EFFECTS OF VARIOUS RATES OF ORGANIC AND INORGANIC FERTILIZERS ON REED CANARYGRASS

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by

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Dedicated to a Dear Friend

John M. Henderson

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ABSTRACT

High rates of beef and swine manure, up to 672 kg N/ha, were applied to two Manitoba soils growing reed canarygrass and the results were compared to reed canarygrass grown under similar conditions but fertilized with an inorganic fertilizer. There were no harmful effects on either the sand or clay soil studied in terms of high nitrate-nitrogen or conductivity. Yields of the reed canarygrass exceeded 10 MT/ha on the clay soil and 9 MT/ha on the sand soil. Crude protein levels averaged 19.64% on the clay and 16.27% on the sand. Toxic levels (0.30%) of nitrate-nitrogen of total nitrate in the plant tissue were not a problem when beef or swine manure was applied but high rates of the inorganic fertilizer did result in potentially toxic levels of nitrate. No mineral deficiencies were apparent in the reed canarygrass in any of the treatments.

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I. INTRODUCTION

The animal industry in agriculture especially in North America, South America and Europe, finds itself under greater pressure each year from a growing population to produce increasing quantities of beef, swine and poultry products. In order to keep up with such demand, confinement and rearing of these animals in smaller areas has resulted.

Confinement animal operations, either open or closed, can strain the environment through air, soil and water pollution. A steer will produce 18 to 26 kg of manure per day or the equivalent waste of eleven people. An open confined feedlot of thirty thousand head is not uncommon today and plans are near completion for feedlots with a capacity of one hundred thousand head. The amount of manure produced, in even the smaller feedlots is staggering.

Many feedlots and swine operations do not have adequate land space available for application of the manure produced. This has resulted in stockpiling the manure on the land that is available. This practice has given rise to high nitrate levels in soils and water and odors that have carried for great distances making life unpleasant for surrounding neighbours. Because of the extent of environmental contamination from such agricultural practices, government agencies are now trying to legislate against the stockpiling of manure.

Such restrictive laws have posed another problem for the animal producer and that is how to handle the manure without spoiling the environment or coming in conflict with the authorities. New techniques such as lagoons, oxidation ponds, and oxidation ditches have proven successful to a point but the fact remains; the most economical and best biological method for handling manure is still land disposal.

It has been the belief in agricultural circles in past years that too much manure will decrease yield and crude protein content while at the same time increase the nitrate content of forage crops to a point where nitrate toxicity is a factor. Research in waste management is increasing each year not only to prove new theories and techniques of manure disposal but also to determine just how much manure the land will handle before an environmental problem arises.

The problem of available land for manure disposal, in Canada has not become the problem it has in the United States mainly because of the smaller human population and the greater area. However, as Canada's agricultural industry expands and as urban sprawl gradually takes over agricultural land for residential purposes, available land will have higher priorities than manure disposal.

Such a land use problem is becoming apparent in Manitoba. Studies in heavy manure application rates on Manitoba soils are almost nil. From this fact rises the purpose of this thesis. Various rates of beef and swine manure were applied to reed canarygrass and compared with the results obtained from growing reed canarygrass with a commercial fertilizer. Reed canarygrass was studied because it is already a known fact that forage crops will incorporate more nitrogen than other agricultural crops plus the fact that reed canarygrass utilizes more nitrogen than many other forage crops. Reed canarygrass is known for its ability to withstand extensive flooding for extended periods of time without loss of stand but it is also drought resistant which enables it to adapt to several field conditions thereby making it a much valued hay crop for intensified forage production.

Also studied in this experiment were the effects of these organic and inorganic fertilizers on two Manitoba soils, a clay and a sand, thereby hoping to provide a range of results to encompass various clay-sand soil types. It is hoped that the results obtained may be used in developing guidelines for the application of heavy rates of livestock waste on Manitoba soils.

II. LITERATURE REVIEW

Intensive forage production requires a high degree of nitrogen fertilization and as a result, a great deal of literature is available on the various effects of nitrogen fertilization (mainly commercial fertilizer) on all of the forage species grown. In the following review, only a short time will be given to pertinent aspects of nitrogen fertilization of forages in order to provide an adequate knowledge of the general rule of behaviour of forages when fertilized with nitrogen. From this, a more detailed review will be given on the studies and behaviour of reed canarygrass under heavy nitrogen fertilization. The third section of the review will deal with the environmental effects of application of animal manure on crops and soils under practical field conditions.

Nitrogen fertilization will increase dry matter (DM) yield and crude protein (CP) content; the higher the rate of fertilization the greater the crude protein content and the higher the dry matter production. Ramage et al. (54) fertilized various forages with rates ranging from 55 to 448 kg N/ha and found the average yields of each rate increased from 6949 kg DM/ha to 10,332 kg DM/ha as the rate of nitrogen increased. The report on crude protein in this experiment is that all rates averaged 16.5% (2.64% nitrogen).

In an experiment studying crude protein Reid et al. (57) increased the rate of nitrogen fertilization from 0 to 448 kg N/ha. Crude protein values increased with each increase in nitrogen from 11.6 to 20.0% in the first cut and 9.4 to 13.0% in the aftermath cut of hay.

In two separate experiments conducted by Woelfel and Poulton (52, 76) on timothy, yields increased from 790 lbs DM/acre at the zero level of nitrogen application to 2060, 2383, and 2517 lbs DM/acre at the 50, 100 and 200 lb N/acre rate respectively on first cut timothy in the first experiment and 528, 1337, 1487, and 1528 lbs DM/acre respectively on aftermath timothy in the second experiment. The same kind of results were obtained for crude protein. Values in the first experiment were 111, 327, 452, and 521 lbs CP/acre and 69, 200, 307 and 390 lbs CP/acre in the second experiment for 0, 50, 100, 200 lbs N/acre respectively.

A greater concern when fertilizing forage crops with heavy rates of nitrogen is the amount of nitrate the crop will assimilate. Forage is noted for assimilating high levels of nitrate (NO_3^-) although according to Crawford et al. (15), not as much as annual crops such as wheat and oats. Murphy and Smith (46) in Missouri, classified sudangrass and orchardgrass as accumulators of exceptionally large amounts of nitrate-nitrogen (NO_3-N). Tall fescue, bromegrass, timothy, and bluegrass all accumulated less NO_3-N than did orchardgrass. Ryan et al. (58) added tall fescue to the list of perennial species that accumulate high levels of

NO_3-N in Iowa. Tall fescue and orchardgrass accumulated more than NO_3-N than smooth bromegrass or reed canarygrass.

Nitrate in the plant behaves the same way CP levels and DM yields do in that concentrations increase with increasing rates of nitrogen and decline after each cutting and as the plant matures (22, 46, 57). High nitrate concentrations in forage are a threat to farm livestock especially ruminants because the intestinal bacteria of ruminants converts the nitrate to nitrite (NO_2^-) which in turn causes methemoglobinemia resulting in death by asphyxiation (35, 61, 63, 70). Schipper and Alstad (61) also state that the presence of nitrite interferes with the conversion of the precursors of vitamin A (carotene), so that vitamin A deficiency is often part of the complex of symptoms observed. There is also some evidence that vitamin E is destroyed by nitrate consumption.

Much research has been done on the cause and effects of nitrate toxicity. One of the main issues of debate has centered on the level of nitrate in the feed that the animal can ingest without succumbing to toxic effects. Thomas and Willemsen (68) fed dairy heifers ryegrass and wilted silage containing 3.63% NO_3 and 1.3% NO_3 respectively without it resulting in nitrate poisoning. Contradicting the aforementioned levels, George et al. (23) studied timothy, smooth bromegrass, and orchardgrass and concluded that a level of 0.15% NO_3-N in the feed was potentially toxic.

Hanway et al. (25) concluded that livestock would suffer nitrate poisoning if the NO_3-N level exceeded 0.3% on a dry weight basis. This finding is supported by Wright and

Davison (77) who regarded levels of 0.34 to 0.45% NO_3-N in the feed as potentially toxic.

The two aforementioned studies are indirectly supported by Sinclair and Jones (63) whose study with sheep showed that while a dose of 50 g. of potassium nitrate into the rumen induced methemoglobinemia, adapted animals showed no adverse effects from consuming dried grass containing 0.5% NO_3-N over a period of weeks; only a slight increase in the nitrate level for such a long term of adaptation.

Reed canarygrass has long been studied, especially in the area of response to nitrogen fertilization with regard to DM production, CP content, nitrate accumulation, growth, and palatability.

One of the earliest studies on reed canarygrass was made by Wilkins and Hughes (75). Reed canarygrass was compared to timothy and bromegrass and was the only one to yield on the average greater than 2000 lbs. of dry matter per year over a period of four years. It also outyielded the other species in a drought year.

Reed canarygrass is one of the many forage grasses that is known for its response to nitrogen fertilization (45, 49, 60). Bonin and Tomlin (6) fertilized reed canarygrass with 0, 56, 112, and 224 kg N/ha and had significant yield increases at each successively higher rate of nitrogen. Reed canarygrass produced more aftermath hay than did timothy especially at the highest rate of nitrogen application (224 kg N/ha). In an experiment conducted by Mason and Miltimore (42), an application rate of only 112 kg N/ha doubled the yield of reed canarygrass and sedge over that of the control. Ramage et al. (55) fertilized reed canarygrass with 0 to 400 lbs N/acre. Over a period of three years, DM yield ranged from 4991 lbs/acre to 9319 lbs/acre. Orchardgrass test results were in between the figures for reed canarygrass. Yields of orchardgrass were higher at the lower rates of nitrogen but lower when nitrogen was applied at 400 lbs/acre. Dean and Clark (17) applied up to 672 kg N/ha on reed canarygrass. Yields increased from 2000 kg/ha at the zero level to 8000 kg/ha when the application rate was 672 kg N/ha. Johnson and Nichols (30) compared eleven grasses. Reed canarygrass yields were just behind those of tall wheatgrass when the plots were unfertilized and outyielded all other grasses in DM production when the plots were fertilized with 100 lbs N/acre. Decker et al. (18) also compared reed canarygrass to other species. Yields of 5 to 6 tons/acre were recorded when reed canarygrass was fertilized at 400 lbs N/acre although it is noted these yields were greatly affected by precipitation. Also the aftermath yield of reed canarygrass in mid-season was high compared to the other species. In a study comparing reed canarygrass and bromegrass, Marten and Donker (41) found that 157 kg N/ha doubled the yield of reed canarygrass over the control. The reed canarygrass also had a greater carrying capacity than did bromegrass and this led to increased heifer gains per hectare.

