Producing No-Till Cereal or Corn following Alfalfa on Furrow-Irrigated Land

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Improved cropping systems are needed to reduce production inputs, increase production efficiency, protect water quality, and reduce soil erosion on furrow-irrigated land. Five field studies were conducted to evaluate the feasibility of producing cereal or corn (*Zea Mays* L.) without tillage following alfalfa (*Medicago sativa* L.) on furrow-irrigated land. The primary purposes of these studies were to reduce tillage costs and use N that becomes available through decomposition and mineralization following killing of alfalfa. Results demonstrated that no-till crops can be successfully irrigated with a high degree of water application uniformity, and with less water than for traditionally tilled crops. Production costs were lower resulting in higher net income for the no-till produced crops in all studies. Corn can be produced successfully with all of its required N being supplied from the decomposing alfalfa roots and nodules. The rate at which NO_3–N is formed from this source parallels the N-requirements of corn. All of the N requirements for cereals can be supplied from the alfalfa source if the alfalfa is killed in the early fall so that there will be ample time at soil temperatures sufficiently high to permit some accumulation of NO_3–N in the soil before the rapid N uptake period required by cereals. If this regime is not followed, cereals may need to be supplemented with added N to assure adequacy. The use of N by corn or cereal following alfalfa reduces the potential for nitrate leaching as compared to conditions when low N requiring crops are grown after alfalfa.

TRADITIONALLY, furrow-irrigated land has been intensively tilled to bury crop residues and avoid perceived irrigation problems. Most furrow irrigation farmers believe that fields cannot be successfully irrigated with residues on or mixed in the soil surface. This intensive tillage has resulted in serious soil erosion (Berg and Carter, 1980; Brown et al., 1974; Carter and Berg, 1983) that has drastically reduced the crop production potential (Carter et al., 1985). No-tillage and reduced tillage farming has been used on rainfed croplands for over two decades to control rainfall and snowmelt-caused erosion, but the application of these practices to furrow-irrigated land has been limited. Wheat (*Triticum aestivium* L.) was grown successfully following sorghum (*Sorghum vulgare* L.) and corn, and sorghum following wheat without tillage on furrow-irrigated land on the Southern Plains. using large-graded furrows (Allen et al., 1976; Musick et al., 1977). Aarstad and Miller (1979) used a method they called till planting in corn residue, without previous tillage, to control soil erosion on furrow-irrigated land. Results of these research efforts have not been widely applied.

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The recent expanded interest to control irrigation furrow erosion stimulated a number of studies that have provided considerable control technology. Several researchers applied straw to furrows resulting in good erosion control, improved water infiltration, and in some cases, increased crop yields (Aarstad and Miller, 1981; Berg, 1984; Brown, 1985; Miller and Aarstad. 1983). Cary (1986) used sodded furrows to irrigated row crops and control erosion, but controlling the grass sod required careful use of herbicides and questions were raised about the practicality of this method. Carter and Berg (1983) developed a buried pipe runoff control system that controlled erosion at the lower ends of fields, but had no effect on furrow erosion on the remainder of the field.

Controlled placement of residues in furrows has demonstrated that successful irrigation can be accomplished with residues in furrows. A more reasonable approach would be to manage residues from the last crop grown on a field to control erosion during production of the subsequent crop. Such residue management requires tillage practices differing from those traditionally used on furrow-irrigated land.

Research was initiated in 1985 with the goal of effectively applying conservation tillage practices for irrigation furrow erosion control. Our first report (Carter and Berg, 1991) demonstrated that conservation tillage farming and furrow irrigation could be compatible, furrow erosion can be effectively controlled by conservation tillage, and that farmer net income could be significantly increased by using conservation tillage practices over the entire crop rotation. We also found that in rotations including alfalfa, six to 10 tillage operations could be eliminated if the next crop could be grown without tillage instead of using the traditional tillage practices to bury the alfalfa crowns and roots and form a firm seedbed for crops like dry edible beans (*Phaseolus vulgaris* L.). This paper reports results of our research evaluating the feasibility and advantages of producing cereal or corn following alfalfa on furrow-irrigated land.

MATERIALS AND METHODS

Several field research projects were conducted on highly erosive Portneuf silt loam soil (*Durixerollic Calcorthid*) or similar associated silt loam soils in south central Idaho. In all cases, alfalfa stands were 3 or more years old and included some invading grasses.

