

NITRATE ACCUMULATION IN SOILS AND WATER
AS AFFECTED BY NITROGEN FERTILIZATION

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B. S., Kansas State University, 1970

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

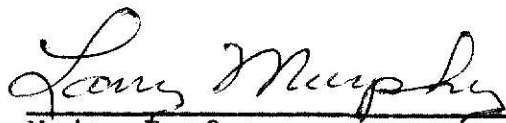
MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1971

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INTRODUCTION

Chemical pollution of drinking water supplies is a major concern in many regions of the world. With the rapid increase in population and the widening use of chemicals for agricultural and industrial purposes, many water supplies are becoming contaminated either by carelessness or by ignorance of the potential of the polluting agents.

The recent growth in concern over pollution and the recognition of nitrates in water supplies has been concomitant with a rapid increase in the use of nitrogenous fertilizers. The source of nitrate in water supplies may be quite varied. Sewage, industrial and packing house wastes, drainage from livestock feeding areas, farm manures, legumes (and other decomposing plant materials), mineralization of soil nitrogen and chemical fertilizers are all possible sources (28).

High concentrations of nitrates can be toxic to animals under certain conditions. Human infants are highly susceptible to nitrate toxicity and may develop methemoglobinemia as a result of consuming water containing a high concentration of nitrates. The U. S. Public Health Service drinking water standards state that 10 ppm nitrate-nitrogen (45 ppm nitrate) is the maximum concentration for water that should be utilized for human consumption (32).

This investigation was conducted with the purpose of studying the possible movement of inorganic fertilizer nitrogen into

surface and sub-surface water supplies. Information was sought on the rate, quantity, and method of nitrate movement in the soil. Nitrate accumulation was studied in irrigation runoff water, ground water, and in deep soil cores collected from irrigated soils receiving high rates of inorganic fertilizer nitrogen.

REVIEW OF LITERATURE

Health Hazards From Nitrate Ingestion

The seriousness of nitrate accumulations in water supplies was not recognized until 1945 when Comly (6) reported that methemoglobinemia (blue babies' disease) could result from ingestion of water high in nitrates by human infants, usually less than six months in age.

Nitrate-induced methemoglobinemia results from ingested nitrates being reduced to nitrites by bacteria in the upper gastrointestinal tract. The resulting nitrite reacts with hemoglobin by oxidizing the ferrous iron in hemoglobin to the ferric form. This reaction produces methemoglobin to which oxygen is so tightly bound that it can not function in the alternate oxygenation and deoxygenation processes of respiration. If the concentration of methemoglobin in the blood reaches an excessive level, a condition known as methemoglobinemia, the subject will suffer from asphyxia resulting in possible serious consequences, perhaps even death (33).

Cornblath and Hartmann (7) found that the growth of nitrate-reducing bacteria was inhibited at pH levels below 4.9. Based on this evidence, they concluded that an infant's susceptibility to methemoglobinemia is due to the lack of acidity in the gastric juices. In older children, the acidity

of the gastric juices inhibits the growth of nitrate-reducing bacteria and lowers the susceptibility to methemoglobinemia.

Although most cases of infant methemoglobinemia are associated with nitrate-nitrogen concentrations in excess of 40 ppm, it is considered inadvisable to use well water containing more than 10 or 20 ppm nitrate-nitrogen in preparing an infant's feeding formula. The permissible nitrate-nitrogen concentration in water which may cause infant methemoglobinemia is dependent on the individual's susceptibility, the increase in nitrate-nitrogen concentration due to boiling the water, the quantity of boiled water consumed per day per unit weight of the infant, the duration of exposure to the high nitrate water, and possible other factors (33).

Some animals, particularly ruminants are susceptible to nitrate toxicity. Nonruminants, or monogastric animals, are not easily poisoned by nitrate because consumed nitrate undergoes little reduction until it reaches the colon. According to Whelan (36) most nitrate has been absorbed and excreted by the kidneys prior to reaching the colon.

Ruminants are especially susceptible to nitrate toxicity because much metabolism and absorption of nitrate and its reduction products occurs in the rumen, anterior to the stomach. Bacteria present in the rumen are capable of reducing nitrate to nitrite in toxic quantities. Horses and mules have bacterial activity in their enlarged caecum and colon similar to that in the rumen of ruminants. Wright and Davison (37) cited

cases where nitrate toxicity had been reported in horses, mules, cattle and sheep. They also reviewed cases where lowered growth and milk production, abortions, vitamin A and iodine nutritional problems have been included among sublethal effects of nitrate consumption.

Donahoe (1949) suggested the possibility of infant methemoglobinemia occurring from nitrate present in milk (10), but more recent studies have been unable to detect significant increases in the nitrate content of either milk or meat from livestock on high nitrate rations (25, 36).

Nitrate Contamination of Well Water

The occurrence of toxic levels of nitrate in well water is widespread in the United States and Canada. Reports of infant methemoglobinemia resulting from nitrate-contaminated waters have been reported in Belgium, Manitoba, Ontario, Saskatchewan, Illinois, Nebraska, Kansas, Michigan, Indiana, and several other states (37). Most of these cases were traced to shallow dug wells or drilled wells of poor location or construction.

Bosch, et al. (3) reported that from 1947 to 1950, 139 cases of methemoglobinemia, including 14 deaths, due to nitrate-nitrogen in farm well-water supplies were reported in Minnesota. They sampled several wells where cases of methemoglobinemia had been reported and noted that 125 of 129 wells investigated were hand dug, 83 were within 50 feet of a source of human or

animal contamination (barnyard, hogpen, privy, cesspool, etc.) and many were not properly protected from surface contamination. They compared the nitrate concentration of rural school wells to similarly constructed nearby farm wells and found less nitrate in the school wells.

Metzler (21) investigated nitrate concentrations in 52 public and private water supply wells in North Central Kansas and found an excellent correlation between the depth at which the water sample was taken and the nitrate content. He reported that of 36 deep observation wells having depths of 27 to 66 feet, nitrates ranged from 0.4 to 15.6 ppm (as NO_3^-) with only a few values above 5 ppm. In 17 shallow observation wells having depths of 9 to 29 feet, nitrate concentrations ranged from 0.7 to 487 ppm with only a few values below 20 ppm. Metzler noted very little vertical mixing of the ground water resulting in stratification of nitrates in the water table. He reported that 370 tons of nitrate have been pumped in water from a city well in Wilson, Kansas over a 16-year period suggesting a renewable source of nitrates rather than a fixed buried source. The stratification of nitrates shows clearly that the nitrates originate at or near the ground surface in the cases studied. He accredited the nitrate pollution to nitrogenous materials of animal origin, especially sewage and manure. No correlation was found

between high nitrate waters and fertilizer applications, organic matter decay, nitrate fixation by legumes, or normal soil nitrate fixation (21).

Crabtree (8) investigated approximately 250 private wells in Marathon county, Wisconsin. He reported that 70 per cent of the wells contained a nitrate level of 45 mg/l NO_3^- at one time or another within a period of a year and about 45 per cent of the wells contained in excess of 45 mg/l nitrate throughout the year. A lack of correlation between well depth and nitrate content was noted probably due to the pervious nature of the soil and the existence of extensive fractures and crevices in the bedrock. Crabtree compared the nitrate content of waters from farms supporting large dairy herds to water well samples from non-dairy farms. He noted that 44 per cent of the dairy farms had water with 45 mg/l nitrate while on non-dairy farms approximately 35 per cent of the well water samples contained 45 mg/l nitrate.

Hanway et al. (14), reported that the nitrate level may fluctuate widely in ground water. Nitrates tend to accumulate in the upper portion of the ground water table and remain there for an indefinite period of time depending on concentration of nitrates and movement of the ground water. Nitrates move with ground water and may contaminate a well a considerable distance from the nitrate source (14).

Factors Affecting Soil Nitrate Accumulations

The amount of inorganic nitrogen in any particular soil varies greatly over a period of time. At one time a soil may have over 100 kg/ha of available nitrogen, and at another time the level may be near zero (31). This fluctuation depends largely on the rate of organic matter decomposition, the amount of supplemental nitrogen added to the soil, and the rate of crop absorption.

Microbial degradation of organic matter produces ammonium-N which is subsequently oxidized to the mineral form, nitrate-N. This mineralization of organic nitrogen was extensively reviewed by Harmsen and Van Schreven (17) and was found to occur most readily under conditions favoring the activity of microorganisms, for example in moist, warm, well-aerated soils. The optimum conditions are: moisture content of 50 - 60 per cent of water-holding capacity, temperatures of 30 - 35°C, and soil aggregates not exceeding 3.5 mm in diameter.

Most inorganic soil nitrogen is either in the form of ammonium or nitrate. Plants can utilize either of these forms and they each have their advantages. In the case of ammonium, the ions are usually held on the base-exchange complex by chemical absorption. This attraction prevents their leaching with soil water (15, 24). Nitrate ions, however, are negatively charged, the same as the clay colloids and

are therefore not bound leaving them free to move with soil water. For this reason, nitrate-nitrogen is the form most likely to enter shallow aquifers or surface water supplies.

Most inorganic fertilizers added to the soil are applied in the ammonium form or at an equally reduced oxidation state, only about 12 per cent being applied directly as nitrate (20). As mentioned, however, under favorable conditions most $\text{NH}_4\text{-N}$ is rapidly converted to $\text{NO}_3\text{-N}$ by soil organisms. Dow Chemical Company has recently developed fertilizer additives which can reduce the rate of nitrification of ammonium fertilizers. Their objective is to increase the efficiency of ammonium fertilizers by decreasing leaching losses and volatilization losses resulting from denitrification. This would decrease the potential of fertilizer nitrate pollution and would effect an economical advantage due to reduced fertilizer losses.

Soil Characteristics Affecting Leaching

Many studies have been conducted on the loss of nitrates by deep leaching. However, more attention has been given to proving the loss of nitrates than exploring the soil characteristics responsible for the leaching.

Webster and Gasser (34) found it very difficult to remove nitrates completely from any soil, even with heavy leaching. They found that a coarse textured soil lost nitrate more quickly than did a fine textured soil. These conclusions have been confirmed by several other investigators (2,15,26).

Cunningham and Cooke (9) reported that where nitrate fertilizers had been applied, soil nitrate remained high for several weeks and was unaffected by light rainfall. Most of the nitrate disappeared from the surface soil in a short time following heavy rains. They found that leaching from heavy textured soil was much less rapid than had been expected. They suggested that nitrate may be absorbed within structural aggregates in medium and heavy textured soils, and if percolating rainfall merely passes around aggregates, nitrate may persist in the soil through periods of heavy rainfall (9). Webster and Gasser (34) reported similar results and suggested that following dry weather the first drainage takes place through the spaces between the soil structural units and not through the soil mass.

Gasser (12) while working with light soils, pointed out that the degree of soil aggregation would be less likely to apply on a light soil which contained few large and stable aggregates. He concluded that the mechanisms of nitrate movement in light and heavy soils differ in the degree of aggregation rather than the type of soil. Wetselaar (35) applied nitrate to the surface of a clay soil and concluded that it moved downward 1.1 inch per inch of rainfall. He also noted that movement out of the topsoil was enhanced by channels left by partly decomposed roots.

Some investigations have shown a capillary rise of nitrate in the soil during dry seasons. An accumulation in the surface 2 inches resulting from a decrease in nitrate in the 6 - 9 inch and 9 - 12 inch layer during drying has been demonstrated by several studies (11,27,29,35). When rainfall is insufficient to cause complete leaching, nitrate may accumulate at a depth in the subsoil (18,35). Although some nitrates may move upwards in the surface layers during drying of the soil, Stephens (29) did not consider that nitrate accumulated at depth could ever move in significant amounts to the surface.

Soil pH may also have an effect on the leaching of nitrates. Broadbent and Tyler (5) found a strong correlation between pH and nitrogen immobilization. They concluded that as pH decreased, greater amounts of nitrate were immobilized.

Ayres and Doi (1) studied the influence of soil temperature on nitrate leaching under established sugar cane grown in a lysimeter. Their results demonstrate extensive losses of mineral nutrients at 62°F as compared to 80°F despite the presence of a well-established root system. It would appear that where soil temperatures are low and where rainfall ranges as high as 200 inches per annum, losses of nitrogen by leaching might be expected even under an established cane crop (1).

Horizontal Translocation of Nitrates

Horizontal translocation of nitrate through the soil appears inextensive. Diffusion of nitrates laterally from placed fertilizers has not been large. However, lateral movement may cause nitrates to accumulate in ridges with furrow irrigation (26,30). Harmsen and Kolenbrander (16) state that horizontal translocation is seldom important except in a sloping soil which contains a parched impervious layer or which is situated above shallow lying bedrock. In such soils, lateral movement of nitrates may be appreciable after heavy rains.

Nitrate Losses From Surface Runoff

Moe et al. (22,23) have reported data indicating that surface nitrate losses can occur from sod and fallow areas when runoff rates are high. Greatest losses were noted when fertilizer nitrogen was applied to sloping soils that were wet or had a surface seal or crust. The greatest loss amounted to only 15 per cent of the fertilizer applied and this occurred on a 13 per cent slope. Similar studies on a Missouri claypan soil showed runoff nitrate losses to be much greater from a fallow soil that had received no fertilizer application than from a soil supporting a corn crop to which large fertilizer applications had been made (28).

Several studies have been conducted concerning nitrates in runoff waters, but most are traced to feedlot and sewage

disposal practices and usually fertilizer losses are not considered a major source.

Seasonal Variations of Nitrate Losses

Damp soils may lose considerable amounts of nitrates during the winter months because of leaching. Lundegardh (19) pointed out that when the soil is covered with vegetation, nitrates are reabsorbed by the roots as soon as they are formed, and so less leaching occurs. In autumn and spring, when the soil is not covered by vegetation, large quantities of nutritive materials are washed out. Substantiating evidence was presented by Metzler (21) who suggested that bacterial activity is greater in thawed soils which were recently frozen causing conditions favorable to more rapid nitrification. Also, studies by Crabtree (8) monitoring the nitrate concentration in water wells have demonstrated an exceptional number of wells with a peak nitrate concentration in November and December. A satisfactory explanation has not been presented, but it is possible that the phenomenon may be due to the lack of vegetative absorption of nitrates during the winter months.

METHODS AND MATERIALS

Design of Experiment

Three media of possible nitrate accumulation were studied in this experiment: irrigation runoff water, ground water, and soil cores. In an attempt to create optimum conditions for fertilizer nitrate losses, the study areas were selected in level, heavily irrigated sandy soils underlain with shallow aquifers. The locations of the study areas were: Unit 1, Ashland Agronomy Farm, Riley County; Sandyland Experiment Station, Stafford County; and Pessemier Company Farms, Pottawatomie County, Kansas.

In Riley and Stafford counties, areas selected for nitrate leaching studies received a solid application of 336 kg N/ha annually as ammonium nitrate. The Riley County site was cropped with irrigated corn, and the Stafford County site with irrigated grain sorghum. Annual soil cores were collected in the fall, after harvest, to a depth of approximately 3 meters in Stafford County and 5 meters in Riley County. Shallow water wells were periodically sampled in and in the vicinity of the plot area at each location to detect any fluctuation in ground water nitrates.

A separate study on the Ashland Agronomy Farm was designed to monitor irrigation tail-water nitrate losses as affected by depth of placement of ammoniacal fertilizers. This study was arranged in a randomized complete block

design with 3 replications of 4 treatments. The treatments are shown in Table 1. The plot areas were 3.6 meters wide and 180 meters long. Soil cores were collected to a depth of two meters prior to N applications. The area was planted to grain sorghum and furrow irrigated with gated pipe. Thirty days after fertilizer application the first irrigation was conducted. The rate at which water was applied was measured at the gates by the use of an eight-liter container and a stopwatch. V-shaped weirs were inserted in the furrow at a distance of approximately 91 meters from the gated pipe. Below the weirs, holes were dug large enough to insert the eight-liter bucket, and the rate of runoff was measured with a stopwatch. At half-hour intervals from time zero when the water first reached the weirs, water samples were collected at the weir in each plot throughout the period of irrigation. These samples were analyzed for nitrate and ammonium nitrogen.

In the fall, following harvest, two soil cores were collected from each plot and analyzed for downward movement of nitrogen.

In Pottawatomie County, the differences in leaching due to time of N applications of urea were studied. The study consisted of a randomized complete block design with 4 replications of 19 treatments (Table 2). The area was planted to corn and furrow irrigated. Six-meter soil cores were collected each fall from plots receiving spring or fall

Table 1. Ashland N-placement treatments.

N Treatments kg/ha	Carrier	Depth
0	----	----
224	Urea	Surface
224	NH ₃	15 cm
224	NH ₃	30 cm

Table 2. Time of N application treatments.

N Treatments kg/ha	Time N Application
0*	----
56	Fall
112*	"
168	"
224*	"
280	"
336	"
392	"
448*	"
504	"
56	Spring
112*	"
168	"
224*	"
280	"
336	"
392	"
448*	"
502	"

*Plots from which annual soil cores were taken to test nitrogen leaching.

applications of 0, 112, 224, or 448 kg N/ha. These soil samples were analyzed for ammonium and nitrate-nitrogen.

Sampling Techniques

All soil core samples were taken with a truck-mounted hydraulic soil probe complete with rotary attachment, swinging mast and anchors (Figure 2). This probe is self powered with a 12 1/2 horsepower Wisconsin engine. A 4-foot slotted stainless steel sampling tube was attached to the drive head and forced into the soil to a depth of approximately 1 meter and pulled back out with an intact soil core inside. The soil core was removed from the sampling tube with a wooden dowel and cut into samples representing various depths. The surface meter was separated into 10-cm increments and the remainder of the core was sampled in 20-cm increments. The samples were individually bagged and kept frozen until they could be analyzed.

Groundwater samples were obtained from observation wells within and surrounding the plot areas. The wells were established by removing a 3 3/4-cm diameter soil core to the surface of the water table with the soil sampling equipment. A 3 1/8-cm diameter sand point with a 75-cm screen was then attached to a joint of pipe, lowered into the core hole, and hand driven into the surface of the water table with a lead-headed post driver.

These wells were sampled periodically by screwing a pitcher pump onto the pipe as shown in Figure 3. The pump was primed with distilled water to prevent contamination and approximately 10-gallons of water were pumped before the first sample was taken. Ten gallon increments of water were also pumped between additional samples.

The samples were collected in 114-ml plastic bottles and kept in the laboratory under refrigeration until they could be analyzed. Runoff water was collected in similar 114-ml plastic bottles from the furrow in the manner mentioned and handled with the same procedure as ground water samples.

Laboratory Analysis Procedures

Nitrogen analyses of soil samples were performed by steam distillation using the procedure described by Bremner and Keeney (4). The frozen soil samples were placed in a forced-air oven and dried at 55°C. They were then ground and screened through a 14-mesh screen. A 5-gram portion was weighed from each sample for analysis. Each 5-g sample was placed in a separate 300-ml distillation flask along with 20 mls of 2 M KCl and approximately 0.2 g of MgO. This mixture was steam distilled with the equipment shown in Figure 1, and 25 mls of distillate were collected in a 5-ml aliquot of 2.0% H_3BO_3 -methyl purple indicator solution.¹ The 30-ml mixture of indicator solution and

1/ Indicator solution consisted of 20 g H_3BO_3 and 20 mls methyl purple dissolved in 200 mls 95% ethanol and dilluted with 780 mls of deionized water; adjusted with 0.05 N NaOH.

distillate were then titrated with a standard 0.00462 N sulfuric acid to determine the amount of ammonium-nitrogen present.

Nitrate-nitrogen was determined on the same soil sample following ammonium-nitrogen determination, by adding approximately 0.2 g of ball-milled Devarda alloy to the distillation flask and immediately distilling another 25 mls of distillate into 5 mls of the H_3BO_3 -methyl purple indicator solution. The titration of this sample with the standard sulfuric acid determined the amount of nitrate-nitrogen present in the soil sample.

Water samples were also analyzed by steam distillation. A 20-ml aliquot of each sample was placed in the distillation flask along with approximately 0.2 g of MgO . These samples were then analyzed for ammonium and nitrate-nitrogen by the procedure described above.

Figure 1. Steam distillation apparatus used for nitrogen determinations.

Figure 2. Truck-mounted hydraulic soil probe used for collecting soil core samples.

Figure 3. Pitcher pump used for collecting ground water samples.

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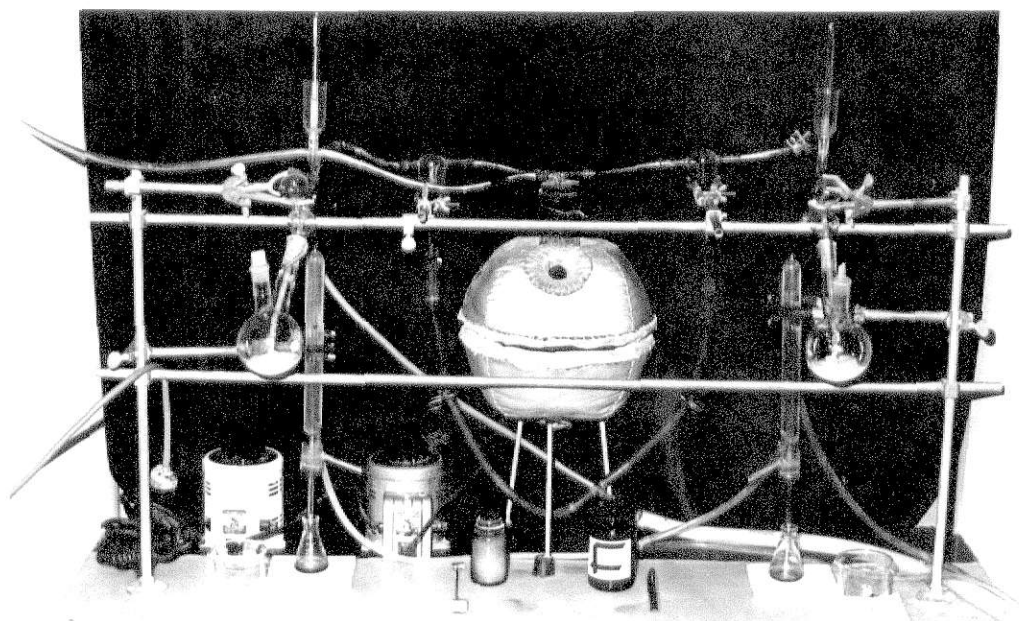


Figure 1

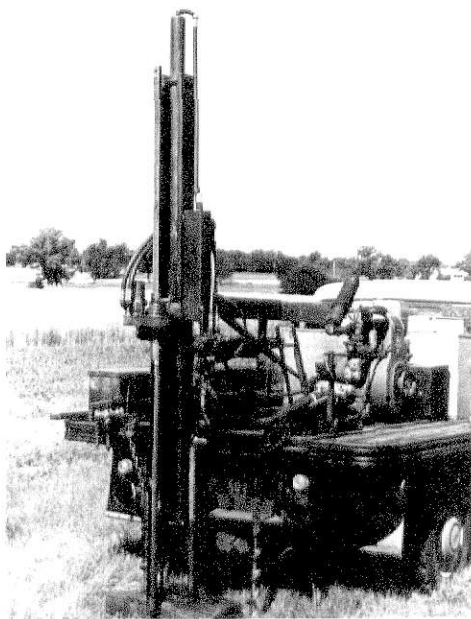


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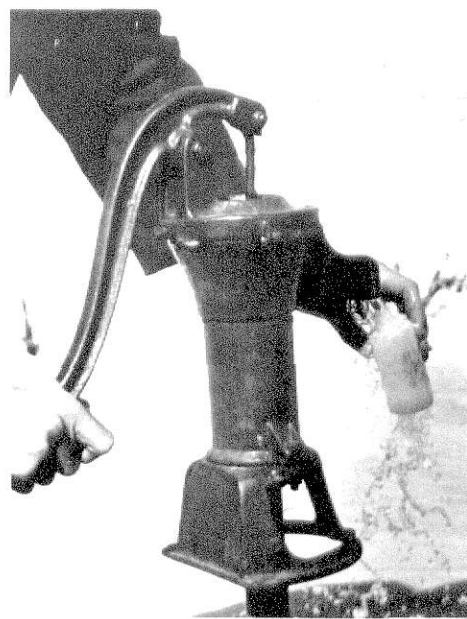


Figure 3

RESULTS AND DISCUSSION

Riley County Nitrate Leaching Study

The nitrate leaching study in Riley County consisted of an area 58.5 meters by 76.1 meters which received an annual fertilizer application of 336 kg N/ha, plus an untreated area approximately 30 meters west of the fertilized area which received no nitrogen application.

The study area was selected because its unique characteristics deemed it optimum for nitrate leaching. The soil is alluvial in origin consisting of sand, loam, and silt loam classes of materials deposited in layers throughout the profile. The soil is readily permeable to water and has a shallow water table at approximately 6 meters. The area was furrow irrigated as required throughout the growing season of the corn crop.

Soil cores were collected from the plot area in December of 1969 and December of 1970. At the same time, cores were collected from the control area. These sectioned cores were analyzed for ammonium-N and nitrate-N. Since the entire plot area received the same treatment, the nitrate-N was averaged at each depth between the representative soil cores for each year and the resulting averages of nitrate-N versus depth were plotted for the check area in Figure 4 and for the fertilized area in Figure 5.

Prior to this project, the plot area had been used for a similar study which received 336 kg N/ha also. By combining recent data with that of the previous study, the following table of nitrate-N accumulation in the soil was constructed:

Table 3. Soil $\text{NO}_3\text{-N}$ kg/ha to a depth of 4 meters in Riley County.

	4-67*	2-68*	4-69*	12-69	12-70
Check	517	---	381	679	346
Plot I-4	320	186	391	304	325
Plot II-5	127	200	232	120	126
Plot III-6	112	242	173	202	236
Plot IV-7	315	523	159	350	163
Plot II-13	---	---	---	195	193
Avg. within plot area	218	288	239	234	209

* Data collected by Gosch (13).