As stated earlier, CP levels usually increase with increasing rates of nitrogen (5, 49). Unfertilized reed canarygrass averages a CP content of 10 to 14% (29). Crude protein of fertilized reed canarygrass increase quite significantly. Chalupa et al. (13) reported CP levels of 21.64% at the 200 lbs N/acre rate which was superior to alfalfa at 18.1%. Dean and Clark (17) reported CP levels of more than 20% at the highest level of nitrogen fertilization (672 kg N/ha). Johnson and Nichols (30) stated that reed canarygrass was highest in crude protein, DM yield, and persistance of the eleven grasses they tested while Duell (20) reported reed canarygrass to contain the highest mean CP percent when compared to orchardgrass and Kentucky bluegrass over a period of three years.

Although previously stated that DM yield and crude protein both increased with increasing rates of nitrogen, it is am important fact to note that DM yields and crude protein increase in a linear fashion only to a certain point and then fall off. Dean and Clark (17) found both DM yield and crude protein to increase in a linear fashion up to 336 kg N/ha and then fall off although this response was more pronounced for DM yield. Ramage et al. (55) noted this fall-off response in DM yield in reed canarygrass after 300 lbs N/acre whereas CP levels fell off after application rates exceeded 400 lbs N/acre. Similar findings on DM yields were reported by Armitage and Templeman (4) for ryegrass in England while Dotzenko (19) found the fall-off response at lower rates between 160 and 320 lbs N/acre on six grasses grown under irrigation and Carter and Scholl (11) reported the fall-off response at an even lower range of 120 to 240 lbs N/acre in orchardgrass and bromegrass. Brockman (8) obtained a linear response in perennial ryegrass up to 320 lbs N/acre. In the case of crude protein many workers (12, 20, 27, 53) support the findings of Ramage et al. (55) and Armitage and Templeman (4) of a linear increase to a higher level of nitrogen before the fall-off response occurred. Duell (20) reported that CP linearly increased to a level of 640 lbs N/acre.

The height at which reed canarygrass is cut can greatly affect both DM yield and CP content. Lawrence and Ashford (33) found that DM yield decreased with increasing heights of cutting and increased with advancing maturity at the time of taking the initial harvest. The highest yields were obtained from all species studied when cut at a height of 3.8 cm during the seed stage of development. Davis (16) studied clipping heights from 1 to 5 inches on reed canarygrass. The plants were allowed to grow 10 inches in height before being cut. One or more clippings were obtained from the 3 inch stubble and two or more clippings from the 4 to 5 inch stubble than were obtained from the 1 to 2 inch stubble. As the height of the stubble increased, the number of days needed to grow 10 inches of regrowth decreased. The number of tillers and DM yield were significantly higher in the 4 to 5 inch stubble than any of the others. Cutting at this particular height offset the harmful effects of frequent defoliation by leaving enough active photosynthetic tissue to meet the needs of the plants for carbohydrates. These results are in agreement with the findings of Brougham (9) with respect to the relation of rate of grass regrowth to defoliation and photosynthetic activity. Lawrence et al. (34) studied the effect of the height of cutting on crude protein in intermediate wheatgrass, bromegrass and reed canarygrass. Although intermediate wheatgrass was recommended because of its higher DM yield, reed canarygrass CP levels were significantly higher than the other two grasses over a period of four years. As the height of cutting increased CP content increased. However, CP yield decreased as the height of cutting increased with the highest CP yield occurring at a height of 3.8 cm (640 kg CP/ha).

Reed canarygrass has proven valuable as a fall-saved pasture (10, 72, 73), that is, extending the grazing season into fall. Wedin et al. (73) defines the term "fall saving of pasture" as the growth accumulated from early August to late October and made available for grazing in late October, November and December. Reed canarygrass was found to extend the grazing season eight weeks or more over other grasses in previous experiments.

The last aspect of reed canarygrass to be considered is palatability. Reed canarygrass if often reported low in palatability. Andrews and Hoveland (3) fertilized reed canarygrass with a 0, 45, 90, and 135 lbs NH_4NO_3/acre, and fed the products to cattle. It was found that the apparent palatability of reed canarygrass increased with increasing levels of nitrogen. The forage available, forage consumed, and % of forage consumed increased with increasing levels of fertilization.

In the last decade, growing concern over the amount of animal waste produced from confined animal operations and their effect on the environment has occurred (31). This situation has arisen from many factors. Before the time of confined operations, a cycle existed on the farms where the manure produced was applied to grass crops which in turn were fed back to the cattle (35). With the coming of easier to handle commercial fertilizers, it became uneconomical for the farmer to handle his manure. This resulted in the cycle being broken when the farmer stockpiled the manure which in turn began to pollute ground and surface water. Another factor to be considered is that a growing population has increased the demand for beef and swine products (69). To keep up with this demand, the only way to maximize profit was to go to confined operations. Viets (69) reports that in 1954 only 40% of America's cattle came from feedlots. By 1968 this figure had increased to 67%. McCalla (37) reports that approximately 2 billion tons of manure are produced in the United States each year.

Although there has been much research done on proper application rates and the effects of these rates, detailed information is lacking concerning optimum and maximum application rates of animal waste (2). Information that has already been gathered shows a wide variation, and is sometimes in conflict with other reports. In the papers he covered on proper application rates, Gray (24) reports recommendation rates ranging from 5 to 300 tons/acre/year. Weeks et al. (74) reported that corn was fertilized with as much as 600 tons manure/acre without any toxic effects at any level. However, he concluded by stating the most economical rate was 20 tons/acre. Reddell et al. (56) applied rates as high as 450 MT/ha (dry weight basis) to soil in Texas, ploughed it under and grew crops such as corn and sorghum. There were no toxic effects to the crops and no risk of pollution. This was supported by Murphy et al. (47) where application rates were as high as 720 MT/ha (dry weight basis). A general trend noted here is ploughing the manure under the soil. This prevents a great loss of nitrogen due to volatilization for as McCalla (36) noted, as much as 90% of the nitrogen in manure can be lost in only three weeks when left on the surface soil. Sommerfeldt et al. (64) reported that land application of manure at a rate of 70 MT/ha for over 40 years did not cause an undesirable buildup of N, P, or soluble salts in the soil or pollute a nearby lake or three permanent streams.

The main concern of environmentalists regarding handling of animal waste is the formation and deposition of nitrate into the environment. Under aerobic conditions, nitrate is formed which with sufficient moisture can pollute ground and surface water (50, 67). As stated before, nitrate in water can be harmful and a government regulation in the United States declares that any water with a nitrate-nitrogen concentration of 10 ppm or higher is declared unsafe to drink by man or beast (38, 40, 66, 71). Groundwater and soil directly beneath feedlots are not usually a source of nitrate (21) because the constant deposition of urine and manure prevent aerobic conditions from forming in the soil. All that is formed under the anaerobic conditions that do exist is ammonia (67) which is usually lost through volatilization. A problem that occurs around feedlots and land where irrigation is poor and manure is heavily applied besides high nitrate is a high salinity content in the soil (1, 43, 67). Olsen et al. (50) also reported that under such conditions, a waxy material formed on the surface of the soil which prevented water absorption. Mathers and Stewart (43) report that good crop production can be obtained when high rates of manure are applied as long as proper irrigation exists to prevent high nitrate and salt buildup in the soil.

Kimble et al. (32) compared dairy manure to a commercial N fertilizer. Corn was fertilized at rates of 0 and 224 kg N/ha. Nitrate concentrations in the soil profile were higher for the commercial fertilizer treatments than the dairy manure treatments. Consequently, more nitrate leached from the commercial fertilizer soil profile creating a greater environmental hazard than the dairy manure.

Grass response to feedlot runoff is favourable as demonstrated by Satterwhite and Gilbertson (59). Nine grasses were tested. Reed canarygrass was fourth in DM yield behind orchardgrass, switchgrass and little bluestem and first in CP content with a value of 23.18%. The results obtained by this experiment demonstrate clearly the value of forages for utilizing the nutrients from animal wastes.

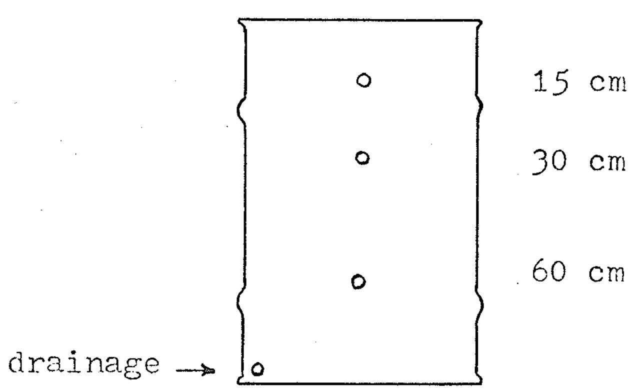
III. MATERIALS AND METHODS

The experiment was conducted from the 19th of May to the 26th of September 1973 in a sheep field on the west side of the campus. An area of 50' x 90' was needed for the experiment. This area was enclosed by a fence to prevent the sheep from getting in.

The containers used in this experiment, as large planters, were eighty-four, 25 gallon oil drums measuring 74 cm in height and 46 cm in diameter. One end of each drum had been cut away for the experiment. The circumference of each drum was marked off in thirds and at each mark, three holes, 2.54 cm (1 inch) in diameter, were drilled in the side of the drum at the 18, 33, and 64 cm level.