Therefore a mixture of 1 qt of glyphosate and 2 qt of 2,4-*D* were applied per acre. Cereals were seeded without prior tillage parallel to the irrigation furrows with conventional double disk opener drills normally used on tilled land. No specialized or no-till drills were used. Traditionally tilled plots were included for comparison. Seeding rates were 100 lb/acre for winter wheat, and spring barley (*Hordeum vulgare* L) and 80 lb/acre for spring wheat. Corn was seeded by placing bull tongue shanks directly in front of the planter and setting them to assure an opening about 2.5 in. deep so that the planter would place the seed about 2 to 2.5 in. deep. A bull tongue is a curved chisel point that attaches to a vertical shank so that it enters the soil at an angle, cutting a narrow groove with a lifting action. Corn seeding rates were adjusted to place seeds about 5 to 7 in. apart for silage corn and 7 to 9 in. apart for sweet corn. Rows were 30 in. apart, and these seed spacings were used to obtain approximately 32 000 and 26 000 plants per acre for silage and sweet corn, respectively. The furrows used to irrigate the previous alfalfa crop were cleaned simultaneously with corn seeding on no-till plots and new furrows were formed on the traditionally tilled plots. Existing furrows were cleaned or new furrows formed in the respective no-tillage or traditional tillage cereal plots in an operation separate from seeding, in the spring before the first irrigation.

Traditional tillage included disking twice, moldboard plowing and roller harrowing twice, or sometimes disking was used following plowing. This prepared a suitable seedbed, but it differed somewhat from farmer practices. We conducted a survey to determine the tillage practices traditionally used following alfalfa. We found that a range of 6 to 14 operations were used. About 60% of the farmers kill the alfalfa with herbicide before tilling, whereas the other 40% are satisfied with the kill achieved with crowning twice. Crowning is accomplished by pulling wide V-shaped sweeps through the soil 3 to 4 in. below the surface to cut the tap roots from the crowns. It is usually done twice with the second tillage being 45 to 90° from the first. Some farmers crown even after spraying, but others use only disking following spraying before moldboard plowing. Farmers using crowning perform more tillage operations after alfalfa than those who use only disking. We chose the more conservative approach for our traditionally tilled plots which was usually six operations. The particular operations for each study are listed later. The cost of crowning twice is $24 per acre and the cost for herbicide and its application is $26 per acre.

The roller harrow is a tillage implement comprised of a "sheeps foot" roller followed by two off set rows of S-tines, then another "sheeps foot' roller followed by thin, spring loaded, vertical tines. The implement is designed to break up clods, and smooth and firm the soil surface. It is commonly used on irrigated land.

Experimental plots were randomized strips over the entire field length, which ranged from 400 to 600 ft for the various studies with a width of not less than 12 ft. Field-length plots were used to represent furrow irrigation over normal field lengths used in the area. One of the traditional fears of furrow-irrigation farmers is that they will be unable to irrigate the entire field length in the presence of crop residue on and in the soil surface. To avoid credibility problems, we chose to use field-length plots in our studies.

Cereal yields were determined by combining an 8-ft-wide strip from the center of each plot over the entire length, except that about 20 ft at each end was excluded to eliminate field end effects. The cereal was placed into a weighed truck which was weighed again to determine plot yield. Corn silage yields were determined by hand-cutting 10-ft sections from the center four rows of each plot at two or more locations in each plot, weighing the harvested material, and averaging the results to obtain plot yields. The corn stocks and ears were chopped and sampled to obtain moisture content. Yields were corrected to 65% moisture content which is standard for corn silage in the study area. Sweet corn yields were determined by hand-picking ears suitable for processing from 10-ft sections of the four center rows at two or more locations in each plot, weighing, and averaging to obtain plot yields.

Phosphorus requirements were determined by soil sampling to a depth of 2 ft and analyzing for available P by $NaHCO_3$ extraction (Watanabe and Olsen, 1965). Phosphorus fertilizer was surface-applied over the entire plot area if the soil test indicated a need for P. Nitrogen was surface-applied to plots of some studies to determine if there was a yield response to applied N. Available NO_3–N was measured in the soil several times during the season, and in the plant material at several growth stages to monitor N availability and uptake. The nitrate electrode was used for these measurements (Milham et al., 1970). Total N was determined by Kjeldahl analyses for some studies to calculate protein content and to ascertain N adequacy or inadequacy. Nitrogen was applied and monitored only to determine adequacy or inadequacy for the cropping systems being evaluated. Therefore, detailed data will not be presented, but rather adequacy or inadequacy will be stated, and yield response or lack of it will be mentioned.

