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RECOVERY OF ^{15}N FROM ALFALFA RESIDUE IN SOIL,
MICROBIAL BIOMASS AND A SUBSEQUENT CORN CROP

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RECOVERY OF ^{15}N FROM ALFALFA RESIDUE IN SOIL, MICROBIAL BIOMASS AND A SUBSEQUENT CORN CROP

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ABSTRACT

RECOVERY OF ^{15}N FROM ALFALFA RESIDUE IN SOIL, MICROBIAL BIOMASS AND A SUBSEQUENT CORN CROP

By

Glendon Hamilton Harris, Jr.

Recent economic and environmental concerns have caused renewed interest in using legumes to provide N to subsequent crops in rotation. The objective of this study was to quantify the recovery of ^{15}N from alfalfa residue in soil, microbial biomass and subsequent corn crop.

^{15}N-labeled alfalfa shoots or roots/crowns were incorporated into field microplots in Fall, 1985, and Spring, 1986, at two Michigan locations. Corn and soil were harvested from the microplots in Fall, 1986, and analyzed for ^{15}N.

Corn recovered 16.7 and 25.0 % of the alfalfa-^{15}N applied to loam and sandy loam soils, respectively. Recovery from soil averaged 45.5 % of N input, of which 94.5 % was recovered from the organic fraction. Recovery in microbial biomass accounted for 22.5 % of that recovered in the soil organic fraction. More ^{15}N was recovered from shoots than roots/crowns at both locations and from spring-incorporated than fall-incorporated residues on the loam soil.

"This one goes out to the one I love"

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PREFACE

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INTRODUCTION

For economic and environmental reasons, there has been a renewed interest in using legumes in crop rotations to provide N to subsequent non-legume crops. The importance of accurately assessing legume N contributions has therefore increased. Despite considerable past research, debate continues over both the amount of legume N contributed to subsequent crops and the methods of measuring this contribution.

Two methods used to quantify legume N contributions to subsequent crops are the fertilizer replacement value method and the ^{15}N tracer method. Numerous fertilizer replacement value studies have been conducted to measure the alfalfa (*Medicago sativa* L.) N contribution to corn (*Zea mays* L.). This is the first study to measure the alfalfa N contribution to corn using ^{15}N. The objectives were i) to quantify the amount of incorporated alfalfa-^{15}N recovered by a subsequent corn crop and in various soil fractions (total N, inorganic N, organic N and microbial biomass N) and ii) to determine the effect of plant part (shoots vs. roots/ crowns) and time of incorporation (fall vs. spring) on recovery of alfalfa-^{15}N.

LITERATURE REVIEW

Fertilizer Replacement Value Method

Most fertilizer recommendations base legume N credits on the fertilizer replacement value, which is the amount of inorganic N fertilizer required to produce a subsequent non-legume crop yield equivalent to that produced following a legume. Fertilizer replacement value estimates of alfalfa (*Medicago sativa* L.) N contribution to a subsequent corn (*Zea mays* L.) crop range from 31 (Stickler et al., 1959) to 180 (Voss and Shrader, 1979) kg N ha^{-1} depending on alfalfa cultivar, harvest management and age of the stand. A good stand of alfalfa is commonly credited with 112 to 156 kg N ha^{-1} (Bundy, 1985; Jokela et al., 1981; Voss and Shrader, 1984; Warncke et al., 1985). While these recommendations give an indication of expected corn grain yield response to a preceding alfalfa crop in terms of an inorganic N fertilizer application, it is assumed that the entire response is due to legume N, and that legume N and inorganic fertilizer N are equally available. Evidence exists disputing both of these assumptions. Several researchers have concluded that beneficial non-N, or "rotation", effects contribute to the yield response of a non-legume following a legume in rotation (Bruulsema and Christie, 1987; Heichel et al., 1987; Hesterman et. al., 1987; Russell et al., 1987; Voss and Shrader, 1984). In one study, up to 25 % of a non-legume yield response to a legume was attributed to such effects (Baldock et al., 1981). Several reports suggest that legume N and inorganic N fertilizer are not equally available for crop uptake. Fribourg and Johnson (1956) reported that alfalfa N is utilized by corn 34 % as efficiently as NH_4NO_3-N. In a direct comparison of legume N and fertilizer N use efficiencies, Ladd and Amato (1986) found that wheat (*Triticum aestivum* L.) utilized 46 % of applied fertilizer N compared to 17 % of legume N applied at the same rate.

Field studies indicate that crops recover about 50 % of applied inorganic fertilizer-^{15}N (Hauck, 1971). Typical fertilizer N use efficiency values for corn range from 40 to 70 % (Stanford, 1973). Kitur et al. (1984) reported 36 and 62 % recovery of ^{15}N-labeled NH_4NO_3 by corn (grain and stover) depending on application rate and tillage system. Bigeriego et al. (1979) found that corn (grain and stover) recovered between 48 and 81 % ^{15}N-labeled $(NH_4)_2SO_4$ depending on application rate and time of application.

^{15}N Tracer Method

Another method of quantifying legume N contributions is to trace ^{15}N from labeled residues into a subsequent crop. In the first reported study using ^{15}N-labeled residues, Norman and Werkman (1943) found that 25 % of ^{15}N from soybean [*Glycine max* L. (Merr.)] shoots was recovered by soybean plants growing in pots in a greenhouse. Moore (1974) reported a 30 % recovery of rhodesgrass (*Chloris gayana*)-^{15}N by two subsequent rhodesgrass cuttings grown in greenhouse pots. Yaacob and Blair (1980) measured the recovery of ^{15}N from either soybean shoots (minus beans) or sirato (*Macroptilium atropurpureum*) shoots by rhodesgrass in greenhouse pots containing soil previously cropped with 1, 3 or 6 years of soybeans and sirato, respectively. Rhodesgrass recovered an average of 15 % of the soybean-^{15}N regardless of previous cropping history, whereas 14, 42 and 55 % of sirato-^{15}N was recovered by rhodesgrass with 1,3 and 6 previous sirato crops, respectively. Higher recovery of ^{15}N from sirato compared to soybean was attributed to either the higher N content of sirato or difference in chemical composition of the two materials. The higher recovery of sirato-^{15}N in soil with more years of sirato cropping was attributed to an increased priming effect, or stimulated release of native soil organic matter caused by addition of organic residues, and ultimately to the nitrogen content and chemical composition of organic matter of the soils. Azam et al. (1985) found that corn growing in greenhouse pots recovered about 5 % of incorporated *Sesbania aculeata* (Pers.)-^{15}N.

In a field study, Vallis (1983) found that after one year, 7 to 10 % of ^{15}N from surface applied sirato and desmodium (*Desmodium intortum*) stems and leaves was recovered by a rhodesgrass pasture in Australia. Sirato contributed more ^{15}N than *Desmodium*, and leaves of both legumes contributed more ^{15}N than stems. Also in Australia, Ladd et al. (1981, 1983, 1986) have reported between 11 and 28 % recovery of ^{15}N from incorporated medic (*Medicago littoralis* L.) residues by wheat growing in the field. From these studies, Ladd et al. concluded that the primary value of the legume was long term maintenence of soil organic N levels high enough for adequate delivery of N to future cereal crops.

Tracing ^{15}N from applied residues and inorganic fertilizer gives a direct measurement of N contributed to a subsequent crop. However, this method does not account for N initially released from the microbial biomass, nor the soil N accumulated under the legume stand, as contributions from the legume. Jansson and Persson (1976) stated that lower recoveries are expected when measuring fertilizer-^{15}N uptake by crops compared to when using the conventional method of measuring the difference in crop uptake of N between a fertilized treatment and an unfertilized control. They attribute the lower recoveries using ^{15}N to either a priming effect, in which fertilizer N leads to an increase in net mineralization of soil N, or mineralization-immobilization turnover (MIT), the continuous transfer of inorganic soil N to organic N, and vice versa, by the soil microbial biomass.

MATERIALS AND METHODS

This study was conducted at two Michigan locations; the Michigan State University Experiment Station at East Lansing (EL), and the Kellogg Biological Station (KBS) at Hickory Corners. Soil types were a Capac loam (fine-loamy, mixed, mesic, Aeric Ochraqualf) and Oshtemo sandy loam (coarse-loamy, mixed, mesic Typic Hapludalf) at EL and KBS, respectively. The previous crop at both sites was alfalfa (EL - 5 yr, KBS - 1 yr). Soil characteristics and climatological data for each location appear in Table 1.

^{15}N-enriched alfalfa shoots (8.1 % atom excess, C:N = 13:1) or roots/crowns (6.9 % atom excess, C:N = 22:1) were applied to field microplots in both Fall, 1985, and Spring, 1986 (11 and 14 Nov or 19 and 25 May at EL and KBS, respectively). Labeled residues were obtained by growing 'Vernal' alfalfa in a sand-filled greenhouse bench and fertilizing weekly with a nutrient solution containing $K^{15}NO_3$ (12 % atom excess). Residues were incorporated to a 15 cm depth at a rate equivalent to 112 kg N ha^{-1}. Microplots consisted of 0.60 m dia. by 0.60 m deep undisturbed soil columns enclosed by open-ended sheet metal cylinders that extended 5 cm above the soil surface. The cylinders were spaced at least 1.5 m apart and were installed by trenching around the soil column with a gaspowered posthole digger. The top 15 cm of soil was excavated and existing alfalfa roots were removed by handpicking and sieving (0.4 cm). ^{15}N-enriched alfalfa residues (cut to 7 cm lengths) were mixed into the sieved soil and returned to microplots. Unlabeled alfalfa residues were incorporated into separate, 15 cm-deep, microplots in 2 of 4 replications to provide ^{15}N backround levels.

In spring (2 and 8 May at EL and KBS, respectively), 1986, 6 corn seeds ('Pioneer 3737') were hand-planted into each microplot, and thinned to 3 plants soon after emergence. The area surrounding the microplots was planted with the same hybrid at a population of 59 000 plants ha^{-1}. One week prior to planting, both sites were sprayed with 2.24 kg a.i. ha^{-1} glyphosate [N-(phosphonomethyl) glycine] to kill the existing alfalfa. At planting, 28 kg ha^{-1} P_2O_5 (0-46-0) was broadcast at the EL site as recommended by the Michigan State Soil Testing Lab. At planting, both locations received 0.56 kg a.i. ha^{-1} paraquat (1,1'-dimethyl-4,4'-bipydridinium ion) , 2.8 kg a.i. ha^{-1} alachlor [2-chloro-2'-6'-diethyl-N-(methoxymethyl) acetanilide], 1.4 kg a.i. ha^{-1} cyanizine (2-{[4-chloro-6-(ethylamino)-1,3,5-triazine-2-yl] amino}-2-methylpropanenitrile) and, 0.56 kg a.i. ha^{-1} atrazine [6-chloro-N-ethyl-N'-(1-methylethyl)-1,3,5-triazine-2,4-diamine] to control weeds throughout the growing season. During the growing season, microplots received no supplemental N, and any weeds emerging in the microplots were pulled and left on the surface. After corn plants had reached physiological maturity (6 and 14 Oct at EL and KBS, respectively), corn grain, stover (stalks + cobs), and roots were harvested from each microplot. Roots were harvested from the 0-15 cm layer of soil by handpicking and sieving (0.4 cm), then washed with tap water before drying. All harvested plant material was dried at 60 °C for 4 days, weighed, and ground to pass a 40 mesh screen. Samples were analyzed for total N by micro-Kjeldahl digestion (Bremner, 1965) and colorimetric determination of NH_4^+ in a Lachat flow-injection autoanalyzer by Lachat QuikChem$^{T.M.}$ Method No. 10-107-06-2-E (Lachat Chemicals, Inc.). Plant samples were analyzed for ^{15}N on a Micromass 622 mass spectrometer after a micro-Kjeldahl digestion and steam distillation of NH_3.

Percent N in corn derived from alfalfa was calculated by : ^{15}N atom % excess corn / ^{15}N atom % excess alfalfa x 100. Recovery of alfalfa-^{15}N by corn calculated by : percent N in corn derived from alfalfa x corn total N uptake / amount of alfalfa N applied; where corn total N uptake = corn dry matter yield x N content.

After harvesting roots from the entire 0-15 cm soil layer of each microplot, 3 consecutive soil layers of 15 cm depth (15-30, 30-45, 45-60 cm) were excavated from half of the microplots. Each layer was weighed, mixed, and sampled. Subsamples were dried for 4 days at 60 °C to determine moisture content. Dried subsamples were then analyzed for total N and ^{15}N on a Europa Scientific Tracermass mass spectrometer after conversion of sample N to N_2 by Dumas combustion in a Roboprep CN analyzer (Preston and Owens, 1983). Soil inorganic N (NO_3^- and NH_4^+) in filtered KCl extracts (100 ml 2 M KCl : 20 g dry soil, shaken 1 hr) was measured colorimetrically on the Lachat flow-injector analyzer by Lachat QuikChem T.M. method no. 12-107-04-1-A (Lachat Chemicals, Inc.). Soil inorganic ^{15}N in KCl extracts was released as NH_3 following reduction of NO_3^- with Devarda's alloy and addition of MgO. The released NH_3 was trapped on acidified glass filter disks (6 mm) as NH_4^+ (Brooks, 1987). The $^{15}NH_4^+$ was analyzed on the Europa Scientific Tracermass after combustion of the filter disks in the Roboprep CN analyzer.

Recovery of alfalfa-^{15}N in total and inorganic soil N was calculated by an equation similar to that used to calculate recovery by corn. Recovery in the organic soil N fraction was calculated by subtraction (total - inorganic).

Microbial biomass C and N in fresh samples from the 0-15 soil layer of each microplot were determined by the chloroform fumigation-incubation method (Jenkinson and Powlson, 1976). Soils were not inoculated after fumigation; biomass C = C_f/K_c, where C_f = CO_2-C evolved from the fumigated sample and K_c = 0.41; and biomass N = N_f/K_n, where Nf = NH_4^+-N released during incubation after fumigation and $K_n = -0.014(C_f/N_f) + 0.39$ (Voroney and

Paul, 1980). N_f and $^{15}N_f$ were determined as described above for inorganic soil N and ^{15}N, and then used to calculate recovery of alfalfa-^{15}N in microbial biomass.

N mineralization potential and percent mineralized N derived from alfalfa were also determined for the fresh subsample taken from the 0-15 cm soil layer after corn harvest. The amount of NO_3^- and NH_4^+ mineralized during a 20-day aerobic incubation at 25 °C (measured in KCl extracts as previously described) was taken as the N mineralization potential (Ladd et al., 1983). The percent of mineralized soil N derived from alfalfa was calculated after analyzing the inorganic N in KCl extracts for ^{15}N by the method described above.

To detect leaching of inorganic N from alfalfa residues below 0.60 m, 5 core samples (2.5 cm dia.) from the 60-75 cm soil layer of each microplot were pooled and analyzed for ^{15}N.

Analysis of variance for a randomized complete block (4 replications), 2 x 2 factorial experiment was performed on all data. Factors included alfalfa plant part incorporated (shoots or roots/crowns) and time of incorporation (fall or spring). Locations were analyzed separately.

Spring barley (*Hordeum vulgare* L.) was planted in all microplots at EL and KBS in Spring, 1987 (10 and 17 April, respectively) to measure recovery of alfalfa-^{15}N by a second subsequent crop. After sampling in Fall 1986, soil was returned by layer to the microplots, which were left fallow over winter. No additional N was applied to the microplots during 1987. After the barley reached physiological maturity (14 and 23 Jul at EL and KBS, respectively), grain, stover (straw) and roots were harvested from each microplot and analyzed for ^{15}N on the Europa Scientific Tracermass. Recovery of alfalfa-^{15}N by barley was then calculated by the same equation used for recovery by corn.