Figure 1

Position of Soil Sampling Holes in Drum

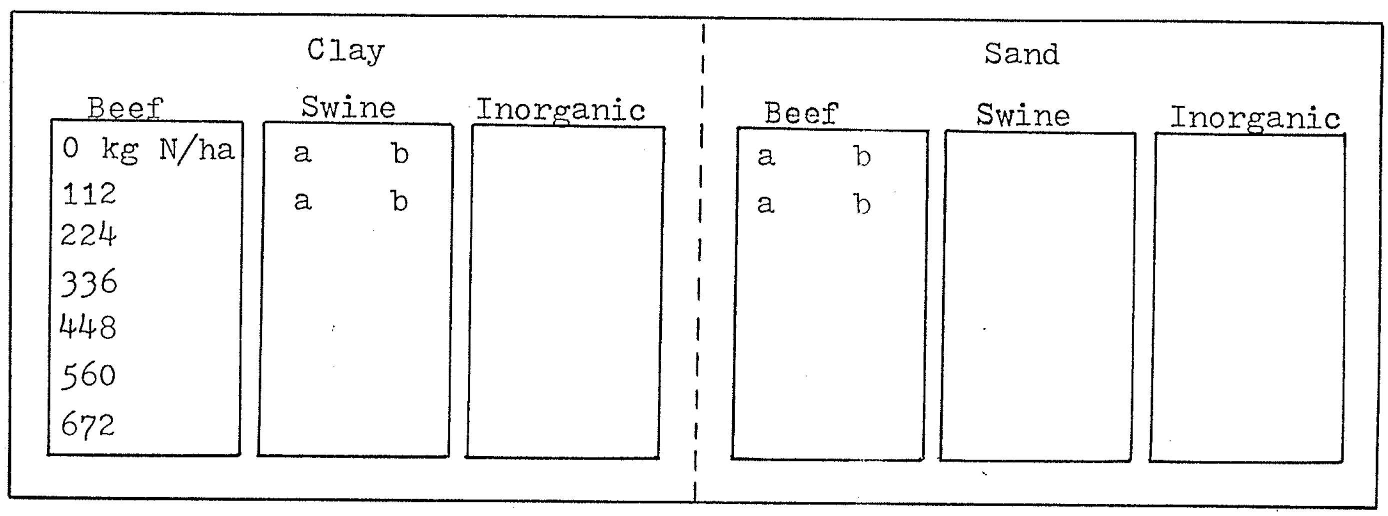


There was a 3 cm clearance allowed at the top since the drum would not be filled with soil right to the top. Therefore the holes drilled represent the 15, 30 and 60 cm soil depth. A tenth hole was also drilled at the bottom of the drum to allow for the collection of any leachate from the soil profile. Each drum was painted white to prevent the soil from heating from the side of the container.

After the drilling was completed, the drums were set up in the enclosure in rows according to soil type, fertilizer treatment and rate (Figure 2). There were two replications (a and b) for each soil, treatment and rate.

Figure 2

Layout of Experimental Design



Each drum was made level on the ground to ensure even seepage of moisture through the soil profile. Also each drum was set at least 1.2 meters (4 feet) away from surrounding drums to ensure no shadows would cover the plants during the day. The labelling of each drum was carried out in the following manner: the first letter representing the soil, the second representing the kind of fertilizer, the number representing the rate of application and the non-capital letter representing the replication. Therefore CS-5a would be interpreted as clay soil, swine manure, 560 kg N/ha, first replication. CS-0a, CI-0b, etc. would be the controls because no fertilizer was applied.

The two soils tested were a Red River clay taken from a summerfallow field at the Glenlea Research Station and an Almassippi loamy sand brought in from Carman, Manitoba, fifty miles south-west of Winnipeg. Before the soils were put into the drums, a sample was taken from each and analysed at the Provincial Soil Testing Laboratory at the University of Manitoba. The results are shown below in Table 1.

Table 1

Soil Analysis Before Fertilizers Were Applied

Depth ins.	Texture	$CaCO_3$	pH	Cond. mmhos	NO_3-N ppm	Total N lbs	Avail. P ppm	Avail. K ppm
0-6	Clay	V.Low	7.0	0.2	18.6	29.9	22.4	700+
0-6	LFS	V.Low	7.5	0.7	3.8	6.9	1.2	33

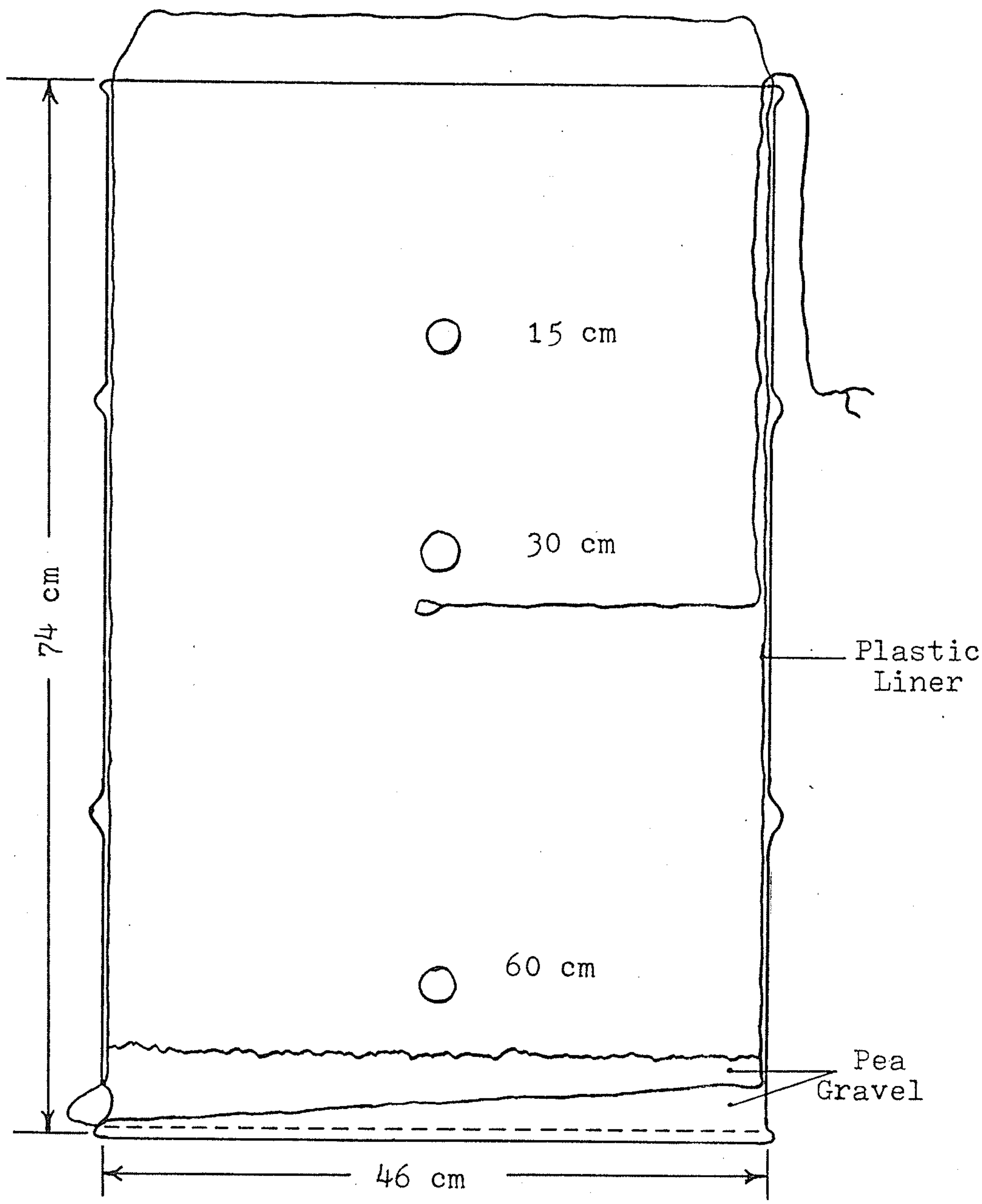
The filling of the containers was carried out in the following order. Pea gravel (0.64 cm in diameter) was placed in the bottom of the drum sloping toward the drainage hole. Plastic bags that had been made to fit the inside dimensions of the drum were put in place so that one corner of the bag protruded from the drainage hole to allow extraction of any leachate by hypodermic needle and a 10 to 12 cm margin of bag extending above the top of the drum. This margin would later be folded in toward the center of the drum to prevent any precipitation from reaching the bottom of the soil profile along the inside of the plastic. The bags would prevent any metal contamination of the soil from the drums. Pea gravel was then placed at the bottom of the drum in the bag and levelled. Total depth of the pea gravel both inside and outside the plastic bag was approximately 4.25 cm. The soil was then put in the drums packing it by hand every now and then to aid settling and soil shrinkage due to compaction later on. In the drums that would be used to study the effects of beef manure, thermocouples were placed in both clay and sand drums at the 30 cm levels to study soil temperature. Thermocouples were also placed in the soil of the enclosure; one thermocouple in the middle of each half of the compound. This enabled a comparison of soil temperature between the drums and the enclosure. Temperatures were taken once a week. A side view of a completed drum is as shown in Figure 3.

Three days after the completion of filling the drums with soil, the fertilizers were applied. The beef and swine manure were brought in from Glenlea Research Station; the beef manure freshly scraped from a paved enclosure containing very little straw and the swine slurry obtained from the pit below the farrowing barn. The inorganic fertilizer used was strictly a nitrogen fertilizer (46-0-0) in the form of urea (NH_2CONH_2). To determine the amount of nitrogen in the manures, four samples of each manure were analysed using the Kjeldahl method. The beef manure averaged 0.65% N and the swine manure averaged 0.90% N. From this, calculations

Figure 3

SIDE VIEW OF EXPERIMENTAL DRUM

SCALE 1CM = 5CM



were made and the following weights of manures were applied resulting in the desired rates.

Table 2

Weights of Fertilizers Applied for Desired Rates

Rate kg N/ha	Beef Manure kg	Swine Manure kg	Inorg. Fert. kg
0	0	0	0
112	0.283	0.204	0.004
224	0.565	0.408	0.008
336	0.848	0.612	0.012
448	1.130	0.816	0.016
560	1.413	1.020*	0.020
672	1.696	1.225	0.024

*Drum CS-5b had a slightly larger diameter of 47 cm so that 1.076 kg of swine manure was applied to equal 560 kg N/ha.