Irrigation was accomplished by using furrows spaced 30 in. apart for all crops. Every furrow received water each irrigation for the cereals, but only every second furrow received water for silage or sweet corn. Usually, alternate furrows were irrigated each successive irrigation. Soil moisture measurements were made to determine when to irrigate to avoid water deficits. Irrigations were generally 12 or 24 h in duration.

Herbicides were applies to kill alfalfa when close examination showed that all plants were growing. This is important because plants without growing shoots are generally not killed by contact herbicides, and many of these will grow later. The timing of the spraying and killing of the alfalfa is an important aspect of growing cereal and corn following alfalfa. It effects both the killing of the plants and N availability for the subsequent crop.

The specific studies reported in this paper are presented in the following paragraphs with specific dates, operations, etc., not covered in the preceding discussion.

Study 1—Winter Wheat

The third cutting of alfalfa was harvested from a uniform, 3-acre field in late September 1984. By 5 October, all alfalfa plants appeared to be growing, and the field was sprayed with herbicide to kill the alfalfa. Traditional tillage plots were disked twice, moldboard plowed, and roller harrowed twice. 'Stephens' winter wheat was seeded on all plots 16 Oct. 1984. All plots were sprayed 20 May 1985 to kill broadleaf weeds in the wheat. Nitrogen fertilizer was applied at a rate of 100 lb/acre to some plots on 3 Oct. 1984. Wheat plants were sampled 17 June 1985 and analyzed for NO_3–N to monitor N adequacy. The plots were irrigated 4 and 24 May, 8 and 26 June, and 7 July 1985. Harvesting was accomplished 7 Aug. 1984. Grain samples were evaluated for protein and quality parameters and N adequacy.

Study 2—Silage Corn

The third-cutting alfalfa was harvested from a 2-acre field in late September 1984. Herbicide was applied to kill the alfalfa 5 Oct. 1984. Traditional-tillage plots were disked and moldboard plowed 25 Oct. 1984, then disked and roller harrowed twice in late April. Nitrogen plots received 100 lb N per acre on 4 April 1985. Silage corn was seeded 2 May 1985. Irrigation dates were 3 and 23 May, 8 and 18 June, 2 and 12 July, and 8 and 21 August. Harvesting was on 4 Sept. 1985. Corn plant samples were taken at silking and harvesting to monitor N adequacy.

Study 3—Spring Wheat

Third-cutting alfalfa was removed in late September 1984 and herbicide applied to kill the alfalfa 5 October. Nitrogen was applied at a rate of 100 lb N per acre, 3 Oct. 1984 to appropriate plots. Traditional-tillage plots were disked and plowed 25 October. Fielder spring wheat was seeded 9 Apr. 1985. Broadleaf weeds were killed by spraying 22 May 1985. Irrigation dates were 29 Apr., 22 May, 6 and 19 June, and 4 July 1985. Soil samples were collected at about weekly intervals to monitor NO_3–N concentrations in the soil in this study. Wheat plant and grain samples were evaluated for N adequacy. Plots were harvested 7 Aug. 1985.

Study 4—Spring Barley

Herbicide was applied to kill alfalfa 29 Oct. 1985 after third-cutting alfalfa had been removed. Traditional tillage plots were disked and moldboard plowed 4 Nov. 1985 and disked and roller harrowed twice in late March 1986. 'Steptoe' barley was seeded 26 Mar. 1986. Irrigation dates were 17, 5 and 24 June, and 10 and 23 July. Plots were harvested 6 Aug. 1986. Soil samples were taken 6 Mar. 1986 to determine available NO_3–N, and plant samples were collected at flowering to determine N adequacy. No plots were fertilized with N in this study.

Study 5—Sweet Corn

Growing alfalfa was sprayed 12 Apr. 1989. Traditional tillage plots were disked twice, moldboard plowed, roller harrowed twice. Sweet corn was seeded 22 May 1989. Irrigation dates were 4 May, 20 June, 7, 18 and 28 July, and 8 and 18 August. Nitrogen fertilizer was applied at a rate of 100 lbs N per acre. Soil samples were taken seven times during the growing season at 1-ft intervals to a depth of 4 ft to measure N availability as the season progressed. We wanted to determine if NO_3–N from decomposition and nitrification would adequately supply the needs of the corn as the season progressed when the alfalfa was killed in the spring. Plant samples were collected at silking to determine N adequacy. Harvesting was completed 28 Aug. 1989. The agricultural operations, a symbol for each, and their costs based upon custom rates (Withers, 1983) are shown in Table 1. These costs have remained about the same since 1983.