RESULTS AND DISCUSSION

Corn (grain + stover + roots) recovered 16.7 and 25.0 % of applied alfalfa-^{15}N at EL and KBS, respectively (Tables 2 and 3). These results are comparable to other legume-^{15}N decomposition and recovery studies (Azam, 1985; Moore, 1974; Norman and Werkman, 1943; Vallis, 1983; Yaacob and Blair, 1980), and agree especially well with those reported by Ladd et al. (1981, 1983, 1986) who also incorporated a *Medicago* species into field soil and found between 11 and 28 % recovery by wheat.

Sixty, 37 and 3 % of the alfalfa-^{15}N recovered by corn was found in the grain, stover and roots, respectively, at EL. Sixty-four, 33 and 3 % was found in the grain, stover, and roots, respectively, at KBS. The above-stated recovery of alfalfa-^{15}N by corn roots may be an underestimate because we did not attempt to separate fine root material from the 0-15 cm soil layer, nor any roots from soil in deeper layers. Another indication that not all roots were separated from soil comes from a previous study conducted in Michigan. Foth (1962) found that over 75 % of corn root dry matter yield occured in the top 22.5 cm of soil, and shoot:root dry weight ratios for mature corn were approximately 11:1. Using data from Table 4, corn shoot: root dry weight ratios for EL and KBS were 15:1 and 20:1, respectively. However, ^{15}N in corn roots not separated from soil was included in soil sampled from that layer.

The higher recovery of alfalfa-^{15}N by corn at KBS compared to EL was not due to differences in corn dry matter yield or total N uptake between the 2 locations (Table 4). Instead, the higher recovery was due to a smaller, more active, mineralizable soil N pool at KBS compared to EL. This resulted in both a greater contribution of alfalfa-^{15}N to the mineralizable N pool (on a percentage basis), and higher turnover of alfalfa-^{15}N through the mineralizable N pool at KBS compared to EL. The lower N and OM content of the KBS soil (Table 1) indicates that the mineralizable soil N pool at KBS was smaller than at EL. The higher percent mineralized N derived from alfalfa (for fresh soil sampled from the 0-15 cm layer after corn harvest) at KBS (Table 5) indicates the percentage contribution to the mineralizable N pool was greater at KBS than at EL. The higher N mineralization capacity at KBS suggests higher turnover of alfalfa-^{15}N through the mineralizable N pool compared to EL. Therefore, corn (grain + stover + roots) derived more N from alfalfa at KBS compared to EL (Table 6). And since corn dry matter yields were the same at both locations, there was higher recovery of alfalfa-^{15}N at KBS.

The above-stated explanation for higher recovery of alfalfa-^{15}N by corn at KBS is supported by results of Ladd et al. (1983) who also reported a greater percentage contribution of legume-^{15}N to the mineralizable soil N pool for topsoil with low (0.9 g kg^{-1}), compared to high (1.7 g kg^{-1}), total N content. The higher recovery of alfalfa-^{15}N by corn on the coarser textured soil at KBS is also supported by Hesterman et al. (1987) who found that more alfalfa N was recovered by corn growing on a coarse textured than a fine textured soil.

Corn recovered more ^{15}N from alfalfa shoots than roots/crowns at both EL and KBS (Tables 2 and 3; F values significant at the 0.05 and 0.10 levels of probability at EL and KBS, respectively). The higher C:N ratio of roots/crowns compared to shoots probably resulted in slower decomposition and availablity of N for uptake by corn. The rate of residue decomposition decreases as C:N ratio increases (Parr and Papendick, 1978). Bruulsema and Christie (1987) suggested that the composition of plant material (including C : N ratio) may have as much influence on N release to soil as the total N yield of the plowdown crop itself.

Time of incorporation had no significant effect on recovery of alfalfa-^{15}N by corn at KBS (Table 4). At EL, more ^{15}N was recovered by corn from spring-incorporated than fall-incorporated alfalfa (Table 3; F value significant at the 0.05 level of probability). This result could have been due to better temporal synchrony, i.e. more timely N release or mineralization from the alfalfa residues for uptake by corn when spring-incorporated.

Recovery of alfalfa-^{15}N in soil after corn harvest at EL and KBS measured 47.8 and 43.3 % of the initial input, respectively (Tables 2 and 3). Most of the alfalfa-^{15}N recovered in soil was found in the organic fraction (97 and 94 % at EL and KBS, respectively). In other legume-^{15}N field studies, Ladd et al. (1981, 1983, 1986) and Vallis (1983) also reported that most of the legume-^{15}N recovered from soil had been incorporated into the organic fraction.

Plant part and time of incorporation factors had a similar effect on recovery of alfalfa-^{15}N in soil as in corn : more alfalfa-^{15}N was recovered from shoots vs. roots/crowns at both locations, time of incorporation had no effect on recovery of alfalfa-^{15}N at KBS, and more ^{15}N was recovered when alfalfa was incorporated in the spring vs. fall at EL (Tables 2 and 3).

Recovery of alfalfa-^{15}N in soil microbial biomass was higher at EL compared to KBS (Tables 2 and 3). The higher recovery at EL was related to the longer legume cropping history and higher soil OM levels compared to KBS. Bolton et al. (1985) reported that a soil with a long legume cropping history (almost 80 years, and with no inorganic N applications) had a larger microflora population than a soil which received anhydrous ammonia as a N source for at least 30 years. Schnurer et al. (1985) found that microbial biomass C and N were positively correlated with soil organic matter. The microbial biomass C and N contents of the soil at EL measured 545 and 88 ug g^{-1}

respectively compared to 291 ug C g^{-1} and 48 ug N g^{-1} at KBS. Microbial biomass-^{15}N accounted for 24 and 21 % of alfalfa-^{15}N recovered in the organic soil fraction (0-15 cm) at EL and KBS, respectively.

Total recovery of alfalfa-^{15}N (corn + soil), averaged 64.5 and 68.3 % of input at EL and KBS. There was no time of incorporation effect on total recovery of alfalfa-^{15}N at KBS on a sandy loam soil, but on the loam soil at EL, total ^{15}N recovery was higher from spring-incorporated than fall-incorporated alfalfa (75 vs. 54 %; F value significant at the 0.05 level of probability). In a lysimeter study conducted in Alabama, Jones (1933) reported as much as 70 % loss (by leaching) of soybean-, cowpea (*Vigna sinensis*)-, and crotalaria (*Crotalaria spectabilis*)-N when fall-incorporated. Nitrogen loss from these legumes was reduced by almost 50 % when spring-incorporated.

Most of the alfalfa-^{15}N not recovered at EL was likely lost from microplots by denitrification. Above average rainfall during the growing season and poorly-drained, fine-textured soil at this site created conditions favorable for denitrification. Although alfalfa-^{15}N was detected in the 60-75 cm soil layer (0.02583 atom % excess in inorganic fraction; 0.00412 atom % excess in total N fraction), indicating some loss by leaching, denitrification is still suspected as the major loss mechanism. Leaching of NO_3^--N from alfalfa residues below the 60 cm microplots is the major mechanism of loss suspected at KBS, where alfalfa-^{15}N was also detected in soil samples from the 60-75 cm depth at KBS (0.02274 atom % excess in inorganic fraction; 0.01366 atom % excess in total N fraction). Above average rainfall during the growing season and well-drained, coarse-textured soil at this site combined to create conditions conducive to leaching.

Total ^{15}N recovery at EL and KBS was lower than that reported in field studies by Ladd et al. (1981, 1983, 1986), suggesting there is more loss of legume-N from an alfalfa-corn rotation in Michigan, with a temperate climate than a medic-wheat rotation in the arid conditions of Australia. Ladd et al. (1981) also attributed losses of legume-^{15}N to denitrification on a fine-textured soil and leaching on a coarse-textured soil.

Distribution of alfalfa-^{15}N recovered in soil, by depth, (Table 7) shows that 94 % recovery from the organic fraction and 90% recovery from the inorganic fraction occured in the top 30 cm. Distribution of inorganic alfalfa-^{15}N in the soil profile at both locations does not indicate leaching from the system at the time of sampling (fall). However, lack of large amounts of inorganic ^{15}N in lower depths at KBS does not eliminate the possibility of significant leaching earlier in the season. A portion of the alfalfa-^{15}N recovered in the organic soil N fraction at the lower depths was probably contained in corn roots not separated from soil as discussed earlier.

Tracing alfalfa-^{15}N into a second subsequent crop, only 1 % was recovered by the 1987 spring barley crop at both EL and KBS (Table 8). This result is also compatable with other legume-^{15}N studies. Ladd et al. (1983) reported 4 % recovery of medic-^{15}N by a second wheat crop and Vallis (1983) found that uptake of ^{15}N from sirato and desmodium by rhodesgrass in second and third years was only 23 and 12 % respectively of that in the first year.

Poor stand establisment resulted in low dry matter yield by barley at KBS compared to EL (Table 8). However, recovery of alfalfa-^{15}N by barley was almost identical at the two locations due to the higher N content and percent N derived from alfalfa at KBS compared to EL. The higher N content and percent N derived from alfalfa by barley at KBS further suggests that the mineralizable soil N pool was smaller and more active than at EL, again causing a greater contribution of alfalfa-^{15}N to the mineralizable N pool and higher turnover of alfalfa-^{15}N through that pool.

CONCLUSIONS

Results for recovery of alfalfa-^{15}N by corn at EL and KBS compare well with other legume-^{15}N studies in which less than 30 % of legume N was contributed to a subsequent non-legume crop. These recovery values are lower than those for recovery of fertilizer-^{15}N reported earlier. Also, assuming a typical quantity of 112 kg N h^{-1} returned to soil in alfalfa residues, the ^{15}N recovery values at EL and KBS would translate to alfalfa N contributions of 19 and 28 kg N h^{-1}, respectively. These values for N contribution based on the ^{15}N tracer method are low compared to the alfalfa N credit of 112 to 156 kg N h^{-1} based on fertilizer replacement value studies. The reason for this large discrepancy is that the fertilizer replacement value method measures the overall effect of alfalfa on corn yield in terms of an inorganic N fertilizer application, whereas the ^{15}N method measures recovery of N from alfalfa residues (and not from the resident microbial biomass N pool or soil N accumulated under the alfalfa stand).

More alfalfa ^{15}N was incorporated into the soil organic N pool than was recovered by corn. This indicates that the alfalfa N contribution to maintenance of soil N levels for adequate N release to future crops is as important, if not more so, than the contribution to the first subsequent crop. Recovery of legume N by crops suceeding the first subsequent crop however are very low, as suggested by the results of this study and those reported by Ladd et al. (1983) and Vallis (1983) mentioned earlier.

Total alfalfa-^{15}N recovery values from this study suggest that approximately 30 % of N from alfalfa residues may be lost by leaching or denitrification. Since there was higher recovery of ^{15}N from spring-incorporated alfalfa by corn and in soil at EL, it may be advantageous to incorporate alfalfa residues in the spring vs. fall for more efficient N use.

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Table 1. Soil characteristics and climatalogical data for East Lansing (EL) and Kellogg Biological Station (KBS).

	Soil(0-15 cm) †				Precipitation		Mean Air Temperature	
Location	pH	CEC	OM	N	May-Sept ‡ 1986	Long-term § average	May-Sept‡ 1986	Long-term § average
		(me/100g)	--- g/kg ---		--------- mm ---------		----------°C ---------	
EL	7.2	15	28	2.0	630	366	18.0	18.4
KBS	6.9	11	16	1.0	748	495	19.4	19.2

†Sampled Oct 1985

‡Data recorded at National Weather Service Stations at Michigan State University, East Lansing and Kellogg Biological Station, Hickory Corners, MI.

§Long term averages compiled from official weather station at Lansing, MI National Weather Service Office and National Weather Service Climatological Station, Kellogg Biological Station, Hickory Corners, MI.

Table 2. Recovery of alfalfa-^{15}N by corn and in soil at EL.

	Fall		Spring			
	Shoots	Roots/crowns	Shoots	Roots/crowns	Mean	CV
	------- Recovery of alfalfa-^{15}N (% of input) --------					
Corn						
Grain	9.5	7.7	13.5	9.6	10.1	36
Stover	5.2	4.4	9.3	5.4	6.1	22
Roots	0.44	0.40	0.60	0.47	0.5	24
Total(Corn)	15.1	12.5	23.4	15.5	16.7	26
Soil						
Inorganic	1.44	1.23	2.00	1.57	1.5	17
Organic	39.2	37.6	57.6	50.7	46.3	18
Microbial Biomass	8.4	7.7	11.1	8.3	8.9	11
Total(Soil)	40.6	38.3	59.6	52.2	47.8	17
Total (Corn + Soil)	55.7	51.3	83.0	67.7	64.4	11

Table 3. Recovery of alfalfa-^{15}N by corn and in soil at KBS.

	Fall		Spring			
	Shoots	Roots/crowns	Shoots	Roots/crowns	Mean	CV
	------- Recovery of alfalfa-^{15}N (% of input) --------					
Corn						
Grain	15.1	18.2	19.2	11.1	15.9	43
Stover	10.8	6.1	10.1	6.3	8.3	12
Roots	1.00	0.45	0.87	0.72	0.8	27
TotalCorn)	26.9	24.7	30.2	18.1	25.0	28
Soil						
Inorganic	2.59	2.31	2.45	2.53	2.5	30
Organic	42.5	36.4	46.1	38.4	40.8	11
Microbial Biomass	6.7	6.4	7.7	6.1	6.7	24
Total(Soil)	45.1	38.7	48.5	41.0	43.3	10
Total (Corn + Soil)	72.0	63.4	78.7	59.1	68.3	11

TABLE 4 : Effect of plant part and time of incorporation on corn dry matter yield and total N uptake at EL and KBS.

	Grain		Stover		Root		Grain+Stover+Root	
	D.M. Yield	Total N Uptake	D.M. Yield	Total N Uptake	D.M. Yield	Total N Uptake	D.M. Yield	Total N Uptake
	(g/plot)							
	EL							
Plant part								
Shoot	234	3.2	224	2.0	32.2	0.18	490	5.4
Root/crown	253	3.4	205	1.8	29.0	0.17	488	5.4
Time of incorporation								
Fall	271	3.5	236	2.0	35.8	0.20	542*	5.7
Spring	216	3.1	194	1.9	26.4	0.16	436	5.1
Mean	243	3.3	215	1.9	31.1	0.18	489	5.4
CV	23	24	11	19	20	25	12	18
	KBS							
Plant part								
Shoot	263	3.6	222	2.0	24.9	0.21	510	5.8
Root/crown	240	3.2	206	1.9	22.1	0.18	469	5.2
Time of incorporation								
Fall	257	3.4	218	2.0	23.6	0.19	498	5.6
Spring	247	3.4	211	1.8	23.4	0.20	482	5.4
Mean	252	3.4	214	1.9	23.5	0.19	490	5.5
CV	20	24	11	20	20	23	15	18

* F value significant at 0.05 level of probability (Fall > Spring)

Table 5. N mineralization potential and percent mineralized N derived from alfalfa for fresh soil sampled from the 0-15 cm layer after corn harvest at EL and KBS.

	Fall		Spring			
Location	Shoots	Roots/crowns	Shoots	Roots/crowns	Mean	CV
	--------- N mineralization potential (ug/g) ---------					
EL	10.8	10.8	11.4	10.1	10.8	10
KBS	15.1	13.7	14.3	14.8	14.4	13
	--- Percent mineralized N derived from alfalfa (%) ---					
EL	6.9	8.6	5.4	6.7	6.9	8
KBS	9.0	11.9	18.9	13.1	10.7	30

Table 6. Percent N in corn (grain + stover + roots) derived from alfalfa at EL and KBS.

Location	Fall		Spring		Mean	CV
	Shoots	Roots/crowns	Shoots	Roots/crowns		
	----- Percent N in corn derived from alfalfa (%) ----					
EL	8.5	7.2	14.7	9.8	10.0	13
KBS	14.6	15.4	16.9	11.4	14.6	22

TABLE 7. Recovery of alfalfa-^{15}N (% of input) in total, inorganic, organic, and microbial biomass soil N by depth at EL and KBS.