Each fertilizer was covered over with soil in the drum to represent the ploughing under of the fertilizer. The layer of fertilizer was approximately in the 2.5 to 6.5 cm layer of the soil profile. In addition to the nitrogen fertilizer, the sand soil received 3g of 11-48-0 and 3g of 0-0-60 fertilizer to bring its nutrient content up to a level recommended by the Provincial Soil Testing Laboratory.

An additional breakdown of the manure was carried out for various forms of nitrogen and for phosphorous. The results are shown in Table 3.

Table 3

LEVELS OF NH_3-N, ORG-N AND P

IN THE MANURES

Sample		NH_3-N	ORG-N	P
		mg/gm*		
Beef	1	0.437	0.155	1.03
	2	0.486	0.233	0.88
Swine	1	3.15	2.57	4.57
	2	2.86	2.62	4.19

*dry weight basis

The manures and inorganic fertilizer were applied ten days before the reed canarygrass was put in the drums. The reed canarygrass was sown in pots over two months before being transplanted to the drums. When the grass reached a height of 3 to 5 cm or one month of age, it was transplanted into flats. At two months of age grass in the flats was moved outdoors to harden before the transplanting into the drums. At the time of transplanting eleven reed canarygrass plants were planted per drum equalling a seeding rate of 0.56 kg/ha (0.5 lbs/acre).

Procedure

A daily log of air temperature and any precipitation was kept during the course of the experiment. Air temperature was taken at 3 p.m. every afternoon. Soil temperature was also recorded but only once a week. The potentiometer used to read the soil temperature was only available every Wednesday morning so temperatures were read at 10 a.m. Due to the possible variance of temperature between 10 a.m. and 3 p.m., afternoon soil temperatures were taken at 3 p.m. twice during the experiment and the results compared.

Although reed canarygrass is known to be highly drought resistant, it was decided to water the plants with an additional 12.5 cm (5 inches) of water over the course of the experiment to ensure enough moisture. This watering was done twice a week adding 650 mls of water each time. As it turned out, the very dry period during the second and third period of August required the remaining water for the experiment (2.8 l) to be added to the plants all at once over the course of one morning to prevent any further wilting.

Soil sampling was carried out in the third week of each month over the four month period. It was originally intended to sample the soil through the side of the drum at each level for the first three months; thus explaining the division of each drum into thirds. The fourth and last sampling was to be a core sampling from the top of the soil profile. Unfortunately, a core sampler was not available on the days of sampling and the samples had to be obtained from the side of the drums through holes already used. The soil samples were obtained using a length of electrical conduit (2.54 cm in diameter) made into a large spatula. Upon obtaining the sample the hole in the side of the drum was corked to prevent any water leakage during rainfall of watering. The 254 samples collected each month were then oven dried at 100°C overnight, ground, and sent to the Provincial Soil Testing Laboratory where they were analysed for nitrate-nitrogen and conductivity according to techniques outlined by Bremner (7).

There were two cuts of hay taken, the first in the third week of July and the second during the third week of September. Plants were cut by hand using grass shears. As soon as the plants were cut, they were packaged in plastic bags and sealed to prevent moisture loss. Harvesting took one full day so that the weighing of the wet grass was not carried out until the next day. The weights recorded for the wet and dry grass include the weight of the grass, plastic bag, elastic band and label. After wet weighing, the grass was oven dried at 100°C overnight, weighed the next day for dry weight and ground for analysing. According to the results by Davis (16) and Brougham (9), the grass was cut to leave a stubble of 12.5 cm (5 inches) to ensure maximum dry matter yield and regrowth for the second cut.

Upon harvesting and processing the reed canarygrass, samples were analysed for % nitrogen (crude protein) using Kjeldahl Techniques; K, Ca, Mg, Fe, Mn and Zn using atomic absorption; P and B using a colorimeter and nitrate analysis using a technique developed by Milham et al. (44) in Australia.

<u>Nitrate Analysis</u>

The technique developed by Milham to determine nitrate content in plant tissue involves the use of an anion-exchange electrode. Only slight changes were made from the original procedure.

An orion liquid ion exchanger was used in conjunction with a PHM53 digital pH/mV meter (Radiometer, Copenhagen, Denmark), to give millivolt (mV) readings. The instrument conditions were as follows: the indicating electrode was hooked up to the main connector, the reference electrode was at +450, the range selector was on monovalent ion and the polarity switch was on -ax-mV.

A standard curve was needed to interpret the MV readings. The standard stock used in preparing the standard solutions used KNO_3 at a concentration of 1000 ug NO_3^-/ml. The solution also contained 0.225% NO_3-N. The standard solutions prepared contained 0, 50, 100, 200, 500, 1000, 2000, and 3500 ug NO_3^-/ml.

The buffer solution used in this analysis contained: 13.3290 g 0.01 M aluminum sulphate ($Al_2(SO_4)3.18H_2O$); 6.2366 g 0.01 M silver sulphate (Ag_2SO_4); 2.4732 g 0.02 M boric acid (H_3BO_3); 3.8840 g 0.02 M sulphamic acid (H_2NSO_2OH). The prepared buffer had a pH of 3.0. Any adjustment of the buffer to pH 3.0 was made using 0.1 M sulphuric acid.

The plant samples analysed were done in duplicate. The sample contained 10 ml of buffer added to a 200 mg plant sample. To this 10 ml of water were added. The mixture was stirred, allowed to stand for 10 minutes and then a millivolt reading was obtained. This was a change from the original procedure of Milham who used a 100 mg plant sample to which he added only 5 ml buffer and 5 ml of water and obtained the mV reading after only four minutes of agitation. An air-driven magnetic stirrer was used while the mV reading was being obtained. Once the electrodes were placed into the mixture, a mV reading was obtained at exactly two minutes from the time of electrode immerson. This two minute period allowed the mV reading to stabilize.

From the standard curve, the mV reading gave ug total NO_3^- in the mixture (the original curve gave NO_3-N in ppm). Dividing ug total NO_3^- by the weight of the plant sample gave ug NO_3^-/g plant material which in turn was divided by 1000 to give % NO_3^- in the plant tissue. The amount of NO_3-N in the plant material was easily obtained by multiplying the % NO_3^- by 0.225. Since two samples were done from each drum the final value given in the appendix is the average of both.

Statistical Analysis

Factorial analysis was carried out on NO_3-N in soil, conductivity in soil, height of plant growth, DM yield, CP content, and % nitrate in the plant tissue. Significance found in fertilizer treatments was further analysed using orthogonal contrast while significance in rate, month or depth was further analysed by linear regression.

IV. RESULTS

<u>Climate</u>

The weather during the course of the experiment was good for the most part. Daily air temperatures for each month are listed in Appendix 1.

Total rainfall for the experiment was good and fairly well distributed except for the last week in August when little moisture and high temperature required watering the plants with the remainder of the additional water. The dates of additional watering are listed in Appendix 3. The amount of rainfall each month is listed below in Table 4 and is compared to the average rainfall over the same period from 1874 to 1971 (39). The figures quoted for rainfall at the enclosure were recorded at the University weather station 0.4 kilometers away from the experimental area.

Table 4

Rainfall

Month	Enclosure		Average 1874-1971	
	ins	cm	ins	cm
May	1.96	4.97	2.20	5.59
June	4.45	11.30	3.10	7.87
July	4.45	11.30	3.00	7.62
Aug.	1.98	5.02	2.57	6.53
Sept.	2.96	7.52	2.14	5.44
Total	15.80	40.11	13.01	33.05
Average	3.16	8.02	2.60	6.61

The total amount of moisture the experimental plants received from rainfall and additional watering was 20.8 inches (52.81 cm). Although the total amount of moisture is higher than average rainfall for the same period, the amount of leachate collected was negligible. Only a small number of drums produced a leachate.

Soil Temperature

Soil temperature of the enclosure was usually in between the temperature of the "clay" drums and the "sand" drums especially from the beginning of June to the end of August. Enclosure temperature was lower than drum temperatures during May and higher in September (Figure 4). The highest drum temperature reached by the clay soil was 22.2°C (72°F) on the 11th and 25th of July. The sand soil also reached a high of 22.2°C on the 25th of July. The highest enclosure temperature reached was 20.6°C (69°F) on the 15th of August.

The fluctuation in temperature in the drums from 10 a.m. to 2 p.m. were taken twice during the experiment. The results are shown below in Table 5.