RESULTS AND DISCUSSION

Data for all five studies are presented in Table 2 which will serve as a focus for the comparisons and discussions in this paper. Symbols and costs used in Table 2 were taken from Table 1. Phosphorus fertilizer costs differed for each study depending upon soil test values. The costs are included in Table 2. Nitrogen fertilizer costs are not included. Our purpose for applying N to some plots was to evaluate N sufficiency. We did not anticipate a response to N, nor would we recommend applying N fertilizer the first season following alfalfa, unless the alfalfa was not killed early enough for some decomposition of roots and nodules to occur and mineralization to begin.

Table 1. Agricultural operations costs based upon custom rates in the study area, and herbicide cost per unit (Withers, 1983).

Operation	$/unit
Crowning alfalfa (Cr)	12.00/acre
Moldboard plowing-alfalfa ground (MP)	8.00/acre
Disking (D)	9.00/acre
Roller harrowing (RH)	8.00/acre
Furrowing (F)	8.00/acre
Furrows cleaned (FC)	8.00/acre
Seeding cereal, corn or beans (S)	9.00/acre
Combining cereal (H)	25.00/acre
Corn silage cutting and hauling (H)	5.25/ton
Applying herbicide with spray rig (Sp)	5.00/acre
Fertilizer application-dry broadcast (Fe)	4.50/acre
Herbicide costs	
Glyphosate (Roundup)	15.00/qt
2,4-D	3.00/qt

Study 1—Winter Wheat

Winter wheat produced the same yield (no statistically significant difference) on both no-till and traditionally tilled plots (Table 2). Plant analyses for N showed that N content in the plants was adequate, indicating that NO_3–N being formed through root and nodule decomposition and subsequent mineralization was sufficient to meet the N requirements of the winter wheat. This was verified by the fact that yields were the same for O and supplement N plots. Evidently conditions were favorable for adequate NO_3–N formation to accumulate enough in the soil to meet the high demand rates of winter wheat in May and June. This is not always true for late, fall-killed alfalfa as will be shown later for barley. Westermann (unpublished data) found N deficiency in winter wheat following late, fall-killed alfalfa. As a result of greater tillage costs for the traditional-tillage plots, net income from those plots was only 43% of that from the no-till plots. Wheat prices were low in 1985 and net returns were therefore low for all plots.

Study 2—Silage Corn

Corn silage yields were the same on both no-till and traditionally-tilled plots. Soil and plant sample analyses indicated that adequate N was available through-

Table 2. Crop yields, production costs and economic returns for five field studies to compare no-till production of cereals or corn following alfalfa.

	No-till	Traditional tillage
Study 1. Winter wheat		
Tillage, seeding, furrowing and spraying operations†	Sp,S,FC,Sp	Sp,D,D,MP,RH,RH,S,F,Sp
Cost of above operations, $ per acre	27.00	70.00
Seed, herbicide, fertilizer, etc., cost $ per acre	55.50	55.50
Harvesting cost, $ per acre	25.00	25.00
Crop yield, bu per acre	96	91
Crop unit price, $ per bushel	2.10	2.10
Gross income, $ per acre	201.60	191.10
Operational costs, $ per acre	107.50	150.50
Net income, $ per acre	94.10	40.60
Study 2. Silage corn		
Tillage, seeding, furrowing and spraying operations	Sp,S,Sp	Sp,D,MP,D,RH,RH,S,Sp
Cost of above operations, $ per acre	19.25	71.25
Seed, herbicide, fertilizer, etc., cost $ per acre	55.50	55.50
Harvesting cost, $ per acre	134.40	131.78
Crop yield, ton per acre	25.1	25.6
Crop unit price, $ per ton	18.00	18.00
Gross income, $ per acre	451.80	460.80
Operational cost, $ per acre	209.25	258.53
Net income, $ per acre	242.55	202.27
Study 3. Spring wheat		
Tillage, seeding, furrowing and spraying operations	Sp,S,FC,Sp	Sp,D,D,MP,RH,RH,S,F,Sp
Cost of above operations $ per acre	27.00	70.00
Seed, herbicide, fertilizer, etc., cost $ per acre	55.50	55.50
Harvesting cost, $ per acre	25.00	25.00
Crop yield, bu per acre	77	85*
Crop unit price, $ per bushel	2.10	2.10
Gross income, $ per acre	161.70	174.30
Operational cost, $ per acre	107.50	150.50
Net income, $ per acre	54.20	23.80
Study 4. Spring barley		
Tillage, seeding, furrowing and spraying operations	Sp,S,FC,Sp	Sp,D,MP,D,RH,RH,S,F,Sp
Cost of above operations, $ per acre	27.00	70.00
Seed, herbicide, fertilizer, etc., cost $ per acre	53.50	53.50
Harvesting cost, $ per acre	25.00	25.00
Crop yield, bu per acre	83	100*
Crop unit price, $ per bushel	2.31	2.31
Gross income, $ per acre	191.73	231.00
Operational cost, $ per acre	105.50	148.50
Net income, $ per acre	86.23	82.50
Study 5. Sweet corn		
Tillage, seeding, furrowing and spraying operations	Sp,S	Sp,D,D,MP,RH,RH,S
Cost of above operations, $ per acre	14.00	66.00
Seed, herbicide, fertilizer, etc., cost $ per acre	63.00	63.00
Harvesting cost, $ per acre	90.86	96.25
Crop yield, ton per acre	11.8	12.5
Crop unit price, $ per ton	45.00	45.00
Gross income, $ per acre	531.00	562.50
Operational cost, $ per acre	167.86	225.25
Net income, $ per acre	363.14	337.25