From the data presented in Table 3, it is apparent that no nitrate accumulation occurred in this soil during the period of 1967 through 1970 even though the area received a total of 1344 kg N/ha during that time. This means that either the crop utilized all the applied nitrates,

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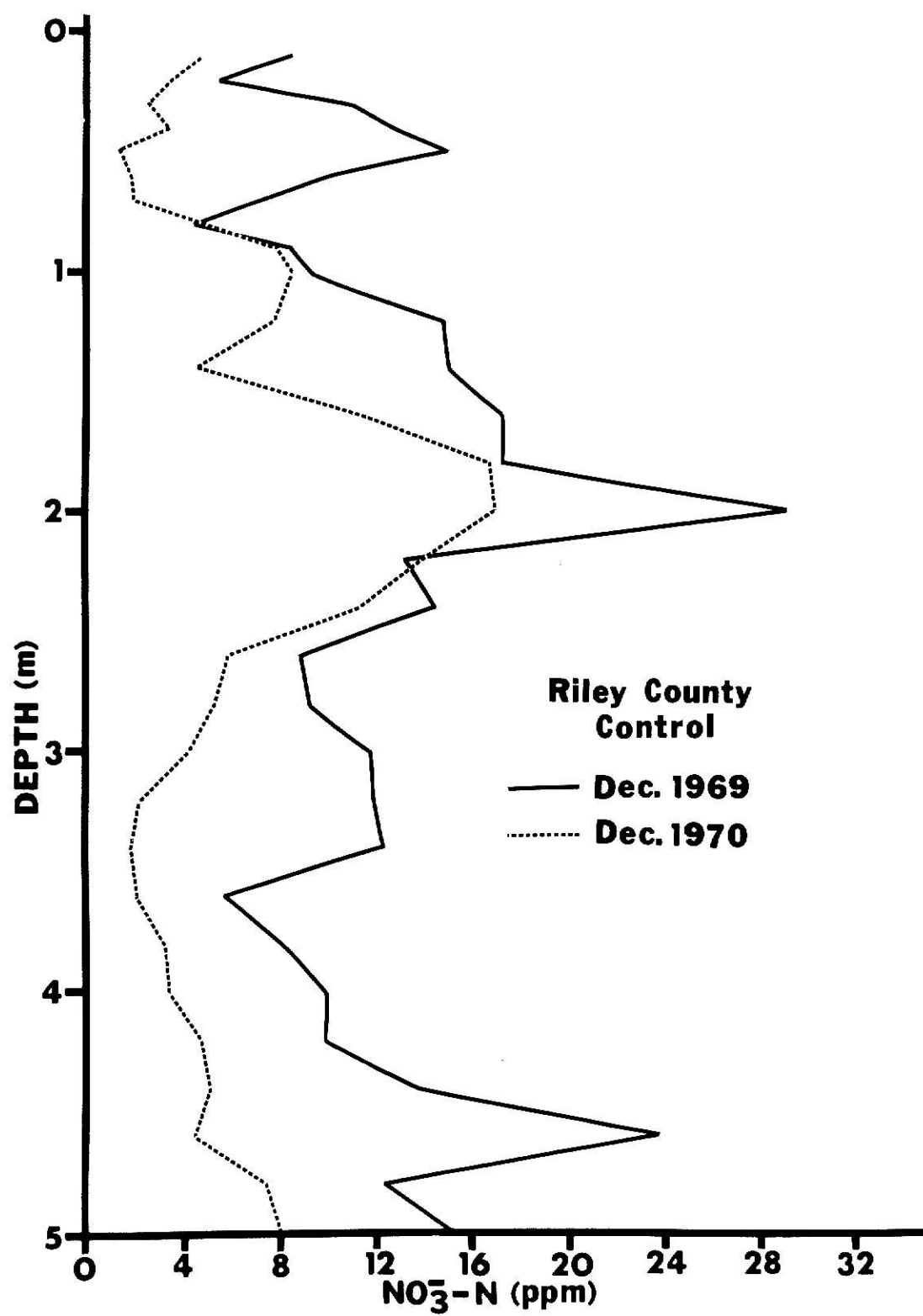
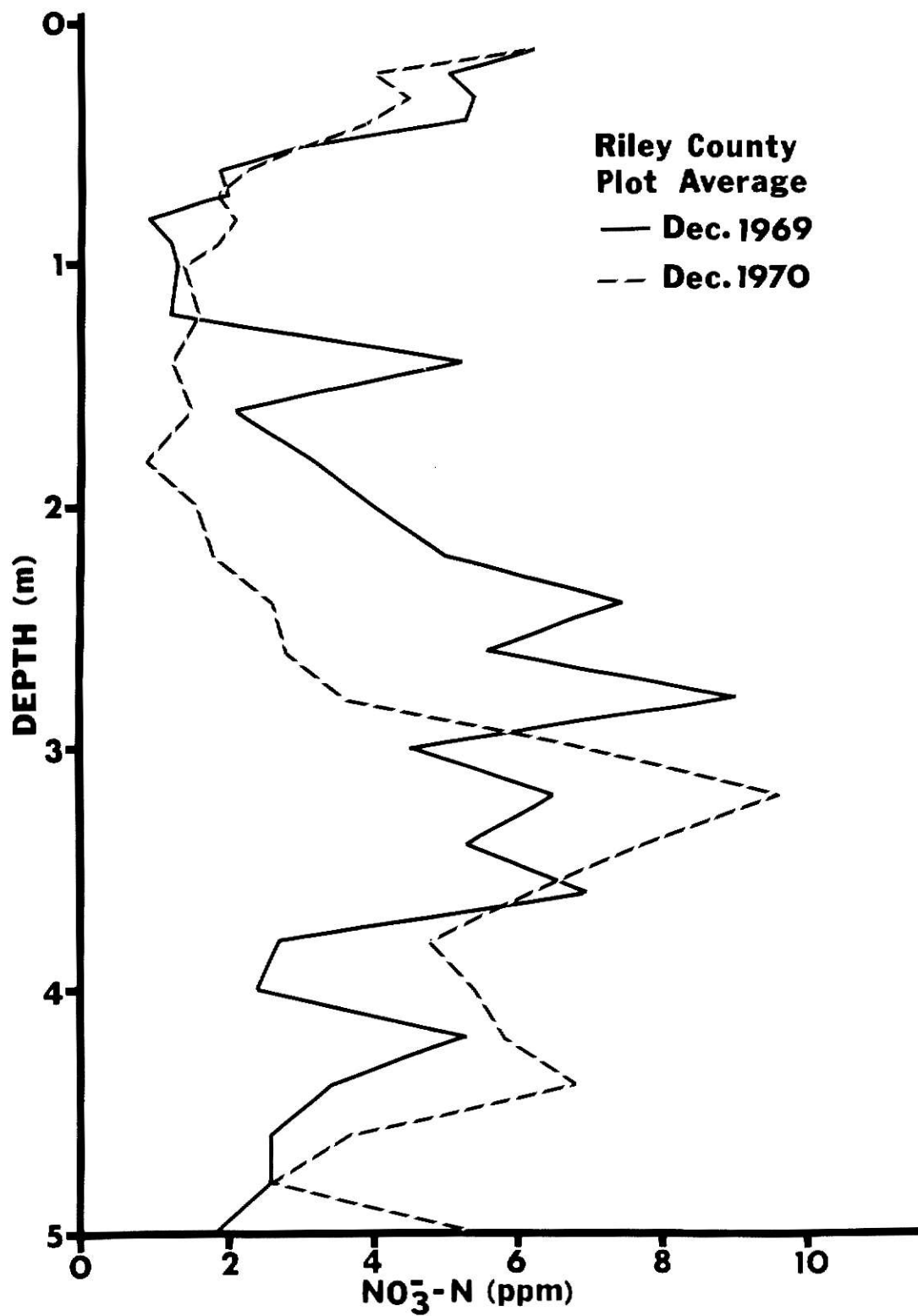


Figure 5. Nitrate-nitrogen distribution in the soil profile beneath a fertilized plot receiving 336 kg N/ha (Riley County).



or all excessive nitrates were lost from the soil. An apparent downward movement of soil nitrates can be seen in Figure 5, but this phenomenon can not be detected in the control area (Figure 4). This may be explained by the fact that the control area was not irrigated and thus, less leaching may have taken place. Assuming that the combination of downward movement of soil nitrates in the fertilized area (as shown in Figure 5) and the lack of nitrate accumulation suggests that excessive nitrates are being leached from the soil, an accumulation of these nitrates should be apparent in the shallow ground water beneath.

To monitor the nitrate-nitrogen content of the ground water, 3 shallow wells within the plot area and 6 wells from surrounding control areas were periodically sampled. Water analysis results from 2 wells within the plot area and one check well located 30 meters west of the fertilized area are given in Figure 6. The high nitrate-N content of the check well indicates possible contamination due to its close proximity to the plot area. Data from more distant check wells (approximately 200 meters from the plot area) are shown in Figure 7.

Results of an analysis of variance of the water sample data for the period of April 1969 through February 1971 are recorded in Table 4.

Table 4. Analysis of variance for nitrate-nitrogen content of water from observation wells in Riley County.

Source	df	SS	MS	F
Total	143	8910.91		
Wells	7	6763.31	966.19	74.49*
Dates	17	604.69	35.57	2.74*
Error	119	1542.91	12.97	

* Differences significant at 0.01 level.

The results of this analysis of variance signify that variance between wells and sampling dates are both significant. The variance of nitrate-N content is of particular interest because Figure 6 indicates that most of the wells reached their peak nitrate-N content during the winter months. This agrees with conclusions drawn by Crabtree (8) who noted that November and December are the months in which the largest number of wells show a peak nitrate content.

Figure 6. Nitrate-nitrogen accumulation in ground water
beneath a fertilized area receiving 336 kg N/ha
annually (Riley County).

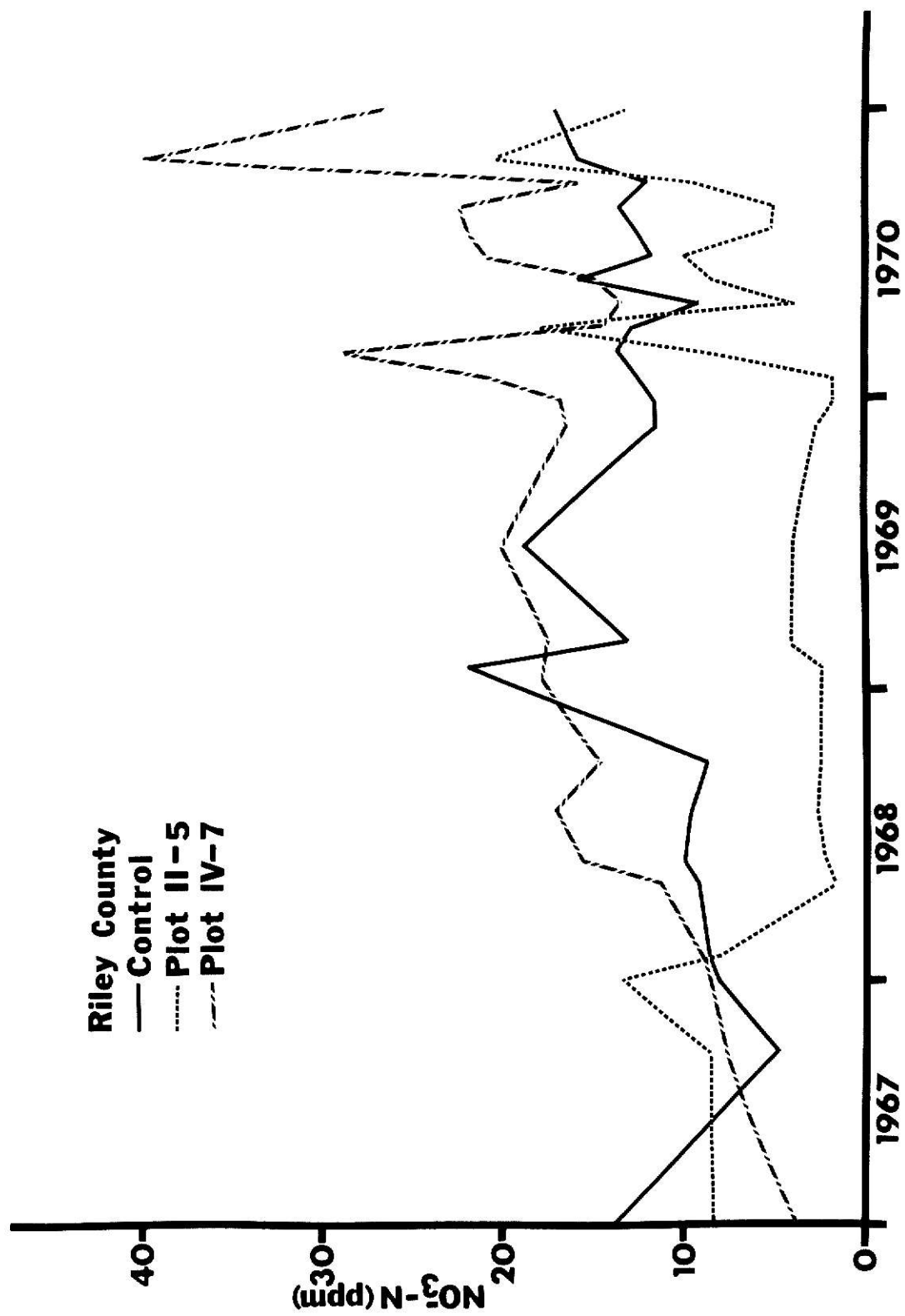
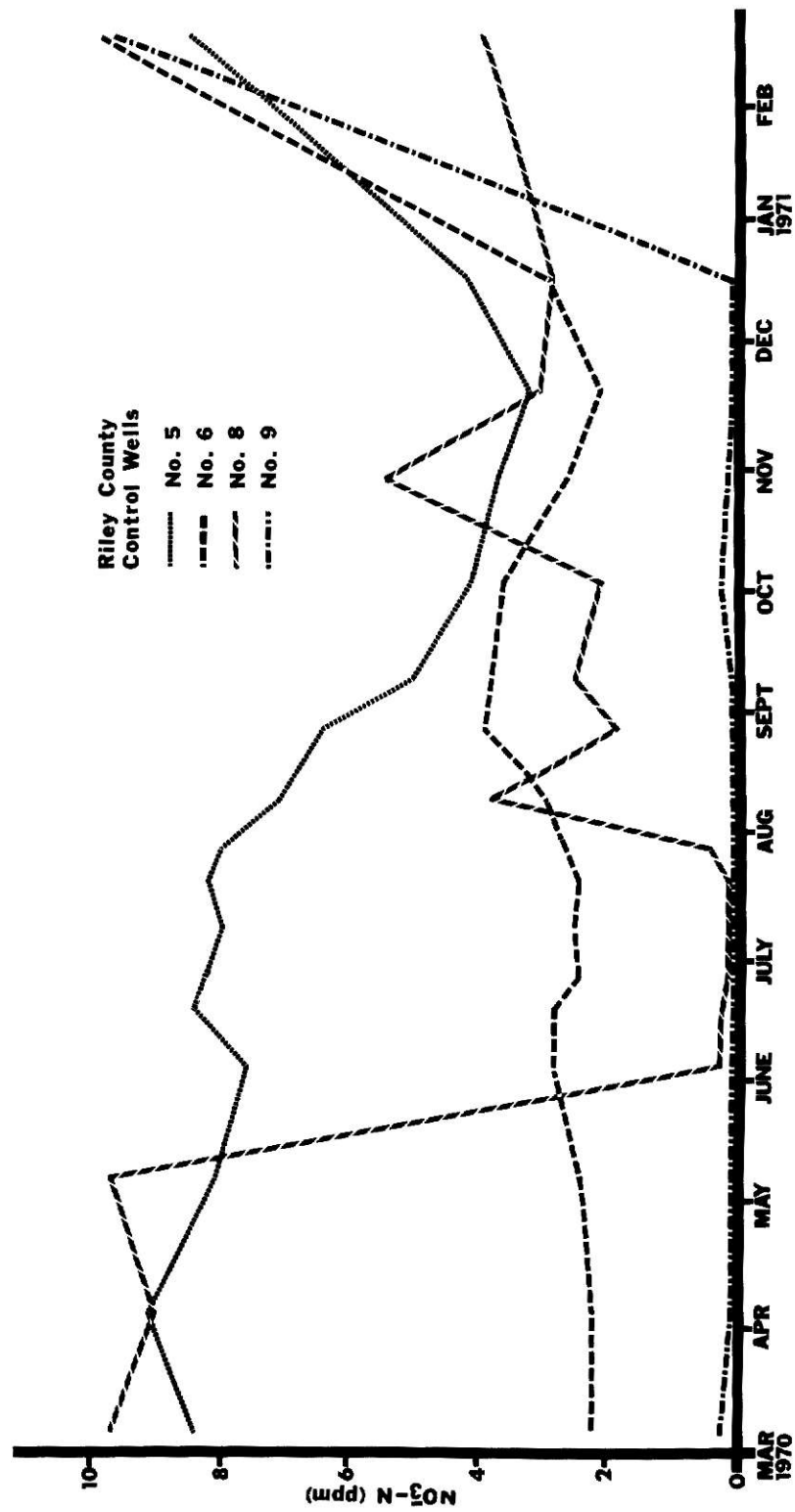


Figure 7. Nitrate-nitrogen content of ground water
beneath control areas (Riley County).



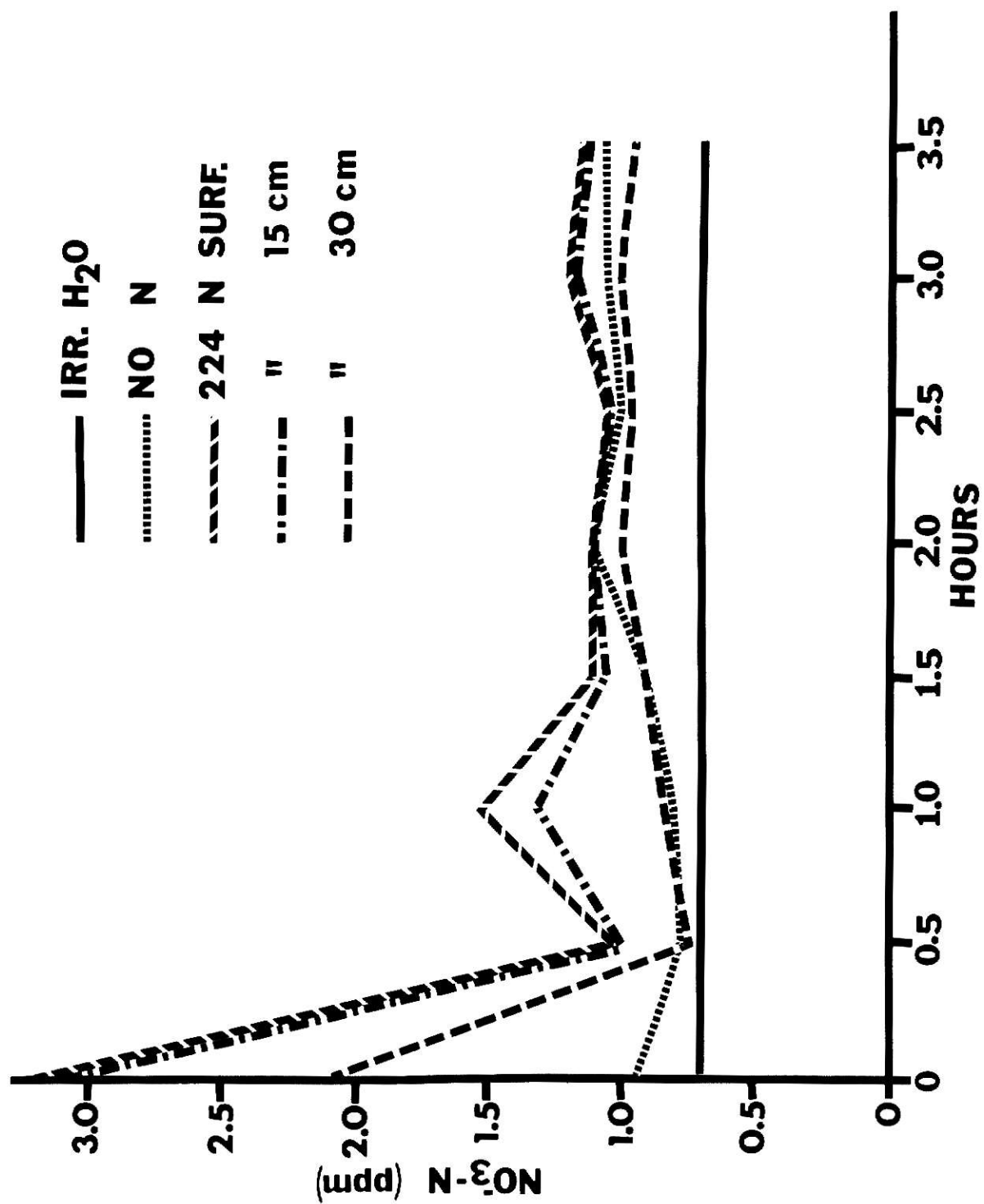
Riley County Runoff Study

A study to determine the loss of fertilizer nitrates in irrigation tail-water in response to fertilizer placement was conducted on the Ashland Agronomy Farm in Riley County. Fertilizer N was applied at the rate of 224 kg N/ha at depths of 0, 15, and 30 cm. The area was seeded to grain sorghum and furrow irrigated with the use of gated pipe. Using the stopwatch technique described earlier, the gates on the irrigation pipe were adjusted until all plots were receiving irrigation water at approximately the same rate. Each row (76 cm width) received approximately 2/3 liter of water per second. Water was passing over the weirs 91.4 meters down the furrows at an average rate of 1/2 liter per second following the initial saturation of the soil. At half-hour intervals starting when the water first reached the weirs, water samples were taken at the weirs for ammonium-N and nitrate-N determinations.

Only trace amounts of ammonium-N were detected in any runoff samples collected. The results of the nitrate-N determination of the runoff samples for the first irrigation are shown in Figure 8.

The first half hour of irrigation showed the most pronounced effect of depth of fertilizer placement on nitrate losses in runoff water. The nearer the fertilizer was applied to the soil surface, the higher the losses appeared to be in the tail-water. Considering the plot area,

Figure 8. Nitrate-nitrogen content of runoff water from the first irrigation of a fertilized plot area (Riley County).



amount of runoff, and concentration of nitrate-N in the runoff, it was found that the highest losses from the plot area occurred where the nitrogen fertilizers were surface applied. These losses were calculated as 274.7 grams N/ha during the initial half hour of irrigation. During the same period, 111.2 grams N/ha were lost from the check plot area. Assuming that the difference between these two values (163.5 grams N/ha) is the loss of nitrate that can be attributed to the application of fertilizers, it was calculated that only 0.073 per cent of the nitrogen applied was lost in runoff from the area receiving surface application during the half hour showing the most severe losses.

The entire study area was irrigated four times during the growing season but the first 1 1/2 hours of the initial irrigation was the only time that losses from the fertilized plots were noticeably greater than from the control plots (Appendix Tables 8 - 11).

Two three-meter soil cores were collected from each of the plots in the runoff study before treatment and again after harvest. These soil samples were analyzed for ammonium-N and nitrate-N to detect downward movement of nitrogen. The results of the determinations are shown in Figures 9 - 16.

An accumulation of nitrate-N in the lower profile of the fertilized plots indicates a possible downward movement in that area. In the case of ammonium-N, no movement

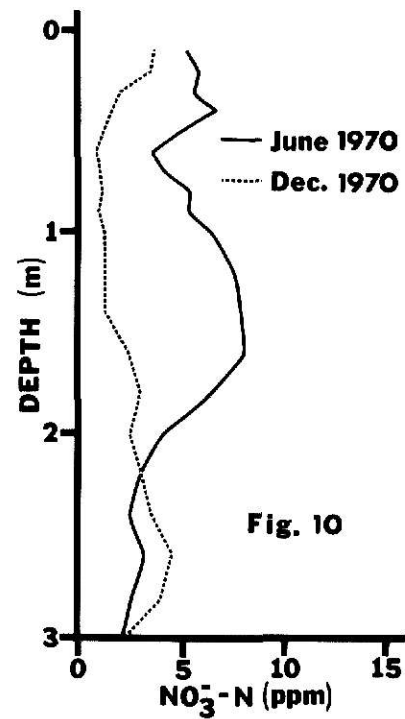
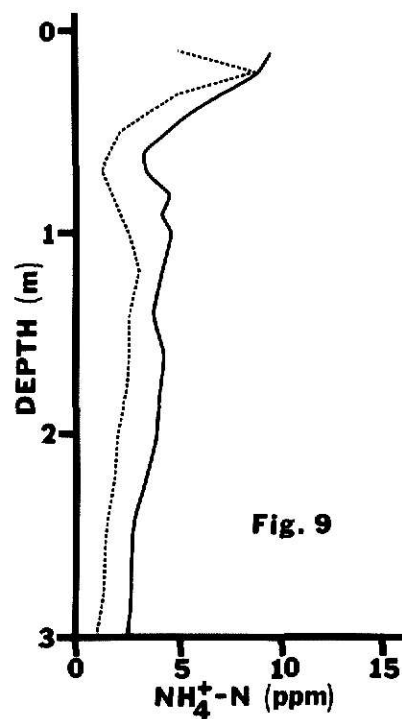
Figure 9. Ammonium-nitrogen distribution in soil profile
from control area of runoff study (Riley County).

Figure 10. Nitrate-nitrogen distribution in soil profile
from control area of runoff study (Riley County).

Figure 11. Ammonium-nitrogen distribution in soil profile
from runoff plots receiving surface applications
of fertilizer (Riley County).

Figure 12. Nitrate-nitrogen distribution in soil profile
from runoff plots receiving surface applications
of fertilizer (Riley County).

0 Kg N/ha



224 Kg N/ha as Urea Surface Applied

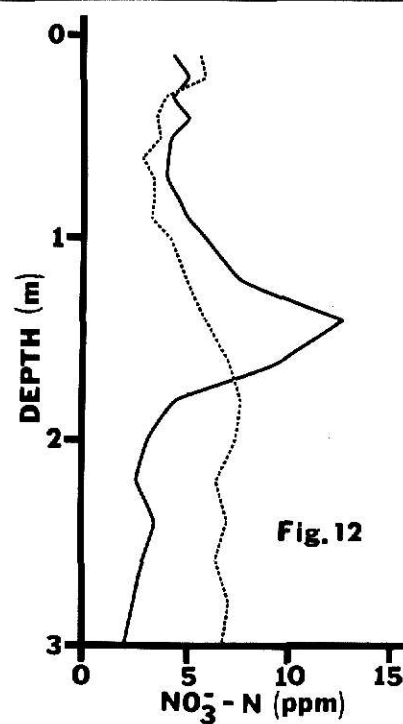
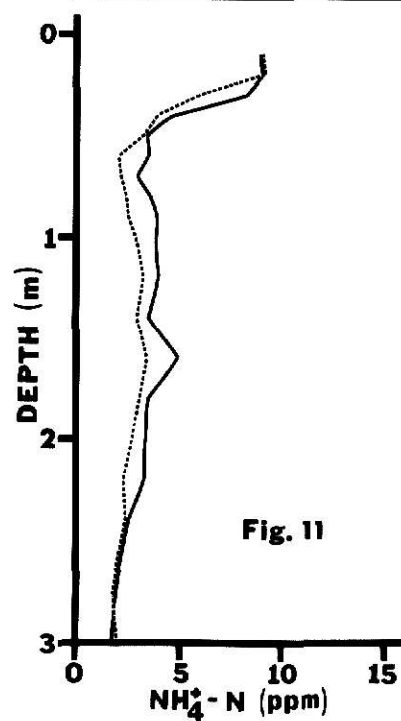
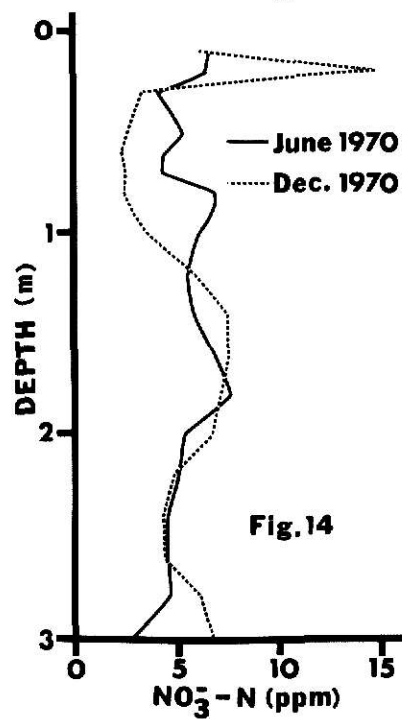
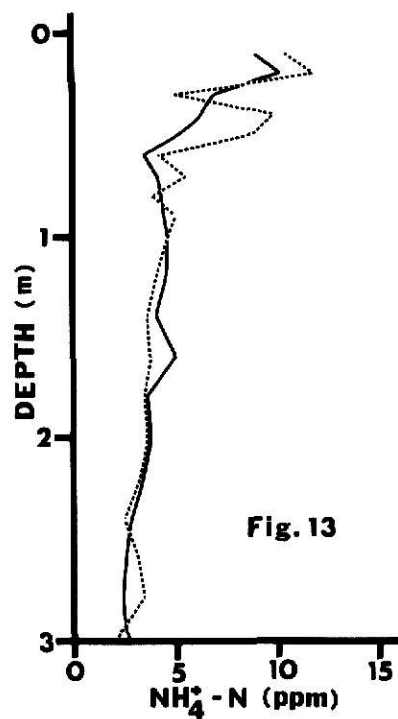
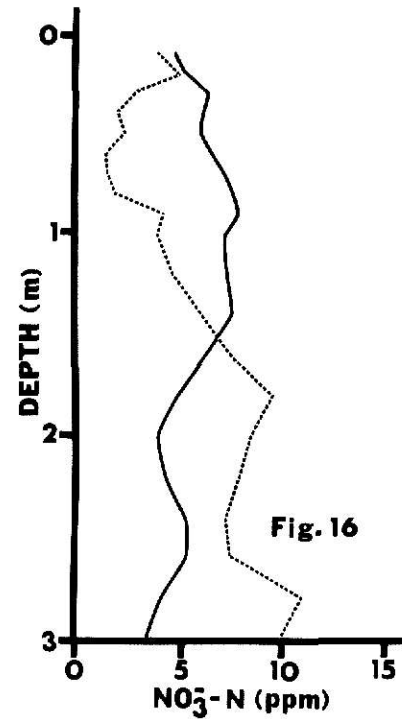
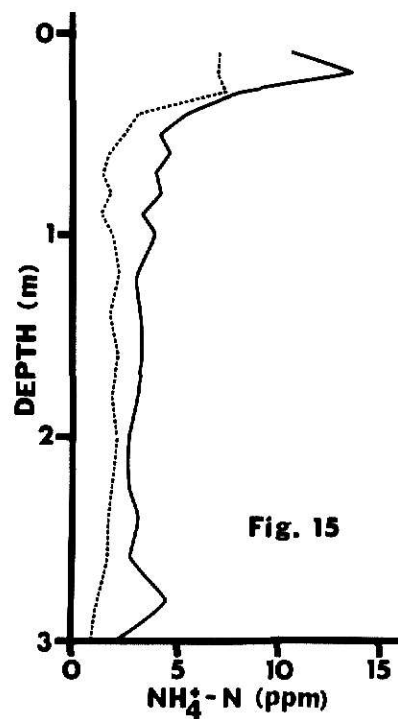


Figure 13. Ammonium-nitrogen distribution in soil profile from runoff plots receiving fertilizer applications 15 cm deep (Riley County).