	Location	
	EL	KBS
	-- Recovery of alfalfa ^{15}N (% of input) †--	
Total Soil N		
0-15	37.3	33.6
15-30	8.2	7.2
30-45	1.3	1.4
45-60	1.1	1.1
Inorganic Soil N		
0-15	1.07	1.65
15-30	0.35	0.57
30-45	0.08	0.13
45-60	0.07	0.11
Organic Soil N		
0-15	36.2	31.9
15-30	7.9	6.6
30-45	1.2	1.3
45-60	1.0	1.0

†Values are averaged over both plant parts (shoot and root/crown) and times of incorporation (fall and spring)

Table 8. Dry matter yield, N content, total N uptake, percent N derived from alfalfa and recovery of alfalfa-^{15}N by barley (grain + stover (straw) + roots) grown in 1987 after corn at EL and KBS.

	Location	
	EL	KBS
Dry matter yield (g/plot)	96	43
N content (mg/g)	9.8	16
Total N uptake (g/plot)	0.95	0.69
Percent N derived from alfalfa (%)	4.0	5.6
Recovery of alfalfa-^{15}N (% of input)	1.15	1.18

APPENDICES

APPENDIX A

APPENDIX A

Recovery of alfalfa-^{15}N -- Data and Calculations

1. Tables A1 and A2

Total N uptake by grain, stover and root components of corn, Variables (V) 11, 12, and 13, respectively, were calculated by multiplying the d.m. yield of the component times the N content (%N). For example:

V11 = V5 x V8/100.

V14 = V11 + V12 + V13

V15 = V5 + V6 + V7

V16 = V14 / (V15/100)

2. Tables A3 and A4

Recovery of alfalfa-^{15}N by each corn component (V14, V15, V16) was calculated by multiplying the d.m. yield of the component times the N content (%N) times the ^{15}N atom % excess, divided by the amount of alfalfa-N applied times the ^{15}N atom % excess of the alfalfa. For example:

If V3 = 1 Then V14 = (V5 x V8/100 x V11) / 0.263292

Else V14 = (V5 x V8/100 x V11) / 0.2256.

Where:

0.2632 = 3.2592 x 8.0746/100

0.2256 = 3.2592 x 6.9220/100

Note: 3.2592 = g of N applied to 60 cm dia. microplots (equivalent to 112 kg N ha^{-1})

8.0746 = ^{15}N atom % excess of alfalfa shoots

6.9220 = ^{15}N atom % excess of alfalfa root/crowns

V17 = V14 + V15 + V16

3. Tables A5 and A6

%N in each corn component derived from alfalfa was calculated by dividing the ^{15}N atom % excess of the component by the atom % excess of alfalfa times 100. For example:

If V3 = 1 Then V12 = V9/8.0746 x 100

Else V12 = V9/6.9920 x 100.

V15 = {[(V12/100 x V5) + (V13/100 x V6) + (V14/100 x V7)] / V8} x 100

4. Tables A7 and A8

Recovery of alfalfa-^{15}N in the total N fraction of each soil layer was calculated by the same principle as recovery by corn components. For example:

If V3 = 1 Then V17 = (V5 x V9/100 x V13) / 0.2632

Else V17 = (V5 x V9/100 x V13)/ 0.2256.

V21 = V17 + V18 + V19 + V20

5. Tables A9 and A10

Recovery of alfalfa-^{15}N in the inorganic N fraction of each soil layer was calculated by the same principle as recovery by corn and total soil N. For example:

If V3 = 1 Then V17 = (V5 x V9 x V13) / 263200

Else V17 = (V5 x V9 x V13) / 225600.

V21 = V17 + V18 + V19 + V20

Note: Recovery of alfalfa-^{15}N in the organic fraction of each soil layer was calculated by subtraction: Values from Tables A9 and A10 (Inorganic N) subtracted from corresponding values from Tables A7 and A8 (Total N) .

6. Tables A11 and A12

Microbial biomass C was calculated by Cf/0.41 as explained in the Materials and Methods section. C10 and C20 (V6 and V7) are provided for recalculation by different methods if desired.

7. Tables A13 and A14

Equations for calculating Kn and microbial biomass N appear with the variable descriptions and were also explained in the Materials and Methods section. Recovery of alfalfa-^{15}N in the microbial biomass was calculated by multiplying the 0-15 soil layer d.w. times microbial biomass N times ^{15}N atom % excess of inorganic N from the fumigated sample, divided by the amount of alfalfa N applied times the atom % excess of the alfalfa. For example:

If V3=1 Then V17 = V5 x V15 x V16 / 263200

Else V17 = V5 x V15 x V16 / 225600.

8. Table A15

^{15}N atom % values for total N and inorganic N from the 60-75 cm soil layer for each microplot at EL and KBS appear in cases 1-16. Six samples from the 60-75 cm soil layer located adjacent to the microplots were analyzed for backround ^{15}N levels in the total N fraction and appear in cases 18-23. Means from V2 and V4/cases 1-16 were compared to the mean from V2/cases 18-23 by a paired t test and found to be significantly different at the 0.05 level of probability. Likewise, means from V3 and V5/cases 1-16 were compared to the mean of V3/cases 18-23 and found to be significantly different at the 0.05 level of probability using a paired t test. In both cases, mean values from cases 1-16 were higher than means from cases 18-23.

9. Table A16

N mineralization capacity was calculated by multiplying the amount of N mineralized during a 20-day aerobic incubation times the volume of KCl used in extract divided by the dry weight of soil used. For example:

V8 = (V7 - V6) * 100/20

where 100 = ml of 2M KCl and 20 = dry weight of soil. Note: NH_4 was not present in KCl extract from either time zero or 20-day samples. Percent mineralized N derived from alfalfa was calculated by dividing ^{15}N atom % excess of 20-day KCl extracted NO_3 by ^{15}N atom % excess of alfalfa. For example:

If V4 = 1 Then V10 = V9/8.0746 x 100

Else V10 = V9/6.9920 x 100.

10. Tables A17 and A18

Percent N derived from alfalfa and total N uptake for barley was calculated in the same manner as for corn. For examples:

If V4 = 1 Then V14 = V11/8.0746 x 100

Else V14 = V11/6.9920 x 100, and

V17 = V5 x (V8/100).

V21 = V5 + V6 + V7

V22 = V20 / (V21/100)

V23 = {[(V14/100 x V17) + (V15/100 x V18) +

(V16/100 x V19)] / V20} x 100

11. Tables A19 and A20

Recovery of alfalfa-^{15}N by barley was calculated in the same manner as recovery by corn. For example:

If V3 = 1 Then V17 = (V5 x V8/100 x V11) / 0.263292

Else V17 = (V5 x V8/100 x V11) / 0.2256.

V20 = V17 + V18 + V19

Table A1. Corn dry matter yield, N content, and total N uptake at EL.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation 1=Fall 2=Spring
5	numeric	Grain D.M. Yield (g/plot)
6	numeric	Stover D.M. Yield (g/plot)
7	numeric	Root D.M. Yield (g/plot)
8	numeric	%N Grain
9	numeric	%N Stover
10	numeric	%N Root
11	numeric	Total N Uptake by Grain (g/plot)
12	numeric	Total N Uptake by Stover (g/plot)
13	numeric	Total N Uptake by Roots (g/plot)
14	numeric	Total N Uptake by Corn - Grain+Stover+Roots (g/plot)
15	numeric	Corn - Grain+Stover+Roots D.M. Yield (g/plot)
16	numeric	Corn - Grain+Stover+Roots %N

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	2	1	264.6	203.5	27.5	1.19	0.80	0.52	3.14	1.62	0.14	4.91	495.6	0.99
2	102	1	1	1	194.0	222.8	27.5	1.27	0.73	0.53	2.46	1.64	0.15	4.24	444.3	0.95
3	103	1	2	2	287.9	182.3	19.7	1.45	0.97	0.57	4.18	1.77	0.11	6.07	489.9	1.24
4	104	1	1	2	117.3	233.2	36.2	1.57	0.84	0.54	1.84	1.96	0.20	4.00	386.7	1.03
5	201	2	2	2	221.9	172.7	19.4	1.30	0.76	0.49	2.89	1.31	0.09	4.30	414.0	1.04
6	202	2	1	2	284.1	199.0	27.6	1.44	0.78	0.55	4.10	1.54	0.15	5.79	510.7	1.13
7	203	2	1	1	254.4	245.5	39.2	1.45	0.72	0.51	3.68	1.76	0.20	5.64	539.1	1.05
8	204	2	2	1	332.7	261.7	46.6	1.32	0.80	0.53	4.39	2.09	0.24	6.72	641.0	1.05
9	301	3	1	1	338.1	235.8	38.3	1.24	0.78	0.55	4.19	1.83	0.21	6.23	612.2	1.02
10	302	3	1	2	186.7	211.7	29.2	1.41	0.96	0.59	2.63	2.03	0.17	4.83	427.6	1.13
11	303	3	2	1	283.4	256.3	36.2	1.23	0.74	0.47	3.48	1.90	0.17	5.54	575.9	0.96
12	304	3	2	2	221.5	202.4	32.0	1.47	1.08	0.70	3.25	2.20	0.22	5.67	455.9	1.24
13	401	4	2	2	180.9	166.3	22.1	1.36	1.01	0.77	2.45	1.68	0.17	4.30	369.3	1.17
14	402	4	2	1	232.5	198.3	36.0	1.40	1.14	0.63	3.24	2.27	0.23	5.74	466.8	1.23
15	403	4	1	2	227.9	183.2	24.7	1.47	1.33	0.57	3.36	2.44	0.14	5.94	435.8	1.36
16	404	4	1	1	266.4	262.1	34.9	1.36	1.19	0.68	3.63	3.11	0.24	6.98	563.4	1.24

Table A2. Corn dry matter yield, N content, and total N uptake at KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation 1=Fall 2=Spring
5	numeric	Grain D.M. Yield (g/plot)
6	numeric	Stover D.M. Yield (g/plot)
7	numeric	Root D.M. Yield (g/plot)
8	numeric	%N Grain
9	numeric	%N Stover
10	numeric	%N Root
11	numeric	Total N Uptake by Grain (g/plot)
12	numeric	Total N Uptake by Stover (g/plot)
13	numeric	Total N Uptake by Roots (g/plot)
14	numeric	Total N Uptake by Corn - Grain+Stover+Roots (g/plot)
15	numeric	Corn - Grain+Stover+Roots D.M. Yield (g/plot)
16	numeric	Corn - Grain+Stover+Roots %N

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	1	1	288.3	261.0	33.9	1.26	1.09	0.75	3.62	2.86	0.25	6.73	583.2	1.15
2	102	1	1	2	312.1	241.0	23.4	1.54	0.95	0.84	4.79	2.29	0.20	7.28	576.5	1.26
3	103	1	2	2	236.9	241.0	33.8	1.16	0.71	0.89	2.74	1.71	0.30	4.75	511.7	0.93
4	104	1	2	1	230.3	227.0	33.0	1.22	1.09	0.68	2.81	2.47	0.22	5.51	490.3	1.12
5	201	2	2	2	257.0	193.0	23.0	1.21	0.93	0.77	3.10	1.79	0.18	5.07	473.0	1.07
6	202	2	1	2	187.0	187.0	23.5	1.28	0.97	0.93	2.40	1.81	0.22	4.43	397.5	1.11
7	203	2	2	1	178.9	152.0	13.8	1.22	0.80	0.81	2.18	1.21	0.11	3.50	344.7	1.02
8	204	2	1	1	211.3	206.0	21.6	1.25	0.88	1.02	2.64	1.82	0.22	4.68	438.9	1.07
9	301	3	2	1	327.0	253.0	19.0	1.53	1.04	0.97	5.02	2.63	0.18	7.83	599.0	1.31
10	302	3	1	2	248.6	207.0	26.8	1.39	0.85	0.91	3.46	1.76	0.25	5.46	482.4	1.13
11	303	3	1	1	362.0	258.0	27.4	1.31	0.71	0.81	4.76	1.82	0.22	6.80	647.4	1.05
12	304	3	2	2	197.7	187.0	15.6	1.57	1.11	0.76	3.11	2.07	0.12	5.30	400.3	1.32
13	401	4	2	2	278.4	208.0	21.2	1.43	0.74	0.78	3.99	1.54	0.17	5.69	507.6	1.12
14	402	4	2	1	218.3	191.0	17.8	1.20	0.80	0.64	2.63	1.54	0.11	4.28	427.1	1.00
15	403	4	1	2	256.5	227.0	20.1	1.39	0.82	0.67	3.58	1.87	0.13	5.58	503.6	1.11
16	404	4	1	1	237.1	193.0	22.5	1.47	0.98	0.86	3.48	1.89	0.19	5.56	452.6	1.23

Table A3. Recovery of alfalfa N-15 by corn at EL.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation 1=Fall 2=Spring
5	numeric	Grain D.M. Yield (g/plot)
6	numeric	Stover D.M. Yield (g/plot)
7	numeric	Root D.M. Yield (g/plot)
8	numeric	%N Grain
9	numeric	%N Stover
10	numeric	%N Root
11	numeric	N-15 Atom % Excess Grain
12	numeric	N-15 Atom % Excess Stover
13	numeric	N-15 Atom % Excess Root
14	numeric	Recovery of alfalfa N-15 by Grain (% of input)
15	numeric	Recovery of alfalfa N-15 by Stover (% of input)
16	numeric	Recovery of alfalfa N-15 by Roots (% of input)
17	numeric	Recovery by Corn - Grain+Stover+Roots (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	101	1	2	1	264.6	203.5	27.5	1.19	0.80	0.52	0.5041	0.5594	0.4771	7.02	4.02	0.30	11.34
2	102	1	1	1	194.0	222.8	27.5	1.27	0.73	0.53	0.5077	0.5115	0.5364	4.74	3.18	0.30	8.22
3	103	1	2	2	287.9	182.3	19.7	1.45	0.97	0.57	0.7332	0.7888	0.7690	13.59	6.19	0.38	20.17
4	104	1	1	2	117.3	233.2	36.2	1.57	0.84	0.54	1.0226	1.2139	0.9257	7.15	9.03	0.69	16.87
5	201	2	2	2	221.9	172.7	19.4	1.30	0.76	0.49	0.6453	0.6731	0.7359	8.26	3.92	0.31	12.49
6	202	2	1	2	284.1	199.0	27.6	1.44	0.78	0.55	1.1740	1.1005	0.9296	18.28	6.45	0.54	25.27
7	203	2	1	1	254.4	245.5	39.2	1.45	0.72	0.51	0.8403	0.7046	0.6173	11.76	4.70	0.47	16.93
8	204	2	2	1	332.7	261.7	46.6	1.32	0.80	0.53	0.4579	0.4488	0.4351	8.90	4.16	0.47	13.54
9	301	3	1	1	338.1	235.8	38.3	1.24	0.78	0.55	0.8467	0.8622	0.6668	13.48	6.00	0.54	20.01
10	302	3	1	2	186.7	211.7	29.2	1.41	0.96	0.59	1.1850	1.2400	0.9078	11.84	9.55	0.59	21.98
11	303	3	2	1	283.4	256.3	36.2	1.23	0.74	0.47	0.4802	0.5085	0.4286	7.40	4.28	0.32	12.00
12	304	3	2	2	221.5	202.4	32.0	1.47	1.08	0.70	0.6468	0.6744	0.6914	9.32	6.56	0.69	16.57
13	401	4	2	2	180.9	166.3	22.1	1.36	1.01	0.77	0.6680	0.6492	0.6687	7.27	4.83	0.50	12.60
14	402	4	2	1	232.5	198.3	36.0	1.40	1.14	0.63	0.5326	0.5172	0.4843	7.66	5.20	0.49	13.35
15	403	4	1	2	227.9	183.2	24.7	1.47	1.33	0.57	1.3178	1.3012	1.0582	16.81	12.08	0.57	29.46
16	404	4	1	1	266.4	262.1	34.9	1.36	1.19	0.68	0.5782	0.6089	0.5235	7.97	7.19	0.47	15.64