Table 5

Comparison of Soil Temperature (°C) Variation in Drums

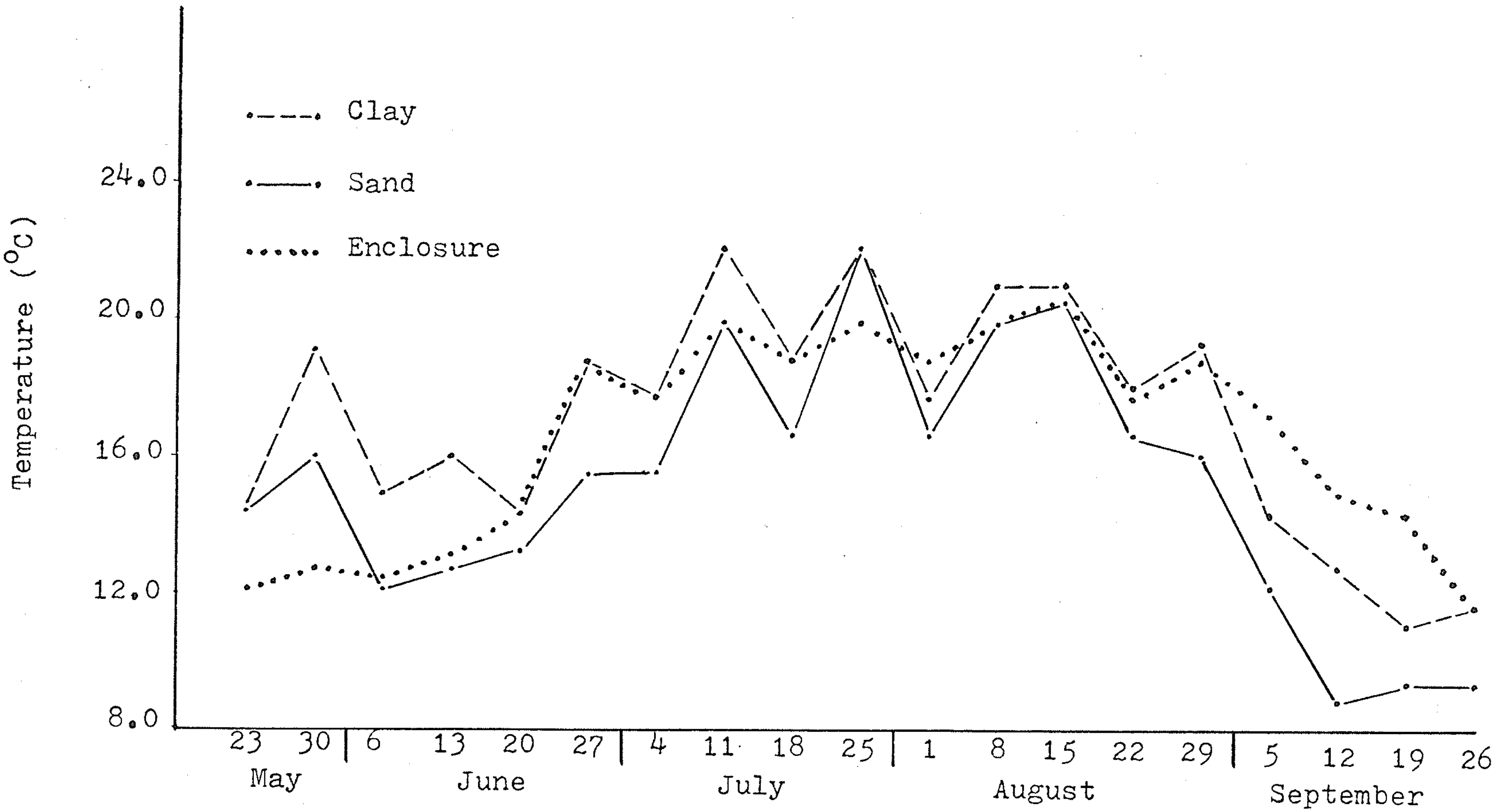
Date	July 11th		Sept. 5th	
Time	10 a.m.	2 p.m.	10 a.m.	2 p.m.
Clay	22.2	23.3	14.4	13.3
Sand	20.0	23.3	12.2	12.2
Enclosure	20.0	20.0	17.3	16.2

The sand fluctuated to a greater degree but it is felt that the increase in temperature during July and the decrease in September was of no detrimental consequence to the plants.

Figure 4

Soil Temperature in the Drums and Enclosure

During Each Week of the Experiment*



*Data listed in Appendix 2

Crop Year

The plants took approximately two weeks to become established in the drums after transplanting. Cold weather and a very hard rain in the beginning of June did not help. However, by the third week in June, the plants were in good physical condition.

By the middle of July, the plant tips began to turn brown and shrivel. This was most apparent in the sand drums with the swine manure treatment. All drums from 336 kg N/ha to 672 kg N/ha contained very brown dry plants. Because harvesting was so close at hand at this point, the watering was suspended until after the harvest and then applied to the stubble. When the first cut of hay was taken some heading had already occurred in some drums and root penetration had extended to 60 cm in all drums of both soil types.

The second growth of hay began very well but dry, hot weather again caused the plants to turn slightly brown by the third week in August. Because of the dry weather, the plants were given the remaining extra water to carry them over. From this point on, plant growth and colouration was good until the second cut of hay was taken in the third week in September.

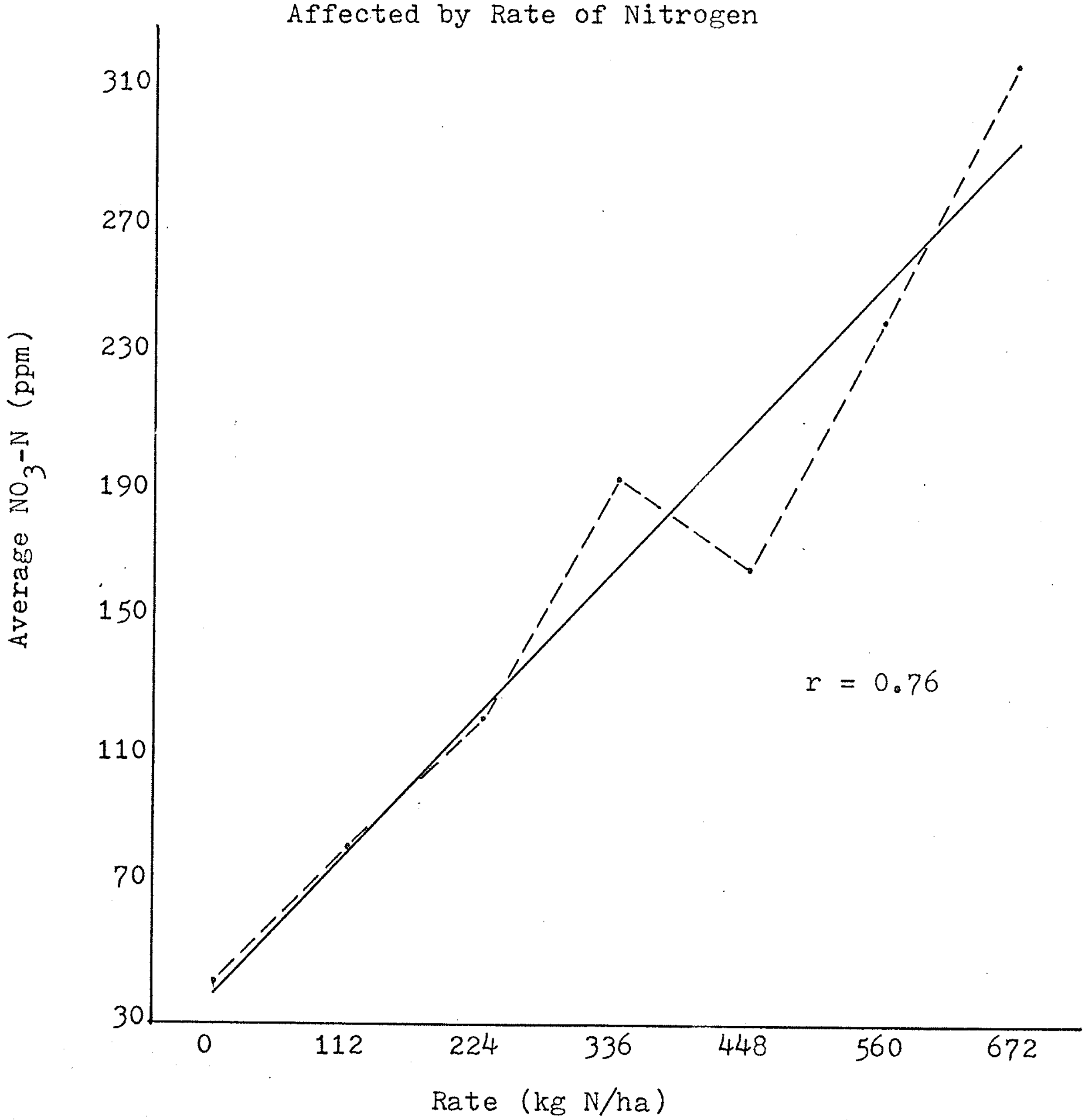
Nitrate-Nitrogen in the Soil

Soils treated with the inorganic fertilizer were significantly higher in NO_3-N than soils treated with either beef or swine manure ($p \leq .01$). The swine manure treated soils were significantly higher in NO_3-N than soils treated with the beef manure ($p \leq .01$). The clay soil contained significantly greater amounts of NO_3-N than the sand soil ($p \leq .01$).

The higher the rate of nitrogen applied, the greater the average NO_3-N content of the soil (r=0.76). As demonstrated by Figure 5, the average NO_3-N in the soils at 0 kg N/ha was 42 ppm which increased to 320 ppm at 672 kg N/ha. A fall-off response in NO_3-N level occurred between 336 kg N/ha and 448 kg N/ha.

Figure 5

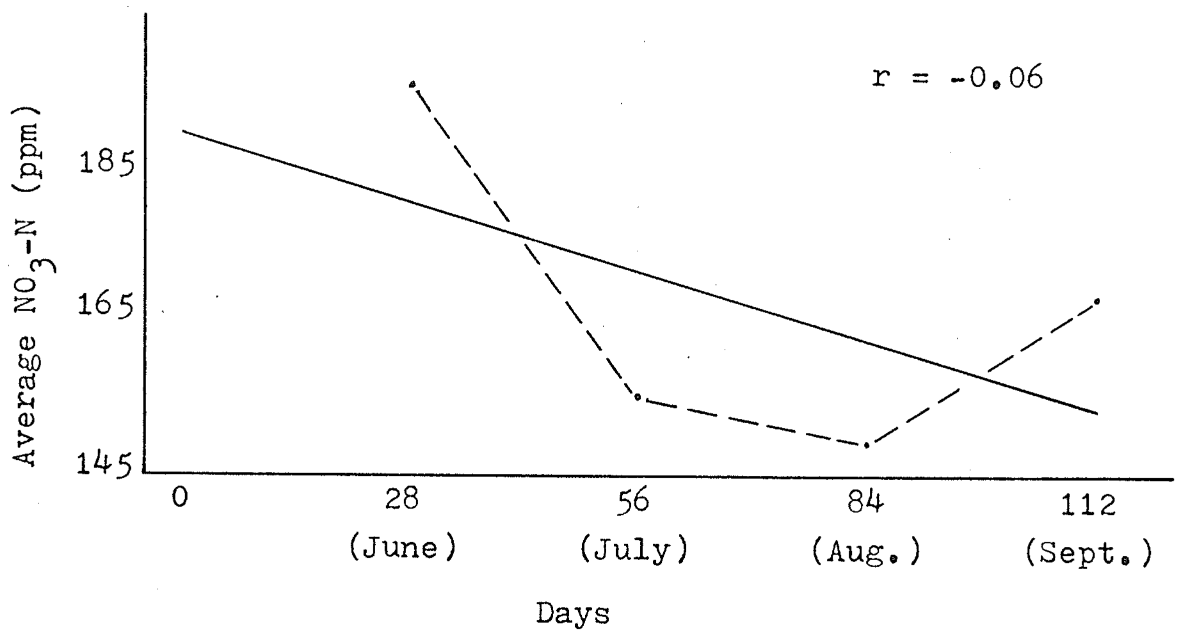
Average Level of NO_3-N in Soil as Affected by Rate of Nitrogen



The level of NO_3-N in the soil was significantly affected by the length of time after application of fertilizer ($p \leq .05$). NO_3-N decreased in concentration from June through to August but increased again in September (Figure 6).