* Indicates a significantly greater yield at the probability level of 0.05 as measured by the *t*-test. Only crop yields were compared statistically.
† Symbols and costs for the various operations are given in Table 1.

out the growing season to meet the N requirements of the corn. Additional evidence of adequate N was provided by the data showing no response to applied N fertilizer. This is not surprising because there was time both in the fall and the spring for decomposition and mineralization to proceed and result in a build up of available soil NO_3-N.

Visual observation indicated a more severe broadleaf weed problem in the no-till than the traditional tillage plots. However, an application of 2,4-*D* effectively killed broadleaf weeds in all plots, and this apparent difference disappeared.

Irrigation application uniformity was far superior on the no-till plots. It was necessary to stop the irrigation water for a day after 24 h of application on the traditional tillage plots and allow the furrows to dry, and then apply water a second time to irrigate all furrows to the lower end of the field. In contrast, water had reached the lower end of all furrows in the no-till plots by 2 h after it was started, and irrigation uniformity all along the furrows was high. Approximately 8 in. more water was applied the first irrigation to the traditional tillage plots than to no-till plots.

The higher operational costs resulting from tillage of the traditional tillage plots reduced net income to 83% of that from no-till plots. Data indicate that tillage operations following alfalfa were unnecessary and costly.

Study 3—Spring Wheat

Broadleaf weed problems were encountered in the no-till spring wheat plots because weather conditions in the spring delayed spraying. Once spraying was accomplished the weeds were effectively killed. Weed competition was likely the cause of lower yield on no-till plots. Broadleaf weeds were also present on traditional tillage plots, but at a much lower population. Where no tillage is done, there is a potential for early weed competition problems because weed seeds are not buried by tillage, and they germinate and grow early in the season. Weed infestations depend upon how weedy the alfalfa stand was before killing it. The alfalfa in this study and in Study 2 were old weedy stands. Results from some of our other studies (unpublished data) indicate that broadleaf weed problems are often less severe in no-till than in traditionally tilled plots when the preceding alfalfa stand was not severely weed infested.

Net income from the no-till plots was more than twice that from the traditional tillage plots even though the yield was higher on the traditionally tilled plots. Again this difference reflects the unnecessary costs of tillage following alfalfa. In this study, mainly as a result of the low wheat price in 1985, growing spring wheat was probably not profitable when other costs such as land, water taxes, interest, etc., were included. The difference in net operation income between no-till and traditional tillage may have made the difference between profit and loss. At least, if there was a loss with both tillage systems it was less for the no-till systems.

Soil and plant analyses showed that there was adequate N available to the wheat to more than meet its requirements throughout the growing season. In fact, our detailed soil NO_3–N data showed an abundant supply of NO_3–N in the soil after the wheat stopped absorbing NO_3^-. Here again, as expected, there was no response to applied N fertilizer.