Table A4. Recovery of alfalfa N-15 by corn at KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation 1=Fall 2=Spring
5	numeric	Grain D.M. Yield (g/plot)
6	numeric	Stover D.M. Yield (g/plot)
7	numeric	Root D.M. Yield (g/plot)
8	numeric	%N Grain
9	numeric	%N Stover
10	numeric	%N Root
11	numeric	N-15 Atom % Excess Grain
12	numeric	N-15 Atom % Excess Stover
13	numeric	N-15 Atom % Excess Root
14	numeric	Recovery of alfalfa N-15 by Grain (% of input)
15	numeric	Recovery of alfalfa N-15 by Stover (% of input)
16	numeric	Recovery of alfalfa N-15 by Roots (% of input)
17	numeric	Recovery by Corn - Grain+Stover+Roots (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	101	1	1	1	288.3	261.0	33.9	1.26	1.09	0.75	1.5137	1.2698	1.1301	20.83	13.78	1.09	35.71
2	102	1	1	2	312.1	241.0	23.4	1.54	0.95	0.84	1.6037	1.3740	1.1668	29.20	11.96	0.88	42.03
3	103	1	2	2	236.9	241.0	33.8	1.16	0.71	0.89	1.0849	0.9810	0.9189	13.19	7.42	1.22	21.84
4	104	1	2	1	230.3	227.0	33.0	1.22	1.09	0.68	0.9111	0.7768	0.6913	11.35	8.51	0.69	20.54
5	201	2	2	2	257.0	193.0	23.0	1.21	0.93	0.77	0.4894	0.4924	0.5452	6.73	3.92	0.43	11.08
6	202	2	1	2	187.0	187.0	23.5	1.28	0.97	0.93	0.9524	0.9654	0.8655	8.67	6.65	0.72	16.03
7	203	2	2	1	178.9	152.0	13.8	1.22	0.80	0.81	1.3066	0.5758	0.5956	12.62	3.10	0.30	16.01
8	204	2	1	1	211.3	206.0	21.6	1.25	0.88	1.02	1.2273	1.1747	1.1413	12.33	8.11	0.95	21.39
9	301	3	2	1	327.0	253.0	19.0	1.53	1.04	0.97	1.3066	0.6472	0.5808	29.05	7.55	0.47	37.07
10	302	3	1	2	248.6	207.0	26.8	1.39	0.85	0.91	1.2526	1.5501	1.2951	16.48	10.35	1.21	28.03
11	303	3	1	1	362.0	258.0	27.4	1.31	0.71	0.81	1.1016	1.6596	1.3459	19.91	11.49	1.13	32.53
12	304	3	2	2	197.7	187.0	15.6	1.57	1.11	0.76	0.5549	0.9329	0.9239	7.65	8.58	0.48	16.71
13	401	4	2	2	278.4	208.0	21.2	1.43	0.74	0.78	0.9532	0.8021	0.9945	16.85	5.47	0.73	23.05
14	402	4	2	1	218.3	191.0	17.8	1.20	0.80	0.64	1.7021	0.7503	0.7297	19.82	5.11	0.37	25.30
15	403	4	1	2	256.5	227.0	20.1	1.39	0.82	0.67	1.6648	1.6064	1.3343	22.61	11.42	0.68	34.72
16	404	4	1	1	237.1	193.0	22.5	1.47	0.98	0.86	0.5637	1.3603	1.0660	7.45	9.75	0.78	17.98

Table A5. Percent corn N derived from alfalfa at EL.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root
4	numeric	Time of Incorporation
5	numeric	Total N Uptake by Grain (g/plot)
6	numeric	Total N Uptake by Stover (g/plot)
7	numeric	Total N Uptake by Roots (g/plot)
8	numeric	Total N Uptake by Corn - Grain+Stover+Roots (g/plot)
9	numeric	N-15 Atom % Excess Grain
10	numeric	N-15 Atom % Excess Stover
11	numeric	N-15 Atom % Excess Root
12	numeric	%N in Grain Derived from Alfalfa
13	numeric	%N in Stover Derived from Alfalfa
14	numeric	%N in Roots Derived from Alfalfa
15	numeric	%N in Corn - Grain+Stover+Roots Derived from Alfalfa

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	101	1	2	1	3.14	1.62	0.14	4.91	0.50410	0.55940	0.47710	7.28	8.08	6.89	7.52
2	102	1	1	1	2.46	1.64	0.15	4.24	0.50770	0.51150	0.53640	6.29	6.33	6.64	6.33
3	103	1	2	2	4.18	1.77	0.11	6.07	0.73320	0.78880	0.76900	10.59	11.40	11.11	10.82
4	104	1	1	2	1.84	1.96	0.20	4.00	1.02260	1.21390	0.92570	12.66	15.03	11.46	13.77
5	201	2	2	2	2.89	1.31	0.09	4.30	0.64530	0.67310	0.73590	9.32	9.72	10.63	9.45
6	202	2	1	2	4.10	1.54	0.15	5.79	1.17400	1.10050	0.92960	14.54	13.63	11.51	14.22
7	203	2	1	1	3.68	1.76	0.20	5.64	0.84030	0.70460	0.61730	10.41	8.73	7.64	9.78
8	204	2	2	1	4.39	2.09	0.24	6.72	0.45790	0.44880	0.43510	6.62	6.48	6.29	6.56
9	301	3	1	1	4.19	1.83	0.21	6.23	0.84670	0.86220	0.66680	10.49	10.68	8.26	10.47
10	302	3	1	2	2.63	2.03	0.17	4.83	1.18500	1.24000	0.90780	14.68	15.36	11.24	14.84
11	303	3	2	1	3.48	1.90	0.17	5.54	0.48020	0.50850	0.42860	6.94	7.35	6.19	7.07
12	304	3	2	2	3.25	2.20	0.22	5.67	0.64680	0.67440	0.69140	9.34	9.74	9.99	9.52
13	401	4	2	2	2.45	1.68	0.17	4.30	0.66800	0.64920	0.66870	9.65	9.38	9.66	9.54
14	402	4	2	1	3.24	2.27	0.23	5.74	0.53260	0.51720	0.48430	7.69	7.47	7.00	7.58
15	403	4	1	2	3.36	2.44	0.14	5.94	1.31780	1.30120	1.05820	16.32	16.11	13.11	16.16
16	404	4	1	1	3.63	3.11	0.24	6.98	0.57820	0.60890	0.52350	7.16	7.54	6.48	7.31

Table A6. Percent corn N derived from alfalfa at KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root
4	numeric	Time of Incorporation
5	numeric	Total N Uptake by Grain (g/plot)
6	numeric	Total N Uptake by Stover (g/plot)
7	numeric	Total N Uptake by Roots (g/plot)
8	numeric	Total N Uptake by Corn - Grain+Stover+Roots (g/plot)
9	numeric	N-15 Atom % Excess Grain
10	numeric	N-15 Atom % Excess Stover
11	numeric	N-15 Atom % Excess Root
12	numeric	%N in Grain Derived from Alfalfa
13	numeric	%N in Stover Derived from Alfalfa
14	numeric	%N in Roots Derived from Alfalfa
15	numeric	%N in Corn - Grain+Stover+Roots Derived from Alfalfa

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	101	1	1	1	3.62	2.86	0.25	6.73	1.51370	1.26980	1.13010	18.75	15.73	14.00	17.29
2	102	1	1	2	4.79	2.29	0.20	7.28	1.60370	1.37400	1.16680	19.86	17.02	14.45	18.82
3	103	1	2	2	2.74	1.71	0.30	4.75	1.08490	0.98100	0.91890	15.67	14.17	13.28	14.98
4	104	1	2	1	2.81	2.47	0.22	5.51	0.91110	0.77680	0.69130	13.16	11.22	9.99	12.14
5	201	2	2	2	3.10	1.79	0.18	5.07	0.48940	0.49240	0.54520	7.07	7.11	7.88	7.11
6	202	2	1	2	2.40	1.81	0.22	4.43	0.95240	0.96540	0.86550	11.80	11.96	10.72	11.81
7	203	2	2	1	2.18	1.21	0.11	3.50	1.30660	0.57580	0.59560	18.88	8.32	8.60	14.90
8	204	2	1	1	2.64	1.82	0.22	4.68	1.22730	1.17470	1.14130	15.20	14.55	14.13	14.90
9	301	3	2	1	5.02	2.63	0.18	7.83	1.30660	0.64720	0.58080	18.88	9.35	8.39	15.44
10	302	3	1	2	3.46	1.76	0.25	5.46	1.25260	1.55010	1.29510	15.51	19.20	16.04	16.75
11	303	3	1	1	4.76	1.82	0.22	6.80	1.10160	1.65960	1.34590	13.64	20.55	16.67	15.59
12	304	3	2	2	3.11	2.07	0.12	5.30	0.55490	0.93290	0.92390	8.02	13.48	13.35	10.27
13	401	4	2	2	3.99	1.54	0.17	5.69	0.95320	0.80210	0.99450	13.77	11.59	14.37	13.22
14	402	4	2	1	2.63	1.54	0.11	4.28	1.70210	0.75030	0.72970	24.59	10.84	10.54	19.28
15	403	4	1	2	3.58	1.87	0.13	5.58	1.66480	1.60640	1.33430	20.62	19.89	16.52	20.28
16	404	4	1	1	3.48	1.89	0.19	5.56	0.56370	1.36030	1.06600	6.98	16.85	13.20	10.55

Table A7. Recovery of alfalfa N-15 in total soil N at EL.

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Plot #	2	Replication
3	Plant part 1=shoots 2=root/crown	4	Time of incorporation 1=fall 2=spring
5	0-15 Total Layer D.W. (g)	6	15-30 Total Layer D.W.
7	30-45 Total Layer D.W. (g)	8	45-60 Total Layer D.W.
9	0-15 Total N (%N)	10	15-30 Total N (%N)
11	30-45 Total N (%N)	12	45-60 Total N (%N)
13	0-15 Total N N-15 Atom % Excess	14	15-30 Total N N-15 Atom % Excess
15	30-45 Total N N-15 Atom % Excess	16	45-60 Total N N-15 Atom % Excess
17	Recovery of alfalfa N-15 in 0-15 (% of input)	18	Recovery of alfalfa N-15 in 15-30 (% of input)
19	Recovery of alfalfa N-15 in 30-45 (% of input)	20	Recovery of alfalfa N-15 in 45-60 (% of input)
21	Recovery of Alfalfa N-15 in 0-60 (% of input)		

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	2	1	46812	51767	66036	54538	0.20	0.16	0.05	0.03	0.07542	0.01887	0.00780	0.00650
2	102	1	1	1	45765	43661	38389	48825	0.20	0.15	0.07	0.04	0.10301	0.01424	0.00569	0.01373
3	103	1	2	2	46328	53452	56154	49315	0.21	0.17	0.06	0.03	0.08111	0.02322	0.00513	0.00944
4	104	1	1	2	49356	47406	58645	48294	0.23	0.17	0.04	0.05	0.12946	0.04707	0.01037	0.00825
5	201	2	2	2	51092	49403	72965	62351	0.19	0.11	0.03	0.03	0.07862	0.02011	0.00498	0.01055
6	202	2	1	2	45490	48747	53397	62821	0.21	0.18	0.05	0.04	0.09740	0.04142	0.01156	0.01369
7	203	2	1	1	47601	57120	67889	63010	0.20	0.18	0.04	0.03	0.09280	0.01412	0.00807	0.01176
8	204	2	2	1	45874	45693	64757	62619	0.20	0.16	0.04	0.03	0.07798	0.02486	0.00612	0.01223
9	301	3	1	1	45858	53631	68827	57745	0.18	0.14	0.04	0.03	0.08682	0.02366	0.01399	0.01298
10	302	3	1	2	43495	47517	61892	59852	0.19	0.13	0.05	0.03	0.13098	0.03840	0.01176	0.02335
11	303	3	2	1	47086	43621	49991	41275	0.18	0.12	0.03	0.03	0.07775	0.01674	0.01404	0.00635
12	304	3	2	2	44264	50960	78658	61954	0.19	0.14	0.03	0.03	0.10622	0.02418	0.01377	0.00972
13	401	4	2	2	45301	41556	53789	59631	0.23	0.16	0.06	0.03	0.12698	0.04006	0.00840	0.02830
14	402	4	2	1	43915	42780	64115	55556	0.21	0.15	0.04	0.03	0.07740	0.02885	0.00914	0.01510
15	403	4	1	2	53831	54143	71352	69022	0.20	0.14	0.03	0.03	0.12191	0.03074	0.01689	0.02613
16	404	4	1	1	46097	51206	58611	67047	0.19	0.14	0.07	0.03	0.09349	0.03042	0.03000	0.01347

	17	18	19	20	21
1	31.02	7.01	1.11	0.49	39.63
2	35.87	3.65	0.61	0.92	41.05
3	35.77	9.18	0.74	0.66	46.35
4	56.36	14.70	1.01	0.73	72.79
5	33.44	4.78	0.56	0.98	39.76
6	35.34	13.80	1.16	1.22	51.52
7	33.15	5.66	0.85	0.89	40.54
8	30.98	8.05	0.75	0.93	40.72
9	27.31	6.55	1.59	0.92	36.37
10	40.45	9.31	1.51	1.48	52.75
11	28.76	4.02	0.84	0.33	33.94
12	39.34	7.47	1.56	0.78	49.15
13	57.99	11.90	1.28	2.59	73.76
14	30.96	7.99	1.00	1.08	41.04
15	49.19	9.04	1.24	1.91	61.38
16	30.73	8.25	4.61	0.98	44.57

Table A8. Recovery of alfalfa N-15 in total soil N at KBS.

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Plot #	2	Replication
2	Plant Part 1=Shoot 2=Root/crown	4	Time of Incorporation 1=Fall 2=Spring
5	0-15 Total Layer D.W. (g)	6	15-30 Total Layer D.W. (g)
7	30-45 Total Layer D.W. (g)	8	45-60 Total Layer D.W. (g)
9	0-15 Total N (%N)	10	15-30 Total N (%N)
11	30-45 Total N (%N)	12	45-60 Total N (%N)
13	0-15 Total N N-15 Atom % Excess	14	15-30 Total N N-15 Atom % Excess
15	30-45 Total N N-15 Atom % Excess	16	45-60 Total N N-15 Atom % Excess
17	Recovery of alfalfa N-15 in 0-15 (% of input)	18	Recovery of alfalfa N-15 in 15-30 (% of input)
19	Recovery of alfalfa N-15 in 30-45 (% of input)	20	Recovery of Alfalfa N-15 in 45-60 (% of input)
21	Recovery of Alfalfa N-15 in 0-60 (% of input)		

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	
1	101	1	1	1	50276	64466	55409	62233	0.10	0.08	0.02	0.01	0.18235	0.06206	0.03273	0.03238	3
2	102	1	1	2	56987	54327	49144	44270	0.10	0.06	0.03	0.02	0.17099	0.04793	0.01598	0.03079	3
3	103	1	2	2	57268	52596	52420	60357	0.09	0.06	0.02	0.01	0.15612	0.04077	0.01859	0.02201	3
4	104	1	2	1	47399	45165	55818	58071	0.09	0.06	0.03	0.01	0.13841	0.07572	0.04109	0.02989	2
5	201	2	2	2	55886	53863	60028	64686	0.11	0.06	0.02	0.02	0.11190	0.02618	0.02555	0.02166	2
6	202	2	1	2	60739	64926	68310	64808	0.10	0.07	0.02	0.01	0.15976	0.04575	0.02491	0.02075	3
7	203	2	2	1	51609	54176	58313	64359	0.09	0.05	0.02	0.01	0.13044	0.05322	0.03038	0.07955	2
8	204	2	1	1	50034	65665	62392	44739	0.09	0.05	0.01	0.01	0.20906	0.07553	0.04318	0.04892	3
9	301	3	2	1	47524	56753	57451	60374	0.09	0.08	0.02	0.01	0.11539	0.04975	0.01115	0.01640	2
10	302	3	1	2	59934	56683	56982	59267	0.09	0.06	0.02	0.01	0.22219	0.03790	0.02965	0.03354	4
11	303	3	1	1	50611	46820	52441	48086	0.09	0.06	0.02	0.02	0.19816	0.04825	0.03652	0.03847	3
12	304	3	2	2	62534	52640	53556	47655	0.09	0.07	0.03	0.02	0.14207	0.03826	0.01834	0.01806	3
13	401	4	2	2	54202	77610	62196	56382	0.10	0.06	0.02	0.02	0.13046	0.03072	0.02473	0.01690	3
14	402	4	2	1	52348	67365	66797	59081	0.11	0.06	0.02	0.01	0.14163	0.04240	0.02423	0.02503	3
15	403	4	1	2	54921	51363	62842	68536	0.09	0.05	0.02	0.02	0.20791	0.07458	0.04368	0.05439	3
16	404	4	1	1	49868	55906	60611	63727	0.08	0.05	0.02	0.01	0.20072	0.07178	0.04534	0.03141	3

	17	18	19	20	21
1	34.99	11.46	1.48	1.04	48.96
2	35.52	5.74	0.92	1.22	43.40
3	37.01	5.43	0.90	0.73	44.08
4	25.66	9.10	2.67	1.02	38.45
5	29.98	3.92	1.58	1.10	36.58
6	37.87	7.54	1.58	0.75	47.74
7	26.14	6.90	1.30	2.76	37.10
8	34.43	9.43	0.95	0.75	45.56
9	20.98	10.14	0.52	0.66	32.29
10	45.14	4.74	1.06	1.05	52.00
11	34.91	5.26	1.77	1.22	43.17
12	33.82	6.21	1.33	0.78	42.15
13	31.93	6.59	1.46	0.84	40.82
14	37.50	7.38	1.33	0.79	46.99
15	39.60	7.05	2.14	2.26	51.05
16	31.71	7.89	2.20	1.05	42.85

Table A9. Recovery of alfalfa N-15 in inorganic soil N at EL.