Figure 14. Nitrate-nitrogen distribution in soil profile from runoff plots receiving fertilizer applications 15 cm deep (Riley County).

Figure 15. Ammonium-nitrogen distribution in soil profile from runoff plots receiving fertilizer applications 30 cm deep (Riley County).

Figure 16. Nitrate-nitrogen distribution in soil profile from runoff plots receiving fertilizer applications 30 cm deep (Riley County).

224 Kg N/ha as NH_3 15 cm Depth224 Kg N/ha as NH_3 30 cm Depth

was apparent other than an obvious decrease in amount in the soil profile which might be due to crop removal, volatilization, or nitrification.

An analysis of variance of the soil nitrate data (Appendix Tables 12 - 27) is recorded in Table 5. This table indicates that treatment had a significant effect on the amount of residual nitrate in the soil. However, the amount of nitrate in the soil beneath the fertilized plots was not significantly different for various depths of placement.

Table 5. Analysis of variance of soil nitrate concentrations from runoff study area (Riley County).

Total	959	19342.01		
Replicates	5	764.76	152.95	
Treatments	3	551.86	183.95	10.83 *
Sampling Dates	1	134.18	134.18	7.90 *
Depths	19	1039.69	54.72	3.22 *
Treatments X Sampling Dates	3	349.58	116.53	6.86 *
Treatments X Depths	57	639.30	11.22	0.66
Sampling Dates X Depths	19	1577.90	83.05	4.89 *
Treatments X Sampling Dates X Depths	57	783.66	13.75	0.81
Error	795	13501.10	16.98	

* Differences significant at 0.01 level.

In summary, the application of nitrogen fertilizer caused a significant increase in residual nitrate as compared to the control plots, but the effect of depth of fertilizer placement was nonsignificant. The variances due to soil depth and sampling dates indicated that nitrates did move in the soil and that the total amount of soil nitrate fluctuated between sampling periods.

Stafford County Leaching Study

The Stafford County study site was located at the Sandyland Experiment Field, 3 miles south of St. John, Kansas. The soil of the experimental site was classified as a Farnum loamy sand, which contains a clayey B horizon and sand-gravel substrata, and a water table at approximately 6 meters depth. The entire study area except for the check plots received 336 kg N/ha. The plot area was planted to grain sorghum and furrow irrigated.

Soil cores were collected from the area in December 1969 and December 1970 to a depth of approximately 3 meters. The nitrate-N contents of the multiple cores were averaged at each sampling depth annually. The data were plotted in Figure 17.

From the data gathered (Appendix Tables 28, 29), no increase in nitrate was evident in the soil to the depth sampled. The amount of accumulated nitrate-nitrogen in the soil profile was calculated and compared to previously collected data in Table 6.

Figure 17. Nitrate-nitrogen distribution in the soil
from a fertilized area (Stafford County).

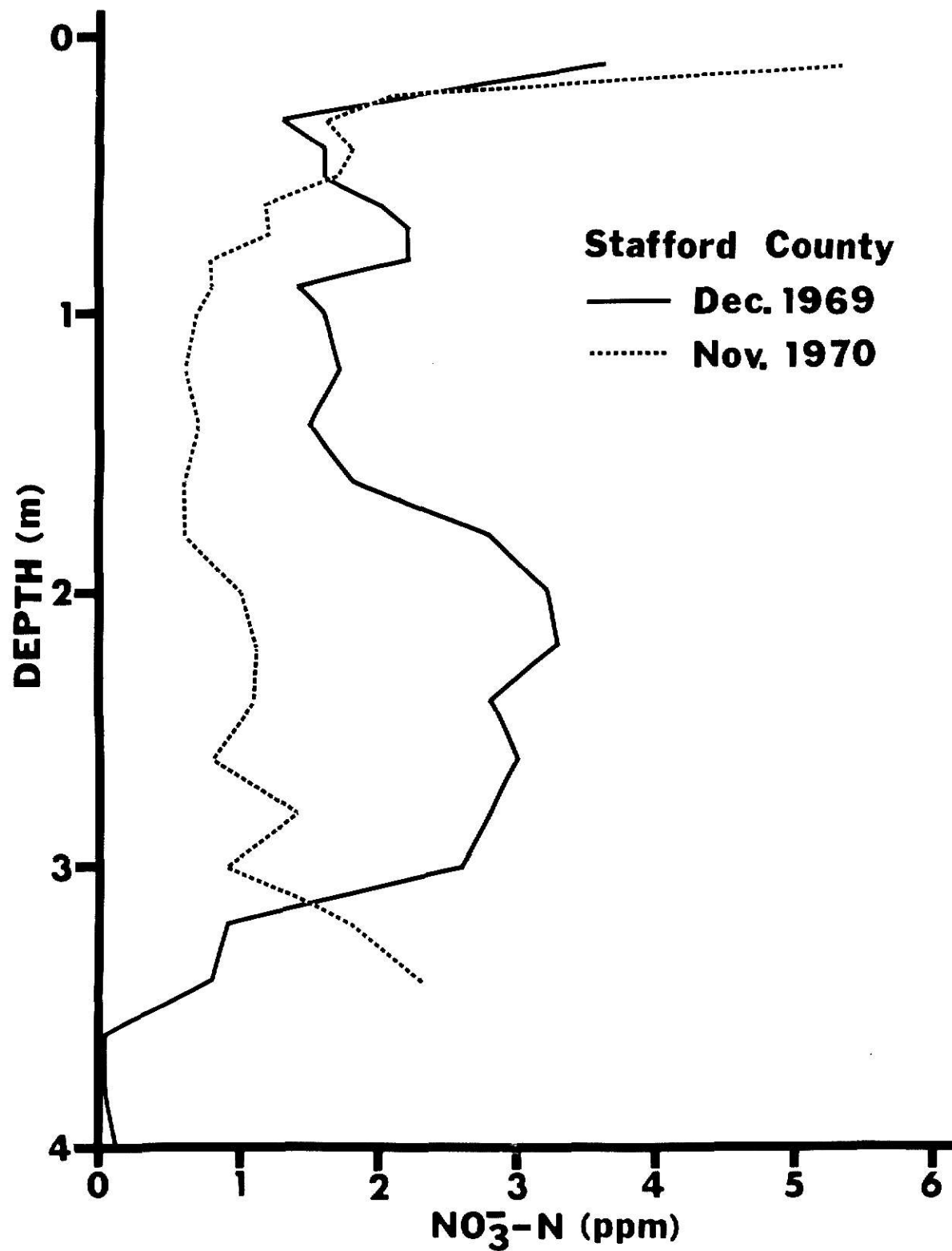


Table 6. Effects of time on the NO_3^- -N content of soil to a depth of 3 meters (Stafford County). The area received 336 kg N/ha/yr.

	kg NO_3^- -N/ha					
	6-67*	2-68*	5-68*	4-69	12-69	11-70
Control	492	---	---	32	40	---
Plot I-4	185	43	77	26	53	28
Plot II-5	602	47	101	72	138	52
Avg. for plot area	393	45	89	49	96	40

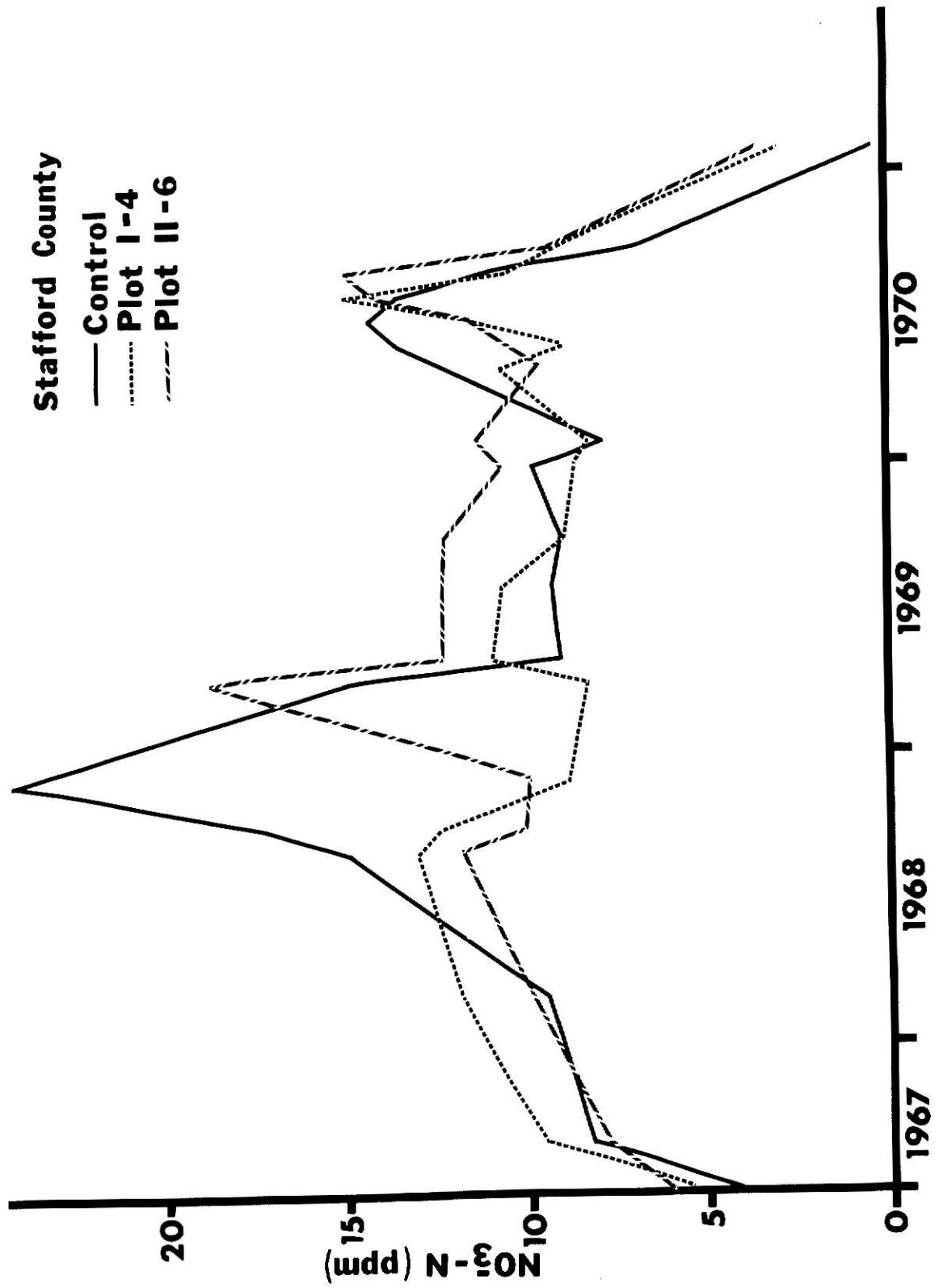
* Data collected by Gosch (13).

From the plot averages in Table 6, it is evident that nitrates did not accumulate in the surface 3 meters of the soil during the period studied.

Downward leaching of nitrates was checked by periodically pumping water samples from directly beneath the fertilized area through 2 observation wells. A nearby control well was also monitored. The nitrate-N contents of the observation wells were recorded and are displayed in Figure 18.

The control well in this study was approximately 10 meters from the fertilized area, and its similarity to the other wells in nitrate content indicates that it was either receiving contamination by nitrates through the soil or ground water, or that the nitrates detected are from

Figure 18. Nitrate-nitrogen content of ground water
beneath a fertilized area (Stafford County).



some source other than the fertilizer nitrogen applied.

No seasonal fluctuation of nitrates in the ground water was evident. Two of the wells showed peak nitrate contents during the winter of 1968-1969 which agreed with Crabtree's (8) results. However, all the wells at this location peaked again in the summer of 1970, a phenomenon for which no explanation is apparent. A good crop of grain sorghum was growing on the soil at that time and no extreme precipitation conditions were experienced.

An analysis of variance of the nitrate-N concentrations in the ground water from this study is recorded in Table 7.

Table 7. Analysis of variance of nitrate-N concentrations in ground water beneath fertilized area (Stafford County).

Source	df	SS	MS	F
Total	38	205.76		
Wells	2	9.23	4.62	1.59
Dates	12	126.79	10.57	3.64*
Error	24	69.74	2.91	

* Differences significant at the 0.01 level.

The analysis of variance disclosed that there was no significant difference between the nitrate content of wells from the fertilized and control areas. Sampling dates were significant, however, indicating that the nitrate content of the ground water fluctuated between sampling

dates, but all wells fluctuated in a similar manner. It appears that either the control well was too close to the fertilized area, or the detected nitrates came from some other source.

Pottawatomie County Time of Nitrogen Application Study

A site on the Pessemier Company Farms near St. Marys in Pottawatomie County was selected for a study comparing nitrogen movement in soil from fall and spring applications of ammoniacal nitrogen. The site consisted of a leveled mixed alluvium soil, readily permeable to water. The area was fertilized as described in Table 2. In April and December of 1969 and December of 1970, soil cores were taken from the plots receiving 0, 112, 224, and 448 kg N/ha in replication I and III. These soil cores were analyzed to a depth of approximately six meters for ammonium-N and nitrate-N. The nitrate-N was averaged at each sampling depth between soil cores receiving similar treatment. The results of these analyses are plotted in Figures 19 - 25. The data from both ammonium and nitrate determinations on the soil cores are presented in the Appendix Tables 31 - 41.

It may be noted that in the first sampling of this study (April 1969), soil nitrate concentrations were relatively high under all treatments. This may be because prior to this study, the plot area had been receiving an annual application of 336 kg N/ha. In the lower rates of application, it is especially obvious that some residual nitrogen was present in the first sampling.

Figure 19. Nitrate-nitrogen distribution in the soil from
a control area (Pottawatomie County).

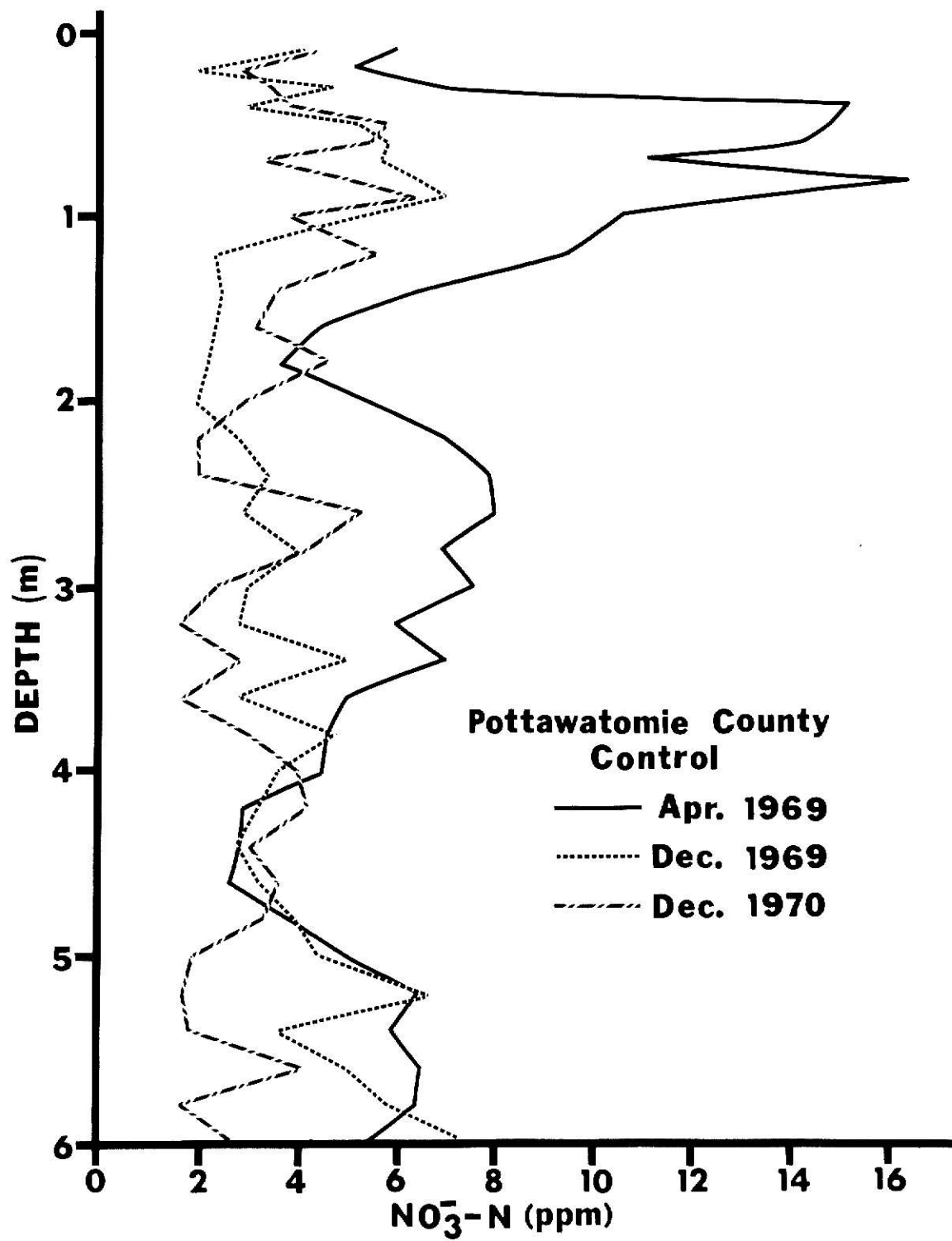


Figure 20. Nitrate-nitrogen distribution in the soil from a plot receiving a fall application of 112 kg N/ha (Pottawatomie County).

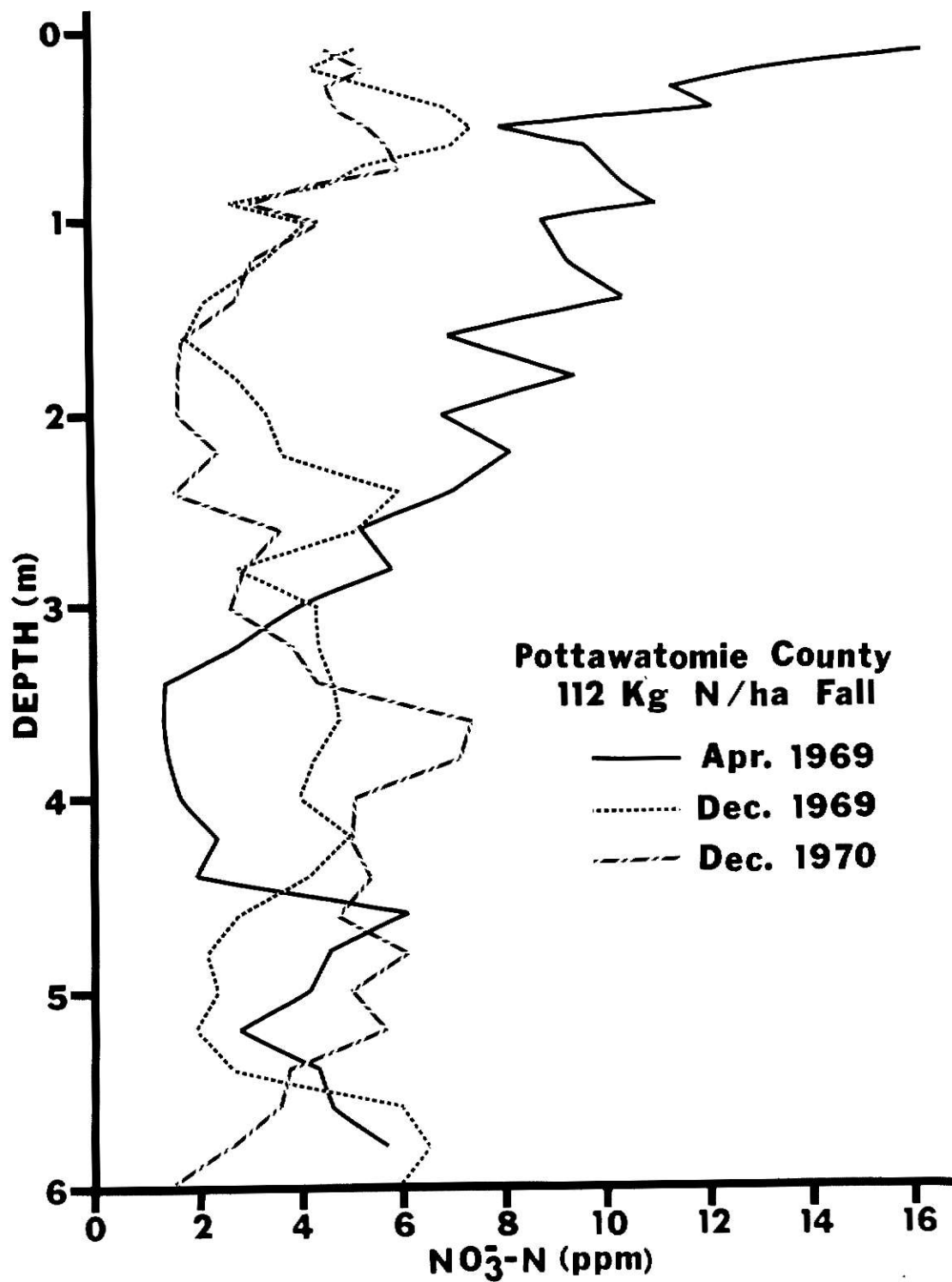


Figure 21. Nitrate-nitrogen distribution in the soil from a plot receiving a spring application of 112 kg N/ha (Pottawatomie County).

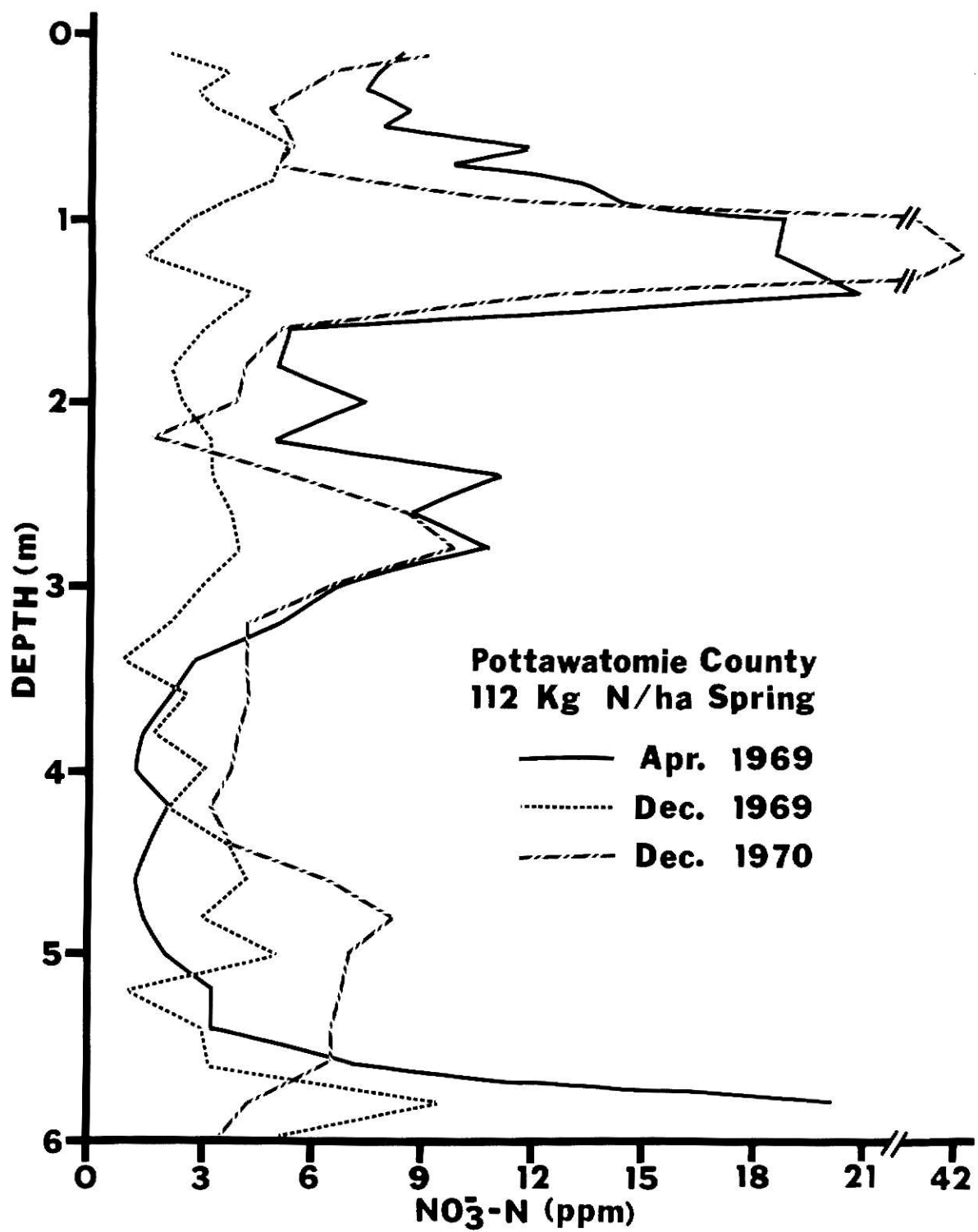


Figure 22. Nitrate-nitrogen distribution in the soil
from a plot receiving a fall application of
224 kg N/ha (Pottawatomie County).