Figure 6

Average Level of NO_3-N in the Soil as Affected by Time after Fertilizer Application



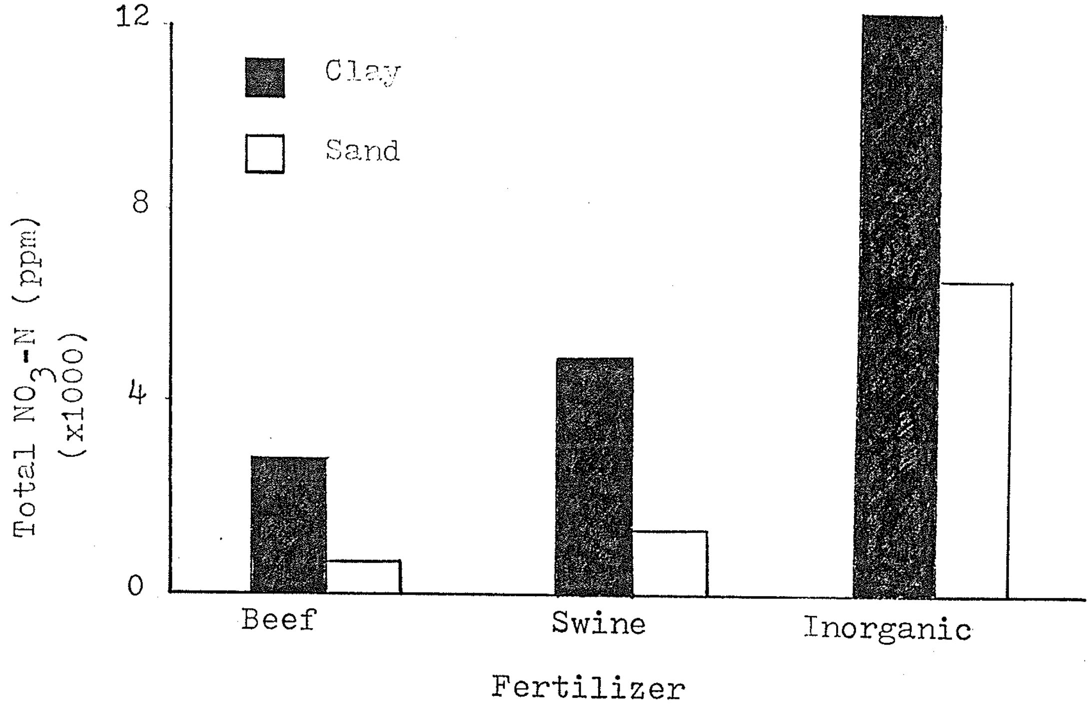
The level of NO_3-N at the 30 cm depth in the drums was significantly higher than concentrations at the 15 or 60 cm depth ($p \leq .01$).

Although five factors were studied in both NO_3-N and conductivity in the soil, namely fertilizer (F), soil (S), rate (R), month (M), and depth (D), only double and triple interactions were analysed since it is felt only these interactions are of significant importance.

As mentioned before in this section, the NO_3-N concentration increased in the soil when different fertilizers were applied. This increase in concentration from beef to swine to inorganic fertilizer was uniform in both clay and sand. However the significant difference in concentration between the two soils is best illustrated in Figure 7.

Figure 7

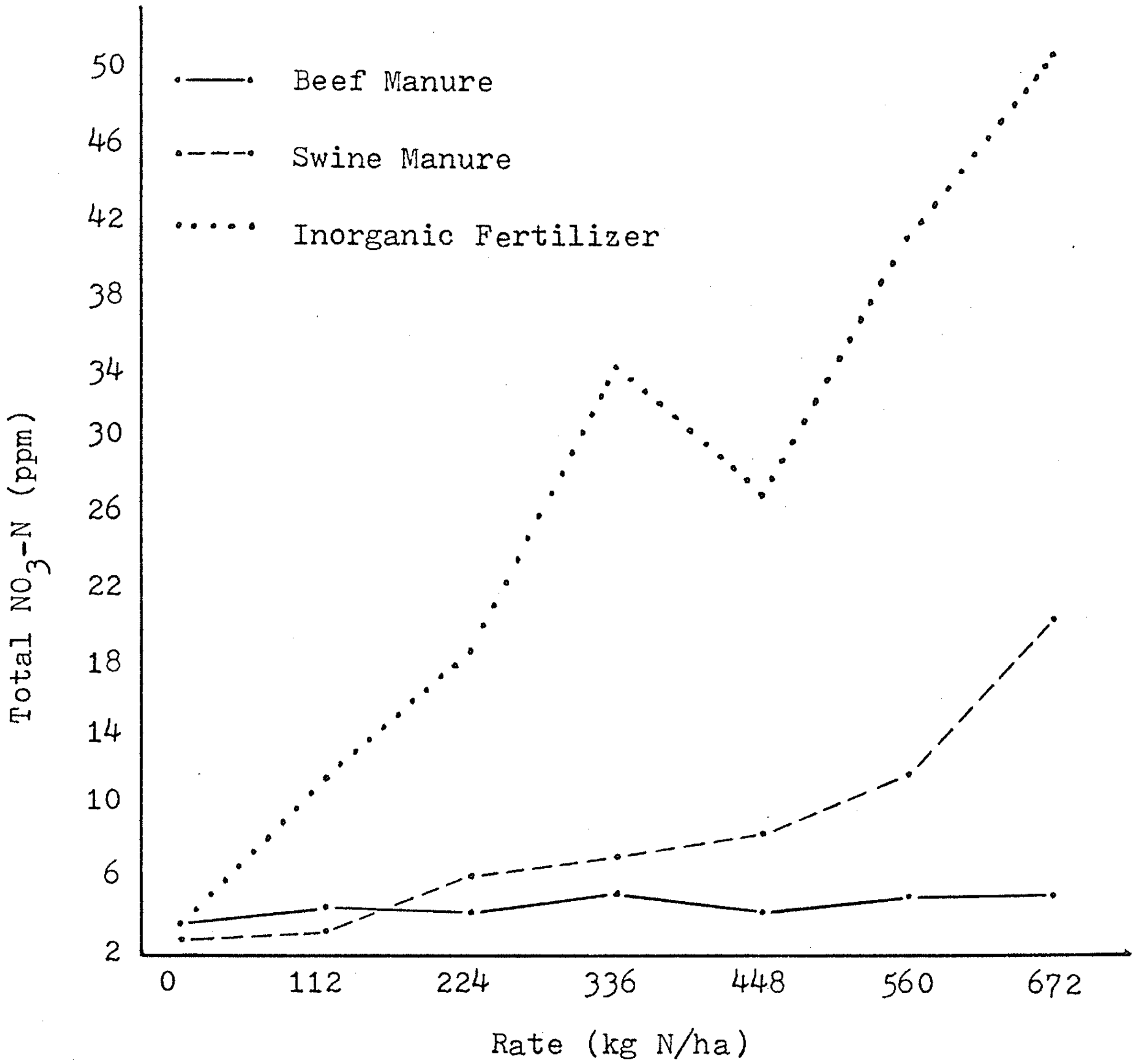
Fertilizer by Soil Interaction



The significant difference in the amount of nitrate in the soil profile from each rate of fertilizer is significantly shown in Figure 8. Swine manure treatments had four times as much NO_3-N in the soil profile as beef manure and the inorganic fertilizer had ten times as much NO_3-N as beef manure at the highest rate ($p \leq .01$).