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Plot #	2	Replication
3	Plant Part 1=Shoot 2=Root/crown	4	Time of Incorporation 1=Fall 2=Spring
5	0-15 Total Layer D.W. (g)	6	15-30 Total Layer D.W. (g)
7	30-45 Total Layer D.W. (g)	8	45-60 Total Layer D.W. (g)
9	0-15 Inorganic N (ug/g)	10	15-30 Inorganic N (ug/g)
11	30-45 Inorganic N (ug/g)	12	45-60 Inorganic N (ug/g)
13	0-15 Inorganic N N-15 Atom % Excess	14	15-30 Inorganic N N-15 Atom % Excess
15	30-45 Inorganic N N-15 Atom % Excess	16	45-60 Inorganic N N-15 Atom % Excess
17	0-15 Inorganic N-15 Recovery (% of input)	18	15-30 Inorganic N-15 Recovery (% of input)
19	30-45 Inorganic N-15 Recovery (% of input)	20	45-60 Inorganic N-15 Recovery (% of input)
21	0-60 Inorganic N-15 Recovery (% of input)		

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	2	1	46812	51767	66036	54538	18.0	11.4	7.8	5.3	0.28919	0.08128	0.02620	0.02090
2	102	1	1	1	45765	43661	38389	48825	19.3	11.4	7.3	7.6	0.34277	0.08543	0.04512	0.03708
3	103	1	2	2	46328	53452	56154	49315	18.8	11.8	7.9	7.7	0.33353	0.16266	0.03996	0.02961
4	104	1	1	2	49356	47406	58645	48294	20.2	15.6	5.8	9.8	0.39692	0.29085	0.08131	0.04574
5	201	2	2	2	51092	49403	72965	62351	15.8	9.9	7.8	4.8	0.34603	0.08646	0.03017	0.03550
6	202	2	1	2	45490	48747	53397	62821	16.5	12.1	8.4	8.6	0.39966	0.22737	0.04438	0.04811
7	203	2	1	1	47601	57120	67889	63010	16.8	16.4	8.6	17.6	0.36340	0.10956	0.04363	0.02040
8	204	2	2	1	45874	45693	64757	62619	17.1	15.6	7.3	10.8	0.27623	0.14616	0.02687	0.01153
9	301	3	1	1	45858	53631	68827	57745	15.4	11.9	5.1	10.8	0.34312	0.09918	0.04124	0.03632
10	302	3	1	2	43495	47517	61892	59852	12.7	11.5	7.2	11.6	0.44474	0.17331	0.05096	0.04308
11	303	3	2	1	47086	43621	49991	41275	12.3	8.3	4.0	5.2	0.31289	0.06535	0.02339	0.01559
12	304	3	2	2	44264	50960	78658	61954	14.1	11.4	6.1	9.6	0.35842	0.13538	0.01125	0.00550
13	401	4	2	2	45301	41556	53789	59631	16.9	12.7	5.8	8.5	0.27152	0.18286	0.05515	0.02587
14	402	4	2	1	43915	42780	64115	55556	15.0	11.2	7.1	9.7	0.25456	0.09485	0.03383	0.02406
15	403	4	1	2	53831	54143	71352	69022	19.8	11.4	7.1	8.0	0.34477	0.18080	0.10055	0.07563
16	404	4	1	1	46097	51206	58611	67047	15.8	11.6	8.1	7.6	0.33910	0.11657	0.04398	0.05147

	17	18	19	20	21
1	1.08	0.21	0.06	0.03	1.38
2	1.15	0.16	0.05	0.05	1.41
3	1.29	0.45	0.08	0.05	1.87
4	1.50	0.82	0.11	0.08	2.51
5	1.23	0.19	0.08	0.05	1.54
6	1.14	0.51	0.08	0.10	1.83
7	1.10	0.39	0.10	0.09	1.68
8	0.96	0.46	0.06	0.03	1.51
9	0.92	0.24	0.06	0.09	1.30
10	0.93	0.36	0.09	0.11	1.49
11	0.80	0.10	0.02	0.01	0.94
12	0.99	0.35	0.02	0.01	1.38
13	0.92	0.43	0.08	0.06	1.48
14	0.74	0.20	0.07	0.06	1.07
15	1.39	0.42	0.19	0.16	2.17
16	0.94	0.26	0.08	0.10	1.38

Table A10. Recovery of alfalfa N-15 in inorganic soil N at KBS.

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Plot #	2	Replication
3	Plant Part 1=Shoot 2=Root/crown	4	Time of Incorporation 1=Fall 2=Spring
5	0-15 Total Layer D.W. (g)	6	15-30 Total Layer D.W. (g)
7	30-45 Total Layer D.W. (g)	8	45-60 Total Layer D.W. (g)
9	0-15 Inorganic N (ug/g)	10	15-30 Inorganic N (ug/g)
11	30-45 Inorganic N (ug/g)	12	45-60 Inorganic N (ug/g)
13	0-15 Inorganic N N-15 Atom % Excess	14	15-30 Inorganic N N-15 Atom % Excess
15	30-45 Inorganic N N-15 Atom % Excess	16	45-60 Inorganic N N-15 Atom % Excess
17	0-15 Inorganic N-15 Recovery (% of input)	18	15-30 Inorganic N-15 Recovery (% of input)
19	30-45 Inorganic N-15 Recovery (% of input)	20	45-60 Inorganic N-15 Recovery (% of input)
21	0-60 Inorganic N-15 Recovery (% of input)		

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	1	1	50276	64466	55409	62233	19.2	14.4	9.4	6.6	0.54455	0.23364	0.11226	0.03970
2	102	1	1	2	56987	54327	49144	44270	20.0	13.7	9.1	11.8	0.48972	0.20295	0.12350	0.22235
3	103	1	2	2	57268	52596	52420	60357	16.9	11.8	6.3	7.9	0.42522	0.10804	0.00942	0.01398
4	104	1	2	1	47399	45165	55818	58071	18.7	14.8	9.8	7.7	0.35677	0.18863	0.05982	0.03488
5	201	2	2	2	55886	53863	60028	64686	22.4	11.9	12.3	6.1	0.24251	0.14897	0.01081	0.01053
6	202	2	1	2	60739	64926	68310	64808	3.9	11.3	14.4	6.7	0.39266	0.13569	0.01177	0.01748
7	203	2	2	1	51609	54176	58313	64359	21.0	12.6	5.2	5.7	0.30235	0.15615	0.05223	0.03105
8	204	2	1	1	50034	65665	62392	44739	20.5	10.4	4.3	8.4	0.54476	0.24720	0.05802	0.02624
9	301	3	2	1	47524	56753	57451	60374	20.2	18.0	7.9	8.5	0.31657	0.17585	0.05003	0.04214
10	302	3	1	2	59934	56683	56982	59267	15.9	12.9	8.9	6.7	0.56353	0.22368	0.08564	0.08340
11	303	3	1	1	50611	46820	52441	48086	26.5	12.6	11.8	6.4	0.43097	0.20860	0.04771	0.22387
12	304	3	2	2	62534	52640	53556	47655	24.9	16.1	13.8	9.8	0.32431	0.18732	0.04747	0.03139
13	401	4	2	2	54202	77610	62196	56382	19.4	9.4	10.3	8.5	0.39983	0.19172	0.11628	0.06600
14	402	4	2	1	52348	67365	66797	59081	19.6	11.1	10.9	4.8	0.40832	0.16478	0.06082	0.04779
15	403	4	1	2	54921	51363	62842	68536	17.7	8.4	8.9	5.7	0.55157	0.25406	0.06421	0.08226
16	404	4	1	1	49868	55906	60611	63727	19.2	13.7	9.9	9.1	0.07396	0.26779	0.05750	0.08112

CASE NO.	17	18	19	20	21
1	2.00	0.82	0.22	0.06	3.10
2	2.13	0.57	0.21	0.44	3.35
3	1.82	0.30	0.01	0.03	2.16
4	1.40	0.56	0.15	0.07	2.17
5	1.34	0.43	0.04	0.02	1.82
6	0.35	0.38	0.04	0.03	0.80
7	1.45	0.47	0.07	0.05	2.05
8	2.12	0.64	0.06	0.04	2.85
9	1.35	0.79	0.10	0.10	2.34
10	2.04	0.62	0.17	0.12	2.95
11	2.20	0.47	0.11	0.26	3.04
12	2.24	0.70	0.16	0.06	3.16
13	1.86	0.62	0.33	0.14	2.96
14	1.86	0.55	0.20	0.06	2.66
15	2.04	0.41	0.14	0.12	2.71
16	0.27	0.78	0.13	0.18	1.36

Table A11. Microbial biomass carbon at EL.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation 1=Fall 2=Spring
5	numeric	Carbon Flush for Fumigation/10 day Incubation - Cf (ug/g)
6	numeric	Carbon Evolved from Unfumigated/10 day Incubation - C10 (ug/g)
7	numeric	Carbon Evolved from Unfumigated/20 day Incubation - C20 (ug/g)
8	numeric	Microbial Biomass Carbon - Cf/0.41 (ug/g)

CASE NO.	1	2	3	4	5	6	7	8
1	101	1	2	1	232.0	122.3	86.8	565.9
2	102	1	1	1	245.4	102.3	102.0	598.5
3	103	1	2	2	228.3	64.0	46.9	556.8
4	104	1	1	2	217.1	44.6	44.6	529.5
5	201	2	2	2	173.7	81.4	71.1	423.7
6	202	2	1	2	234.3	102.6	49.1	571.5
7	203	2	1	1	209.1	90.8	51.4	510.0
8	204	2	2	1	231.7	100.3	53.7	565.1
9	301	3	1	1	223.7	105.1	67.4	545.6
10	302	3	1	2	218.0	98.8	94.0	531.7
11	303	3	2	1	233.4	142.6	90.0	569.3
12	304	3	2	2	220.8	123.7	76.9	538.5
13	401	4	2	2	219.7	98.3	53.1	535.9
14	402	4	2	1	254.3	55.7	55.7	620.2
15	403	4	1	2	220.0	106.0	42.6	536.6
16	404	4	1	1	213.4	100.8	59.7	520.5

Table A12. Microbial biomass carbon at KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation 1=Fall 2=Spring
5	numeric	Carbon Flush for Fumigation/10 day Incubation - Cf (ug/g)
6	numeric	Carbon Evolved from Unfumigated/10 day Incubation - C10 (ug/g)
7	numeric	Carbon Evolved from Unfumigated/20 day Incubation - C20 (ug/g)
8	numeric	Microbial Biomass Carbon - Cf/0.41 (ug/g)

CASE NO.	1	2	3	4	5	6	7	8
1	101	1	1	1	155.7	80.0	80.0	379.8
2	102	1	1	2	120.0	55.4	55.4	292.7
3	103	1	2	2	155.1	89.7	84.8	378.3
4	104	1	2	1	136.6	55.1	57.4	333.2
5	201	2	2	2	137.4	84.8	84.8	335.1
6	202	2	1	2	103.4	68.3	71.7	252.2
7	203	2	2	1	103.1	58.3	78.3	251.5
8	204	2	1	1	102.8	84.6	33.1	250.7
9	301	3	2	1	198.8	102.8	74.3	484.9
10	302	3	1	2	110.0	61.4	11.7	268.3
11	303	3	1	1	81.1	92.8	1.4	197.8
12	304	3	2	2	92.3	58.6	37.4	225.1
13	401	4	2	2	106.6	62.9	53.4	260.0
14	402	4	2	1	115.7	78.3	71.1	282.2
15	403	4	1	2	79.1	85.4	55.7	192.9
16	404	4	1	1	113.4	88.6	41.1	276.6

Table A13. Microbial biomass N and recovery of alfalfa N-15 in microbial biomass at EL.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation
5	numeric	0-15 Total Layer D.W. (g)
6	numeric	Initial NO3 Concentration (ppm)
7	numeric	Initial NH4 Concentration (ppm)
8	numeric	Fumigated/10 day Incubation NO3 Concentration (ppm)
9	numeric	Fumigated/10 day Incubation NH4 Concentration (ppm)
10	numeric	Unfumigated/20 day Incubation NO3 Concentration (ppm)
11	numeric	Unfumigated/20 day Incubation NH4 Concentration (ppm)
12	numeric	Nitrogen Flush - Nf (ug/g)
13	numeric	Carbon Flush -Cf (ug/g)
14	numeric	Kn - -0.014(Cf/Nf) + 0.39
15	numeric	Microbial Biomass N - Nf/Kn (ug/g)
16	numeric	Fumigated/10 Incubation Inorganic N N-15 Atom % Excess
17	numeric	Recovery of alfalfa N-15 in Microbial Biomass (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	101	1	2	1	46812	1.26	0.00	0.93	4.16	3.50	0.00	20.80	232.0	0.234	88.9	0.43016	7.94
2	102	1	1	1	45765	1.43	0.00	0.93	4.41	3.91	0.00	22.05	245.4	0.234	94.2	0.54329	8.89
3	103	1	2	2	46328	1.31	0.00	0.88	4.47	3.31	0.00	22.35	228.3	0.247	90.5	0.46772	8.69
4	104	1	1	2	49356	1.46	0.00	1.16	4.58	3.62	0.00	22.90	217.1	0.257	89.0	0.60317	10.07
5	201	2	2	2	51092	1.07	0.00	0.52	3.58	2.81	0.00	17.90	173.7	0.254	70.4	0.50259	8.02
6	202	2	1	2	45490	1.36	0.00	0.76	4.42	3.38	0.00	22.10	234.3	0.242	91.5	0.63547	10.05
7	203	2	1	1	47601	1.09	0.00	0.52	4.43	2.60	0.00	22.15	209.1	0.258	85.9	0.60709	9.43
8	204	2	2	1	45874	1.28	0.00	0.98	4.78	3.55	0.00	23.90	231.7	0.254	94.0	0.39942	7.63
9	301	3	1	1	45858	0.95	0.00	0.59	4.28	3.45	0.00	21.40	223.7	0.244	87.8	0.51136	7.83
10	302	3	1	2	43495	0.92	0.00	0.48	4.40	3.11	0.00	22.00	218.0	0.251	87.6	0.77995	11.28
11	303	3	2	1	47086	0.86	0.00	0.53	4.27	3.23	0.00	21.35	233.4	0.237	90.1	0.40468	7.61
12	304	3	2	2	44264	1.01	0.00	0.58	4.15	3.36	0.00	20.75	220.8	0.241	86.1	0.45288	7.65
13	401	4	2	2	45301	1.11	0.00	0.82	4.60	3.11	0.00	23.00	219.7	0.256	89.7	0.48584	8.76
14	402	4	2	1	43915	1.03	0.00	0.75	4.56	3.25	0.00	22.80	254.3	0.234	97.5	0.40826	7.75
15	403	4	1	2	53831	1.05	0.00	0.81	4.34	3.30	0.00	21.70	220.0	0.248	87.5	0.72888	13.04
16	404	4	1	1	46097	1.14	0.00	0.74	4.12	3.33	0.00	20.60	213.4	0.245	84.1	0.49548	7.30