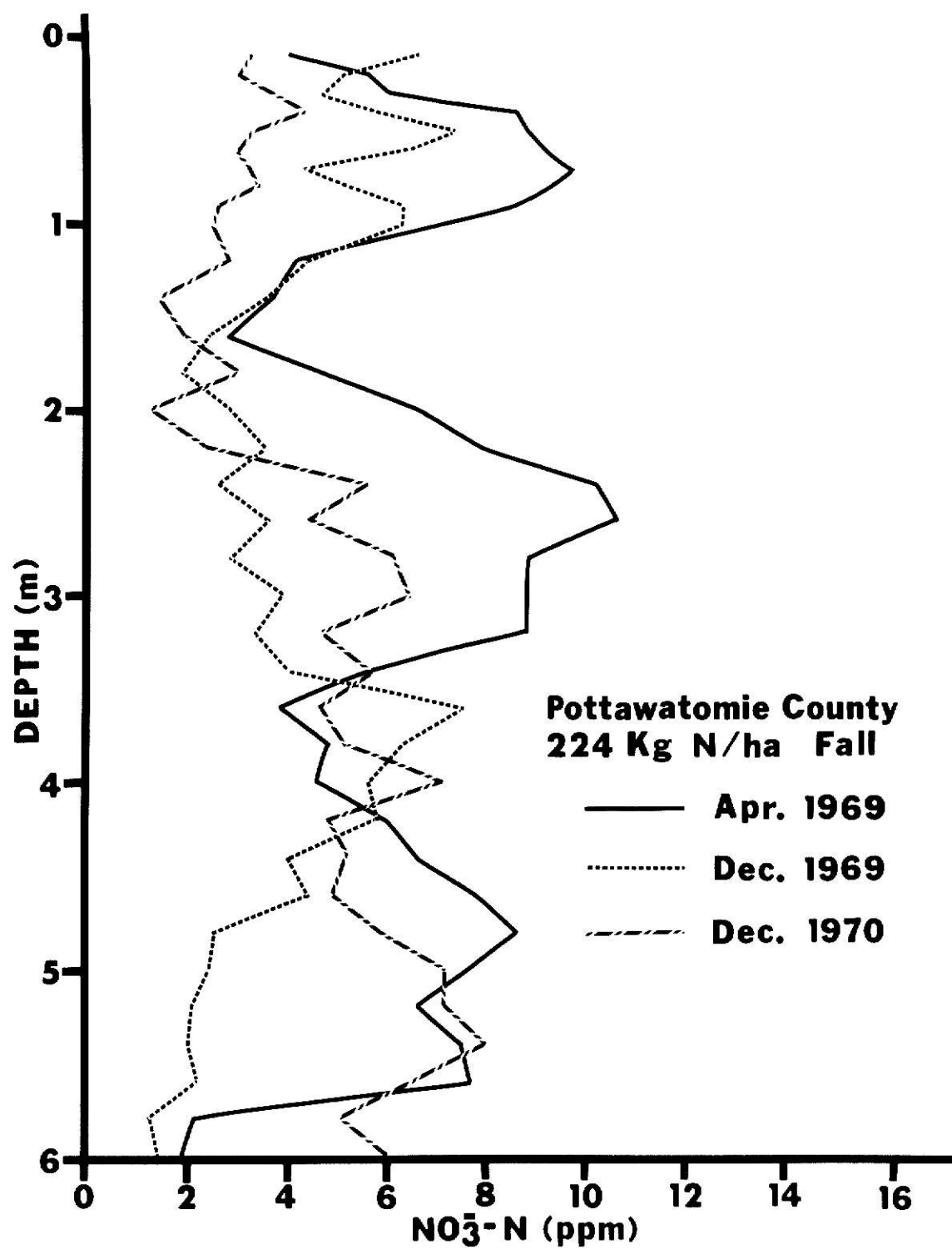


Figure 23. Nitrate-nitrogen distribution in the soil
from a plot receiving a spring application of
224 kg N/ha (Pottawatomie County).

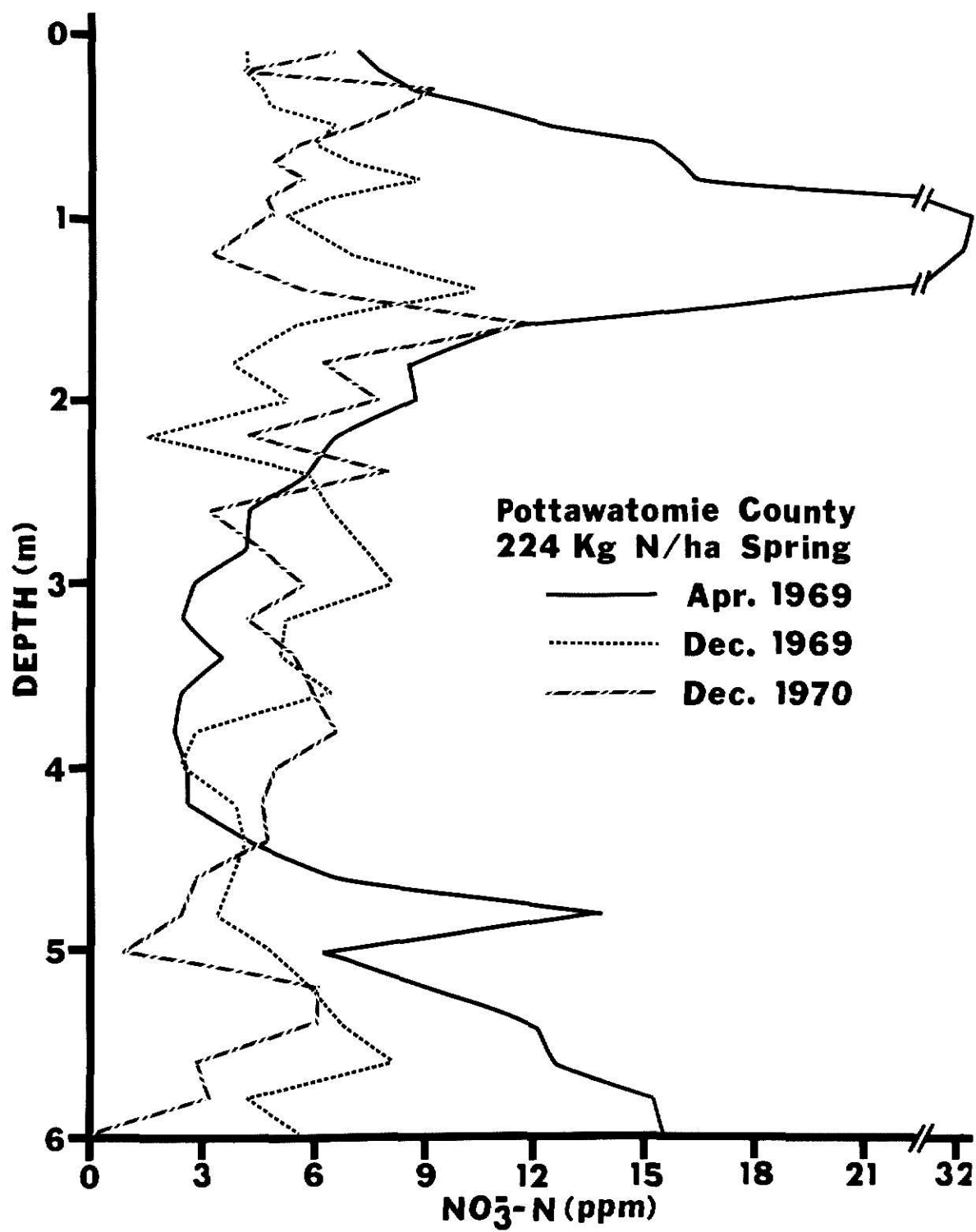


Figure 24. Nitrate-nitrogen distribution in the soil
from a plot receiving a fall application of
448 kg N/ha (Pottawatomie County).

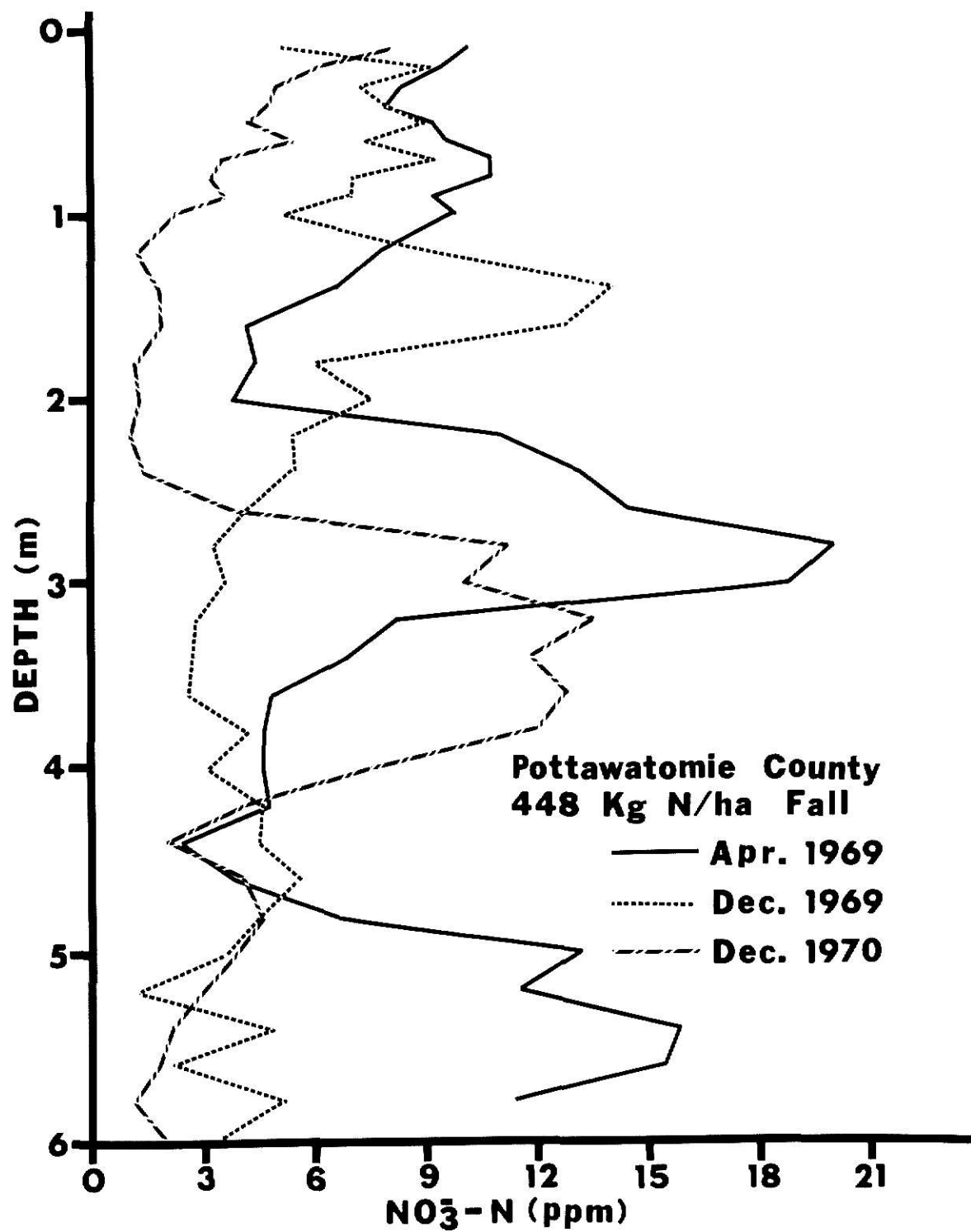


Figure 25. Nitrate-nitrogen distribution in the soil from a plot receiving a spring application of 448 kg N/ha (Pottawatomie County).

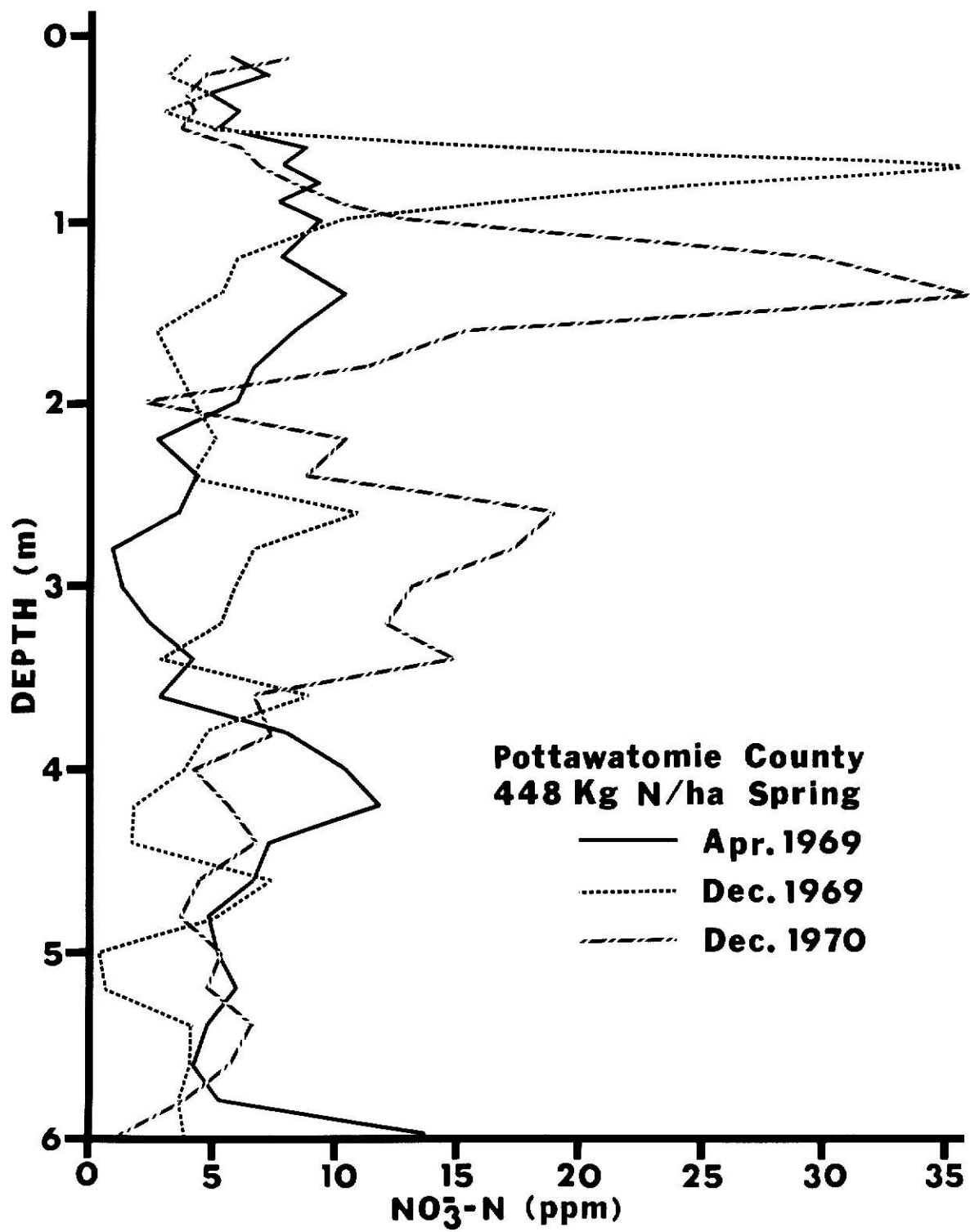


Table 8. Analysis of variance of nitrate distribution in the soil beneath a time of nitrogen application study (Pottawatomie County).

Source	df	SS	MS	F
Total	1385	52620.01		
Replicates	1	2970.30	2970.30	
Treatments	6	1461.49	243.58	7.76*
Sampling dates	2	1887.37	943.69	30.05*
Depths	32	3613.21	112.91	3.60*
Treatments X Sampling dates	12	2170.94	180.91	5.76*
Treatments X Depths	192	5342.93	27.83	0.89
Sampling dates X Depths	64	2578.16	40.28	1.28
Treatments X Sampling dates X Depths	384	10864.81	28.29	0.90
Error	692	21730.79	31.40	

* Difference significant at the 0.05 level.

Table 8 indicates that the concentration of residual nitrate-N varied with treatment, sampling date, and depth. The variation due to treatment can be better explained by the use of the ordered array of treatment means shown in Table 9.

This table shows that the spring applications appear to have a greater amount of residual nitrate than a similar rate applied in the fall. However, these differences were

were not recognized at the 0.05 level of significance except at the 224 kg N/ha rate of application.

Table 9. Ordered array of treatment means for residual nitrate-N in the Pottawatomie County time of nitrogen application study.

Treatment	Mean NO_3^- -N Concentration (ppm)
Control	4.94
112 kg N/ha Fall	5.08
224 kg N/ha Fall	5.19
112 kg N/ha Spring	6.08
448 kg N/ha Fall	6.72
224 kg N/ha Spring	7.02
448 kg N/ha Spring	7.81
	LSD = 1.10

One point which bears recognition is that the residual soil nitrate from all spring applications was significantly different from that of the control treatment, as compared to the fall applications which were not significantly different from the control except at the 448 kg N/ha application rate.

SUMMARY AND CONCLUSIONS

Nitrate Accumulation in Irrigated Soils and Underlying Aquifers

Nitrate accumulation in irrigated soils was examined in four studies at three locations in Kansas. The Riley and Pottawatomie County sites had loamy sand profiles that were readily permeable to water. The Stafford County site, characterized by a loamy sand A horizon with a clay loam to sandy clay loam B horizon at a depth of 1/2 to 1 meter, was less permeable to percolating water.

No large accumulation of nitrate was detected in any soil at any of the sites regardless of treatment. In the more porous soils, movement of nitrate-nitrogen peaks from one sampling period to another indicated possible leaching of fertilizer nitrates. This phenomenon was most pronounced in sandy soils below the rooting zone of the crop plants, as shown in Figure 5. In a control plot which did not receive irrigation (Figure 4) there was no apparent leaching of nitrate. This suggests that irrigation may be equal to or greater in importance than the rate of application in determining the extent of fertilizer nitrate leaching.

The results of the time of nitrogen fertilizer application study suggest possible correlation between time of nitrogen application and the amount of residual soil nitrate. The mean nitrate-nitrogen concentration of the soil from

all spring applications was somewhat greater than the mean concentration from fall applications. However, in most cases, these differences were not large enough to be significant at the 0.05 level. The results obtained were not conclusive, but indications suggest that extended research in this area might be rewarding.

The absence of nitrate accumulations in the soil under extensive fertilization denotes that either all applied nitrates were utilized by the crop or that all excessive nitrates were lost from the soil. Excessive soil nitrates could be removed by several processes. Denitrification may have taken place in the surface soils resulting in gaseous losses of nitrate. This process is dependent on many factors and was not explored in this study. Also, the possibility of downward leaching of nitrates was suggested by movement of peak concentrations of nitrate in the soil between sampling dates. This possibility was investigated by monitoring the nitrate content of ground water in and around fertilized areas.

Nitrates in subsurface water from beneath both fertilized and control areas fluctuated greatly between sampling dates and between wells. No seasonal trend was apparent, but following Crabtree's (8) report that many wells reach peak nitrate content in November and December, many peaks were noted in the winter months, especially under permeable soils (Figure 6). A possible gradual

increase in ground water nitrates under the fertilized area of the Riley County site is indicated in Figure 6, but the variation between samplings is so great and the increase is so slight that a long-range study for monitoring the ground water nitrates would be required before definite conclusions could be drawn.

It was recognized that ground water flow might remove nitrates from beneath the fertilized area. However, control wells located at a distance in all directions from the fertilized area remained well within the safety standards set by the Public Health Service (32), and showed no consistent increase in nitrate content. There is also the possibility of vertical mixing and dilution taking place in the subsurface water, but Metzler (21) noted very little vertical mixing in his study and measurements of ground water flow were not attempted in this study.

Fertilizer Nitrate Losses in Irrigation Tail-Water

An investigation of losses of soil nitrates in irrigation tail-water in response to depth of placement of ammoniacal fertilizers was conducted on a permeable soil. The first 1 1/2 hours of the initial irrigation was the only time that depth of fertilizer placement could be correlated to nitrate losses in tail-water. The most extreme losses of nitrate were only slightly greater than those losses from the control areas, indicating that applied

nitrogen, regardless of depth of application was not removed in significant amounts by irrigation tail-water on this soil. After the first 1 1/2 hours of the initial irrigation, no difference was detected in the nitrate-nitrogen content of tail-water from fertilized or control areas.

Soil cores from this study showed some evidence of downward movement of nitrates between sampling dates. This information is limited by the depth of the cores collected, but Figures 12, 14, and 16 all indicate nitrate peaks in the deeper portions of the profiles studied.

The low amounts of nitrate in the irrigation tail-water is understandable when one recognizes that nitrate, being an anion, is mobile in the soil. The first irrigation water or preceeding rains could or would move the nitrate down into the soil mass rather than moving it laterally down the furrow. Admittedly, the study was conducted on a soil which is quite permeable. More work is needed on soils of varying physical characteristics to more completely evaluate the problem. At this point, however, it seems unlikely that nitrogen applied to the soil will be removed in large quantities from the area to which it was applied by irrigation water flowing over the soil surface.

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APPENDIX

**THIS BOOK
CONTAINS
NUMEROUS PAGES
WITH MULTIPLE
PENCIL AND/OR
PEN MARKS
THROUGHOUT THE
TEXT.**

**THIS IS THE BEST
IMAGE AVAILABLE.**

Table 1.--Nitrate-N distribution in the soil from control area of a leaching study (Riley County).

Depth cm	12-69	12-70		Mean
	NO ₃ -N (ppm)	Core A	NO ₃ -N (ppm) Core B	
0-10	8.3	3.9	5.2	4.6
10-20	5.4	4.7	2.1	3.4
20-30	10.9	2.2	2.7	2.4
30-40	12.5	2.6	3.9	3.2
40-50	14.9	0.6	1.9	1.2
50-60	10.2	1.8	1.3	1.6
60-70	7.0	1.9	1.6	1.8
70-80	4.4	8.1	1.3	4.7
80-90	8.3	9.7	5.4	7.6
90-100	9.2	10.1	6.5	8.3
100-120	14.6	6.7	8.9	7.8
120-140	15.0	4.5	4.5	4.5
140-160	17.1	19.4	3.2	11.3
160-180	17.2	28.6	4.5	16.6
180-200	29.0	22.4	11.3	16.8
200-220	13.1	16.8	10.7	13.8
220-240	14.4	12.7	9.8	11.2
240-260	8.8	5.2	6.5	5.8
260-280	9.2	3.8	6.6	5.2
280-300	11.6	3.6	4.8	4.2
300-320	11.9	2.5	1.8	2.2
320-340	12.2	1.7	1.9	1.8
340-360	5.6	1.6	2.5	2.0
360-380	8.0	3.2	3.1	3.2
380-400	9.8	3.0	3.6	3.3
400-420	9.8	3.9	5.2	4.6
420-440	13.7	3.1	6.9	5.0
440-460	23.7	2.3	6.5	4.4
460-480	12.4	3.5	11.4	7.4
480-500	15.0	3.1	12.9	8.0

ILLEGIBLE DOCUMENT

**THE FOLLOWING
DOCUMENT(S) IS OF
POOR LEGIBILITY IN
THE ORIGINAL**

**THIS IS THE BEST
COPY AVAILABLE**

Table 2.--Ammonium-N distribution in the soil from control area of a leaching study (Riley County).

Depth cm	12-69	12-70		Mean
	NH ₄ -N (ppm)	Core A	Core B	
0-10	6.1	9.3	7.5	8.4
10-20	3.9	5.8	16.8	11.3
20-30	18.0	4.5	8.1	6.3
30-40	6.1	6.5	8.4	7.4
40-50	5.6	2.5	3.9	3.2
50-60	2.5	1.8	2.6	2.2
60-70	2.7	1.3	1.3	1.3
70-80	2.3	1.9	1.0	1.4
80-90	4.1	1.9	4.5	3.2
90-100	3.6	2.6	3.6	3.1
100-120	4.8	4.4	3.2	3.8
120-140	3.2	3.5	1.9	2.7
140-160	3.0	3.5	2.8	3.2
160-180	3.8	2.7	2.1	2.4
180-200	2.1	3.2	1.8	2.5
200-220	1.9	2.6	1.3	2.0
220-240	1.9	2.5	1.9	2.2
240-260	1.7	2.2	1.3	1.8
260-280	2.3	2.1	1.9	2.0
280-300	2.6	1.4	1.6	1.5
300-320	1.9	3.2	0.6	1.9
320-340	1.7	2.7	1.3	2.0
340-360	1.0	2.5	1.6	2.0
360-380	1.7	3.0	3.2	3.1
380-400	2.2	3.1	1.3	2.2
400-420	1.2	1.9	1.4	1.6
420-440	1.7	2.5	1.4	2.0
440-460	2.1	1.0	2.6	1.8
460-480	2.1	2.1	0.6	1.4
480-500	2.2	1.2	1.3	1.2

Table 3.--Nitrate-N distribution in the soil from fertilized area of a leaching study (Riley County, 1969).

Depth cm	12-69 NO ₃ -N (ppm)					Mean
	I-4	II-5	III-6	IV-7	II-13	
0-10	3.0	9.2	9.8	6.0	3.0	6.2
10-20	2.8	7.0	6.6	6.5	2.7	5.1
20-30	2.7	5.0	7.9	6.7	4.5	5.4
30-40	1.8	3.8	9.1	6.1	5.6	5.3
40-50	2.5	2.1	4.9	1.4	3.9	3.0
50-60	1.6	1.8	2.1	0.6	3.5	1.9
60-70	1.7	1.4	1.6	2.8	2.3	2.0
70-80	0.4	1.0	1.3	1.8	0.0	0.9
80-90	0.1	1.0	1.8	1.0	2.1	1.2
90-100	1.7	0.5	2.7	1.3	0.5	1.3
100-120	0.8	0.4	2.7	1.9	0.0	1.2
120-140	14.6	1.0	4.7	5.8	0.1	5.2
140-160	0.0	1.3	5.3	2.5	1.2	2.1
160-180	3.4	1.8	2.3	2.7	5.3	3.1
180-200	0.5	4.3	4.0	2.6	8.8	4.0
200-220	2.8	2.6	4.0	5.8	9.7	5.0
220-240	18.9	3.0	2.7	3.9	8.3	7.4
240-260	7.1	2.6	3.8	6.6	7.9	5.6
260-280	26.3	3.5	3.6	8.7	3.1	9.0
280-300	3.4	3.2	3.0	8.8	3.9	4.5
300-320	5.6	1.7	3.0	18.1	4.0	6.5
320-340	0.3	0.6	2.7	19.9	2.8	5.3
340-360	15.0	0.6	4.7	13.7	1.3	7.1
360-380	1.7	1.4	2.2	7.8	0.6	2.7
380-400	3.4	0.3	2.6	4.5	1.3	2.4
400-420	14.5	1.4	3.8	4.3	2.5	5.3
420-440	0.0	7.2	3.1	5.3	1.3	3.4
440-460		7.0	7.4	5.6	0.0	5.0
460-480		0.3	7.2	3.0	0.0	2.6
480-500			3.5	2.1	0.0	1.9

Table 4.--Ammonium-N distribution in the soil from fertilized area of a leaching study (Riley County, 1969).

