N rates. Based on C:N ratios (Table 1), wheat residues would be expected to decompose more slowly than legume residues because of much higher C:N ratios. In both years, the level of N fertilizer application appeared to have little effect on weight loss over time.

The differences in weight losses of residues between the two years was likely due to climate differences and previous crop residues levels. In 1985 rainfall distribution (Table 2) was favorable during the growing

Table 2. Rainfall recorded from 1 April to 30
September, 1985 at the Milan Experiment Station,
Milan, Tennessee.

Date	April	May	June	July	August	September
	-----mm-----					
1-7	15	13	23	41	28	33
8-14	22	0	13	0	3	0
15-21	0	43	22	0	47	0
22-28	51	0	64	61	26	0
29-30/31	3	0	11	0	0	0
Total	91	56	133	102	104	33

season, while the 1986 season was much drier in July and August (Table 3) resulting in lower yields. Microbial activity and residue decomposition may be expected to be greater under favorable soil moisture conditions as compared to dry soil conditions. Another factor that may have affected residue decomposition and residual weight loss was that plots were clean-tilled prior to fall-seeding cover crops in the first year of the experiment. Therefore, the nylon bags containing cover crop residues may have had greater soil contact because there was no previous crop residue present. If this was the case, residues would probably have had a greater chance for microbial contact and faster decomposition.

In 1985 and 1986, residual carbon losses were different for cover crop residues over time (Figures 6 to 10 and 21 to 25). Residues showed rapid carbon losses in 1985 at 1 to 8 week sampling times, while rapid rates of carbon losses were not observed for residues in 1986. In 1986, residues had about 30% less carbon loss over 16 weeks as compared to residues in 1985. Wheat residues generally had higher carbon losses over time at all N fertilizer rates in 1985, but differences were not significant in some cases. Carbon losses were similar for cover crop residues over 16 weeks at all N rates in 1986. Again, differences in residual carbon losses in 1985 compared with 1986 may be a result of differences in

Table 3. Rainfall recorded from 1 April to 30 September, 1986 at the Milan Experiment Station, Milan, Tennessee.

Date	April	May	June	July	August	September
	-----mm-----					
1-7	34	0	181	9	12	18
8-14	36	8	26	21	0	3
15-21	22	13	0	0	6	39
22-28	0	61	0	39	0	0
29-30/31	22	0	0	0	0	0
Total	114	82	207	69	18	60

rainfall distribution and previous crop residue levels.

Residual nitrogen losses from residues in 1985 and 1986 varied over time. In 1985, cover crop residues generally exhibited rapid nitrogen losses at all N fertilizer rates between 1 and 8 weeks after planting no-till corn. In 1986, nitrogen losses from residues were generally rapid during the period 1 to 2 weeks, then slowed between 2 and 4 weeks, and then maintained a relatively constant rate to 16 weeks. Hairy vetch commonly had the greater N losses in 1985 and 1986 at each N fertilizer rate as compared to the other residues. Hairy vetch may have released residual nitrogen faster than the other residues based on its inherently low C:N ratio, 11:1 (Table 1). During early sampling times, cover crop residues had negative N loss values, especially as N fertilizer rates increased, which may be attributed to the N fertilizer that was placed in the nylon bags. Differences in residual N losses for 1985 and 1986 may be attributed to variation in rainfall distribution between growing seasons and differences in previous crop residues.

Estimated nitrogen contributions from legume cover crops were different for 1985 and 1986 (Figures 31 to 36). In 1985, yield response curves showed that estimated N contributions from legume covers to no-till corn were about 75 to 90 kg N ha⁻¹ when compared with corn planted after no cover and 140 to 154 kg N ha⁻¹ when compared with

corn planted into wheat. In 1986, hairy vetch was estimated to contribute about 112 and 124 kg N ha⁻¹ when compared with corn planted into no cover crop and wheat, respectively. Crimson clover and Austrian winter pea did not contribute N to corn yields when compared with corn after wheat or no cover treatments except at lower N rates in 1986. Winter kill of Austrian winter pea and crimson clover in 1986 reduced dry matter production for these cover crops by about 50% and was probably partly responsible for reduced N contributions to no-till corn. Differences in rainfall distribution among growing seasons and varying rates of decomposition between residues may also be responsible for differences among N contributions of legume covers over the two years.

CHAPTER VI

CONCLUSION

Based on the results of this two year experiment, decomposition rates of cover crop residues appear to be largely determined by climatic factors, such as rainfall distribution, and previous crop residue levels. The amounts and rates of residue decomposition were greater in a near-normal rainfall year (1985) than a much drier growing season (1986). Residue decomposition occurred at a rapid rate during the first 8 weeks in 1985. In 1986, rapid decomposition was not apparent but was steady over the 16-week period. Decomposition rates, as determined by residue weight and carbon losses, were faster for wheat under favorable rainfall conditions. In a dry growing season, such as 1986, decomposition rates of legume and wheat residues were generally similar. Rainfall differences between the two growing seasons also appeared to affect N losses from cover crop residues. Rapid N loss occurred during the first 8 weeks in 1985, while the rate of N loss was erratic over the first 8 weeks in the drier season of 1986. Residual N loss for hairy vetch was usually greater in both 1985 and 1986 as compared with Austrian winter pea, crimson clover, and wheat residues. This was expected since C:N ratios were the lower for

hairy vetch. Results suggest that hairy vetch may be a more reliable cover crop than Austrian winter pea and crimson clover for contributing significant amounts of fixed N to a succeeding no-till corn crop. Nitrogen contributions from vetch to no-till corn ranged from 90 to 154 N ha⁻¹. Over the two years, hairy vetch appeared to be better adapted to the growing conditions of West Tennessee. Austrian winter pea and crimson clover had significant winter kill during the winter of 1986.

As with all methods for studying residue decomposition, the nylon bag technique is not 100% accurate, but may currently be the most reliable method for estimating decomposition of plant residues. Nylon bags in direct contact with soil can have differences in residue decomposition as compared with bags having less soil contact. The fine mesh-size of the nylon bags allowed only microorganisms to enter the bags and did not account for breakdown of residues that may have occurred by larger organisms, such as earthworms. Placing N fertilizer inside the nylon bags was most likely responsible for increases in residue N at early sampling periods, but did not appear to affect decomposition at later sampling times.

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VITA

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In August 1975, he enrolled at Purdue University, West Lafayette, Indiana, and received his Bachelor of Science degree in Agriculture with a major in Natural Resources and Environmental Science in May 1983. Following graduation he accepted a Soil Scientist position on a field research project with Oregon State University in Corvallis, Oregon. In November 1983, he accepted a position with the Shelby County Soil Survey as a County Soil Scientist in Shelbyville, Illinois.

A Graduate Teaching Assistant position was offered and accepted in November 1984 and the author began a M. S. program in the Plant and Soil Science Department at the University of Tennessee, Knoxville in January 1985. He received a Master of Science degree in Agriculture with a major in Plant and Soil Science in December 1990.

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