Table A14. Microbial biomass N and recovery of alfalfa N-15 in microbial biomass at KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	Plant Part 1=Shoot 2=Root/crown
4	numeric	Time of Incorporation
5	numeric	0-15 Total Layer D.W. (g)
6	numeric	Initial NO3 Concentration (ppm)
7	numeric	Initial NH4 Concentration (ppm)
8	numeric	Fumigated/10 day Incubation NO3 Concentration (ppm)
9	numeric	Fumigated/10 day Incubation NH4 Concentration (ppm)
10	numeric	Unfumigated/20 day Incubation NO3 Concentration (ppm)
11	numeric	Unfumigated/20 day Incubation NH4 Concentration (ppm)
12	numeric	Nitrogen Flush - Nf (ug/g)
13	numeric	Carbon Flush -Cf (ug/g)
14	numeric	Kn - -0.014(Cf/Nf) + 0.39
15	numeric	Microbial Biomass N - Nf/Kn (ug/g)
16	numeric	Fumigated/10 Incubation Inorganic N N-15 Atom % Excess
17	numeric	Recovery of alfalfa N-15 in Microbial Biomass (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	101	1	1	1	50276	1.24	0.00	1.37	2.58	4.68	0.00	12.90	155.7	0.221	58.4	0.78954	8.80
2	102	1	1	2	56987	1.74	0.00	1.85	2.50	4.44	0.00	12.50	120.0	0.256	48.9	0.75686	8.01
3	103	1	2	2	57268	1.22	0.00	1.17	2.37	4.07	0.00	11.85	155.1	0.207	57.3	0.57895	8.42
4	104	1	2	1	47399	1.54	0.00	1.62	2.10	4.53	0.00	10.50	136.6	0.208	50.5	0.52367	5.56
5	201	2	2	2	55886	1.49	0.00	1.65	2.08	4.67	0.00	10.40	137.4	0.205	50.7	0.43009	5.40
6	202	2	1	2	60739	1.70	0.00	1.66	2.21	5.03	0.00	11.05	103.4	0.259	42.7	0.71757	7.07
7	203	2	2	1	51609	1.57	0.00	1.62	1.96	3.89	0.00	9.80	103.1	0.243	40.4	0.49803	4.60
8	204	2	1	1	50034	1.73	0.00	1.72	1.97	4.79	0.00	9.85	102.8	0.244	40.4	0.84700	6.50
9	301	3	2	1	47524	1.60	0.00	1.59	1.88	4.92	0.00	9.40	198.8	0.094	100.1	0.45671	9.63
10	302	3	1	2	59934	1.13	0.00	1.20	1.95	3.46	0.00	9.75	110.0	0.232	42.0	0.95669	9.15
11	303	3	1	1	50611	1.22	0.00	1.60	1.72	4.01	0.00	8.60	81.1	0.258	33.3	0.77553	4.97
12	304	3	2	2	62534	1.97	0.00	2.04	1.85	4.69	0.00	9.25	92.3	0.250	37.0	0.51200	5.24
13	401	4	2	2	54202	2.20	0.00	1.94	2.30	5.25	0.00	11.50	106.6	0.260	44.2	0.51249	5.44
14	402	4	2	1	52348	1.65	0.00	1.59	2.34	4.44	0.00	11.70	115.7	0.252	46.5	0.54146	5.84
15	403	4	1	2	54921	1.33	0.00	1.24	2.15	3.92	0.00	10.75	79.1	0.287	37.5	0.85418	6.68
16	404	4	1	1	49868	1.66	0.00	1.50	2.34	4.48	0.00	11.70	113.4	0.254	46.0	0.76288	6.65

Table A15. N-15 atom % of total N and inorganic N in soil samples from the 60-75 cm depth at EL and KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Total N N-15 Atom % 60-75 : EL
3	numeric	Total N N-15 Atom % 60-75 : KBS
4	numeric	Inorganic N N-15 Atom % 60-75 : EL
5	numeric	Inorganic N N-15 Atom % 60-75 : KBS

CASE NO.	1	2	3	4	5
1	101	0.36996	0.39542	0.37660	0.37805
2	102	0.36612	0.41240	0.37553	0.51985
3	103	0.36787	0.37879	0.39753	0.37292
4	104	0.37028	0.39024	0.38965	0.38303
5	201	0.37197	0.38235	0.39213	0.38265
6	202	0.37129	0.38590	0.39763	0.36874
7	203	0.37025	0.36359	0.38766	0.38489
8	204	0.37461	0.40833	0.38358	0.39908
9	301	0.37857	0.38864	0.40640	0.39369
10	302	0.38137	0.38512	0.41641	0.39366
11	303	0.37255	0.38946	0.38077	0.38978
12	304	0.37042	0.36859	0.37116	0.37797
13	401	0.36998	0.37865	0.38010	0.39082
14	402	0.38179	0.36243	0.42962	0.36789
15	403	0.37766	0.40145	0.44312	0.41491
16	404	0.37843	0.38074	0.39258	0.39957
17					
18	1	0.37137	0.37683		
19	2	0.36825	0.37237		
20	3	0.36957	0.37107		
21	4	0.36842	0.36476		
22	5	0.36832	0.36895		
23	6	0.36931	0.37861		

Table A16. N mineralization potential and percent mineralized N derived from alfalfa at EL and KBS.

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Location 1=EL 2=KBS
2	numeric	Plot #
3	numeric	Replication
4	numeric	Plant Part 1=Shoot 2=Root/crown
5	numeric	Time of Incorporation 1=Fall 2=Spring
6	numeric	Unfumigated Time Zero NO3-N (ppm)
7	numeric	Unfumigated 20-day NO3-N (ppm)
8	numeric	N mineralization capacity (ug/g)
9	numeric	N-15 atom % excess of mineralized N (20-day NO3)
10	numeric	Percent mineralized N derived from alfalfa

CASE NO.	1	2	3	4	5	6	7	8	9	10
1	1	101	1	2	1	1.26	3.50	11.20	0.37079	5.36
2	1	102	1	1	1	1.43	3.91	12.40	0.48017	6.94
3	1	103	1	2	2	1.31	3.31	10.00	0.45641	6.59
4	1	104	1	1	2	1.46	3.62	10.80	0.53789	7.77
5	1	201	2	2	2	1.07	2.81	8.70	0.49790	7.19
6	1	202	2	1	2	1.36	3.38	10.10	0.56155	8.11
7	1	203	2	1	1	1.09	2.60	7.55	0.52275	7.55
8	1	204	2	2	1	1.28	3.55	11.35	0.36774	5.31
9	1	301	3	1	1	0.95	3.45	12.50	0.47046	6.80
10	1	302	3	1	2	0.92	3.11	10.95	0.66875	9.66
11	1	303	3	2	1	0.86	3.23	11.85	0.37682	5.44
12	1	304	3	2	2	1.01	3.36	11.75	0.44980	6.50
13	1	401	4	2	2	1.11	3.11	10.00	0.44775	6.47
14	1	402	4	2	1	1.03	3.25	11.10	0.37447	5.41
15	1	403	4	1	2	1.05	3.30	11.25	0.62377	9.01
16	1	404	4	1	1	1.14	3.33	10.95	0.43815	6.33
17	2	101	1	1	1	1.24	4.68	17.20	0.72353	10.45
18	2	102	1	1	2	1.74	4.44	13.50	0.68405	9.88
19	2	103	1	2	2	1.22	4.07	14.25	0.54174	7.83
20	2	104	1	2	1	1.54	4.53	14.95	0.48945	7.07
21	2	201	2	2	2	1.49	4.67	15.90	1.28668	18.59
22	2	202	2	1	2	1.70	5.03	16.65	1.08711	15.71
23	2	203	2	2	1	1.57	3.89	11.60	0.42578	6.15
24	2	204	2	1	1	1.73	4.79	15.30	0.68009	9.83
25	2	301	3	2	1	1.60	4.92	16.60	0.94170	13.60
26	2	302	3	1	2	1.13	3.46	11.65	0.95289	13.77
27	2	303	3	1	1	1.22	4.01	13.95	0.47705	6.89
28	2	304	3	2	2	1.97	4.69	13.60	0.94893	13.71
29	2	401	4	2	2	2.20	5.25	15.25	0.84246	12.17
30	2	402	4	2	1	1.65	4.44	13.95	0.59799	8.64
31	2	403	4	1	2	1.33	3.92	12.95	0.57404	8.29
32	2	404	4	1	1	1.66	4.48	14.10	0.61129	8.83

Table A17. Spring barley dry matter yield, N content, percent N derived from alfalfa and total N uptake at EL.

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Plot #	13	Root N-15 atom % excess
2	Replication	14	Grain %NDFA
3	PP 1=shoot 2=root/crown	15	Stover %NDFA
4	TOI 1=fall 2=spring	16	Root %NDFA
5	Grain D.M. Yield (g/plot)	17	Grain TNU (g/plot)
6	Stover D.M. Yield (g/plot)	18	Stover TNU (g/plot)
7	Root D.M. Yield	19	Roots TNU (g/plot)
8	Grain %N 9 Stover %N	20	Grain + Stover + Roots TNU (g/plot)
10	Root %N	21	Grain + Stover + Roots D.M. Yield (g/plot)
11	Grain N-15 atom % excess	22	Grain + Stover + Roots %N
12	Stover N-15 atom % excess	23	%NDFA in Grain + Stover + Roots

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	2	1	44.14	32.93	24.51	1.542	0.374	0.582	0.23730	0.23706	0.21974	3.39	3.39	3.17
2	102	1	1	1	57.77	32.70	20.07	1.547	0.369	0.530	0.26806	0.25801	0.24799	3.32	3.20	3.07
3	103	1	2	2	39.98	26.62	12.09	1.577	0.521	0.754	0.26524	0.26453	0.24658	3.79	3.78	3.56
4	104	1	1	2	58.62	33.39	14.20	1.533	0.419	0.724	0.31916	0.29838	0.18392	3.95	3.70	2.28
5	201	2	2	2	33.18	27.52	11.24	1.527	0.471	0.682	0.30486	0.26779	0.26595	4.36	3.83	3.84
6	202	2	1	2	56.78	38.62	18.89	1.467	0.383	0.601	0.38564	0.35731	0.34088	4.78	4.43	4.22
7	203	2	1	1	60.20	36.98	14.98	1.533	0.408	0.754	0.30456	0.29968	0.27818	3.77	3.71	3.45
8	204	2	2	1	65.93	41.09	17.24	1.614	0.579	0.725	0.23879	0.23967	0.24410	3.42	3.43	3.53
9	301	3	1	1	38.18	32.64	13.73	1.382	0.461	0.727	0.33540	0.27334	0.27316	4.15	3.39	3.38
10	302	3	1	2	37.42	33.56	11.90	1.336	0.409	0.659	0.44029	0.41940	0.39157	5.45	5.19	4.85
11	303	3	2	1	51.39	41.33	11.18	1.265	0.381	0.776	0.26158	0.24874	0.22342	3.74	3.56	3.23
12	304	3	2	2	41.28	34.94	10.50	1.372	0.490	1.000	0.34180	0.33017	0.26068	4.89	4.72	3.77
13	401	4	2	2	45.82	37.26	9.24	1.453	0.393	0.935	0.28026	0.26142	0.23467	4.01	3.74	3.39
14	402	4	2	1	35.39	35.04	10.40	1.472	0.466	0.723	0.25797	0.24558	0.22445	3.69	3.51	3.24
15	403	4	1	2	42.10	34.97	13.00	1.538	0.445	0.697	0.41758	0.39070	0.33778	5.17	4.84	4.18
16	404	4	1	1	47.49	35.08	11.28	1.387	0.370	0.757	0.27579	0.26970	0.25042	3.42	3.34	3.10

CASE NO.	17	18	19	20	21	22	23
1	0.68	0.12	0.14	0.95	101.6	0.93	3.36
2	0.89	0.12	0.11	1.12	110.5	1.01	3.28
3	0.63	0.14	0.09	0.86	78.7	1.09	3.77
4	0.90	0.14	0.10	1.14	106.2	1.07	3.77
5	0.51	0.13	0.08	0.71	71.9	0.99	4.21
6	0.83	0.15	0.11	1.09	114.3	0.96	4.67
7	0.92	0.15	0.11	1.19	112.2	1.06	3.73
8	1.06	0.24	0.12	1.43	124.3	1.15	3.43
9	0.53	0.15	0.10	0.78	84.6	0.92	3.91
10	0.50	0.14	0.08	0.72	82.9	0.86	5.34
11	0.65	0.16	0.09	0.89	103.9	0.86	3.66
12	0.57	0.17	0.11	0.84	86.7	0.97	4.71
13	0.67	0.15	0.09	0.90	92.3	0.97	3.90
14	0.52	0.16	0.08	0.76	80.8	0.94	3.61
15	0.65	0.16	0.09	0.89	90.1	0.99	5.01
16	0.66	0.13	0.09	0.87	93.9	0.93	3.37

Table A18. Spring barley dry matter yield, N content, percent N derived from alfalfa and total N uptake at KBS.