Depth cm	12-69 NH ₄ ⁺ -N (ppm)					Mean
	I-4	II-5	III-6	IV-7	II-13	
0-10	55.8	30.1	16.4	8.4	4.1	23.0
10-20	10.7	9.4	5.4	7.0	9.7	8.4
20-30	15.9	9.4	5.4	6.6	28.1	13.1
30-40	4.4	16.9	7.5	7.8	9.7	9.3
40-50	4.7	4.4	3.9	3.4	4.5	4.2
50-60	5.6	3.6	2.8	3.9	2.6	3.7
60-70	2.7	6.5	1.2	4.9	2.7	3.6
70-80	2.1	3.4	2.2	4.4	1.4	2.7
80-90	1.4	6.9	2.2	3.2	2.2	3.2
90-100	2.5	4.7	2.2	1.4	2.3	2.6
100-120	4.0	1.3	4.4	1.2	2.2	2.6
120-140	2.3	4.1	2.2	3.2	1.9	2.7
140-160	2.7	3.2	1.6	3.4	2.1	2.6
160-180	3.6	4.5	1.6	2.1	3.5	3.1
180-200	4.5	4.0	2.2	2.1	4.7	3.5
200-220	3.0	4.0	3.1	4.8	3.2	3.6
220-240	3.1	3.6	89.3	3.9	3.0	20.6
240-260	4.1	2.2	92.8	4.1	2.6	21.2
260-280	2.5	3.6	47.5	4.7	2.5	12.2
280-300	3.2	3.1	40.0	2.5	1.6	10.1
300-320	2.8	1.9	62.4	2.6	1.7	14.3
320-340	0.4	1.2	31.4	2.8	1.4	7.4
340-360	2.1	0.9	33.9	3.1	1.6	8.3
360-380	2.2	1.7	11.0	3.1	1.8	4.0
380-400	2.3	0.8	7.4	1.3	1.7	2.7
400-420	2.6	0.6	9.3	2.1	2.7	3.5
420-440	1.4	1.2	14.0	3.2	2.6	4.5
440-460		1.7	18.8	2.2	0.5	5.8
460-480		0.1	1.4	1.9	0.3	3.9
480-500			8.4	2.7	0.6	3.9

Table 5.--Nitrate-N distribution in the soil from fertilized area of a leaching study (Riley County, 1970).

Depth cm	NO ₃ -N (ppm)										Mean
	I-4		II-5		III-6		IV-7		II-13		
	A	B	A	B	A	B	A	B	A	B	
0-10	4.3	3.6	3.6	8.8	8.0	4.4	5.7	4.8	10.2	7.9	6.1
10-20	4.3	4.5	3.0	2.7	8.0	3.8	2.3	2.6	4.1	4.5	4.0
20-30	5.0	6.0	3.1	4.3	6.7	3.2	2.3	4.9	5.2	4.3	4.5
30-40	2.2	4.5	2.1	2.8	7.6	4.8	1.4	4.1	5.4	3.0	3.8
40-50	2.6	3.4	1.4	2.8	5.0	3.0	0.9	3.9	4.0	3.6	3.1
50-60	2.3	4.3	1.6	1.7	3.0	2.8	0.8	1.3	2.5	3.1	2.3
60-70	0.9	4.1	0.9	2.2	2.7	0.6	0.8	1.6	3.0	1.4	1.8
70-80	0.9	6.1	1.7	2.6	1.4	0.8	1.0	3.2	2.2	2.1	2.2
80-90	0.1	2.3	1.4	2.6	2.7	1.0	0.6	3.2	2.5	1.6	1.8
90-100	2.2	1.3	0.3	2.2	2.1	1.3	1.0	1.3	1.3	0.9	1.4
100-120	0.5	1.9	1.2	1.8	3.2	2.3	0.4	1.6	1.2	1.9	1.6
120-140	0.0	2.6	0.5	1.4	3.9	1.9	0.4	1.0	0.5	0.0	1.2
140-160	0.0	2.6	2.2	1.2	2.5	2.3	0.5	1.7	0.1	1.6	1.5
160-180	0.0	0.6	1.2	0.6	1.7	2.3	0.3	0.5	0.5	1.6	0.9
180-200	1.0	4.1	2.1	1.4	3.5	1.9	0.4	1.2	0.9	0.0	1.6
200-220	0.8	2.6	1.8	2.2	1.8	4.3	1.7	0.6	0.4	1.6	1.8
220-240	0.1	2.8	2.8	1.0	1.3	3.1	2.8	1.7	1.7	8.3	2.6
240-260	0.6	3.0	1.6	1.0	1.7	3.5	5.4	1.2	3.8	6.2	2.8
260-280	2.5	2.3	1.8	3.2	2.5	3.0	4.1	1.7	10.6	3.8	3.6
280-300	11.3	17.1	2.2	3.9	12.3	3.2	3.1	1.6	10.2	3.1	6.8
300-320	19.1	15.3	1.8	5.7	11.4	15.4	6.7	10.1	4.9	5.3	9.6
320-340	14.6	12.7	1.3	3.5	6.7	17.2	8.8	5.2	3.4	5.0	7.8
340-360	12.9	4.9	0.8	8.0	1.2	11.4	5.3	10.6	1.3	5.4	6.2
360-380	17.5	0.0	2.1	2.3	3.5	3.9	5.7	5.2	3.2	5.4	4.8
380-400	17.1	0.0	2.7	4.8	1.9	4.0	3.0	5.2	10.0	5.2	5.4
400-420	11.0		2.5	2.8	4.3	5.4	1.8	5.8	9.2	8.7	5.8
420-440	8.4		4.4	8.7	4.5	8.1	3.9	11.4	9.1	2.6	6.8
440-460	1.7		1.2	2.6	3.5	10.7	2.5	6.1	3.0	2.3	3.7
460-480	1.7		0.8	2.8	1.7	7.1	1.6	3.2	2.2		2.6
480-500					10.0	1.4		4.5			5.3

Table 6.--Ammonium-N distribution in the soil from fertilized area of a leaching study (Riley County, 1970).

Depth cm	NH ₄ ⁺ -N (ppm)										Mean
	I-4		II-5		III-6		IV-7		II-13		
	A	B	A	B	A	B	A	B	A	B	
0-10	9.2	10.5	8.3	12.5	21.5	8.8	7.1	7.1	10.9	6.0	10.2
10-20	36.5	10.7	19.7	7.9	10.9	9.1	8.0	6.5	7.2	8.3	13.1
20-30	10.6	10.0	7.1	6.7	6.2	7.1	6.7	8.0	7.6	8.3	7.8
30-40	7.1	6.1	7.2	5.0	7.4	6.5	5.8	7.8	10.6	8.1	7.2
40-50	6.2	5.2	4.0	5.4	6.7	6.5	3.2	5.8	4.7	7.4	5.5
50-60	5.0	6.0	4.3	3.9	6.7	6.3	2.7	3.6	6.0	4.9	4.9
60-70	2.8	7.4	2.1	4.4	4.0	2.5	3.1	5.2	11.5	4.1	4.7
70-80	3.9	7.5	1.8	4.4	4.3	2.7	2.8	5.8	3.1	5.3	4.2
80-90	2.8	5.3	2.7	3.4	4.5	3.8	3.0	7.4	1.4	4.3	3.9
90-100	2.7	5.2	1.6	4.8	4.3	4.8	3.9	5.0	0.6	4.3	3.7
100-120	1.8	7.4	1.4	2.1	3.6	3.0	1.7	5.2	1.9	2.7	3.1
120-140	2.5	9.7	2.1	3.8	3.6	2.8	1.9	3.2	0.5	5.3	3.5
140-160	2.8	4.3	3.4	3.4	4.0	3.6	2.2	4.5	1.0	3.1	3.2
160-180	3.9	3.9	4.1	3.1	4.1	1.7	2.7	4.5	0.8	4.0	3.3
180-200	5.4	5.8	3.1	3.4	4.7	3.6	3.2	9.7	2.5	4.7	4.6
200-220	4.5	4.8	3.1	3.1	7.0	3.0	3.2	6.5	1.4	3.4	4.0
220-240	3.4	4.5	2.1	4.4	4.5	2.3	4.8	3.6	2.6	2.7	3.5
240-260	4.9	5.2	2.7	2.7	4.5	3.6	3.2	4.9	2.2	3.4	3.7
260-280	2.8	7.4	1.2	4.0	3.1	3.9	3.0	3.9	2.5	2.3	3.4
280-300	3.5	5.6	2.5	4.0	3.2	2.2	1.9	4.3	1.4	6.3	3.5
300-320	1.9	4.0	1.4	3.2	2.7	4.5	2.8	5.8	1.2	13.3	4.1
320-340	1.7	3.2	1.4	2.5	1.9	3.8	2.7	4.5	1.0	4.1	2.7
340-360	1.0	3.2	1.0	2.1	1.6	2.6	3.2	8.3	2.3	4.0	2.9
360-380	2.8	3.9	1.2	2.1	1.8	2.3	1.7	2.2	4.0	3.9	2.6
380-400	1.9	3.6	0.4	2.5	1.3	4.0	1.2	3.5	2.6	4.1	2.5
400-420	1.9	2.6	0.6	4.7	1.2	2.8	0.9	2.3	2.7	1.7	2.1
420-440	1.9	3.5	2.1	3.5	1.8	2.3	0.6	2.8	3.4	4.3	2.6
440-460	0.0	1.6	0.8	2.1	1.7	3.5	0.6	3.2	2.6	2.1	1.8
460-480	2.1		0.1	2.8	1.3	4.0	1.7	3.5	1.7		2.2
480-500					0.1	1.9		1.3			1.1

Table 7.--Nitrate-N content of ground water under and surrounding
fertilized area of leaching study (Riley County).

Date	NO ₃ -N (ppm)								
	Check	Plot	Plot	Plot	Check	Check	Check	Check	Check
	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9
4- -67*	14.4	5.1	3.6						
	12.8	5.1	3.9						
	13.1	5.1	3.8						
11-21-67*	4.3	5.2	7.2						
	4.8	5.5	7.2						
	4.6	5.0	8.0						
2- 9-68*	7.2	6.0	8.7						
	8.4	6.6	8.4						
	8.4	7.2	8.4						
3-15-68*	5.2	4.4	8.3						
	5.0	4.4	9.4						
	5.3	5.0	8.5						
6-25-68*	8.5	1.5	11.6						
	9.7	1.3	11.2						
	9.0	1.6	10.7						
7-23-68*	9.9	1.9	15.3						
	9.7	2.1	16.0						
	10.2	2.1	15.3						
9-11-68*	10.2	2.4	16.3						
	10.9	2.5	17.2						
	10.2	2.5	17.2						
11-11-68*	7.5	2.3	13.8						
	8.9	2.5	14.6						
	9.4	2.5	15.1						
3-16-69*	21.3	2.3	13.8						
	22.0	2.4	14.6						
	22.0	2.3	24.6						
4-21-69*	11.8	2.3	9.6						
	13.8	2.4	9.4						
	14.6	2.8	9.6						
2-27-69	10.9	5.5	24.2						
	13.0	5.5	25.9						
	13.2	---	25.6						
8- 7-69	18.2	3.8	20.0						
	18.9	3.8	20.2						
	19.0	4.1	19.8						
1-14-70	11.8	2.5	16.2						
	11.4	2.3	16.5						
	11.1	2.7	16.4						
2-16-70	11.1	1.7	16.7						
	11.5	1.7	16.8						
	11.6	1.7	16.7						

(Continued)

* Data collected by Gosch (13).

Table 7
(continued)
NO₃-N (ppm)

Date	Plot II-5		Plot IV-7		Plot II-13		Check		Check		Check		Check		Check	
	Well 1	Well 2	Well 3	Well 4	Well 5	Well 6	Well 7	Well 8	Well 9	Well 10	Well 11	Well 12	Well 13	Well 14	Well 15	Well 16
3- 5-70	12.4	1.7	20.8	16.5	8.7	2.3	12.8	9.9	0.2							
	12.9	1.8	20.8	15.9	8.1	2.2	12.7	9.5	0.1							
4- 5-70	13.3	8.9	29.2	13.6	9.2	2.2	11.9	9.1	0.0							
	13.6	8.2	28.2	13.3	8.7	2.1	11.9	8.9	0.0							
5- 5-70	12.6	18.3	14.7	13.3	8.3	2.4	11.3	10.0	0.0							
	12.8	17.5	14.3	12.9	7.9	2.4	11.4	9.4	0.0							
6-10-70	11.7	3.8	9.9	10.5	7.7	2.9	10.0	0.1	0.0							
	11.8	3.7	9.9	10.5	7.4	2.7	10.2	0.3	0.0							
6-17-70	7.8	3.5	13.3	12.6	8.6	2.9	9.9	0.1	0.1							
	9.9	3.4	13.3	12.5	8.3	2.8	10.0	0.3	0.2							
6-25-70	6.6	4.6	16.7	14.2	8.3	2.4	9.9	0.0	0.0							
	7.2	4.4	16.7	14.1	8.1	2.5	9.9	0.1	0.0							
7- 7-70	16.6	8.0	15.8	17.2	8.2	2.5	12.4	0.0	0.0							
	16.9	8.0	15.9	17.2	7.9	2.5	12.4	0.0	0.0							
7-20-70	16.5	8.1	11.7	19.4	8.4	2.5	---	0.0	0.0							
	16.3	8.0	11.7	19.4	8.1	2.4	---	0.0	0.0							
7-28-70	13.7	9.7	17.6	20.6	8.0	2.7	---	0.3	0.0							
	14.0	10.0	17.6	20.5	8.0	2.7	---	0.5	0.0							
8- 7-70	13.0	12.6	19.0	20.9	7.4	2.9	---	3.8	0.0							
	13.1	12.6	19.1	20.1	6.8	2.9	---	3.8	0.0							
8-13-70	11.1	10.7	20.6	21.0	7.2	3.2	---	3.1	0.0							
	11.1	10.7	20.3	20.3	6.7	3.2	---	3.2	0.0							
8-26-70	11.4	6.4	23.2	19.4	6.8	4.0	---	1.9	0.0							
	11.4	6.3	23.2	19.0	6.0	3.8	---	1.8	0.0							
9- 8-70	12.6	5.1	21.9	19.3	5.1	3.8	---	2.6	0.0							
	12.7	5.3	21.6	19.7	4.8	3.7	---	2.4	0.0							
10- 2-70	13.0	4.8	20.9	22.2	4.0	3.8	---	2.1	0.2							
	13.0	4.6	21.0	20.7	4.2	3.4	---	2.1	0.2							
10-27-70	13.9	5.2	23.0	25.2	3.8	3.0	---	5.5	0.1							
	13.6	5.6	22.5	24.7	3.6	2.4	---	5.3	0.1							
11-20-70	11.8	9.2	16.0	27.7	2.9	1.8	---	3.6	0.0							
	12.1	9.5	15.6	28.1	3.5	2.4	---	2.4	0.0							
12-15-70	16.0	20.4	39.9	23.1	4.0	3.3	---	2.8	0.0							
	15.7	20.5	39.8	26.3	4.3	2.8	---	2.7	0.0							
2-18-71	17.0	12.9	27.5	22.5	8.4	9.9	6.0	3.9	9.7							
	16.9	13.4	25.5	23.5	8.3	9.7	6.0	3.9	9.5							

Table 8.--Nitrate-N content of tail-water from first irrigation of runoff study (Riley County, 7-15-70).

Treatment	Plot	NO ₃ ⁻ -N (ppm)							
		Time 0	$\frac{1}{2}$ hr.	1 hr.	1 $\frac{1}{2}$ hr.	2 hr.	2 $\frac{1}{2}$ hr.	3 hr.	3 $\frac{1}{2}$ hr.
Control	I	2.1	1.3	0.9					
	V	0.2	0.4	0.7	1.0	1.1	1.0	1.0	1.0
	IX	0.5	0.6	0.8	0.8	1.1	1.0	1.1	1.1
	Mean	0.9	0.8	0.8	0.9	1.1	1.0	1.0	1.0
Surface application	IV	4.1	1.6	2.5					
	VIII	3.2	0.9	1.1	1.2	1.1	1.0	1.2	1.2
	XI	2.2	0.6	1.0	1.0	1.1	1.1	1.2	1.1
	Mean	3.2	1.0	1.5	1.1	1.1	1.0	1.2	1.2
Applied 15 cm deep	II	4.9	1.5	1.3					
	VII	2.0	0.7	0.7	1.0	1.0	0.9	1.1	1.1
	XII	2.3	0.8	1.1	1.1	1.2	1.2	1.3	1.2
	Mean	3.1	1.0	1.0	1.0	1.1	1.0	1.2	1.2
Applied 30 cm deep	III	2.7	1.2	1.2					
	VI	3.3	0.7	0.8	---	0.9	0.9	1.0	0.9
	X	0.2	0.3	0.5	0.9	1.1	1.0	1.0	1.0
	Mean	2.1	0.7	0.8	0.9	1.0	1.0	1.0	1.0
Irrig. Water		0.7							

Table 9.--Nitrate-N content of tail-water from second irrigation of runoff study (Riley County, 7-28-70).

Treatment	Plot	NO ₃ ⁻ -N (ppm)					
		Time 0	$\frac{1}{2}$ hr.	1 hr.	1 $\frac{1}{2}$ hr.	2 hr.	2 $\frac{1}{2}$ hr. 3 hr. 3 $\frac{1}{2}$ hr.
Control	I	0.9	1.3	1.2	1.2	1.1	
	V	0.8	1.2	1.1	1.1	1.2	
	IX	0.8	1.2	1.1	1.1	1.0	
	Mean	0.8	1.2	1.1	1.1	1.1	
Surface applied	IV	0.9	1.2	1.2	1.2	1.2	
	VIII	1.1	1.2	1.3	1.1	1.2	
	XI	1.1	1.3	1.4	1.4	1.2	
	Mean	1.0	1.2	1.3	1.2	1.2	
Applied 15 cm deep	II	1.1	1.2	1.2	1.0	1.2	
	VII	1.2	1.3	1.2	1.2	1.1	
	XII	1.7	1.4	1.3	1.3	1.2	
	Mean	1.3	1.3	1.2	1.2	1.2	
Applied 30 cm deep	III	1.2	1.3	1.3	1.4	1.3	
	VI	1.0	1.2	1.4	1.2	1.3	
	X	1.3	1.4	1.2	1.2	1.2	
	Mean	1.2	1.3	1.3	1.3	1.3	
Irrig. Water		0.9					

Table 10.--Nitrate-N content of tail-water from third irrigation of runoff study (Riley County, 8-11-70).

Treatment	Plot	NO ₃ ⁻ -N (ppm)							
		0	$\frac{1}{2}$ hr.	1 hr.	1 $\frac{1}{2}$ hr.	2 hr.	2 $\frac{1}{2}$ hr.	3 hr.	3 $\frac{1}{2}$ hr.
Control	I	1.3	1.3	1.3	1.6	1.4			
	V	1.2	1.6	1.1	1.1	1.1			
	IX	1.2	1.3	1.3	1.1	1.2			
	Mean	1.2	1.4	1.2	1.3	1.2			
Surface applied	IV	1.3	1.2	1.2	1.1	1.3			
	VIII	1.4	1.4	1.3	1.3	1.2			
	XI	1.4	3.5	1.6	1.5	1.3			
	Mean	1.4	2.0	1.4	1.3	1.3			
Applied 15 cm deep	II	1.6	1.5	1.5	1.2	1.2			
	VII	1.2	1.3	1.3	1.2	1.3			
	XII	1.5	1.3	1.2	1.4	1.2			
	Mean	1.4	1.4	1.3	1.3	1.2			
Applied 30 cm deep	III	1.2	1.3	1.2	1.3	1.4			
	VI	1.2	1.3	1.3	1.2	1.3			
	X	1.4	1.3	1.2	1.5	1.2			
	Mean	1.3	1.3	1.2	1.3	1.3			
Irrig. Water		0.9							

Table 11.--Nitrate-N content of tail-water from fourth irrigation of runoff study (Riley County, 9-1-70).

Treatment	Plot	NO ₃ ⁻ -N (ppm)					
		Time 0	½ hr.	1 hr.	1½ hr.	2 hr.	2½ hr. 3 hr. 3½ hr.
Control	I	1.1	1.3	1.3	1.2	1.3	
	V	0.9	1.2	1.4	1.3	1.2	
	IX	1.0	1.3	1.3	1.3	1.3	
	Mean	1.0	1.3	1.3	1.3	1.3	
Surface applied	IV	1.5	1.4	1.4	1.3	1.2	
	VIII	1.3	1.4	1.4	1.3	1.5	
	XI	1.4	1.5	1.4	1.4	1.4	
	Mean	1.4	1.4	1.4	1.3	1.4	
Applied 15 cm deep	II	1.7	1.5	1.3	1.3	1.2	
	VII	1.2	1.2	1.2	1.1	1.3	
	XII	2.0	1.5	1.3	1.2	1.3	
	Mean	1.6	1.4	1.3	1.2	1.3	
Applied 30 cm deep	III	1.1	1.2	1.3	1.1	1.3	
	VI	1.2	1.2	1.3	1.3	1.3	
	X	1.3	1.3	1.3	1.3	1.5	
	Mean	1.6	1.2	1.3	1.2	1.4	
Irrig. Water		1.2					

Table 12.--Nitrate-N distribution in soil from check areas of runoff study (Riley County, 6-8-70).

Depth cm	Plot I		Plot V		Plot IX		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	6.2	5.2	4.9	6.3	5.3	3.5	5.2
10-20	7.4	7.8	6.5	4.4	5.8	2.8	5.8
20-30	8.7	4.1	5.8	4.4	7.1	3.8	5.6
30-40	12.4	3.6	8.5	7.1	3.4	5.2	6.7
40-50	6.3	3.0	6.5	5.2	3.2	5.0	4.9
50-60	3.8	1.9	4.1	3.9	2.2	6.0	3.6
60-70	3.9	2.5	5.8	5.2	1.8	5.3	4.1
70-80	6.1	4.9	7.4	6.2	2.6	5.0	5.4
80-90	3.8	6.7	2.5	8.5	3.5	6.7	5.3
90-100	4.3	6.3	8.7	6.7	2.6	10.0	6.4
100-120	4.8	4.4	9.1	15.5	2.3	9.6	7.6
120-140	10.0	4.1	12.2	12.4	1.9	6.6	7.9
140-160	20.7	10.7	8.8	3.2	1.8	3.4	8.1
160-180	8.5	14.1	7.2	4.4	3.0	1.6	6.5
180-200	3.6	4.8	6.6	3.1	2.7	3.9	4.1
200-220	3.1	3.1	2.6	4.4	1.7	2.6	2.9
220-240	2.1	2.1	2.2	1.7	3.0	3.4	2.4
240-260	2.3	2.1	1.3	2.5	1.0	9.6	3.1
260-280	1.4	1.6	0.9	0.9	2.1	8.3	2.5
280-300	2.1	1.0	1.7	2.1	1.3	4.4	2.1

Table 13.--Ammonium-N distribution in soil from check areas of runoff study (Riley County, 6-8-70).

Depth cm	Plot I		Plot V		Plot IX		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	9.8	7.1	9.3	8.8	8.9	13.1	9.5
10-20	9.3	10.3	7.0	7.5	8.8	10.0	8.8
20-30	9.6	6.9	6.5	7.4	6.1	7.0	7.2
30-40	8.7	4.9	4.3	4.0	3.8	6.0	5.6
40-50	6.0	4.4	3.9	2.7	4.4	4.5	4.3
50-60	4.5	3.5	2.7	2.7	2.2	3.5	3.2
60-70	4.1	3.2	2.2	3.9	2.8	3.6	3.3
70-80	4.5	6.1	3.6	6.0	2.5	3.8	4.4
80-90	4.3	8.1	2.2	3.9	4.1	2.1	4.1
90-100	6.5	5.3	3.4	4.1	5.7	2.6	4.6
100-120	4.1	5.6	3.0	4.5	4.5	3.1	4.1
120-140	3.0	4.4	4.7	3.4	5.0	1.6	3.7
140-160	6.2	4.8	3.2	2.8	3.2	5.3	4.2
160-180	6.0	4.4	1.9	6.3	2.7	2.8	4.0
180-200	5.4	3.4	3.9	2.3	4.1	3.4	3.8
200-220	5.6	3.6	3.5	2.2	3.1	2.5	3.4
220-240	3.1	2.8	3.1	1.9	3.6	2.5	2.8
240-260	3.4	2.8	2.5	1.6	1.9	3.5	2.6
260-280	2.8	3.2	3.2	1.9	2.8	1.4	2.6
280-300	6.9	2.1	2.6	1.3	0.8	1.4	2.5

Table 14.--Nitrate-N distribution in soil receiving surface fertilizer application in runoff study (Riley County, 6-8-70).

Depth cm	Plot IV		Plot VIII		Plot XI		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	
0-10	2.3	4.4	4.7	3.6	6.2	4.5	4.3
10-20	6.1	4.0	3.4	1.6	9.7	5.4	5.0
20-30	7.9	1.3	4.7	2.3	5.6	4.0	4.3
30-40	8.1	1.0	4.0	1.2	5.6	10.0	5.0
40-50	3.5	0.8	5.0	1.4	3.2	10.6	4.1
50-60	3.9	0.4	3.0	1.4	5.6	9.8	4.0
60-70	1.4	1.7	4.1	2.1	5.3	8.7	3.9
70-80	5.7	4.9	6.6	4.0	4.3	2.1	4.6
80-90	2.5	5.0	8.3	4.8	4.8	4.8	5.0
90-100	2.2	5.8	13.8	2.6	8.8	2.2	5.9
100-120	1.7	0.9	19.7	7.9	12.4	2.3	7.5
120-140	6.5	8.9	22.8	16.3	11.5	9.8	12.6
140-160	9.6	5.8	7.5	16.3	14.2	4.8	9.7
160-180	6.7	1.9	2.6	6.2	7.0	2.1	4.4
180-200	3.1	2.2	2.7	3.8	2.2	4.3	3.0
200-220	1.3	1.0	0.5	2.5	2.2	7.2	2.4
220-240	1.3	0.5	1.2	2.1	1.9	13.6	3.4
240-260	0.9	0.3	1.2	1.0	0.3	13.2	2.8
260-280	0.5	1.2	0.5	0.5	0.8	10.6	2.4
280-300	0.3	1.8	0.6	2.2	1.7	5.2	2.0

Table 15.--Ammonium-N distribution in soil receiving surface fertilizer application in runoff study (Riley County, 6-8-70).

Depth cm	Plot IV		Plot VIII		Plot XI		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	
0-10	11.6	9.6	7.2	9.6	7.5	7.1	8.8
10-20	6.1	9.7	8.3	11.1	12.0	6.1	8.9
20-30	16.8	6.1	6.6	10.1	3.6	5.8	8.2
30-40	3.8	4.9	3.1	6.5	4.4	4.5	4.5
40-50	1.9	4.0	3.0	3.4	2.2	5.2	3.3
50-60	2.6	6.0	2.5	2.1	3.5	3.4	3.4
60-70	0.9	3.4	3.1	1.8	3.6	4.3	2.8
70-80	2.6	4.8	3.8	4.9	3.9	1.0	3.5
80-90	2.7	6.1	3.9	4.7	4.5	1.4	3.9
90-100	2.3	4.1	3.9	3.4	5.8	2.6	3.7
100-120	2.8	5.2	3.6	6.2	3.6	2.2	3.9
120-140	2.8	3.8	2.7	6.1	3.0	1.9	3.4
140-160	4.7	7.5	3.2	5.0	4.9	3.9	4.9
160-180	3.2	3.4	1.8	5.6	3.5	3.1	3.4
180-200	2.8	3.2	4.1	3.1	2.5	3.9	3.3
200-220	3.2	2.6	2.5	4.0	4.4	2.5	3.2
220-240	2.2	1.7	2.1	3.0	2.8	3.2	2.5
240-260	1.7	1.3	1.7	3.1	1.7	3.2	2.1
260-280	2.2	0.9	1.4	1.4	3.1	1.9	1.8
280-300	1.9	1.4	1.6	1.7	2.3	1.3	1.7

Table 16.--Nitrate-N distribution in soil receiving 15 cm deep
fertilizer application in runoff study (Riley County, 6-8-70).