Figure 8

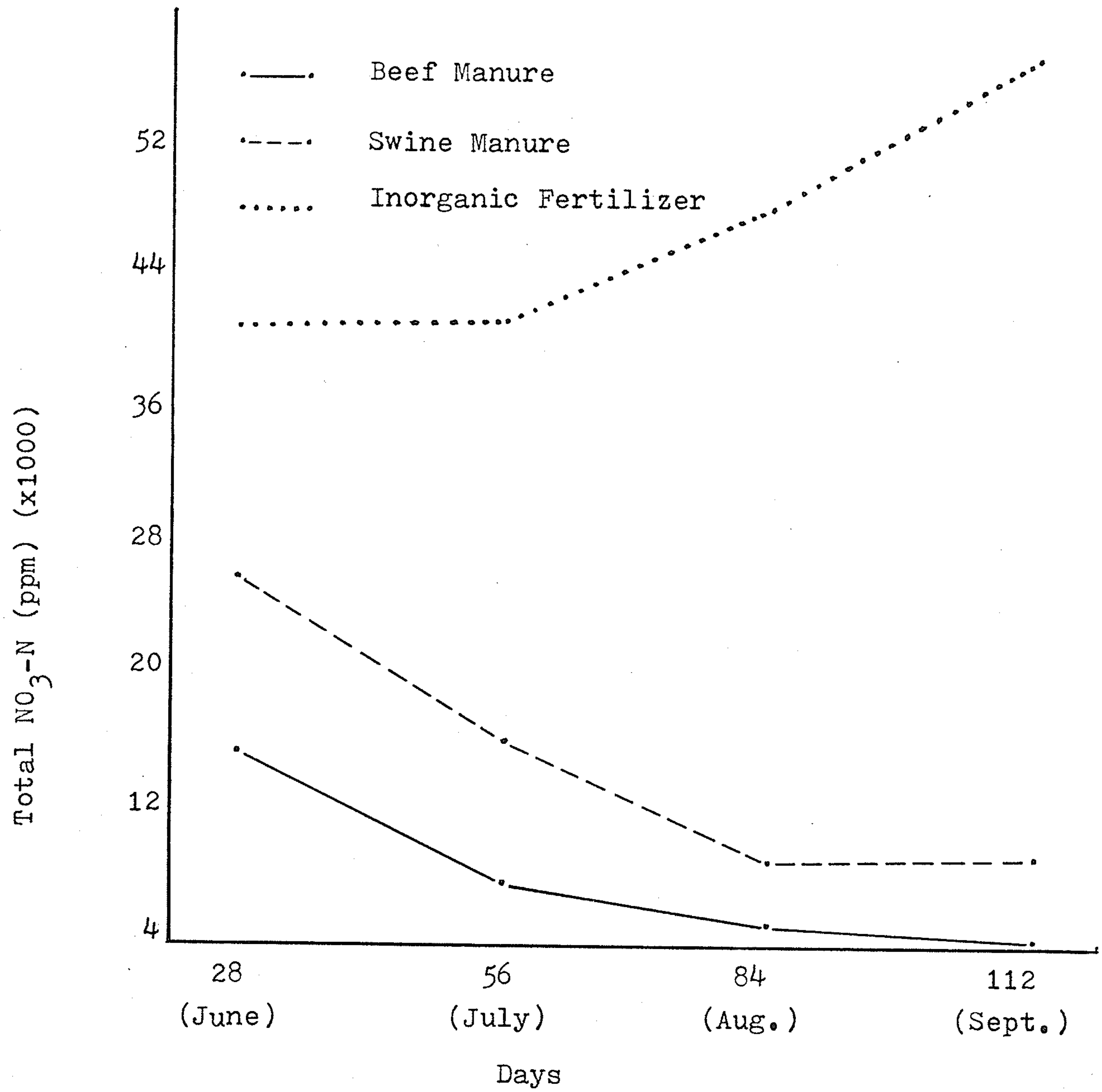
Fertilizer by Rate Interaction



The fertilizer by month interaction was significant to the 1% level. NO_3-N levels from each manure decreased in concentration from the time of application while the amount of NO_3-N in the soil profile from the inorganic fertilizer increased in concentration each month from the time of application (Figure 9).

Figure 9

Fertilizer x Month Interaction



The level of NO_3-N in each soil was significantly different on a monthly basis. The general trend in the clay was a decrease in NO_3-N concentration from June to September with a very slight increase in August. The NO_3-N concentration in the sand, however, increased from June to September except for a slight decrease in concentration during August.

There was no significant interaction between rate and month but there was between rate and soil ($p \leq .01$). Both soils increased in NO_3-N with an increase in rate. The clay had a significantly higher NO_3-N concentration. There was a fall-off response between 336 kg N/ha and 448 kg N/ha in the clay soil but no such response occurred in the sand.

The highest accumulation of NO_3-N in the soil profile was at the 30 cm level. Interactions of depth with month, soil, rate, and fertilizer were all significant ($p \leq .01$) and in all cases the highest concentrations were never lower in the profile than 30 cm. The interaction between soil profile depth and kind of fertilizer clearly demonstrates where accumulation took place and what fertilizer contributed the most NO_3-N (Figure 10).

Figure 10

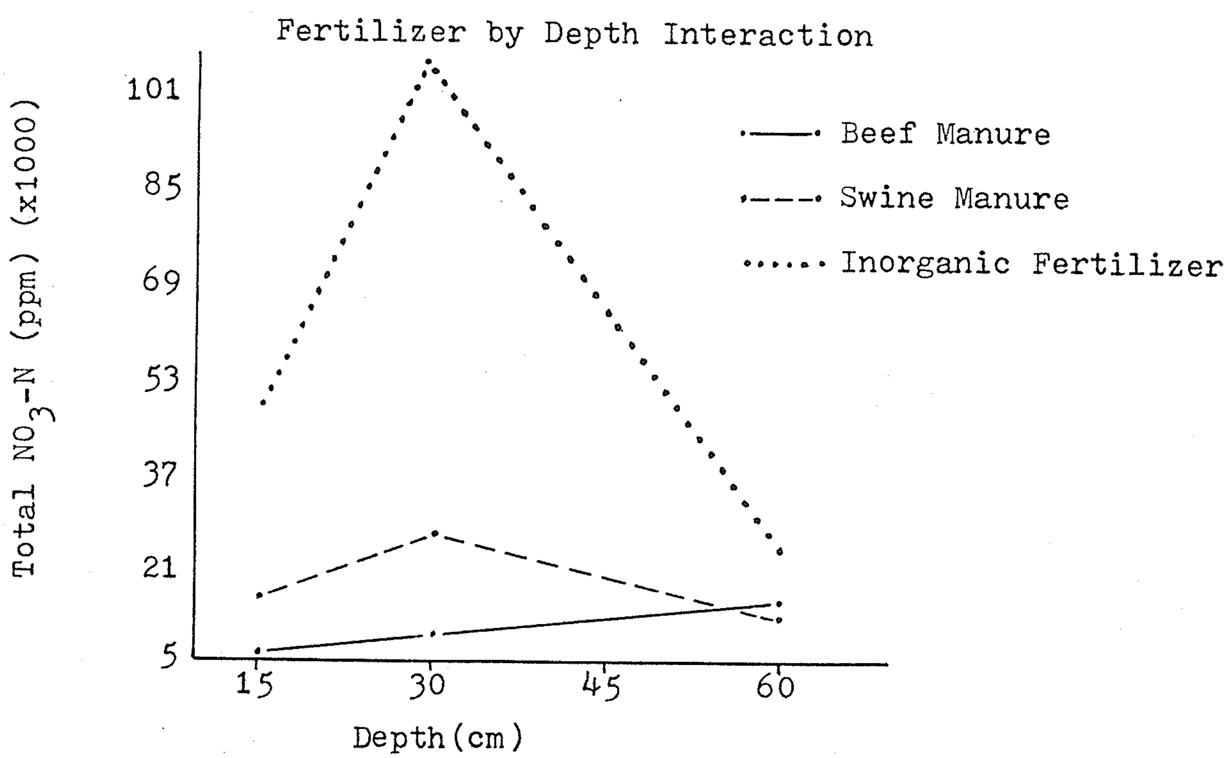


Figure 10 also shows a break from the general trend in that the total NO_3-N concentration on the beef manure treatments was highest at the 60 cm depth.

There were several three-way interactions that were significant. The FxRxS interaction was significant ($p \leq .01$). The NO_3-N concentrations of the inorganic fertilizer on the sand soil were higher than either beef or swine NO_3-N concentrations on the clay or sand. Fall-off responses to fertilization occurred on the beef and inorganic fertilizer treatments on the clay soil and the beef and swine treatments on the sand soil.

The MxRxS interaction was significant ($p \leq .01$). The two main points of interest shown by this interaction are: 1) the NO_3-N concentration in the clay soil was highest in June but the total NO_3-N concentration of each fertilizer levelled off with slight fluctuation from July to September; 2) the NO_3-N concentration in the sand soil in September was significantly greater at the higher rates than previous concentrations from June through August.

From the DxMxF interaction ($p \leq .01$), it is noted that increases in NO_3-N concentration occurred at the 15 and 30 cm depth in all three fertilizers from August to September but such a response did not occur at the 60 cm depth. Also, concentrations of NO_3-N increased at each month at the 15 and 30 cm depth when treated with inorganic fertilizer but this was not the case at the 60 cm depth. Concentrations decreased each month in all three fertilizers.

The significance found in the DxMxS interaction was low ($p \leq .05$) compared to the others. The main significance was that concentrations of NO_3-N were higher in clay than in sand soil and the fact that the 30 cm depth had the highest concentrations, both points of which have been stated before.

The remaining two significant triple interactions (DxFxR and DxFxS) will not be elaborated upon; the main points of interests have already been discussed in other interactions. The interactions that were not discussed are listed in the factoral analysis table for soil nitrate-nitrogen (Appendix 5).

Conductivity in the Soil

Conductivity increased and decreased in proportion to the rising and falling of NO_3-N in the soil. This response only occurred, however, until conductivity levels were in the range of 0.2 to 0.4 mmhos. Once these levels were reached, conductivity remained relatively stable. Stabilization of conductivity did not usually occur until as late as August. The factors studied for conductivity were the same as those for NO_3-N. The same interactions that were significant for NO_3-N were also significant for conductivity, with the exception of one or two. The one difference between the sets of interactions is that the reasons for significance differ slightly.

Soil treated with beef manure had a significantly higher salinity content than did soil treated with swine manure ($p \leq .01$). The swine manure treatments had the lowest salinity content of the three fertilizers. There was also a significant difference in conductivity between the manures and the inorganic fertilizer ($p \leq .05$).