VAR	DESCRIPTION
1	Plot #
2	Replication
3	PP 1=shoot 2=root/crown
4	TOI 1=fall 2=spring
5	Grain D.M. Yield (g/plot)
6	Stover D.M. Yield (g/plot)
7	Root D.M. Yield
8	Grain %N 9 Stover %N
10	Root %N
11	Grain N-15 atom % excess
12	Stover N-15 atom % excess
13	Root N-15 atom % excess
14	Grain %NDFA
15	Stover %NDFA
16	Root %NDFA
17	Grain TNU (g/plot)
18	Stover TNU (g/plot)
19	Root TNU (g/plot)
20	Grain + Stover + Root TNU (g/plot)
21	Grain + Stover + Roots D.M. Yield (g/plot)
22	Grain + Stover + Roots %N
23	Grain + Stover + Roots %NDFA

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	1	1	11.34	21.20	9.24	2.636	1.102	0.931	0.50286	0.47541	0.50100	6.23	5.89	6.20
2	102	1	1	2	20.57	25.67	10.40	2.548	1.184	1.066	0.49812	0.47444	0.45140	6.17	5.88	5.59
3	103	1	2	2	13.59	32.23	13.00	2.407	1.089	1.057	0.37011	0.31559	0.36972	5.29	4.51	5.34
4	104	1	2	1	17.37	17.90	11.28	2.304	0.985	0.896	0.38905	0.37597	0.34077	5.56	5.38	4.92
5	201	2	2	2	16.84	21.34	4.50	2.340	0.981	1.225	0.28716	0.26714	0.27953	4.11	3.82	4.04
6	202	2	1	2	16.75	25.34	4.50	2.468	1.322	0.960	0.48398	0.49301	0.44283	5.99	6.11	5.48
7	203	2	2	1	13.06	20.86	6.54	2.434	1.104	1.125	0.32225	0.34929	0.31883	4.61	5.00	4.61
8	204	2	1	1	12.99	20.34	3.56	2.410	0.988	1.030	0.49880	0.47057	0.48962	6.18	5.83	6.06
9	301	3	2	1	14.06	17.63	4.32	2.635	1.066	1.019	0.29199	0.28998	0.28485	4.18	4.15	4.12
10	302	3	1	2	19.91	18.69	9.98	2.086	1.166	1.011	0.54411	0.53884	0.52346	6.74	6.67	6.48
11	303	3	1	1	17.08	19.34	2.97	2.590	1.127	0.986	0.54313	0.50781	0.52215	6.73	6.29	6.47
12	304	3	2	2	21.01	21.31	8.34	2.476	1.077	0.804	0.34007	0.33244	0.30811	4.86	4.75	4.45
13	401	4	2	2	15.42	19.83	5.32	2.474	1.208	1.011	0.35813	0.34720	0.35557	5.12	4.97	5.14
14	402	4	2	1	11.19	19.10	6.20	2.293	1.261	1.073	0.40154	0.38192	0.36780	5.74	5.46	5.31
15	403	4	1	2	13.52	17.21	3.91	2.825	1.471	1.127	0.53446	0.53190	0.48359	6.62	6.59	5.99
16	404	4	1	1	10.58	17.17	7.66	2.474	1.506	0.862	0.49791	0.49745	0.46109	6.17	6.16	5.71

CASE NO.	17	18	19	20	21	22	23
1	0.30	0.23	0.09	0.62	41.8	1.48	6.10
2	0.52	0.30	0.11	0.94	56.6	1.66	6.01
3	0.33	0.35	0.14	0.82	58.8	1.39	4.97
4	0.40	0.18	0.10	0.68	46.5	1.46	5.42
5	0.39	0.21	0.06	0.66	42.7	1.54	4.01
6	0.41	0.33	0.04	0.79	46.6	1.70	6.01
7	0.32	0.23	0.07	0.62	40.5	1.54	4.75
8	0.31	0.20	0.04	0.55	36.9	1.49	6.04
9	0.37	0.19	0.04	0.60	36.0	1.67	4.16
10	0.42	0.22	0.10	0.73	48.6	1.51	6.68
11	0.44	0.22	0.03	0.69	39.4	1.75	6.58
12	0.52	0.23	0.07	0.82	50.7	1.61	4.80
13	0.38	0.24	0.05	0.67	40.6	1.66	5.07
14	0.26	0.24	0.07	0.56	36.5	1.55	5.57
15	0.38	0.25	0.04	0.68	34.6	1.96	6.57
16	0.26	0.26	0.07	0.59	35.4	1.66	6.11

Table A19. Recovery of alfalfa N-15 by spring barley at EL.

VAR	DESCRIPTION
1	Plot #
2	Replication
3	PP 1=shoot 2=root/crown
4	TOI 1=fall 2=spring
5	Grain D.M. Yield (g/plot)
6	Stover D.M. Yield (g/plot)
7	Root D.M. Yield
8	Grain %N
9	Stover %N
10	Root %N

VAR	DESCRIPTION
11	Grain N-15 atom % excess
12	Stover N-15 atom % excess
13	Root N-15 atom % excess
14	Grain %NDFA
15	Stover %NDFA
16	Root %NDFA
17	Recovery by grain (% of input)
18	Recovery by stover (% of input)
19	Recovery by roots (% of input)
20	Recovery by grain+stover+roots (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	2	1	44.14	32.93	24.51	1.542	0.374	0.582	0.23730	0.23706	0.21974	3.39	3.39	3.17
2	102	1	1	1	57.77	32.70	20.07	1.547	0.369	0.530	0.26806	0.25801	0.24799	3.32	3.20	3.07
3	103	1	2	2	39.98	26.62	12.09	1.577	0.521	0.754	0.26524	0.26453	0.24658	3.79	3.78	3.56
4	104	1	1	2	58.62	33.39	14.20	1.533	0.419	0.724	0.31916	0.29838	0.18392	3.95	3.70	2.28
5	201	2	2	2	33.18	27.52	11.24	1.527	0.471	0.682	0.30486	0.26779	0.26595	4.36	3.83	3.84
6	202	2	1	2	56.78	38.62	18.89	1.467	0.383	0.601	0.38564	0.35731	0.34088	4.78	4.43	4.22
7	203	2	1	1	60.20	36.98	14.98	1.533	0.408	0.754	0.30456	0.29968	0.27818	3.77	3.71	3.45
8	204	2	2	1	65.93	41.09	17.24	1.614	0.579	0.725	0.23879	0.23967	0.24410	3.42	3.43	3.53
9	301	3	1	1	38.18	32.64	13.73	1.382	0.461	0.727	0.33540	0.27334	0.27316	4.15	3.39	3.38
10	302	3	1	2	37.42	33.56	11.90	1.336	0.409	0.659	0.44029	0.41940	0.39157	5.45	5.19	4.85
11	303	3	2	1	51.39	41.33	11.18	1.265	0.381	0.776	0.26158	0.24874	0.22342	3.74	3.56	3.23
12	304	3	2	2	41.28	34.94	10.50	1.372	0.490	1.000	0.34180	0.33017	0.26068	4.89	4.72	3.77
13	401	4	2	2	45.82	37.26	9.24	1.453	0.393	0.935	0.28026	0.26142	0.23467	4.01	3.74	3.39
14	402	4	2	1	35.39	35.04	10.40	1.472	0.466	0.723	0.25797	0.24558	0.22445	3.69	3.51	3.24
15	403	4	1	2	42.10	34.97	13.00	1.538	0.445	0.697	0.41758	0.39070	0.33778	5.17	4.84	4.18
16	404	4	1	1	47.49	35.08	11.28	1.387	0.370	0.757	0.27579	0.26970	0.25042	3.42	3.34	3.10

CASE NO.	17	18	19	20
1	0.72	0.13	0.14	0.98
2	0.91	0.12	0.10	1.13
3	0.74	0.16	0.10	1.00
4	1.09	0.16	0.07	1.32
5	0.68	0.15	0.09	0.93
6	1.22	0.20	0.15	1.57
7	1.07	0.17	0.12	1.36
8	1.13	0.25	0.14	1.51
9	0.67	0.16	0.10	0.93
10	0.84	0.22	0.12	1.17
11	0.75	0.17	0.09	1.01
12	0.86	0.25	0.12	1.23
13	0.83	0.17	0.09	1.09
14	0.60	0.18	0.07	0.85
15	1.03	0.23	0.12	1.37
16	0.69	0.13	0.08	0.90

Table A20. Recovery of alfalfa N-15 by spring barley at KBS.

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Plot #	11	Grain N-15 atom % excess
2	Replication	12	Stover N-15 atom % excess
3	PP 1=shoot 2=root/crown	13	Root N-15 atom % excess
4	TOI 1=fall 2=spring	14	Grain %NDFA
5	Grain D.M. Yield (g/plot)	15	Stover %NDFA
6	Stover D.M. Yield (g/plot)	16	Root %NDFA
7	Root D.M. Yield	17	Recovery by grain (% of input)
8	Grain %N	18	Recovery by stover (% of input)
9	Stover %N	19	Recovery by roots (% of input)
10	Root %N	20	Recovery by grain+stover+roots (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	101	1	1	1	11.34	21.20	9.24	2.636	1.102	0.931	0.50286	0.47541	0.50100	6.23	5.89	6.20
2	102	1	1	2	20.57	25.67	10.40	2.548	1.184	1.066	0.49812	0.47444	0.45140	6.17	5.88	5.59
3	103	1	2	2	13.59	32.23	13.00	2.407	1.089	1.057	0.37011	0.31559	0.36972	5.29	4.51	5.34
4	104	1	2	1	17.37	17.90	11.28	2.304	0.985	0.896	0.38905	0.37597	0.34077	5.56	5.38	4.92
5	201	2	2	2	16.84	21.34	4.50	2.340	0.981	1.225	0.28716	0.26714	0.27953	4.11	3.82	4.04
6	202	2	1	2	16.75	25.34	4.50	2.468	1.322	0.960	0.48398	0.49301	0.44283	5.99	6.11	5.48
7	203	2	2	1	13.06	20.86	6.54	2.434	1.104	1.125	0.32225	0.34929	0.31883	4.61	5.00	4.61
8	204	2	1	1	12.99	20.34	3.56	2.410	0.988	1.030	0.49880	0.47057	0.48962	6.18	5.83	6.06
9	301	3	2	1	14.06	17.63	4.32	2.635	1.066	1.019	0.29199	0.28998	0.28485	4.18	4.15	4.12
10	302	3	1	2	19.91	18.69	9.98	2.086	1.166	1.011	0.54411	0.53884	0.52346	6.74	6.67	6.48
11	303	3	1	1	17.08	19.34	2.97	2.590	1.127	0.986	0.54313	0.50781	0.52215	6.73	6.29	6.47
12	304	3	2	2	21.01	21.31	8.34	2.476	1.077	0.804	0.34007	0.33244	0.30811	4.86	4.75	4.45
13	401	4	2	2	15.42	19.83	5.32	2.474	1.208	1.011	0.35813	0.34720	0.35557	5.12	4.97	5.14
14	402	4	2	1	11.19	19.10	6.20	2.293	1.261	1.073	0.40154	0.38192	0.36780	5.74	5.46	5.31
15	403	4	1	2	13.52	17.21	3.91	2.825	1.471	1.127	0.53446	0.53190	0.48359	6.62	6.59	5.99
16	404	4	1	1	10.58	17.17	7.66	2.474	1.506	0.862	0.49791	0.49745	0.46109	6.17	6.16	5.71

CASE NO.	17	18	19	20
1	0.57	0.42	0.16	1.16
2	0.99	0.55	0.19	1.73
3	0.54	0.49	0.23	1.25
4	0.69	0.29	0.15	1.14
5	0.50	0.25	0.07	0.82
6	0.76	0.63	0.07	1.46
7	0.45	0.36	0.10	0.91
8	0.59	0.36	0.07	1.02
9	0.48	0.24	0.06	0.78
10	0.86	0.45	0.20	1.51
11	0.91	0.42	0.06	1.39
12	0.78	0.34	0.09	1.21
13	0.61	0.37	0.08	1.06
14	0.46	0.41	0.11	0.97
15	0.78	0.51	0.08	1.37
16	0.49	0.49	0.12	1.10

APPENDIX B

APPENDIX B

Recovery of Fertilizer-^{15}N -- Data and Calculations

Four microplots identical to those which recieved alfalfa-^{15}N were established at both EL and KBS on areas adjacent to the alfalfa-^{15}N microplots but where corn had been the previous crop. $K^{15}NO_3$ ferilizer (23.8 atom % excess) was applied to the surface of these microplots in Spring, 1986 at a rate equivalent to 112 kg N ha^{-1} and incorporated to a 5 cm depth. Corn was planted, harvested, and along with sampled soil, analyzed for N and ^{15}N -- all according to methods described in the Materials and Methods section for microplots that recieved alfalfa-^{15}N. Results are presented in raw data form in the following tables.

1. Table B1

Recovery of ferilizer ^{15}N by corn grain, stover and roots was calculated by equations similar those described in Appendix A. For example:

$$V12 = V3 \times V6/100 \times V9 \; / \; 0.7756896$$

Where: 0.7756896 = 3.2592 x 23.8/100

3.2592 g of fertilizer-N applied

2.3 = ^{15}N atom % excess of fertilizer

$$V15 = V12 + V13 + V14$$

2. Table B2

Recovery of fertilizer-^{15}N in total N soil fraction was also calculated by equations similar to those in Appendix A. For example:

$$V15 = V3 \times V7/100 \times V11 / 0.7756896$$

$$V19 = V15 + V16 + V17 + V19$$

3. Table B3

Recovery of fertilizer-^{15}N in the inorganic soil N fraction was also calculated by equations similar to those in Appendix A. For example:

$$V15 = V3 \times V7 \times V11 / 775689.6$$

$$V19 = V15 + V16 + V17 + V19$$

4. Table B4

Microbial biomass C was calculated by Cf/0.41 as described in the Materials and Methods section.

5. Table B5

Microbial Biomass N was calculated as in Appendix A and described in the Materials and Methods section. Recovery of fertilizer-^{15}N in microbial biomass was calculated as follows:

$$V15 = V3 \times V13 \times V14 / 775689.6$$

Table B1. Corn dry matter yield, N content and recovery of fertilizer N-15 by corn at EL and KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Location 1=EL 2=KBS
2	numeric	Plot #
3	numeric	Grain D.M. Yield (g/plot)
4	numeric	Stover D.M. Yield (g/plot)
5	numeric	Root D.M. Yield (g/plot)
6	numeric	%N Grain
7	numeric	%N Stover
8	numeric	%N Roots
9	numeric	N-15 Atom % Excess Grain
10	numeric	N-15 Atom % Excess Stover
11	numeric	N-15 Atom % Excess Roots
12	numeric	Recovery of Fertilizer N-15 by Grain (% of input)
13	numeric	Recovery of Fertilizer N-15 by Stover (% of input)
14	numeric	Recovery of Fertilizer N-15 by Roots (% of input)
15	numeric	Recovery by Corn - Grain+Stover+Roots (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	266.3	207.6	20.1	1.13	0.51	0.43	0.43870	0.53260	0.86740	1.70	0.73	0.10	2.53
2	1	2	333.7	268.6	30.6	1.20	0.44	0.40	6.41800	5.73020	4.22160	33.13	8.73	0.67	42.53
3	1	3	176.8	214.1	22.0	1.21	0.55	0.46	6.47220	4.99540	4.24700	17.85	7.58	0.55	25.99
4	1	4	433.3	341.2	47.8	1.22	0.54	0.49	4.06560	4.24390	3.73300	27.71	10.08	1.13	38.91
5	2	1	213.8	160.0	14.6	0.72	0.86	0.52	1.38760	0.98170	0.77140	2.75	1.74	0.08	4.57
6	2	2	179.1	159.0	17.4	0.94	0.57	0.47	0.45567	0.31000	0.26590	0.99	0.36	0.03	1.38
7	2	3	217.8	153.0	12.9	0.88	0.51	0.44	0.47650	0.43260	0.35010	1.18	0.44	0.03	1.64
8	2	4	311.3	230.0	21.3	1.00	0.54	0.49	1.73130	1.44770	0.71770	6.95	2.32	0.10	9.36

Table B2. Recovery of fertilizer N-15 in total soil N at EL and KBS.

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Location 1=EL 2=KBS	11	0-15 Total N N-15 Atom % Excess
2	Plot #	12	15-30 Total N N-15 Atom % Excess
3	0-15 Total Layer D.W. (g)	13	30-45 Total N N-15 Atom % Excess
4	15-30 Total Layer D.W. (g)	14	45-60 Total N N-15 Atom % Excess
5	30-45 Total Layer D.W. (g)	15	Recovery of fert. N-15 in 0-15 (% of input)
6	45-60 Total Layer D.W. (g)	16	Recovery of fert. N-15 in 15-30 (% of input)
7	0-15 Total N (%N)	17	Recovery of fert. N-15 in 30-45 (% of input)
8	15-30 Total N (%N)	18	Recovery of fert. N-15 in 45-60 (% of input)
9	30-45 Total N (%N)	19	Recovery of fert. N-15 in 0-60 (% of input)
10	45-60 Total N (%N)		

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	56800	58200	67500	30800	0.09	0.09	0.02	0.02	0.00837	0.00714	0.01334	0.04437	0.55
2	1	2	55000	58800	68500	60100	0.10	0.06	0.03	0.02	0.03579	0.03211	0.04680	0.04880	2.54
3	1	3	54900	55400	53900	52100	0.12	0.10	0.04	0.03	0.04730	0.01492	0.01954	0.02590	4.02
4	1	4	49500	62600	58800	56700	0.15	0.09	0.03	0.02	0.02764	0.02027	0.02411	0.01644	2.65
5	2	1	49600	58900	72600	59800	0.11	0.08	0.02	0.02	0.00889	0.00632	0.02276	0.02015	0.63
6	2	2	46000	54800	66300	54400	0.10	0.08	0.01	0.02	0.00564	0.01250	0.00820	0.01141	0.33
7	2	3	46600	69500	74300	67500	0.09	0.07	0.01	0.01	0.00455	0.00822	0.00975	0.00848	0.25
8	2	4	37700	59900	50000	55900	0.15	0.13	0.07	0.04	0.00533	0.01023	0.00851	0.01766	0.39

	16	17	18	19
1	0.48	0.23	0.35	1.62
2	1.46	1.24	0.76	5.99
3	1.07	0.54	0.52	6.15
4	1.47	0.55	0.24	4.91
5	0.38	0.43	0.31	1.75
6	0.71	0.07	0.16	1.27
7	0.52	0.09	0.07	0.93
8	1.03	0.38	0.51	2.31

Table B3. Recovery of fertilizer N-15 in inorganic soil N at EL and KBS.