Depth cm	Plot II		Plot VII		Plot XII		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	7.2	6.0	12.5	3.2	5.0	5.7	6.6
10-20	7.6	6.0	9.3	3.4	7.2	5.0	6.4
20-30	3.5	3.8	5.4	2.5	4.4	4.8	4.1
30-40	5.6	2.8	10.0	1.6	5.3	2.5	4.6
40-50	5.4	3.0	7.5	1.0	5.8	8.3	5.2
50-60	3.2	3.6	7.0	2.5	6.7	2.7	4.3
60-70	4.4	5.0	6.3	4.1	2.8	2.6	4.2
70-80	6.1	5.8	15.9	2.8	8.0	2.2	6.8
80-90	6.5	4.7	14.2	2.6	8.7	3.1	6.6
90-100	5.6	4.3	11.0	2.3	6.0	6.9	6.0
100-120	4.8	2.3	8.0	3.4	10.0	4.5	5.5
120-140	5.8	1.9	7.2	3.8	11.3	4.5	5.8
140-160	7.8	4.1	4.9	2.6	17.1	3.9	6.7
160-180	7.8	11.5	2.5	7.4	12.7	3.9	7.6
180-200	6.6	3.8	2.8	2.1	10.6	5.0	5.2
200-220	8.9	2.1	1.8	5.6	3.0	8.7	5.0
220-240	10.1	3.1	2.2	1.9	2.2	7.4	4.5
240-260	3.8	1.8	2.1	2.7	2.6	14.1	4.5
260-280	2.3	0.0	2.5	2.5	2.1	18.4	4.6
280-300	2.3	0.5	3.2	1.0	1.6	8.0	2.8

Table 17.--Ammonium-N distribution in soil receiving 15 cm deep
fertilizer application in runoff study (Riley County, 6-8-70).

Depth cm	Plot II		Plot VII		Plot XII		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	7.2	10.6	1.6	11.4	7.4	15.1	8.9
10-20	8.4	8.7	6.5	18.0	6.2	13.6	10.2
20-30	8.8	5.0	4.8	7.6	6.2	7.8	6.7
30-40	7.1	5.4	5.2	5.4	8.0	6.2	6.2
40-50	7.2	3.6	3.5	1.7	8.3	6.1	5.1
50-60	4.0	5.4	2.8	3.0	3.5	1.4	3.4
60-70	5.2	6.9	1.7	3.8	3.5	2.8	4.0
70-80	5.2	5.2	3.8	3.9	4.4	2.8	4.2
80-90	5.8	5.2	4.0	3.5	3.5	3.9	4.3
90-100	4.7	4.4	4.9	4.8	3.8	4.8	4.6
100-120	4.3	3.6	7.0	4.4	4.1	3.4	4.5
120-140	3.5	3.0	4.5	3.8	6.0	3.2	4.0
140-160	7.2	4.5	3.9	3.6	5.8	5.2	5.0
160-180	4.9	2.7	3.6	2.3	3.5	4.9	3.6
180-200	3.8	2.7	3.6	2.8	4.1	5.0	3.7
200-220	5.7	2.1	3.0	2.3	4.1	3.5	3.4
220-240	4.3	2.6	3.4	1.4	3.2	1.7	2.8
240-260	3.6	2.5	2.2	1.2	3.6	1.8	2.5
260-280	3.2	1.7	2.8	1.3	1.9	3.6	2.4
280-300	5.3	1.9	2.6	1.2	2.5	2.2	2.6

Table 18.--Nitrate-N distribution in soil receiving 30 cm deep
fertilizer application in runoff study (Riley County, 6-8-70).

Depth cm	Plot III		Plot VI		Plot X		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	6.0	5.2	7.4	4.5	2.1	3.9	4.8
10-20	10.1	5.2	4.5	4.1	4.7	2.2	5.1
20-30	8.3	4.3	9.3	4.8	8.9	2.3	6.3
30-40	5.6	3.8	13.5	3.8	8.9	1.2	6.1
40-50	3.5	10.3	10.3	4.4	3.9	2.5	5.8
50-60	4.5	15.7	9.3	5.2	1.0	2.8	6.4
60-70	3.0	16.4	12.2	3.4	3.0	4.8	7.1
70-80	6.7	14.1	8.7	4.8	4.8	6.1	7.5
80-90	6.9	12.4	10.2	3.5	5.4	8.3	7.8
90-100	5.4	12.5	10.2	2.6	2.8	9.3	7.1
100-120	4.4	15.4	11.3	1.3	3.1	8.1	7.3
120-140	6.1	14.0	7.8	2.5	11.0	4.1	7.6
140-160	12.8	12.2	2.7	6.9	0.9	1.4	6.2
160-180	9.8	6.6	2.3	6.5	2.7	0.9	4.8
180-200	6.9	3.2	1.2	4.5	3.1	3.8	3.8
200-220	4.1	1.0	2.2	1.6	2.1	14.1	4.2
220-240	0.8	1.2	1.3	2.2	2.2	23.5	5.2
240-260	2.3	1.2	1.4	2.8	1.6	21.7	5.2
260-280	0.8	2.5	4.1	4.1	1.2	11.1	4.0
280-300	1.3	2.3	4.5	5.7	1.0	5.4	3.4

Table 19.--Ammonium-N distribution in soil receiving 30 cm deep
fertilizer application in runoff study (Riley County, 6-8-70).

Depth cm	Plot III		Plot VI		Plot X		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	7.4	10.1	13.2	11.9	6.3	14.5	10.6
10-20	20.1	12.7	15.3	12.2	7.4	13.8	13.6
20-30	9.1	11.3	7.8	8.3	5.8	6.7	8.2
30-40	8.3	7.0	4.5	4.4	4.7	5.0	5.6
40-50	4.5	6.6	3.5	2.7	3.9	4.0	4.2
50-60	5.6	4.3	6.7	3.0	2.2	5.7	4.6
60-70	3.1	4.7	3.5	4.4	3.9	3.9	3.9
70-80	4.0	7.1	3.5	1.2	3.5	6.1	4.2
80-90	3.4	5.4	3.2	3.2	1.4	3.1	3.3
90-100	3.0	4.1	4.3	5.7	2.8	3.6	3.9
100-120	2.6	5.4	3.2	2.5	0.8	3.4	3.0
120-140	4.5	4.0	4.1	1.6	2.2	3.1	3.2
140-160	4.9	3.1	4.3	1.0	3.6	2.8	3.3
160-180	6.1	2.8	2.2	1.7	2.8	1.9	3.0
180-200	3.9	3.4	2.2	1.8	2.3	1.8	2.6
200-220	3.6	3.5	2.7	1.6	2.2	1.8	2.6
220-240	5.6	3.2	3.5	2.3	2.3	2.2	3.2
240-260	5.8	3.2	2.2	0.9	1.2	2.2	2.6
260-280	4.4	2.8	3.8	10.6	2.3	2.2	4.4
280-300	4.0	3.2	1.6	1.6	2.2	0.9	2.2

Table 20.--Nitrate-N distribution in soil from check areas of runoff study (Riley County, 12-70).

Depth cm	Plot I		Plot V		Plot IX		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	
0-10	5.0	2.1	3.8	5.2	2.3	3.4	3.6
10-20	4.8	2.8	3.1	5.8	1.3	3.0	3.5
20-30	2.6	2.8	1.8	1.4	1.3	2.3	2.0
30-40	1.4	0.9	1.0	0.9	2.1	3.4	1.6
40-50	1.6	0.0	0.6	2.5	0.1	2.1	1.2
50-60	0.0	0.3	0.3	1.3	1.0	1.9	0.8
60-70	0.0	0.5	0.6	1.8	1.0	1.3	0.9
70-80	0.0	1.9	0.9	0.6	1.3	2.1	1.1
80-90	0.4	2.2	0.4	0.1	1.2	0.8	0.8
90-100	1.9	1.7	0.3	0.0	0.5	2.5	1.2
100-120	1.3	0.9	0.8	0.3	0.1	4.0	1.2
120-140	0.5	0.8	0.6	1.4	1.3	2.6	1.2
140-160	9.3	0.1	0.8	1.0	0.8	2.1	2.4
160-180	13.2	0.1	0.3	1.0	0.1	3.6	3.0
180-200	4.9	0.0	0.6	0.9	1.4	6.9	2.4
200-220	3.4	0.0	0.5	1.0	0.4	11.9	2.9
220-240	3.0	1.0	1.3	1.3	0.3	13.5	3.4
240-260	2.1	0.6	2.7	1.6	0.4	19.4	4.5
260-280	2.5	1.7	3.1	8.5	0.8	7.2	4.0
280-300	2.8	1.3	3.8	4.9	0.4	1.7	2.5

Table 21.--Ammonium-N distribution in soil from check areas of runoff study (Riley County, 12-70).

Depth cm	Plot I		Plot V		Plot IX		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	
0-10	5.8	0.8	5.0	7.0	5.2	5.6	4.9
10-20	14.9	4.7	5.0	9.1	9.2	8.8	8.6
20-30	5.8	5.8	3.9	3.1	5.6	6.6	5.1
30-40	5.4	3.4	3.4	1.4	2.3	5.6	3.6
40-50	3.2	1.2	2.5	0.1	1.7	3.6	2.0
50-60	1.2	0.8	1.3	0.6	2.6	3.1	1.6
60-70	1.3	0.8	0.6	0.0	2.3	2.1	1.2
70-80	1.2	1.4	2.2	0.1	2.1	2.3	1.6
80-90	2.8	1.4	1.9	0.5	3.2	1.6	1.9
90-100	2.1	3.2	2.3	1.0	4.9	1.3	2.5
100-120	3.4	7.9	3.0	1.6	2.1	0.0	3.0
120-140	2.7	2.7	2.5	1.9	1.4	3.6	2.5
140-160	3.5	2.1	1.7	2.1	2.7	3.6	2.6
160-180	3.1	0.8	1.6	3.5	1.9	3.2	2.4
180-200	1.7	0.6	1.7	2.8	2.1	2.3	1.9
200-220	2.1	0.8	1.7	2.6	1.7	2.7	1.9
220-240	1.4	0.5	1.7	1.3	1.3	3.0	1.5
240-260	2.1	0.0	1.7	0.9	1.0	2.1	1.3
260-280	2.1	0.1	1.8	1.3	1.9	0.8	1.3
280-300	2.1	0.6	1.0	0.0	1.3	0.4	0.9

Table 22.--Nitrate-N distribution in soil receiving surface fertilizer application in runoff study (Riley County, 12-70).

Depth cm	Plot IV		Plot VIII		Plot XI		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	4.5	5.3	3.2	8.7	1.8	10.2	5.6
10-20	4.3	3.8	3.6	14.2	3.0	5.7	5.8
20-30	1.7	1.9	2.1	8.9	1.8	6.2	3.8
30-40	1.3	0.9	0.0	9.6	1.0	7.4	3.4
40-50	1.3	0.6	1.7	7.1	0.4	10.5	3.6
50-60	0.8	0.8	0.9	5.0	0.1	8.8	2.7
60-70	2.1	1.2	1.3	3.9	0.9	10.3	3.3
70-80	3.5	0.6	1.3	3.0	0.3	10.9	3.3
80-90	4.1	1.8	0.8	3.1	1.7	7.9	3.2
90-100	4.1	3.2	1.0	3.4	1.6	11.4	4.1
100-120	5.6	4.4	1.3	1.6	2.1	14.4	4.9
120-140	3.4	2.3	1.2	3.1	2.2	22.4	5.8
140-160	2.7	5.4	1.2	9.8	1.8	21.1	7.0
160-180	0.5	9.4	1.3	11.9	3.0	19.5	7.6
180-200	1.6	11.1	1.6	11.6	3.9	14.1	7.3
200-220	1.7	10.5	1.9	9.4	3.0	11.8	6.4
220-240	1.9	12.0	0.9	10.1	4.0	12.7	6.9
240-260	3.0	6.0	0.9	12.5	4.7	11.3	6.4
260-280	3.5	3.6	0.9	16.2	3.5	14.1	7.0
280-300	4.4	2.8	1.0	13.2	3.2	15.9	6.8

Table 23.--Ammonium-N distribution in soil receiving surface fertilizer application in runoff study (Riley County, 12-70).

Depth cm	Plot IV		Plot VIII		Plot XI		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	5.8	7.6	6.0	17.2	5.6	11.5	9.0
10-20	8.4	7.8	6.6	15.9	7.9	7.8	9.1
20-30	3.9	4.7	8.3	6.3	3.4	8.0	5.8
30-40	3.5	1.7	3.8	5.4	0.6	7.6	3.8
40-50	3.4	1.9	4.4	2.6	1.6	5.3	3.2
50-60	1.8	2.2	2.2	2.2	0.8	3.1	2.0
60-70	2.2	1.4	1.7	1.4	1.2	4.0	2.0
70-80	2.3	2.1	2.7	1.6	1.4	3.1	2.3
80-90	2.6	1.9	3.5	1.2	2.3	2.5	2.3
90-100	2.6	2.1	3.1	2.8	3.1	2.6	2.7
100-120	2.6	2.1	4.5	2.1	3.9	3.5	3.1
120-140	3.0	0.8	2.6	2.3	2.8	5.2	2.8
140-160	3.6	2.3	2.3	4.0	3.9	4.4	3.4
160-180	2.3	2.1	2.2	3.1	4.5	4.0	3.0
180-200	1.8	2.1	2.6	3.4	2.3	4.1	2.7
200-220	0.6	1.7	1.8	3.1	2.5	3.8	2.2
220-240	2.3	1.0	2.2	4.1	1.7	2.8	2.4
240-260	3.6	0.8	1.0	2.7	1.8	2.2	2.0
260-280	2.1	0.6	1.0	2.2	0.9	3.4	1.7
280-300	1.8	0.8	1.7	1.4	1.6	3.2	1.8

Table 24.--Nitrate-N distribution in soil receiving 15 cm deep fertilizer application in runoff study (Riley County, 12-70).

Depth cm	Plot II		Plot VII		Plot XII		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	6.5	3.9	4.1	4.1	15.0	3.8	6.2
10-20	27.3	7.9	4.3	4.9	37.5	7.0	14.8
20-30	1.9	2.3	1.7	2.3	8.5	2.5	3.2
30-40	0.5	0.6	2.7	0.8	11.0	1.4	2.8
40-50	0.0	0.5	0.8	1.3	12.0	0.5	2.5
50-60	0.5	0.9	1.2	1.8	7.2	1.3	2.2
60-70	0.9	1.6	1.7	1.0	7.6	2.3	2.5
70-80	1.4	2.1	1.0	2.1	5.7	1.8	2.4
80-90	1.9	4.7	1.9	2.6	3.8	1.9	2.8
90-100	1.9	6.6	1.6	0.8	8.5	1.8	3.5
100-120	2.2	14.5	1.6	1.3	12.2	3.6	5.9
120-140	1.9	18.2	0.8	1.7	18.5	4.1	7.5
140-160	2.1	9.6	0.0	2.7	26.4	4.0	7.5
160-180	2.8	7.5	0.5	2.6	24.3	5.0	7.1
180-200	4.3	9.7	1.3	3.1	17.1	4.7	6.7
200-220	5.8	4.8	2.7	3.6	10.9	1.3	4.8
220-240	6.1	3.1	3.2	3.4	8.7	0.8	4.2
240-260	6.6	4.0	3.7	4.7	5.4	2.3	4.4
260-280	8.8	1.9	8.5	9.8	6.0	2.1	6.2
280-300	10.7	0.8	8.9	7.5	3.8	7.8	6.6

Table 25.--Ammonium-N distribution in soil receiving 15 cm deep fertilizer application in runoff study (Riley County, 12-70).

Depth cm	Plot II		Plot VII		Plot XII		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	14.4	5.3	15.1	8.1	12.7	6.6	10.4
10-20	11.1	8.5	13.3	5.6	13.2	19.1	11.8
20-30	3.8	3.8	4.1	4.9	6.7	6.1	4.9
30-40	2.6	1.7	7.9	1.7	40.0	4.1	9.7
40-50	1.9	1.4	2.5	2.7	41.8	2.7	8.8
50-60	1.7	1.3	3.1	2.1	11.8	4.8	4.1
60-70	1.6	1.2	3.5	1.2	20.2	4.5	5.4
70-80	2.6	1.4	3.2	1.0	10.3	3.6	3.7
80-90	1.9	2.2	3.6	2.3	17.6	2.6	5.0
90-100	1.9	1.9	5.0	2.3	11.9	4.4	4.6
100-120	2.3	1.9	3.2	1.7	10.9	4.3	4.0
120-140	2.3	1.0	2.8	2.8	7.6	5.2	3.6
140-160	2.7	0.9	1.6	1.9	10.7	4.5	3.7
160-180	3.1	0.6	1.9	2.5	8.8	3.2	3.4
180-200	3.0	1.0	3.2	2.3	7.4	5.4	3.7
200-220	1.6	0.3	2.6	1.4	11.1	3.6	3.4
220-240	2.3	1.0	2.3	1.4	6.2	1.7	2.5
240-260	2.8	0.3	1.4	3.0	9.8	1.3	3.1
260-280	1.6	0.1	1.7	2.1	13.7	1.4	3.4
280-300	1.6	0.6	1.3	1.0	7.0	0.9	2.1

Table 26.--Nitrate-N distribution in soil receiving 30 cm deep
fertilizer application in runoff study (Riley County, 12-70).

Depth cm	Plot III		Plot VI		Plot X		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	2.7	4.5	4.0	4.4	3.8	3.9	3.9
10-20	7.5	5.3	3.1	6.6	3.1	3.1	4.8
20-30	3.5	3.0	2.1	0.6	5.3	2.1	2.8
30-40	1.0	0.8	0.0	0.0	6.6	3.1	1.9
40-50	1.3	2.2	1.3	0.0	4.7	3.5	2.2
50-60	0.3	2.7	1.9	0.4	1.6	1.2	1.4
60-70	1.0	1.4	2.2	1.7	1.8	0.5	1.4
70-80	1.2	1.3	2.8	1.7	1.2	2.1	1.7
80-90	1.4	3.1	3.2	3.0	1.6	12.3	4.1
90-100	0.8	3.2	0.0	2.2	1.6	14.7	3.8
100-120	1.4	7.9	0.4	2.2	1.2	14.5	4.6
120-140	1.3	15.3	0.6	7.2	2.6	8.7	6.0
140-160	4.9	15.5	3.6	6.7	4.3	9.4	7.4
160-180	8.1	17.5	6.5	5.8	7.2	11.8	9.5
180-200	12.3	8.7	4.1	5.0	8.5	11.6	8.4
200-220	9.6	12.5	2.2	4.1	3.0	15.1	7.8
220-240	4.3	10.2	0.8	3.9	3.8	20.3	7.2
240-260	5.6	13.1	2.6	3.6	3.5	15.8	7.4
260-280	8.5	20.2	7.5	5.0	5.7	17.6	10.8
280-300	12.4	10.5	13.5	2.6	5.7	15.4	10.0

Table 27.--Ammonium-N distribution in soil receiving 30 cm deep
fertilizer application in runoff study (Riley County, 12-70).

Depth cm	Plot III		Plot VI		Plot X		Avg.
	Core A	Core B	Core A	Core B	Core A	Core B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	3.9	6.7	6.3	7.2	5.3	13.3	7.1
10-20	4.1	4.7	7.2	11.1	4.8	10.2	7.0
20-30	4.3	5.2	7.0	6.7	7.5	13.8	7.4
30-40	2.1	1.0	2.3	3.9	4.4	4.3	3.0
40-50	1.6	2.2	1.4	2.2	2.3	4.9	2.4
50-60	1.6	0.8	0.4	2.1	3.6	1.3	1.6
60-70	0.8	1.8	0.3	1.4	3.1	0.4	1.3
70-80	1.7	2.1	0.6	1.4	1.9	2.3	1.7
80-90	1.9	1.0	0.6	1.6	1.0	1.3	1.2
90-100	1.0	0.9	4.0	0.6	2.6	1.9	1.8
100-120	1.8	1.6	3.8	1.2	2.3	1.9	2.1
120-140	2.6	1.2	1.8	1.3	1.7	1.0	1.6
140-160	1.8	0.9	2.8	2.8	1.7	2.5	2.1
160-180	1.2	0.3	2.2	1.9	2.5	2.1	1.7
180-200	2.2	0.6	2.1	1.6	2.8	2.6	2.0
200-220	2.2	0.3	1.9	2.1	1.9	2.2	1.8
220-240	1.4	0.9	2.3	2.7	1.0	1.4	1.6
240-260	1.0	1.0	2.2	2.3	0.3	2.5	1.6
260-280	0.6	0.3	1.8	1.8	1.3	1.0	1.1
280-300	0.6	0.3	1.8	0.9	0.0	1.7	0.9

Table 28.--Nitrate-N distribution in the soil profile from a
fertilizer leaching study (Stafford County).

Depth cm	12-69				11-70				
	Cont. 1	12-69			I-4		II-6		Avg.
		ppm	ppm	ppm	A	B	A	B	
		ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	2.5	3.9	3.2	3.6	2.5	6.0	8.8	3.8	5.3
10-20	4.3	2.7	2.1	2.4	1.6	1.6	3.4	1.8	2.1
20-30	4.3	1.6	1.0	1.3	1.6	1.6	2.1	1.3	1.6
30-40	2.6	2.3	0.9	1.6	1.7	2.5	1.6	1.6	1.8
40-50	4.0	1.9	1.4	1.6	1.8	1.2	1.9	1.8	1.7
50-60	2.5	1.6	2.5	2.0	1.0	2.1	1.3	0.6	1.2
60-70	1.0	1.7	2.7	2.2	1.4	0.9	1.8	0.8	1.2
70-80	1.4	1.8	2.7	2.2	0.1	1.0	1.3	0.9	0.8
80-90	0.8	1.7	1.2	1.4	0.5	0.4	1.3	1.0	0.8
90-100	1.3	1.3	1.8	1.6	0.0	0.9	1.0	0.9	0.7
100-120	---	1.6	1.8	1.7	0.3	0.8	0.9	0.4	0.6
120-140	0.3	0.9	2.1	1.5	0.5	0.3	1.7	0.4	0.7
140-160	0.4	0.3	3.4	1.8	0.1	0.0	1.7	0.5	0.6
160-180	0.0	0.8	4.7	2.8	0.0	0.3	1.8	0.3	0.6
180-200	0.4	1.2	5.2	3.2	0.3	0.8	2.8	0.3	1.0
200-220	0.5	0.8	5.8	3.3	0.0	0.3	3.6	0.4	1.1
220-240	0.4	0.8	4.9	2.8	0.3	0.0	3.2	0.8	1.1
240-260	0.0	0.6	5.4	3.0	0.0	0.1	3.2	0.3	0.9
260-280	0.1	1.0	4.5	2.8	1.2	0.3	3.1	0.8	1.4
280-300	---	1.4	3.9	2.6	0.0	0.0	2.8		0.9
300-320	0.0	0.6	1.2	0.9	0.1		3.4		1.8
320-340	0.3	0.0	1.7	0.8			2.3		2.3
340-360	0.1	0.0		0.0					
360-380	0.5	0.0		0.0					
380-400	0.0	0.1		0.1					

Table 29.--Ammonium-N distribution in the soil profile from a
fertilizer leaching study (Stafford County).

Depth cm	12-69					11-70				
	12-69		12-69		Avg.	I-4		II-6		Avg.
	Control		I-4	II-6		A	B	A	B	
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	3.1	26.9	8.0	17.4		4.1	12.4	9.3	8.9	8.7
10-20	4.0	16.7	3.1	9.9		2.1	4.7	4.5	3.9	3.8
20-30	5.7	12.9	3.4	8.2		3.2	3.2	3.9	3.9	3.6
30-40	2.7	11.8	3.0	7.4		2.8	3.4	2.7	2.5	2.8
40-50	20.8	10.2	2.1	6.2		2.3	2.6	2.7	3.1	2.7
50-60	2.8	15.0	2.3	8.6		2.1	2.5	1.9	3.1	2.4
60-70	2.1	14.1	2.2	8.2		1.6	1.6	3.2	3.0	2.4
70-80	2.7	19.9	2.2	11.0		1.2	1.7	3.1	2.3	2.1
80-90	1.6	23.5	2.2	12.8		0.8	1.0	2.1	1.8	1.4
90-100	2.8	14.9	2.7	8.8		0.9	1.6	1.6	1.3	1.4
100-120	---	7.4	3.4	5.4		1.2	2.1	1.8	1.8	1.7
120-140	0.5	4.0	3.0	3.5		1.2	2.5	2.1	4.1	2.5
140-160	1.2	4.9	1.3	3.1		1.6	2.1	2.6	1.6	2.0
160-180	1.4	3.6	2.2	2.9		0.9	2.3	2.3	1.6	1.8
180-200	1.2	5.4	1.7	3.6		1.6	2.6	2.1	1.6	2.0
200-220	0.6	2.5	1.6	2.0		1.0	1.9	1.8	1.4	1.5
220-240	0.5	3.1	1.0	2.0		1.2	1.2	1.9	1.0	1.3
240-260	0.4	1.8	1.7	1.8		0.9	1.2	1.3	1.2	1.2
260-280	0.6	1.7	1.2	1.4		1.8	1.4	1.2	1.2	1.4
280-300	---	1.7	0.9	1.3		1.2	1.9	1.3		1.5
300-320	0.1	1.2	0.0	0.6		1.9		0.5		1.2
320-340	0.3	0.5	0.6	0.6				1.0		1.0
340-360	0.3	0.5		0.5						
360-380	0.4	0.0		0.0						
380-400	0.4	0.3		0.3						

Table 30.--Nitrate-N content of ground water under and surrounding
fertilized area of leaching study (Stafford County).

Date	Control	NO ₃ -N (ppm)	
		Plot II-6	Plot I-4
6-10-67*	1.8	6.6	5.8
	5.3	5.7	5.2
	5.8	5.5	5.5
8- 2-67*	7.8	8.3	9.9
	8.8	7.5	9.0
	8.3	7.9	9.5
2-10-68*	9.9	9.8	12.5
	9.4	9.8	12.5
	9.0	9.8	12.5
8- 5-68*	14.3	11.2	13.2
	15.6	12.0	12.9
	14.7	12.0	12.9
9- 6-68*	15.3	10.9	11.6
	15.3	11.6	11.6
	15.3	11.6	11.6
9-28-68*	20.6	8.8	12.9
	16.3	8.8	12.4
	20.6	8.5	11.6
11-10-68*	23.4	10.0	8.8
	24.8	9.7	8.8
	24.8	10.0	8.8
3-16-69*	13.8	18.7	7.7
	14.6	18.7	8.6
	14.6	18.7	8.6
4-23-69*	8.7	12.1	11.0
	9.0	12.5	11.0
	9.4	12.1	10.7
7- 8-69	9.2	12.7	10.6
	9.2	11.7	10.6
	9.0	12.1	8.9
9-11-69	8.9	12.3	8.9
	9.6	10.7	8.4
	10.0	10.7	8.3
2-10-70	10.1	10.5	8.9
	7.8	11.0	8.1
	7.6	11.4	8.1
5- 9-70	7.9	11.3	8.0
	8.3	9.4	10.4
	8.2	9.6	10.7
	8.1	9.7	10.7

(Continued)

* Data collected by Gosch (13).

Table 30
(Continued)

Date	Control	NO ₃ ⁻ -N (ppm)	
		Plot II-6	Plot I-4
6- 4-70	11.0	10.7	8.8
	11.2	10.5	8.7
	10.8	10.5	8.8
6-23-70	13.4	10.2	8.8
	13.5	10.2	8.7
7- 1-70	14.3	9.5	9.4
	13.9	9.7	9.3
7-14-70	15.7	12.9	13.6
	12.4	12.9	13.0
8- 6-70	12.4	13.6	16.7
	12.4	13.4	16.4
8-24-70	14.5	14.7	12.9
	14.1	14.3	13.0
9-10-70	10.7	14.8	10.3
	10.8	14.7	10.3
10-30-70	6.7	9.2	8.9
	6.8	9.2	9.1
2-13-71	0.3	3.9	2.8
	0.2	3.0	2.9

Table 31.--Nitrate-N distribution in soil from a control area of Time of Application study (Pottawatomie County).