Study 4—Spring Barley

The spring barley on both the no-till and traditionally tilled plots was N deficient as indicated by plant N concentration at boot and kernel filling growth stages. This resulted from killing the alfalfa very late in the fall, 29 October. The barley was planted early the following spring, 26 March. There was not sufficient time at high enough soil temperatures for decomposition and mineralization to occur to meet the N needs of the rapidly growing barley in the spring. Barley on the traditionally tilled plots was less N deficient than that on the no-till plots, and this is reflect in the yields. We found in Study 3 that soil NO_3-N concentration increased more rapidly in tilled than nontilled soil following the killing of alfalfa indicating that tillage hastens root and nodule decomposition. Another factor was that the herbicide did not give a 100% kill on the alfalfa in the no-till plots, and some alfalfa plants grew in the spring. Alfalfa is a very efficient N extractor from the soil, and these growing plants may have used some of the NO_3-N formed in the soil that spring, thereby reducing the amount available to the barley.

Unfortunately, there were no plots receiving N fertilizer in this study, but in a companion study underway the same year no-till barley plots receiving 100 lbs N per are following spring killed alfalfa produced 122 bu/acre compared to the 100 and 83 bu on the traditionally tilled and no-till, respectively. This comparison illustrates about how much yields were decreased as a result of N deficiency. On still another study (unpublished data) where spring barley was grown no-till following spring-killed alfalfa, we found that 40 lbs N per acre was an adequate N supplement to prevent N deficiency in the barley.

The net economic return favored the no-till barley slightly, again showing that the cost of tillage negatively impacts net returns.

Study 5—Sweet Corn

Corn can be grown successfully following the killing of alfalfa in either the fall or spring. In this study, high sweet corn yields were produced both without tillage and with traditional tillage. There was no response to added N, and the N content of corn plants indicated that the crop was adequately supplied with N. Our detailed soil sampling showed well above adequate available N throughout the growing season. Incidentally, these results also showed higher NO_3-N concentrations earlier in the tilled plots than in the no-till plots. Concentrations up to 50 ppm were measured under growing corn. We also measured available NO_3-N under living alfalfa in adjacent plots and found that the concentration never exceeded 2.0 ppm at any time during the season.

The yields of 11.8 and 12.5 tons/acre for no-till and traditional-till plots respectively, compare favorably with the average of about 10 ton/acre for this same corn grown under contract for a processing plant in the area. The net return was $26 per acre greater for the no-till corn, again indicating the negative economic impact of unneeded tillage.

INTERPRETIVE SUMMARY

Results from these five field studies have clearly demonstrated that cereal or corn can be grown successfully without tillage following alfalfa on furrow-irrigated land. There was an economic benefit to no-till cropping in all studies. This benefit is even greater than our data show when considering wear, depreciation cost, interest, etc., on tillage equipment. It is true that most irrigated land farmers already have the equipment used on these studies, and use it to produce other crops. However, it is evident they could use it much less than they do, and possibly they could get by with one or two fewer tillage implements, if they produced no-till cereal or corn following alfalfa.

One of the fears of furrow-irrigation farmers is that they will not be able to get the water to the ends of the furrows in the presence of residue on and in the soil surface. These five studies and many more not reported in this paper (Carter and Berg, 1990; unpublished data) demonstrated that no-till, furrow-irrigated land can be effectively irrigated. Generally, the first irrigation on no-till land resulted in more uniform water application than on traditionally tilled land. Furthermore, less water is needed to irrigate no-till lands the first irrigation than is needed to irrigate traditionally tilled land. This was particularly evident in the spring-seeded crops. Details of irrigation practices and water savings that can result from no-till on furrow-irrigated land will be reported in another paper.

Corn is a better choice for a crop following alfalfa than is cereal, because corn needs N later in the season and requires N to be supplied at a lower rate throughout the season than does cereal. In other words, the N requirements of corn tends to parallel the rate at which NO_3-N is formed in the soil following the killing of alfalfa. However, cereal can be adequately supplied with required N from the symbiotically fixed source if alfalfa is killed early in the fall so that the decomposition and mineralization processes can produce some NO_3-N reserve in the soil before the rapid N uptake requirements of cereal. If there is a question about N adequacy, soil and tissue testing should be done. If an N-deficiency is indicated, a low rate of N can be applied to supplement that becoming available from the alfalfa.

Another important aspect of this work is that growing corn or cereal following alfalfa decreases nitrate leaching as compared to growing dry beans or some other low-N-requiring crop, or a crop with a limited-rooting system. The N absorbed by the corn or cereal will not be leached, whereas the frequent irrigating of dry beans leaches nitrate as it is formed in the soil. Detailed studies are underway to quantify N leaching and uptake parameters while producing these different crops.

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