LIST OF VARIABLES

VAR	DESCRIPTION	VAR	DESCRIPTION
1	Location 1=EL 2=KBS	11	0-15 Inorganic N N-15 Atom % Excess
2	Plot #	12	15-30 Inorganic N N-15 Atom % Excess
3	0-15 Total Layer D.W. (g)	13	30-45 Inorganic N N-15 Atom % Excess
4	15-30 Total Layer D.W. (g)	14	45-60 Inorganic N N-15 Atom % Excess
5	30-45 Total Layer D.W. (g)	15	0-15 Inorganic N-15 Recovery (% of input)
6	45-60 Total Layer D.W. (g)	16	15-30 Inorganic N-15 Recovery (% of input)
7	0-15 Inorganic N (ug/g)	17	30-45 Inorganic N-15 Recovery (% of input)
8	15-30 Inorganic N (ug/g)	18	45-60 Inorganic N-15 Recovery (% of input)
9	30-45 Inorganic N (ug/g)	19	0-60 Inorganic N-15 Recovery (% of input)
10	45-60 Inorganic N (ug/g)		

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	56800	58200	67500	30800	11.8	31.0	5.6	6.5	0.07360	0.05217	0.02399	0.01362	0.1
2	1	2	55000	58800	68500	60100	14.3	8.8	5.8	2.6	0.20293	0.15083	0.11506	0.11564	0.2
3	1	3	54900	55400	53900	52100	20.0	10.8	5.6	2.5	0.29490	0.13886	0.15579	0.07160	0.4
4	1	4	49500	62600	58800	56700	15.4	7.9	6.3	4.2	0.15184	0.12040	0.05434	0.04440	0.1
5	2	1	49600	58900	72600	59800	23.5	15.7	7.1	10.2	0.03312	0.01634	0.01008	0.00616	0.0
6	2	2	46000	54800	66300	54400	20.0	13.3	5.0	6.7	0.02786	0.01181	0.00696	0.00462	0.0
7	2	3	46600	69500	74300	67500	15.1	11.6	7.1	5.7	0.02895	0.05623	0.00733	0.00210	0.0
8	2	4	37700	59900	50000	55900	30.7	19.4	14.3	9.1	0.05382	0.23855	0.03701	0.03572	0.1

	16	17	18	19
1	0.121	0.012	0.004	0.200
2	0.101	0.058	0.023	0.387
3	0.107	0.061	0.012	0.596
4	0.077	0.026	0.013	0.265
5	0.019	0.007	0.005	0.081
6	0.011	0.003	0.002	0.049
7	0.058	0.005	0.001	0.091
8	0.356	0.034	0.024	0.494

Table B4. Microbial biomass carbon at EL and KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Location 1=EL 2=KBS
2	numeric	Plot #
3	numeric	Carbon Flush for Fumigation/10 day Incubation - Cf (ug/g)
4	numeric	Carbon Evolved for Unfumigated 10 day Incubation - C10 (ug/g)
5	numeric	Carbon Evolved for Unfumigated 20 Incubation - C20 (ug/g)
6	numeric	Microbial Biomass Carbon - Cf/0.41 (ug/g)

CASE NO.	1	2	3	4	5	6
1	1	1	125.1	49.7	55.7	305.2
2	1	2	136.0	56.6	47.4	331.7
3	1	3	144.8	82.9	68.3	353.3
4	1	4	145.1	63.1	51.4	354.0
5	2	1	70.3	54.6	42.9	171.4
6	2	2	70.3	54.6	22.3	171.4
7	2	3	38.0	28.9	3.4	92.7
8	2	4	102.3	80.0	35.1	249.5

Table B5. Microbial biomass N and recovery of fertilizer N-15 in microbial biomass at EL and KBS.

LIST OF VARIABLES

VAR NAME/DESCRIPTION
1 Location 1=EL 2=KBS
2 Plot #
3 0-15 Total Layer D.W. (g)
4 Initial NO3 Concentration (ppm)
5 Initial NH4 Concentration (ppm)
6 Fumigated/10 day Incubation NO3 Concentration (ppm)
7 Fumigated/10 day Incubation NH4 Concentration (ppm)
8 Unfumigated/20 day Incubation NO3 Concentration (ppm)
9 Unfumigated/20 day Incubation NH4 Concentration (ppm)
10 Nitrogen Flush - Nf (ug/g)
11 Carbon Flush - Cf (ug/g)
12 Kn - -0.014(Cf/Nf) + 0.39
13 Microbial Biomass N - Nf/Kn (ug/g)
14 Fumigated/10 day Incubation Inorganic N N-15 Atom % Excess
15 Recovery of fert. N-15 in Microbial Biomass (% of input)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	1	1	56800	1.26	0.00	1.30	1.75	3.57	0.00	8.75	125.1	0.190	46.1	0.08897	0.30
2	1	2	55000	1.41	0.00	1.18	2.15	3.73	0.00	10.75	136.0	0.213	50.5	0.25184	0.90
3	1	3	54900	2.08	0.00	1.99	2.65	4.75	0.00	13.25	144.8	0.237	55.9	0.31690	1.25
4	1	4	49500	2.00	0.00	1.50	2.49	4.79	0.00	12.45	145.1	0.227	54.9	0.16977	0.59
5	2	1	49600	1.82	0.00	1.75	1.88	4.05	0.00	9.40	70.3	0.285	32.9	0.03775	0.08
6	2	2	46000	1.45	0.00	1.40	1.34	3.37	0.00	6.70	70.3	0.243	27.6	0.02997	0.05
7	2	3	46600	1.33	0.00	1.21	1.16	2.92	0.00	5.80	38.0	0.298	19.4	0.03099	0.04
8	2	4	37700	2.38	0.00	2.25	2.30	4.48	0.00	11.50	102.3	0.265	43.3	0.05327	0.11

APPENDIX C

APPENDIX C

N Fertilizer Replacement Value of Alfalfa

An experiment was conducted on areas adjacent to the microplots which recieved ^{15}N fertilizer at EL and KBS, previously cropped to corn, to determine the N fertilizer replacement value of alfalfa. The experimental design was a randomized complete block with 4 replications. NH_4NO_3 fertilizer was broadcast on corn plots at rates of 0, 56, 112, 168, and 224 kg N ha^{-1} after planting in the Spring, 1986. Each plot consisted of 4, 6.10 m rows planted on 76.2 cm row spacings at a population of 59 000 plants ha^{-1}. Four plots of the same size were also established at each site on areas adjacent to the microplots which recieved alfalfa-^{15}N (on ground previously cropped to alfalfa).

Corn grain and stover (stalks + cobs) were harvested from the center 2 rows of each plot after the corn reached physiological maturity in the fall. Grain and stover fresh weights were recorded for each plot and samples were taken to determine d.m. percentage.

Grain and stover d.m. yields -- V16 and V17, respectively -- in Tables C1 and C2 were calculated by multiplying plot fresh weight times sample dry weight divided by sample fresh weight, divided by plot area. For example:

$$V16 = V7 \times V9/V8 \ / \ 2.2 \ / \ 0.00931$$

Where: 2.2 = conversion from lbs to kg

0.00931 = plot size in ha.

A 2-way analysis of variance (replication x N rate) was performed on grain yield (V16) for each location and results indicated there was no N response at either location. Therefore, a N fertilizer replacement value could not be determined for either site.

Table C1. N fertilizer replacement value data at EL.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	N Rate (kg/ha) 1=0 w/alfalfa 2=0 3=56 4=112 5=168 6=224
4	numeric	# plants harvested/plot (plot = 2 30" rows x 20')
5	numeric	# ears harvested/plot
6	numeric	Grain and cob F.W. (lbs/plot)
7	numeric	Grain F.W. (lbs/plot)
8	numeric	Sample grain F.W. (g)
9	numeric	Sample grain D.W. (g)
10	numeric	Sample cob F.W. (g)
11	numeric	Sample cob D.W. (g)
12	numeric	Stover F.W. (lbs/plot)
13	numeric	Sample stover F.W. (g)
14	numeric	Sample stover D.W. (g)
15	numeric	Grain moisture (%)
16	numeric	Grain yield (kg/h D.M.)
17	numeric	Stover yield (kg/h D.M.)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	100	1	1	55	60	36	28.9	500	347.3	237.1	132.1	42.8	2023	598	30.5	9801	6177
2	101	1	5	52	79	37	29.6	500	349.0	219.1	116.8	46.1	1782	515	30.2	10087	6505
3	102	1	3	40	56	27	21.7	500	343.2	208.5	95.0	36.1	2410	683	31.4	7272	4995
4	103	1	2	44	53	29	22.7	500	341.4	244.9	121.9	38.7	1892	556	31.7	7567	5553
5	104	1	6	49	67	34	27.4	500	353.7	220.6	110.0	46.6	1912	539	29.3	9463	6414
6	105	1	4	55	68	35	27.5	500	351.4	224.8	118.9	48.5	2198	667	29.7	9436	7186
7	200	2	1	57	58	35	27.8	500	344.0	221.7	111.2	42.7	1846	526	31.2	9338	5940
8	201	2	4	47	77	36	28.9	500	352.5	183.3	84.9	41.6	2127	647	29.5	9948	6178
9	202	2	2	39	57	29	22.6	500	342.0	232.5	113.3	37.0	2064	563	31.6	7547	4928
10	203	2	6	44	53	30	23.6	500	348.7	204.7	104.9	42.5	1861	579	30.3	8036	6456
11	204	2	5	49	53	31	24.4	500	353.5	253.8	134.4	42.6	2056	589	29.3	8422	5958
12	205	2	3	51	59	30	24.1	500	357.0	200.9	102.5	42.1	1936	590	28.6	8401	6264
13	300	3	1	50	52	32	25.1	500	346.0	206.1	98.2	40.0	1864	567	30.8	8480	5941
14	301	3	6	47	63	34	26.9	500	357.7	212.9	111.1	39.6	1970	577	28.5	9396	5663
15	302	3	5	42	55	31	24.3	500	344.9	213.2	106.8	39.4	2126	601	31.0	8184	5438
16	303	3	4	45	58	34	26.6	500	347.0	166.5	80.8	47.5	1820	530	30.6	9013	6753
17	304	3	3	54	59	34	26.5	500	344.8	235.5	128.7	51.4	2182	654	31.0	8922	7522
18	305	3	2	47	67	37	29.0	500	351.5	232.8	116.3	46.1	2269	696	29.7	9954	6904
19	400	4	1	48	53	34	26.7	500	350.6	204.4	108.5	38.1	1932	572	29.9	9141	5507
20	401	4	4	51	77	41	33.3	500	349.8	216.9	110.6	53.8	2168	633	30.0	11374	7669
21	402	4	2	49	65	34	27.4	500	347.3	197.1	102.5	41.4	2831	696	30.5	9292	4969
22	403	4	5	45	66	36	28.9	500	349.6	209.2	111.3	44.5	1702	540	30.1	9866	6893
23	404	4	6	41	62	35	27.7	500	343.0	239.5	121.7	43.6	2547	711	31.4	9278	5942
24	405	4	3	46	66	38	30.4	500	350.1	204.4	104.4	49.7	2421	727	30.0	10393	7287

Table C2. N fertilizer replacement value data at KBS.

LIST OF VARIABLES

VAR	TYPE	NAME/DESCRIPTION
1	numeric	Plot #
2	numeric	Replication
3	numeric	N Rate (kg/ha) 1=0 with alfalfa 2=0 3=56 4=112 5=168 6=224
4	numeric	# plants harvested/plot (plot = 2 30" rows x 20')
5	numeric	# ears harvested/plot
6	numeric	Grain and cob F.W. (lbs/plot)
7	numeric	Grain F.W. (lbs/plot)
8	numeric	Sample grain F.W. (g)
9	numeric	Sample grain D.W. (g)
10	numeric	Sample cob F.W. (g)
11	numeric	Sample cob D.W. (g)
12	numeric	Stover F.W. (lbs/plot)
13	numeric	Sample stover F.W. (g)
14	numeric	Sample stover D.W. (g)
15	numeric	Grain moisture (%)
16	numeric	Grain Yield (kg/ha D.M.)
17	numeric	Stover Yield (kg/ha D.M.)

CASE NO.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	100	1	1	63	73	34	28.2	500	384.5	169.6	103.3	46.6	1668	541	23.1	10588	7379
2	101	1	2	62	80	40	32.8	500	362.8	186.7	100.3	45.6	1899	536	27.4	11620	6284
3	102	1	5	57	81	39	31.9	500	369.8	169.4	92.2	52.5	2036	587	26.0	11519	7390
4	103	1	6	65	93	43	34.8	500	363.7	168.0	91.8	53.1	2212	640	27.3	12359	7501
5	104	1	3	64	91	40	33.1	500	376.1	186.3	111.0	51.9	1872	529	24.8	12156	7161
6	105	1	4	55	100	46	38.2	500	370.4	162.8	84.2	53.2	1991	606	25.9	13816	7906
7	200	2	1	56	69	36	29.5	500	372.6	188.0	109.7	43.5	1515	472	25.5	10733	6617
8	201	2	4	56	98	45	36.9	500	362.5	185.5	99.8	51.3	1676	482	27.5	13061	7203
9	202	2	2	63	87	41	33.6	500	364.4	191.6	92.1	46.9	1645	469	27.1	11956	6528
10	203	2	6	63	98	45	36.9	500	364.0	198.2	102.5	53.1	1688	481	27.2	13116	7387
11	204	2	3	60	94	45	36.1	500	362.5	233.1	125.9	49.5	2119	585	27.5	12778	6672
12	205	2	5	46	83	37	30.6	472	349.6	211.1	105.5	43.0	2000	593	25.9	11066	6225
13	300	3	1	57	73	33	28.2	500	377.9	169.5	94.3	42.2	1769	524	24.4	10406	6103
14	301	3	5	62	98	47	39.0	500	363.4	177.0	93.8	48.5	1809	530	27.3	13839	6938
15	302	3	6	56	92	43	35.9	500	373.1	172.8	94.2	52.1	1789	557	25.4	13079	7920
16	303	3	2	66	80	43	35.3	500	363.1	191.5	105.6	46.5	1628	460	27.4	12516	6415
17	304	3	3	68	103	47	38.7	500	374.5	161.4	87.7	49.3	1585	477	25.1	14152	7244
18	305	3	4	66	100	48	39.4	500	372.8	177.4	91.8	49.7	1834	543	25.4	14343	7184
19	400	4	1	61	62	43	26.6	500	378.2	194.1	107.6	39.3	1474	483	24.4	9823	6287
20	401	4	5	56	95	45	36.6	500	368.4	139.0	73.1	52.1	2105	583	26.3	13166	7045
21	402	4	3	62	101	49	40.4	500	368.5	186.8	99.3	53.5	2074	599	26.3	14537	7544
22	403	4	4	65	95	47	38.5	500	370.5	177.0	95.9	55.4	1995	532	25.9	13929	7213
23	404	4	6	56	102	45	37.3	500	373.4	163.5	99.0	51.0	1902	537	25.3	13600	7030
24	405	4	2	59	98	51	41.8	500	378.2	166.5	92.7	48.8	2177	625	24.4	15437	6840