Depth cm	4-11-69												
	Plot 102			Plot 318			Avg.	12-69			12-70		
	A	B	C	A	B	C		102	318	Avg.	102	318	Avg.
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	6.2	12.0	4.5	5.6	4.4	3.6	6.0	6.0	2.2	4.1	3.9	4.9	4.4
10-20	4.5	8.7	4.1	6.1	3.6	4.4	5.2	2.5	1.4	2.0	1.9	3.9	2.9
20-30	5.4	13.5	5.4	5.6	4.3	7.0	6.9	7.2	2.2	4.7	3.1	3.9	3.5
30-40	5.2	18.2	7.4	8.5	21.0	30.7	15.2	3.1	3.0	3.0	1.0	6.6	3.8
40-50	5.4	25.5	24.6	6.2	20.8	6.3	14.8	6.6	3.8	5.2	3.6	8.0	5.8
50-60	9.1	32.4	28.7	6.2	5.3	4.1	14.3	7.4	4.1	5.8	3.5	7.5	5.5
60-70	8.5	10.9	27.9	8.1	6.0	6.0	11.2	8.8	2.6	5.7	4.5	2.1	3.3
70-80	10.7	60.8	7.4	8.4	5.6	5.6	16.4	10.5	2.2	6.4	7.5	2.6	5.0
80-90	10.6	25.1	25.9	7.8	5.2	5.0	13.3	12.5	1.6	7.0	6.1	6.7	6.4
90-100	11.8	10.6	25.6	8.0	4.0	3.9	10.6	9.8	0.9	5.4	4.5	3.2	3.8
100-120	9.4	15.3	23.0	4.8	3.0	1.6	9.5	3.8	0.8	2.3	8.4	2.8	5.6
120-140	4.8	10.9	14.5	2.3	3.6	2.8	6.5	4.4	0.6	2.5	6.2	1.0	3.6
140-160	4.4	11.8	6.0	0.0	3.4	1.3	4.5	3.8	0.8	2.3	6.3	0.1	3.2
160-180	4.0	5.1	9.3	0.0	3.5	0.1	3.7	4.0	0.4	2.2	7.5	1.7	4.6
180-200	7.1	6.9	14.4	2.6	1.0	0.4	5.4	3.2	0.8	2.0	5.2	0.8	3.0
200-220	14.2	6.2	11.0	9.4	0.4	0.5	7.0	3.1	2.6	2.8	4.1	0.0	2.0
220-240	5.4	12.2	17.7	9.4	2.5	0.0	7.9	5.0	1.8	3.4	3.4	0.6	2.0
240-260	10.3	4.0	5.7	19.3	4.9	3.9	8.0	2.6	3.2	2.9	4.8	5.8	5.3
260-280	8.1	4.4	5.3	12.9	7.1	3.9	7.0	4.8	3.2	4.0	6.6	1.9	4.2
280-300	9.1	3.2	6.3	12.4	8.5	6.3	7.6	2.6	3.4	3.0	3.4	1.4	2.4
300-320	8.1	3.6	3.9	7.0	9.7	3.8	6.0	---	2.8	2.8	1.3	2.1	1.7
320-340	9.1	4.0	8.3	1.2	12.8	6.0	7.0	7.6	2.3	5.0	3.1	2.6	2.8
340-360	3.6	5.8	8.9	1.6	9.1	0.8	5.0	3.9	1.8	2.8	2.1	1.3	1.7
360-380	4.5	6.3	8.8	1.6	6.3	0.0	4.6	7.6	2.1	4.8	4.8	1.2	3.0
380-400	4.0	5.7	7.9	0.6	6.6	2.2	4.5	5.0	2.1	3.6	6.0	2.1	4.0
400-420	4.1	2.7	5.6	0.1	3.6	1.2	2.9	3.5	2.8	3.2	6.7	1.7	4.2
420-440	5.3	4.0	4.1	0.8	2.2	0.4	2.8	1.6	4.1	2.8	2.1	4.1	3.1
440-460	5.2	3.0	4.9	1.0	0.8	0.4	2.6	2.5	3.8	3.2	2.6	4.7	3.6
460-480	10.9	2.5	8.4	1.2	0.0	0.0	3.8	6.2	1.6	3.9	2.8	3.8	3.3
480-500	13.6	9.8	5.2	1.4	0.3	0.0	5.0	4.4	---	4.4	0.8	3.0	1.9
500-520	16.0	0.1	21.3	1.7	0.0	0.0	6.5	6.7	---	6.7	0.6	2.8	1.7
520-540	12.2	0.1	19.8	3.0	0.3	0.0	5.9	4.7	2.6	3.6	0.9	2.6	1.8
540-560		15.4	14.6	2.1	0.4	0.0	6.5	5.3	4.8	5.0	5.2	3.0	4.1
560-580		13.5	11.9		0.4	0.0	6.4	6.7	4.8	5.8	2.1	1.0	1.6
580-600		12.9	8.1		0.1	0.9	5.5	7.6	7.0	7.3	0.8	4.3	2.6

Table 32.--Ammonium-N distribution in soil from a control area of Time of Application study (Pottawatomie County).

Depth cm	4-11-69							12-69			12-70		
	Plot 102			Plot 318			Avg.	102	318	Avg.	102	318	Avg.
	A	B	C	A	B	C							
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	47.6	18.6	10.3	44.6	11.1	10.3	23.8	55.0	17.2	36.1	14.5	12.9	13.7
10-20	31.3	6.2	9.4	29.8	8.3	13.7	16.4	33.0	12.5	22.8	8.0	9.4	8.7
20-30	30.8	5.5	7.8	39.8	17.1	25.6	21.1	133.9	14.9	74.4	11.0	9.8	10.4
30-40	46.7	3.6	6.7	44.0	9.6	7.9	19.8	119.4	12.7	66.0	6.2	10.3	8.2
40-50	33.0	4.0	6.2	40.0	6.6	8.5	16.4	65.6	14.6	40.1	14.0	8.7	11.4
50-60	56.9	3.6	10.7	37.5	7.5	3.9	20.0	78.0	10.0	44.0	10.0	7.8	8.9
60-70	38.3	9.5	8.0	41.7	5.4	4.1	17.8	112.9	11.5	62.2	9.6	6.7	8.2
70-80	44.9	1.8	13.7	41.8	9.3	14.4	21.0	132.3	10.7	71.5	9.1	4.5	6.8
80-90	32.6	1.8	11.4	33.6	6.7	4.4	15.1	74.8	14.1	44.4	10.0	3.1	6.6
90-100	36.0	2.5	8.8	28.7	3.5	3.1	13.8	4.9	14.2	9.6	18.2	9.2	13.7
100-120	28.5	6.2	8.5	24.8	2.7	2.1	12.1	47.8	5.6	26.7	16.8	6.5	11.6
120-140	27.9	4.7	6.7	16.6	3.5	4.0	10.6	86.4	7.5	47.0	9.6	3.9	6.8
140-160	33.9	3.6	8.3	9.2	2.5	2.5	10.0	84.1	6.0	45.0	5.6	2.7	4.2
160-180	16.8	2.9	5.2	10.2	2.3	1.7	6.5	33.1	4.4	18.8	6.1	3.9	5.0
180-200	14.5	1.5	4.7	14.6	3.0	2.1	6.7	26.1	7.4	16.8	4.7	2.5	3.6
200-220	12.8	0.0	1.9	18.0	1.7	2.1	6.1	15.9	8.7	12.3	4.3	2.3	3.3
220-240	13.2	2.6	1.9	10.7	3.6	1.2	5.5	21.1	4.3	12.7	2.3	5.7	4.0
240-260	11.9	0.7	2.7	9.7	1.6	2.2	4.8	14.0	6.3	10.2	2.2	3.9	3.0
260-280	11.6	0.7	1.4	9.4	1.0	1.0	4.2	28.8	15.0	21.9	1.9	7.2	4.6
280-300	13.2	3.1	2.5	13.3	3.8	2.1	6.3	23.4	6.1	14.8	3.2	4.3	3.8
300-320	14.9	0.0	1.4	11.4	4.5	0.9	5.5	23.4	6.0	14.7	3.2	4.5	3.8
320-340	31.2	0.0	2.5	8.1	3.8	1.7	7.9	23.5	6.9	15.2	3.1	4.1	3.6
340-360	13.3	0.0	4.1	10.7	2.7	1.8	5.4	19.8	8.0	13.9	0.6	3.0	1.8
360-380	14.9	2.1	1.6	11.0	2.6	1.7	5.6	12.0	9.2	10.6	1.7	4.4	3.0
380-400	18.0	2.2	1.0	6.9	2.3	1.9	5.4	16.8	11.9	14.4	2.1	4.8	3.4
400-420	20.4	1.3	2.3	5.7	4.3	1.8	6.0	7.9	14.0	11.0	5.3	5.2	5.2
420-440	22.1	0.7	3.2	6.5	1.4	1.2	5.8	8.8	10.1	9.4	6.1	3.6	4.8
440-460	13.3	5.2	7.2	6.1	1.7	0.9	5.7	8.5	10.0	9.2	3.1	2.3	2.7
460-480	12.4	2.9	7.8	8.7	1.8	0.8	5.7	32.0	13.1	22.6	2.3	3.2	2.8
480-500	11.3	1.9	6.6	11.4	1.3	0.4	5.5	3.2	---	3.2	2.2	1.9	2.0
500-520	17.7	3.4	2.7	6.9	0.8	1.0	5.4	2.1	---	2.1	2.5	1.7	2.1
520-540	10.7	2.7	1.0	8.1	0.8	0.3	3.9	2.6	10.1	6.4	3.1	2.2	2.6
540-560		3.2	2.2	7.4	0.8	0.1	2.7	2.7	9.4	6.0	5.8	2.8	4.3
560-580		3.6	2.2		0.8	0.1	1.7	2.1	14.2	8.2	6.2	0.9	3.6
580-600		1.4	5.0		1.0	0.5	2.0	3.2	9.1	6.2	7.2	1.3	4.2

Table 33.--Nitrate-N distribution in soil receiving fall application of 112 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	106 ppm	311 ppm	Avg. ppm	106 ppm	311 ppm	Avg. ppm	106 ppm	311 ppm	Avg. ppm
0-10	24.8	7.5	16.2	3.9	6.3	5.1	5.6	3.6	4.6
10-20	21.1	4.8	13.0	3.6	5.0	4.3	5.6	5.0	5.3
20-30	16.7	6.2	11.4	6.7	4.4	5.6	4.4	4.9	4.6
30-40	16.7	7.5	12.1	6.6	7.2	6.9	5.6	4.1	4.8
40-50	9.8	6.3	8.0	7.4	7.2	7.4	4.9	6.0	5.4
50-60	10.2	9.2	9.7	9.4	4.8	7.0	4.3	7.2	5.8
60-70	12.4	7.5	10.0	6.2	4.4	5.3	5.8	6.1	6.0
70-80	12.7	8.0	10.4	5.6	3.5	4.6	5.8	3.0	4.4
80-90	14.2	7.8	11.0	3.6	1.8	2.7	3.1	3.1	3.1
90-100	11.6	6.0	8.8	6.9	1.6	4.2	2.6	6.2	4.4
100-120	14.6	4.0	9.3	5.0	1.8	3.4	3.2	3.0	3.1
120-140	18.9	1.9	10.4	2.2	2.1	2.2	3.0	2.7	2.8
140-160	10.6	3.5	7.0	1.9	1.6	1.8	2.2	1.3	1.8
160-180	8.0	10.7	9.4	2.7	2.8	2.8	2.6	0.8	1.7
180-200	2.2	11.6	6.9	3.4	3.4	3.4	1.6	1.8	1.7
200-220	1.5	15.0	8.2	3.6	3.8	3.7	4.0	1.0	2.5
220-240	1.8	12.4	7.1	6.9	5.2	6.0	2.6	0.6	1.6
240-260	1.5	8.8	5.2	6.6	3.8	5.2	3.2	3.9	3.6
260-280	5.1	6.5	5.8	1.6	4.1	2.8	3.6	2.2	2.9
280-300	3.6	4.5	4.0	5.7	3.0	4.4	3.9	1.6	2.7
300-320	1.8	3.7	2.8	5.3	3.4	4.4	2.8	4.7	3.8
320-340	0.0	2.8	1.4	6.9	2.5	4.7	3.1	5.6	4.4
340-360	0.0	2.9	1.4	7.0	2.5	4.8	6.0	8.8	7.4
360-380	0.0	3.0	1.5	5.8	2.8	4.3	5.8	8.7	7.2
380-400	0.0	3.4	1.7	7.1	2.8	4.0	7.4	2.8	5.1
400-420	3.3	1.6	2.4	6.9	3.1	5.0	5.6	4.3	5.0
420-440	2.5	1.6	2.0	5.4	3.0	4.2	5.8	4.9	5.4
440-460	10.9	1.3	6.1	3.8	1.7	2.8	6.5	3.1	4.8
460-480	8.0	1.1	4.6	2.7	1.6	2.2	10.3	1.9	6.1
480-500	7.6	0.8	4.2	3.6	1.3	2.4	9.1	0.9	5.0
500-520	4.0	1.6	2.8	2.5	1.6	2.0	9.3	2.1	5.7
520-540	4.7	3.9	4.3	4.4	1.0	2.7	7.1	0.5	3.8
540-560	5.1	4.2	4.6	9.8	2.3	6.0	5.7	1.6	3.6
560-580		5.7	5.7	10.7	2.3	6.5	3.6	1.8	2.7
580-600				11.3	0.6	6.0	2.2	0.9	1.6

Table 34.--Ammonium-N distribution in soil receiving fall application of 112 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	106 ppm	311 ppm	Avg. ppm	106 ppm	311 ppm	Avg. ppm	106 ppm	311 ppm	Avg. ppm
0-10	72.1	78.9	75.5	6.3	21.3	13.8	28.8	11.0	19.9
10-20	52.8	37.9	45.4	3.6	11.3	7.4	26.3	8.1	17.2
20-30	41.9	29.0	35.4	85.0	8.8	46.9	25.4	7.8	16.6
30-40	36.4	38.2	37.3	123.8	11.1	67.4	35.3	8.5	21.9
40-50	30.9	33.5	32.2	73.1	7.6	40.4	33.6	7.2	20.4
50-60	27.3	52.3	39.8	76.6	8.4	42.5	38.0	6.9	22.4
60-70	23.7	31.7	27.7	42.4	9.6	26.0	44.0	5.7	24.8
70-80	24.0	33.4	28.7	54.3	11.9	33.1	6.2	4.1	5.2
80-90	32.8	38.5	35.6	90.2	10.9	50.6	7.8	3.2	5.5
90-100	25.5	30.1	27.8	111.9	9.6	60.8	7.1	6.6	6.8
100-120	17.5	17.6	17.6	55.8	10.6	33.2	5.0	5.4	5.2
120-140	20.4	15.7	18.0	35.4	10.6	23.1	4.5	3.6	4.0
140-160	16.4	15.7	16.0	27.2	8.7	18.0	3.2	3.4	3.3
160-180	9.1	15.9	12.5	28.3	7.9	18.1	3.2	3.1	3.2
180-200	2.9	14.2	8.6	38.0	8.0	23.0	1.9	2.5	2.2
200-220	0.0	27.3	13.6	29.4	6.5	18.0	2.8	1.8	2.3
220-240	5.5	24.0	14.8	1.9	3.8	2.8	0.9	4.5	2.7
240-260	0.7	16.1	8.4	1.6	4.7	3.2	13.6	3.0	8.3
260-280	9.1	11.2	10.2	0.9	4.1	2.5	7.1	7.4	7.2
280-300	7.6	12.1	9.8	18.0	4.4	11.2	10.0	3.9	7.0
300-320	4.0	12.3	8.2	13.8	7.9	10.8	8.4	5.4	6.9
320-340	5.8	17.4	11.6	13.8	3.4	8.6	7.9	3.9	5.9
340-360	4.4	16.4	10.4	12.2	5.6	8.9	1.3	3.1	2.2
360-380	7.3	16.2	11.8	14.6	4.0	9.3	3.0	3.5	3.2
380-400	11.3	12.4	11.8	11.9	3.8	7.8	11.4	3.0	7.2
400-420	13.1	12.4	12.8	19.0	4.0	11.5	5.6	1.0	3.3
420-440	6.6	9.8	8.2	26.1	6.2	16.2	3.9	1.8	2.8
440-460	6.2	8.3	7.2	23.4	6.0	14.7	3.0	2.7	2.8
460-480	4.7	8.3	6.5	2.3	7.5	4.9	1.9	1.7	1.8
480-500	7.3	7.2	7.2	1.4	6.3	3.8	1.9	2.1	2.0
500-520	8.0	9.2	8.6	1.0	9.3	5.2	3.0	1.3	2.2
520-540	4.4	10.6	7.5	1.0	4.3	2.6	2.8	1.3	2.0
540-560	5.5	8.5	7.0	2.5	12.2	7.4	3.2	0.9	2.0
560-580		10.2	10.2	1.3	8.8	5.0	1.6	0.0	0.8
580-600				1.8	9.2	5.5	3.6	0.5	2.0

Table 35.--Nitrate-N distribution in soil receiving spring application of 112 kg N/ha (Pottawatomie County).

Depth cm	11-69			12-69			12-70		
	117	308	Avg.	117	308	Avg.	117	308	Avg.
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	6.6	10.1	8.4	1.6	2.6	2.1	7.2	11.1	9.2
10-20	9.7	5.7	7.7	3.1	4.0	3.6	8.8	4.3	6.6
20-30	7.5	7.2	7.4	3.0	2.7	2.8	6.7	4.5	5.6
30-40	8.5	8.8	8.6	2.7	3.9	3.3	3.4	6.2	4.8
40-50	7.5	8.3	7.9	4.8	4.0	4.4	3.5	6.9	5.2
50-60	16.3	7.2	11.8	7.4	3.2	5.3	4.5	6.2	5.4
60-70	12.6	7.0	9.8	6.9	3.2	5.0	6.5	3.6	5.0
70-80	19.0	7.5	13.2	6.3	3.2	4.8	11.8	3.2	7.5
80-90	20.7	7.9	14.3	5.3	1.8	3.6	18.9	4.0	11.4
90-100	29.2	8.4	18.8	2.6	2.7	2.6	49.5	1.4	25.4
100-120	31.6	5.7	18.6	1.4	1.3	1.4	81.9	3.0	42.4
120-140	37.2	4.4	20.8	7.2	1.3	4.2	24.2	1.7	13.0
140-160	6.6	4.0	5.3	5.2	0.9	3.0	6.6	3.6	5.1
160-180	4.6	5.3	5.0	3.9	0.4	2.2	5.6	2.6	4.1
180-200	2.4	12.4	7.4	3.0	1.9	2.4	5.2	2.6	3.9
200-220	2.9	7.2	5.0	4.5	1.8	3.2	3.0	2.2	1.6
220-240	8.7	13.5	11.1	5.3	1.3	3.3	3.0	7.8	5.4
240-260	8.7	8.7	8.7	6.1	1.4	3.8	7.5	9.8	8.6
260-280	12.4	9.1	10.8	7.1	0.9	4.0	5.7	13.8	9.8
280-300	6.3	7.1	6.7	4.5	1.4	3.0	3.5	9.6	6.6
300-320	6.3	4.0	5.2	2.3	2.2	2.2	1.9	6.6	4.2
320-340	2.7	3.0	2.8	0.4	1.4	0.9	3.1	5.4	4.2
340-360	1.5	2.7	2.1	3.9	1.3	2.7	4.5	4.1	4.3
360-380	0.5	2.3	1.4	3.1	0.3	1.7	4.5	3.4	4.0
380-400	0.0	2.3	1.2	5.2	1.0	3.1	5.8	1.9	3.8
400-420	1.2	3.0	2.1	4.1	0.0	2.0	5.2	1.4	3.3
420-440	0.0	3.2	1.6	4.4	3.0	3.7	7.5	0.0	3.8
440-460	0.0	2.5	1.2	6.5	1.9	4.2	11.3	1.7	6.5
460-480	0.5	2.2	1.4	5.2	0.9	3.0	13.3	3.2	8.2
480-500	0.2	3.9	2.0	8.8	1.2	5.0	12.3	1.7	7.0
500-520	0.0	6.6	3.3	1.9	0.0	1.0	10.3	3.4	6.8
520-540	0.0	6.6	3.3	6.0	0.1	3.0	8.1	4.3	6.2
540-560	0.0	14.5	7.2	4.9	1.4	3.2	8.4	4.0	6.2
560-580		20.2	20.2	16.8	2.1	9.4	7.8	0.8	4.3
580-600				4.8	5.7	5.2	3.9	3.4	3.6

Table 36.--Ammonium-N distribution in soil receiving spring application of 112 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	117 ppm	308 ppm	Avg. ppm	117 ppm	308 ppm	Avg. ppm	117 ppm	308 ppm	Avg. ppm
0-10	42.0	305.7	173.8	18.8	14.2	16.5	18.1	7.1	12.6
10-20	57.1	68.0	62.6	12.3	10.0	11.2	20.3	5.0	12.6
20-30	45.9	127.3	86.6	13.2	11.6	12.4	10.5	4.7	7.6
30-40	41.6	114.9	78.2	22.6	12.9	17.8	10.5	6.0	8.2
40-50	36.2	83.2	59.7	13.6	20.4	17.0	23.3	6.6	15.0
50-60	53.9	76.2	65.0	16.6	12.0	14.3	15.0	5.0	10.0
60-70	27.2	81.2	54.2	12.3	14.0	13.2	16.6	3.9	10.2
70-80	63.7	113.8	88.8	21.7	10.1	15.9	15.1	4.5	9.8
80-90	35.0	76.8	55.9	20.1	8.1	14.1	29.5	4.3	16.9
90-100	31.3	73.5	52.4	20.1	9.8	15.0	41.8	3.5	22.6
100-120	26.0	49.7	37.8	15.3	11.0	13.2	27.4	3.5	15.4
120-140	21.1	57.3	39.2	14.5	10.0	12.2	22.0	2.2	12.1
140-160	26.7	47.2	37.0	10.3	5.0	7.6	4.9	3.0	4.0
160-180	17.5	27.9	22.7	6.2	4.8	5.5	15.0	2.1	8.6
180-200	12.2	30.1	21.2	4.9	3.6	4.2	5.2	1.6	3.4
200-220	10.7	21.0	15.8	4.3	3.1	3.7	6.2	1.7	4.0
220-240	12.6	20.3	16.4	5.2	4.0	4.6	14.2	2.2	8.2
240-260	9.0	16.2	12.6	3.2	2.8	3.0	5.3	1.4	3.4
260-280	29.6	16.9	23.2	7.5	4.8	6.2	11.1	1.9	6.5
280-300	8.5	21.3	14.9	6.6	2.1	4.4	6.0	2.2	4.1
300-320	12.4	16.4	14.4	8.1	2.6	5.4	12.7	1.8	7.2
320-340	11.7	19.3	15.5	4.7	6.0	5.4	10.3	2.2	6.2
340-360	9.7	19.9	14.8	10.9	6.6	8.8	15.4	2.6	9.0
360-380	15.6	25.0	20.3	6.9	6.0	6.4	10.6	3.0	6.8
380-400	17.0	18.5	17.8	10.6	5.7	8.2	24.1	2.7	13.4
400-420	13.9	19.3	16.6	6.2	3.4	4.8	21.5	1.6	11.6
420-440	7.8	14.6	11.2	6.3	6.5	6.4	30.4	2.3	16.4
440-460	11.2	13.6	12.4	15.1	4.9	10.0	2.5	1.8	2.2
460-480	12.4	13.2	12.8	15.1	7.0	11.0	10.6	2.8	6.7
480-500	9.0	14.7	11.8	11.3	7.8	9.6	22.8	1.6	12.2
500-520	6.6	21.9	14.2	10.3	5.4	7.8	8.8	1.9	5.4
520-540	8.7	9.6	9.2	11.0	11.3	11.2	7.1	1.4	4.2
540-560	6.3	12.0	9.2	10.5	7.8	9.2	6.7	1.7	4.2
560-580		12.9	12.9	16.4	7.8	12.1	7.6	1.3	4.4
580-600				23.0	5.8	14.4	5.4	2.7	4.0

Table 37.--Nitrate-N distribution in soil receiving fall application of 224 kg N/ha (Pottawatomie County).

Depth cm	4-69			10-69			12-70		
	104 ppm	315 ppm	Avg. ppm	104 ppm	315 ppm	Avg. ppm	104 ppm	315 ppm	Avg. ppm
0-10	4.0	---	4.0	5.3	7.9	6.6	4.9	1.6	3.2
10-20	5.4	6.0	5.7	6.0	4.5	5.2	3.2	2.7	3.0
20-30	5.6	6.5	6.0	6.6	2.8	4.7	3.2	4.0	3.6
30-40	6.1	11.3	8.7	7.4	4.1	5.8	3.0	5.6	4.3
40-50	7.8	9.8	8.8	7.5	7.1	7.3	3.0	3.6	3.3
50-60	8.9	9.6	9.2	6.1	6.9	6.5	2.8	3.1	3.0
60-70	11.8	7.6	9.7	3.9	4.7	4.3	3.9	2.6	3.2
70-80	10.1	8.5	9.3	6.6	3.8	5.2	3.8	3.0	3.4
80-90	9.7	7.6	8.6	9.7	2.8	6.3	2.5	2.7	2.6
90-100	7.1	7.2	7.2	10.3	2.2	6.3	2.8	2.2	2.5
100-120	4.4	3.9	4.2	7.2	1.6	4.4	3.0	2.5	2.8
120-140	3.8	3.6	3.7	6.0	1.3	3.6	2.5	0.4	1.4
140-160	2.8	---	2.8	3.0	1.8	2.4	2.8	1.0	1.9
160-180	7.6	1.8	4.7	2.8	1.0	1.9	4.9	1.0	3.0
180-200	6.3	7.0	6.6	---	2.8	2.8	2.5	0.0	1.2
200-220	13.2	2.6	7.9	---	3.5	3.5	4.0	0.6	2.3
220-240	16.8	3.5	10.2	1.7	3.5	2.6	9.4	1.7	5.6
240-260	18.6	2.5	10.6	3.5	3.6	3.6	6.6	2.2	4.4
260-280	14.5	3.2	8.8	2.1	3.6	2.8	6.6	5.6	6.1
280-300	15.5	2.2	8.8	3.8	4.0	3.9	5.4	7.1	6.4
300-320	8.8	---	8.8	3.8	2.8	3.3	7.5	1.9	4.7
320-340	8.4	2.8	5.6	6.1	1.9	4.0	10.0	1.4	5.7
340-360	5.0	2.7	3.8	13.1	1.9	7.5	8.1	1.2	4.6
360-380	6.6	3.0	4.8	10.7	1.9	6.3	9.2	1.2	5.2
380-400	7.0	2.2	4.6	9.4	1.9	5.6	11.6	2.6	7.1
400-420	9.2	2.7	6.0	9.6	1.9	5.8	9.7	0.0	4.8
420-440	12.2	1.0	6.6	6.0	1.9	4.0	7.5	2.8	5.2
440-460	15.1	0.5	7.8	7.0	1.8	4.4	7.5	2.3	4.9
460-480	17.3	0.0	8.6	3.6	1.4	2.5	11.0	0.6	5.8
480-500	15.1	0.1	7.6	3.5	1.2	2.4	13.3	1.2	7.2
500-520	12.7	0.6	6.6	2.1	---	2.1	12.4	2.1	7.2
520-540	13.2	1.8	7.5	2.5	1.6	2.0	12.4	3.6	8.0
540-560	13.8	1.6	7.7	2.5	1.8	2.2	10.7	2.3	6.5
560-580		2.1	2.1	1.9	0.5	1.2	7.2	3.0	5.1
580-600		1.9	1.9	2.8	0.0	1.4	7.1	4.8	6.0

Table 38.--Ammonium-N distribution in soil receiving fall application of 224 kg N/ha (Pottawamie County).

Depth cm	4-69			12-69			12-70		
	104 ppm	315 ppm	Avg. ppm	104 ppm	315 ppm	Avg. ppm	104 ppm	315 ppm	Avg. ppm
0-10	55.0	---	55.0	9.6	11.4	10.5	11.8	6.7	9.2
10-20	32.3	40.6	36.4	5.7	7.8	6.8	9.3	6.9	8.1
20-30	41.4	34.7	38.0	6.1	15.1	10.6	6.1	7.1	6.6
30-40	36.0	56.4	46.2	7.2	11.9	9.6	7.1	8.4	7.8
40-50	33.2	47.3	40.2	4.7	14.9	9.8	9.4	6.0	7.7
50-60	47.7	46.4	47.0	4.7	8.4	6.6	10.0	4.9	7.4
60-70	53.6	45.9	49.8	9.8	20.1	15.0	10.7	6.1	8.4
70-80	43.9	37.0	40.4	6.6	13.8	10.2	7.5	4.9	6.2
80-90	45.8	28.2	37.0	5.0	16.2	10.6	7.1	4.1	5.6
90-100	33.8	31.8	32.8	5.4	11.9	8.6	10.3	5.2	7.8
100-120	26.9	14.9	20.9	5.2	9.4	7.3	8.8	3.9	6.4
120-140	24.6	22.9	23.8	4.4	7.8	6.1	6.1	1.9	4.0
140-160	17.5	---	17.5	3.1	5.6	4.4	6.5	3.0	4.8
160-180	14.0	9.2	11.6	2.5	6.6	4.6	7.1	1.9	4.5
180-200	18.5	21.1	19.8	---	7.9	7.9	4.0	1.3	2.6
200-220	11.8	10.2	11.0	---	7.0	7.0	4.1	2.6	3.4
220-240	10.2	12.4	11.3	1.3	10.3	5.8	6.7	1.7	4.2
240-260	9.4	11.2	11.8	1.7	7.2	4.4	4.8	1.7	3.2
260-280	10.0	13.3	11.6	2.6	8.8	5.7	3.6	1.2	2.4
280-300	8.0	17.5	12.8	1.6	6.3	4.0	4.4	1.6	3.0
300-320	13.5	---	13.5	13.1	8.8	11.0	4.3	1.8	3.0
320-340	10.7	17.6	14.2	11.5	8.8	10.2	8.0	2.7	5.4
340-360	14.4	18.4	16.4	12.5	5.6	9.0	3.9	3.8	3.8
360-380	11.1	17.2	14.2	10.9	7.2	9.0	3.8	2.2	3.0
380-400	18.1	12.9	15.5	16.6	12.3	14.4	4.0	2.3	3.2
400-420	13.8	19.7	16.8	23.9	8.8	16.4	5.3	0.0	2.6
420-440	17.6	16.6	17.1	37.4	14.7	26.0	9.3	1.7	5.5
440-460	10.2	12.9	11.6	13.6	17.2	15.4	9.3	2.7	6.0
460-480	12.4	10.0	11.2	3.1	13.6	8.4	5.7	0.9	3.3
480-500	12.9	14.0	13.4	4.0	9.3	6.6	7.4	1.3	4.4
500-520	13.8	11.0	12.4	3.4	---	3.4	6.5	1.6	4.0
520-540	13.3	19.4	16.4	2.7	9.1	5.9	7.4	3.0	5.2
540-560	13.7	18.9	16.3	2.6	6.1	4.4	8.1	1.3	4.7
560-580		12.9	12.9	2.2	7.1	4.6	6.0	2.7	4.4
580-600		11.8	11.8	10.2	2.8	6.5	5.8	2.5	4.2

Table 39.--Nitrate-N distribution in soil receiving spring application of 224 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	111 ppm	306 ppm	Avg. ppm	111 ppm	306 ppm	Avg. ppm	111 ppm	306 ppm	Avg. ppm
0-10	6.3	8.1	7.2	3.8	4.7	4.2	4.9	8.4	6.6
10-20	7.0	8.4	7.7	2.2	6.2	4.2	3.9	4.3	4.1
20-30	7.8	9.3	8.6	3.4	5.7	4.6	9.3	9.2	9.2
30-40	10.0	11.1	10.6	5.0	4.5	4.8	9.7	7.2	8.4
40-50	12.2	12.5	12.4	5.7	7.6	6.6	8.5	6.0	7.2
50-60	16.8	13.6	15.2	5.8	6.1	6.0	4.9	6.2	5.6
60-70	19.7	12.4	16.0	7.5	6.6	7.0	3.5	6.3	4.9
70-80	21.6	11.1	16.4	12.0	5.8	8.9	7.8	3.6	5.7
80-90	33.8	11.1	22.4	9.8	3.1	6.4	8.0	1.4	4.7
90-100	53.2	11.5	32.4	6.0	4.4	5.2	5.3	4.5	4.9
100-120	50.1	8.3	29.2	4.8	9.3	7.0	1.6	4.9	3.2
120-140	38.2	6.0	22.1	4.4	16.3	10.4	2.3	9.2	5.8
140-160	19.2	4.0	11.6	4.3	6.7	5.5	2.6	21.1	11.8
160-180	14.6	2.6	8.6	0.5	7.0	3.8	1.8	10.7	6.2
180-200	10.7	6.9	8.8	6.2	4.4	5.3	3.4	12.0	7.7
200-220	7.0	6.3	6.6	1.6	1.2	1.4	6.6	1.7	4.2
220-240	8.3	2.2	5.8	5.6	6.0	5.8	4.5	11.6	8.0
240-260	7.3	1.2	4.2	10.6	2.3	6.4	5.2	1.0	3.1
260-280	6.1	2.1	4.1	8.9	5.7	7.3	6.7	2.1	4.4
280-300	2.9	2.6	2.8	9.7	6.5	8.1	3.6	7.8	5.7
300-320	3.4	2.5	2.4	2.7	7.9	5.3	1.8	6.5	4.2
320-340	3.9	3.1	3.5	2.7	7.5	5.1	4.5	6.3	5.4
340-360	2.4	2.5	2.4	4.7	8.3	6.5	5.3	6.7	6.0
360-380	1.5	2.8	2.2	2.5	3.1	2.8	6.0	7.2	6.6
380-400	0.2	4.9	2.6	2.1	2.7	2.4	3.5	6.6	5.0
400-420	0.0	5.3	2.6	5.7	2.1	3.9	2.1	7.0	4.6
420-440	0.0	5.4	4.2	5.4	3.1	4.2	2.8	6.6	4.7
440-460	3.9	2.2	6.6	5.7	1.8	3.8	0.5	5.0	2.8
460-480	3.2	4.3	13.8	2.1	4.7	3.4	1.0	3.8	2.4
480-500	6.6	6.0	6.3	2.8	7.0	4.9	0.0	1.7	0.8
500-520	9.0	9.6	9.3	2.2	9.8	6.0	9.6	2.5	6.0
520-540	12.2	12.3	12.2	5.0	8.5	6.8	9.1	3.1	6.1
540-560	14.1	11.1	12.6	4.0	12.2	8.1	5.6	0.0	2.8
560-580	16.5	14.1	15.3	6.0	2.3	4.2	6.3	0.0	3.2
580-600	----	15.5	15.5	7.2	4.1	5.6	---	0.0	0.0

Table 40.--Ammonium-N distribution in soil receiving spring application of 224 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	111 ppm	306 ppm	Avg. ppm	111 ppm	306 ppm	Avg. ppm	111 ppm	306 ppm	Avg. ppm
0-10	43.0	118.9	81.0	19.5	33.6	26.6	11.4	7.1	9.2
10-20	45.0	111.4	78.2	14.5	10.6	12.6	10.9	6.0	8.4
20-30	52.5	108.5	80.5	24.1	12.4	18.2	9.8	6.5	8.2
30-40	43.5	151.9	97.7	14.0	12.8	13.4	8.8	4.4	6.6
40-50	62.9	97.8	80.4	9.8	16.0	12.9	8.0	4.9	6.4
50-60	62.2	144.4	103.3	13.1	11.5	12.3	5.2	5.2	5.2
60-70	49.8	116.9	83.4	11.8	15.5	13.6	3.6	4.9	4.2
70-80	37.9	68.3	53.1	12.8	20.8	16.8	6.1	5.2	5.6
80-90	35.2	92.4	63.8	11.8	13.6	12.7	8.8	4.3	6.6
90-100	43.0	95.0	79.0	18.2	14.2	16.2	2.8	4.9	3.8
100-120	32.1	79.6	55.8	10.0	6.1	8.0	6.5	4.3	5.4
120-140	41.1	74.0	57.6	10.2	7.1	8.6	4.4	4.0	4.2
140-160	23.6	38.2	30.9	6.3	7.0	6.6	4.7	3.1	3.9
160-180	24.8	32.3	28.6	7.4	7.9	7.6	4.5	3.0	3.8
180-200	13.9	43.9	28.9	15.0	10.2	12.6	4.4	3.0	3.7
200-220	14.1	43.6	28.8	9.8	10.6	10.2	3.4	0.0	1.7
220-240	20.2	20.7	20.4	7.9	5.0	6.4	4.9	0.4	2.6
240-260	18.7	18.0	18.4	3.4	5.7	4.6	2.8	0.1	1.4
260-280	12.6	25.2	18.9	4.8	7.0	5.9	1.7	0.9	1.3
280-300	11.4	25.6	18.5	7.0	4.6	6.3	0.6	3.2	1.9
300-320	10.0	19.9	15.5	3.6	5.7	4.6	3.1	2.1	2.6
320-340	12.4	28.2	20.3	6.2	5.2	5.7	5.0	4.0	4.5
340-360	13.4	23.9	18.6	4.4	3.9	4.2	4.4	3.4	3.9
360-380	11.7	32.2	22.0	1.2	4.9	3.0	3.6	3.6	3.6
380-400	14.6	30.0	22.3	6.0	7.6	6.8	2.8	4.3	3.6
400-420	19.4	24.1	21.8	11.0	8.9	10.0	2.8	4.0	3.4
420-440	19.4	29.0	24.2	13.1	9.2	11.2	0.8	3.4	2.1
440-460	11.7	24.7	18.2	16.6	6.0	11.3	1.6	1.9	1.8
460-480	8.5	17.6	13.0	9.3	8.0	8.6	1.8	4.7	3.2
480-500	13.9	11.8	12.8	9.3	10.6	10.0	0.0	3.0	1.5
500-520	14.6	6.2	10.4	8.8	7.6	8.2	4.5	2.8	3.6
520-540	9.7	20.1	14.9	13.5	6.3	9.9	3.9	2.1	3.0
540-560	9.0	17.3	13.2	12.0	9.4	10.7	4.3	0.4	2.4
560-580	10.9	25.2	18.0	11.1	7.6	9.4	3.0	0.8	1.9
580-600		23.4	23.4	10.9	7.6	9.2		0.6	0.6

Table 41.--Nitrate-N distribution in soil receiving fall application of 448 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	107 ppm	303 ppm	Avg. ppm	107 ppm	303 ppm	Avg. ppm	107 ppm	303 ppm	Avg. ppm
0-10	7.5	12.9	10.2	6.1	4.3	5.2	11.0	5.2	8.1
10-20	6.8	12.2	9.5	12.7	5.8	9.2	6.1	6.3	6.2
20-30	10.2	6.6	8.4	12.6	4.0	7.3	5.7	4.3	5.0
30-40	7.8	8.1	8.0	12.7	3.1	7.9	4.9	4.8	4.8
40-50	7.8	10.6	9.2	11.4	6.6	9.0	3.6	4.9	4.2
50-60	9.5	9.6	9.6	9.4	5.3	7.4	5.6	5.2	5.4
60-70	11.7	10.0	10.8	12.3	6.0	9.2	3.1	3.9	3.5
70-80	13.6	8.0	10.8	8.4	5.7	7.0	3.2	3.2	3.2
80-90	10.9	7.4	9.2	8.7	5.2	7.0	2.3	5.0	3.6
90-100	12.2	7.4	9.8	5.6	4.8	5.2	2.3	2.3	2.3
100-120	12.2	3.5	7.8	12.3	6.2	9.2	0.6	1.9	1.2
120-140	9.7	3.5	6.6	23.3	4.9	14.1	1.9	1.8	1.8
140-160	6.3	2.1	4.2	18.8	6.7	12.8	1.0	2.5	1.8
160-180	5.8	3.0	4.4	3.9	8.1	6.0	0.6	1.6	1.1
180-200	4.9	2.6	3.8	8.0	7.1	7.6	1.3	1.3	1.3
200-220	18.7	3.2	11.0	7.5	3.4	5.4	1.3	0.6	1.0
220-240	20.7	5.8	13.2	7.0	4.1	5.6	1.0	1.9	1.4
240-260	19.4	9.4	14.4	5.0	3.2	4.1	2.3	5.4	3.8
260-280	22.1	18.0	20.0	6.1	0.5	3.3	10.7	11.6	11.2
280-300	17.7	19.9	18.8	4.8	2.5	3.6	9.4	10.7	10.0
300-320	11.9	4.4	8.2	4.7	0.9	2.8	19.7	7.6	13.6
320-340	9.5	4.0	6.8	3.6	1.8	2.7	17.1	6.5	11.8
340-360	4.6	5.0	4.8	3.5	1.8	2.6	15.5	10.0	12.8
360-380	5.8	3.4	4.6	7.4	0.8	4.1	15.5	8.4	12.0
380-400	7.5	1.7	4.6	5.0	1.2	3.1	7.9	7.2	7.6
400-420	6.8	2.6	4.7	6.0	3.1	4.6	2.2	6.0	4.1
420-440	2.4	---	2.4	8.0	1.0	4.5	4.0	0.0	2.0
440-460	4.9	2.6	3.8	9.4	1.8	5.6	8.1	0.1	4.1
460-480	7.0	6.2	6.6	8.5	0.5	4.5	8.4	0.9	4.6
480-500	15.8	10.5	13.2	6.7	0.5	3.6	7.1	0.8	3.9
500-520	19.0	4.1	11.6	---	1.3	1.3	4.5	1.4	3.0
520-540	20.7	11.1	15.9	8.9	0.8	4.8	3.5	1.0	2.2
540-560	21.6	9.4	15.5	---	2.2	2.2	2.3	1.2	1.8
560-580	11.4		11.4	8.1	2.3	5.2	0.6	1.6	1.1
580-600				5.8	1.2	3.5	1.9	---	1.9

Table 42.---Ammonium-N distribution in soil receiving fall application of 448 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	107 ppm	303 ppm	Avg. ppm	107 ppm	303 ppm	Avg. ppm	107 ppm	303 ppm	Avg. ppm
0-10	48.8	306.2	177.5	97.4	15.0	56.2	10.0	10.3	10.2
10-20	40.3	396.7	218.5	81.6	10.0	45.8	7.5	5.4	6.4
20-30	46.4	46.3	46.4	64.8	9.4	37.1	8.8	5.2	7.0
30-40	26.2	51.1	38.6	86.8	9.4	48.1	6.3	5.4	5.8
40-50	32.1	55.5	43.8	93.5	17.2	55.4	6.9	5.8	6.4
50-60	28.9	34.8	31.8	122.8	12.5	67.6	8.3	5.8	7.0
60-70	28.2	57.2	42.7	84.2	11.6	47.9	6.5	4.9	5.7
70-80	33.5	45.0	39.2	154.5	11.6	83.0	4.5	3.9	4.2
80-90	27.9	43.2	35.6	71.3	12.4	41.8	6.2	5.2	5.7
90-100	35.7	60.4	48.0	110.7	16.6	63.6	3.6	2.7	3.2
100-120	28.4	40.1	34.2	61.6	6.5	34.0	3.6	4.7	4.2
120-140	25.8	25.1	25.4	71.0	7.1	39.0	3.9	3.4	3.6
140-160	18.7	21.3	20.0	48.5	16.9	32.7	2.2	3.6	2.9
160-180	11.9	19.8	15.8	30.1	8.0	19.0	2.3	2.2	2.2
180-200	8.5	15.9	12.2	42.2	6.2	24.2	2.7	2.6	2.6
200-220	9.7	11.9	10.8	22.1	4.5	13.3	1.0	1.4	1.2
220-240	10.7	16.2	13.4	45.8	5.7	25.8	13.6	1.6	7.6
240-260	6.1	21.7	13.9	41.0	5.3	23.2	9.1	1.4	5.2
260-280	7.5	16.9	12.2	26.3	5.6	16.0	10.3	1.6	6.0
280-300	6.3	11.6	9.0	29.2	5.6	17.4	7.9	1.0	4.4
300-320	7.3	18.0	12.6	15.7	4.3	10.0	8.1	1.3	4.7
320-340	5.3	19.1	12.2	15.1	6.6	10.8	10.3	3.0	6.6
340-360	17.0	16.4	16.7	9.8	4.5	7.2	6.3	2.1	4.2
360-380	4.6	14.6	9.6	15.8	4.5	10.2	8.1	2.6	5.4
380-400	27.2	9.6	18.4	19.4	3.8	11.6	9.1	2.8	6.0
400-420	12.6	9.8	11.2	19.5	4.9	12.2	14.9	2.6	8.8
420-440	8.5	---	8.5	42.9	11.6	27.2	14.9	0.9	7.9
440-460	19.9	12.0	16.0	29.1	4.9	17.0	16.3	0.5	8.4
460-480	13.1	12.3	12.7	25.1	9.8	17.4	8.3	0.9	4.6
480-500	8.3	10.3	9.3	11.6	9.4	10.5	7.5	1.4	4.4
500-520	11.4	24.2	17.8	---	8.1	8.1	4.9	0.8	2.8
520-540	12.4	18.6	15.5	16.3	4.1	10.2	2.2	0.9	1.6
540-560	11.2	40.9	26.0	---	6.7	6.7	2.8	1.6	2.2
560-580	14.3		14.3	16.7	5.2	11.0	3.4	0.9	2.2
580-600				21.2	7.5	14.4	4.0		4.0

Table 43.--Nitrate-N distribution in soil receiving spring application of 448 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	119 ppm	301 ppm	Avg. ppm	119 ppm	301 ppm	Avg. ppm	119 ppm	301 ppm	Avg. ppm
0-10	3.3	6.0	5.6	4.5	3.5	4.0	5.8	10.3	8.0
10-20	6.2	7.3	6.8	3.2	3.0	3.1	3.2	6.1	4.6
20-30	2.9	6.6	4.8	5.8	3.8	4.8	4.3	3.5	3.9
30-40	4.7	7.3	6.0	2.3	3.8	3.0	2.6	5.7	4.2
40-50	4.0	6.2	5.1	5.2	4.9	5.0	3.2	4.1	3.6
50-60	9.1	8.4	8.8	16.8	17.7	17.2	6.2	6.0	6.1
60-70	8.4	7.3	7.8	45.9	25.5	35.7	9.7	4.1	6.9
70-80	10.6	8.0	9.3	42.7	8.8	25.8	12.3	4.0	8.2
80-90	8.0	7.3	7.6	13.8	19.1	16.4	17.6	2.3	10.0
90-100	9.1	9.8	9.4	7.4	13.2	10.3	23.0	2.1	12.6
100-120	10.6	5.1	7.8	4.0	8.0	6.0	58.0	1.6	29.8
120-140	16.0	4.7	10.4	4.4	6.2	5.3	69.5	2.5	36.0
140-160	13.5	3.3	8.4	2.3	3.1	2.7	28.5	2.3	15.4
160-180	8.7	4.7	6.7	2.8	4.0	3.4	20.7	2.2	11.4
180-200	4.0	8.0	6.0	4.4	3.8	4.1	2.6	1.9	2.2
200-220	0.7	4.7	2.7	7.0	3.1	5.1	12.0	8.7	10.4
220-240	0.7	8.0	4.4	2.6	5.7	4.2	7.0	10.7	8.8
240-260	0.7	6.6	3.6	16.7	5.0	10.8	4.8	33.0	18.9
260-280	0.0	1.8	0.9	10.1	3.5	6.8	14.4	19.9	17.2
280-300	1.1	1.5	1.3	4.0	8.0	6.0	6.3	20.1	13.2
300-320	2.5	2.2	2.4	3.0	7.6	5.3	6.5	17.7	12.1
320-340	4.0	4.5	4.2	---	2.8	2.8	12.9	16.6	14.8
340-360	2.9	---	2.9	11.6	6.2	8.9	9.4	4.1	6.8
360-380	9.1	6.9	8.0	6.5	3.1	4.8	8.4	6.2	7.3
380-400	12.7	7.9	10.3	---	3.9	3.9	5.3	3.2	4.2
400-420	15.7	8.1	11.9	---	1.8	1.8	7.1	4.3	5.7
420-440	3.6	13.1	7.4	---	1.8	1.8	7.4	6.1	6.8
440-460	3.6	9.8	6.7	12.2	1.6	6.9	4.9	4.1	4.5
460-480	3.6	6.2	4.9	8.4	1.8	5.1	6.5	0.9	3.7
480-500	4.0	6.5	5.2	---	0.3	0.3	9.7	1.0	5.4
500-520	2.2	9.8	6.0	---	0.6	0.6	7.8	1.9	4.8
520-540	1.8	7.9	4.8	7.9	0.6	4.2	10.2	3.0	6.6
540-560	1.1	7.5	4.3	7.5	0.9	4.2	8.4	3.2	5.8
560-580	0.4	10.2	5.3	5.0	2.3	3.6	3.0	4.4	3.7
580-600		13.8	13.8	3.9		3.9	1.2	1.6	1.4

Table 44.---Ammonium-N distribution in soil receiving spring application of 448 kg N/ha (Pottawatomie County).

Depth cm	4-69			12-69			12-70		
	119	301	Avg.	119	301	Avg.	119	301	Avg.
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
0-10	36.0	33.9	185.4	16.8	18.5	17.6	13.8	8.4	11.1
10-20	44.4	21.8	33.1	11.0	11.9	11.4	18.8	5.2	12.0
20-30	50.2	63.3	56.8	11.6	8.9	10.2	17.5	4.3	10.9
30-40	30.2	60.1	45.2	16.2	11.3	13.8	16.6	5.0	10.8
40-50	33.1	38.9	36.0	14.0	10.0	12.0	14.4	4.9	9.6
50-60	41.1	44.8	43.0	10.3	10.6	10.4	15.3	4.9	10.1
60-70	43.0	32.4	37.7	17.2	12.9	15.0	16.8	4.5	10.6
70-80	38.9	33.1	36.0	7.2	9.4	8.3	15.1	4.9	10.0
80-90	26.6	32.8	29.7	12.9	14.7	13.8	12.7	3.9	8.3
90-100	29.5	30.2	29.8	14.2	12.8	13.5	19.0	4.1	11.6
100-120	20.0	31.3	25.6	9.4	17.2	13.3	14.6	3.2	8.9
120-140	21.8	14.9	18.4	4.9	9.4	7.2	19.1	3.6	11.4
140-160	13.8	21.5	17.6	7.1	4.9	6.0	6.6	4.0	5.3
160-180	12.7	14.9	13.8	7.4	5.4	6.4	7.8	2.5	5.2
180-200	14.2	17.8	16.0	7.5	11.9	9.7	3.5	1.7	2.6
200-220	2.9	11.3	7.1	6.5	7.0	6.8	4.9	1.6	3.2
220-240	16.4	15.7	16.0	5.2	9.3	7.2	5.8	1.9	3.8
240-260	10.2	17.1	13.6	4.7	6.1	5.4	3.6	2.5	3.0
260-280	5.8	14.9	10.4	7.0	3.5	5.2	7.1	2.3	4.7
280-300	4.4	12.4	8.4	6.5	6.3	6.4	8.1	1.3	4.7
300-320	7.6	15.3	11.4	4.8	6.1	5.4	3.9	3.0	3.4
320-340	7.6	15.0	11.3	---	7.1	7.1	4.3	28.2	16.2
340-360	6.6	---	6.6	8.3	5.4	6.8	6.5	2.3	4.4
360-380	7.6	14.6	11.1	12.3	6.7	9.5	6.3	4.5	5.4
380-400	17.8	13.7	15.8	---	8.4	8.4	4.3	1.6	3.0
400-420	20.4	14.9	17.6	---	7.8	7.8	10.0	2.6	6.3
420-440	5.8	13.8	9.8	---	11.0	11.0	13.2	2.6	7.9
440-460	9.1	15.2	12.6	17.3	9.2	13.2	9.7	2.6	6.2
460-480	9.5	8.8	9.2	14.4	7.4	10.9	8.0	0.9	4.4
480-500	6.9	8.8	7.8	---	10.6	10.6	8.4	1.3	4.8
500-520	8.4	12.5	10.4	---	5.6	5.6	9.3	1.7	5.5
520-540	5.1	13.3	9.2	10.7	8.4	9.6	6.5	1.9	4.2
540-560	7.6	14.4	11.0	17.5	12.5	15.0	7.1	1.9	4.5
560-580	8.7	11.3	10.0	11.6	12.2	11.9	1.0	1.9	1.4
580-600		20.4	20.4	22.5		22.5	1.2	1.9	1.6

ACKNOWLEDGEMENTS

The author would like to express his appreciation to Dr. Larry S. Murphy, major professor, for the suggestion of this problem and the guidance and advice administered throughout this course of study.

Special gratitude is expressed to Phillips Petroleum Company for partial financial support in this work. The project was funded also as a part of North Central Regional Project NC-98, Nutrient Enrichment of Water by Soils and Sediment.

Sincere thanks are also extended to Dr. D. Robinson and Messers. P. Gallagher, L. Meyer, G. Wallingford, J. Armbruster, R. Voth, D. Knox and others, who in one way or another, have given assistance in the execution of this study.

NITRATE ACCUMULATION IN SOILS AND WATER
AS AFFECTED BY NITROGEN FERTILIZATION

by

CHARLES WINSETT KNIGHT

B. S., Kansas State University, 1970

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Agronomy

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1971

An investigation was conducted at three sites in Kansas to study the possible movement of fertilizer nitrates into surface and subsurface water supplies. Experimental sites were selected on porous, irrigated soils which appeared to be optimum for fertilizer nitrogen movement. Information was sought on the rate, quantity and method of nitrate movement in the soil. Nitrate accumulation was studied in irrigation runoff water, ground water and in deep soil cores collected from the study areas.

Quantity of residual nitrate in the soil was found to be quite varied between sampling dates. Under heavy nitrogen fertilization and irrigated conditions, soil nitrate accumulations were not large.

Ground water samples from beneath both control and heavily fertilized areas were periodically sampled to detect nitrate accumulations in ground water as affected by nitrogen fertilization. More nitrate was found in the ground water beneath the fertilized areas than beneath control areas. However, nitrate variations were too great to determine long-range trends from this study.

Irrigation tail-water appeared to contain very little nitrate. Tail-water from control plots was not significantly different from that of fertilized plots after the first 1 1/2 hour of the initial irrigation following application.

Data collected suggested that fertilizer nitrates may reach ground water sources under excessive rates of nitrogen fertilization coupled with irrigation on permeable soils. However, the data reported in this study did not suggest that the rate of accumulation is rapid nor was the accumulation consistent. A definite trend upward in the nitrate content of ground water was detected at a site in Riley County.