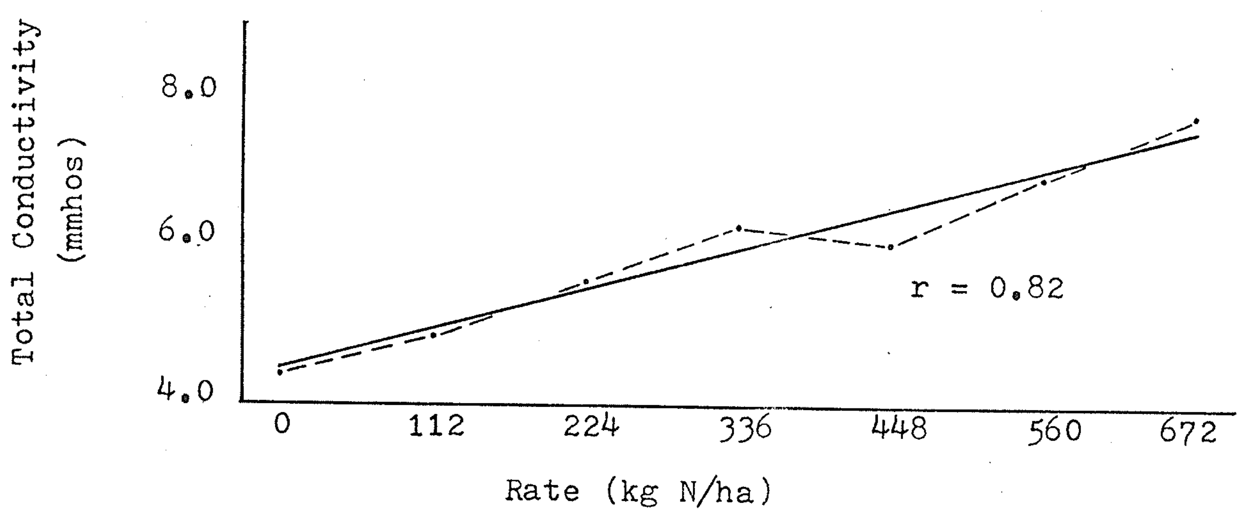
The clay soil was significantly higher in conductivity than the sand soil. Total conductivity in the clay was more than 2.5 times as great as the conductivity in the sand.

The higher the rate of nitrogen application, the greater the soil conductivity ($r=0.82$). As with NO_3-N, a fall-off response also occurred with conductivity levels between 336 kg N/ha and 448 kg N/ha (Figure 11).

Figure 11

Conductivity in the Soil as Applied

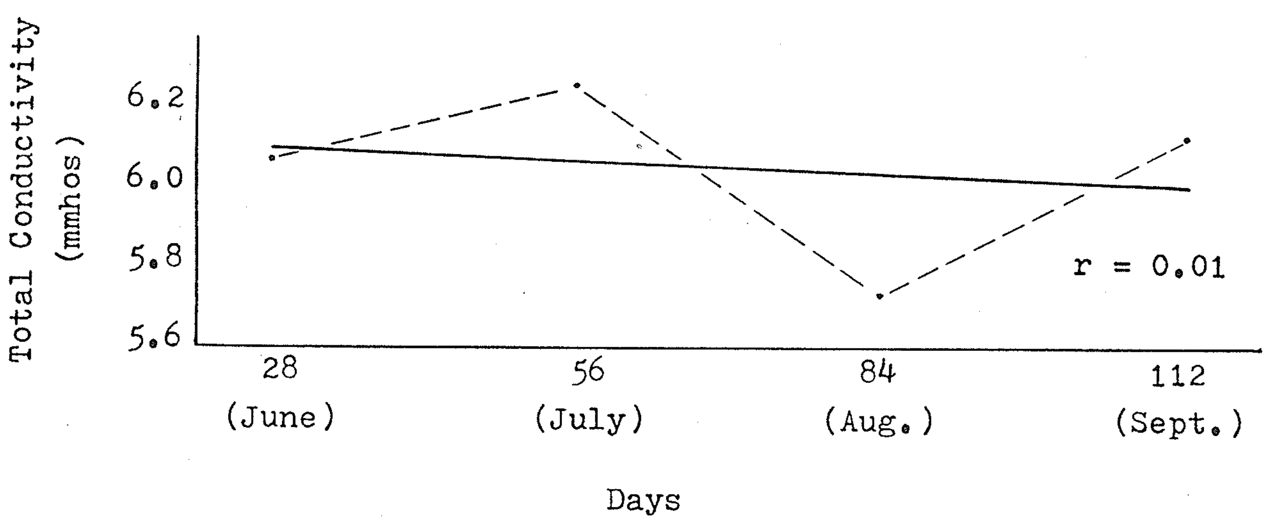
by Various Rates of Nitrogen



There was a significant difference in salinity content in the soil the longer the time period after fertilizer application. As can be seen by Figure 12, conductivity fluctuated significantly and the correlation between conductivity and length of time after fertilizer application is very low.

Figure 12

Conductivity in Soil for Each Month
After Fertilizer Application



The highest salinity content collected at the 30 cm level in both clay and sand soil profiles. This accumulation was significantly higher than accumulations at the 15 or 60 cm depth ($p \leqslant .01$).

The same double interactions that were significant for NO_3-N were also significant for conductivity. Only some of the interactions will be discussed. The fertilizer by soil interaction was significant ($p \leqslant .01$). The conductivity for beef manure and inorganic fertilizer were approximately equal for the clay soil. The sand soil that was treated with beef manure has a much higher content than either of the other sand soil treatments.

Each rate of beef manure contributed a greater amount of salts to the soil profile than either swine or inorganic fertilizer although the inorganic fertilizer was a close second. The same kind of results were obvious in the fertilizer by month interaction ($p \leq .01$). Conductivity in the beef treatments was higher than the other two but the inorganic fertilizer was not far behind. There were slight fluctuations in monthly salinity content as mentioned before but an interesting point brought out by this interaction is that the range of fluctuation was very small in the inorganic fertilizer which remained relatively stable for each month. Fluctuations in salt content were more apparent in the organic fertilizers.

Conductivity levels in the rate by soil interaction ($p \leq .05$) showed a steady increase in salt content with an increase in the rate of nitrogen applied. One slight difference between the soils was that a fall-off response occurred between 336 kg N/ha and 448 kg N/ha in the clay whereas there was always an increase in salt content with each rate in the sand soil.

The remaining double interactions and those triple interactions that were significant will not be discussed since the main points of difference and interest to the reader have already been brought forward. The complete results for conductivity from soil analysis are listed in Appendix 6 and the factorial analysis table for salt content is listed in Appendix 7.

Growth of the Reed Canarygrass

The height of growth of the reed canarygrass due to different fertilizer treatments was not significant. Growth of forage from the beef and swine treatments was almost identical with the inorganic fertilizer treatment slightly higher. Growth was greater on the clay soil than on the sand ($p \leq .01$) and greater for the first cut of hay than for the second ($p \leq .01$).

The general trend for growth in response to different rates of nitrogen fertilization was an increase in height for each increase in rate ($r = 0.83$). A fall-off response occurred in growth from 224 kg N/ha to 336 kg N/ha and while growth increased again from 336 kg N/ha to 448 kg N/ha, it remained unchanged from 448 kg N/ha to 560 kg N/ha. The average height increased from 26 cm at 0 kg N/ha to almost 30 cm at 672 kg N/ha.

The response in growth was found to be significantly dependent in the fertilizer by soil interaction ($p \leq .05$) and the fertilizer by rate interaction ($p \leq .05$). In the F x S interaction growth was highest in the clay soil treated with inorganic fertilizer while swine was higher than beef. In the sand soil, however, the highest growth occurred in the beef manure treatment. The swine treated sand and the inorganic fertilized sand had almost identical responses in growth.

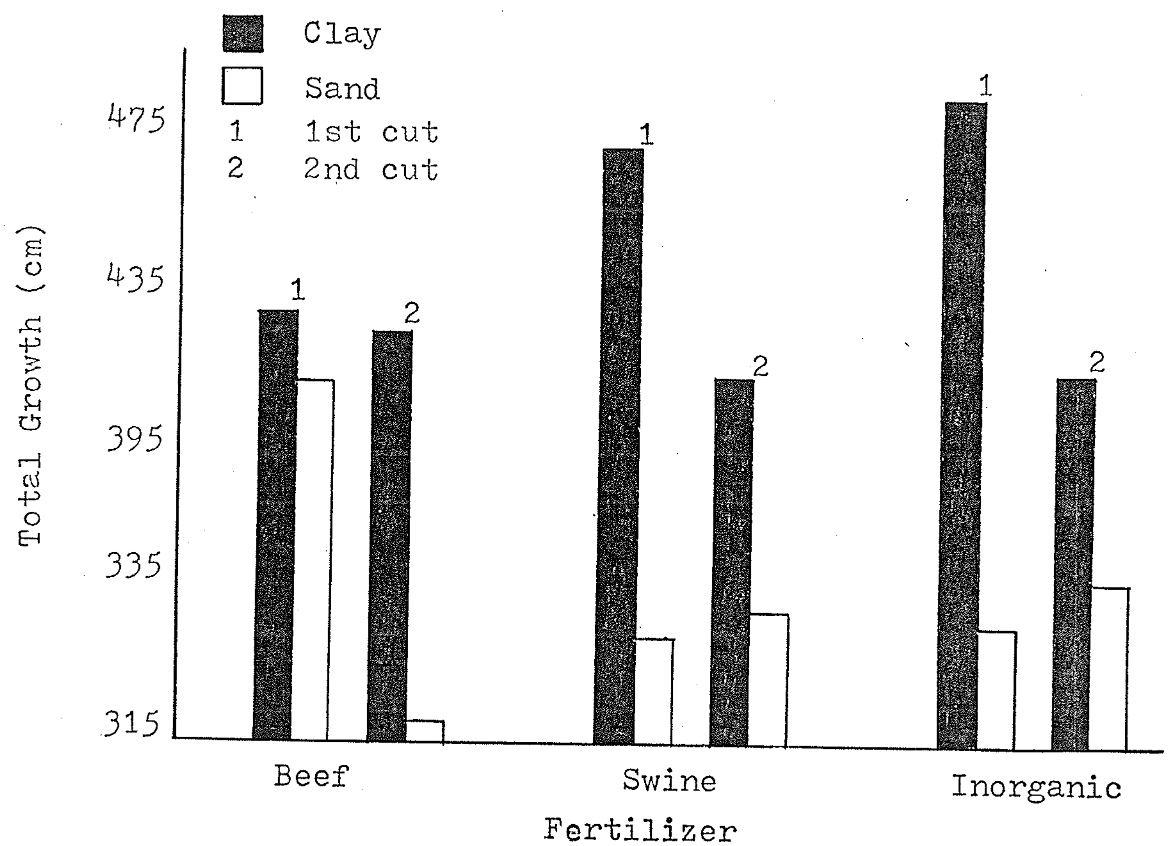
In the fertilizer by rate interaction, the fall-off response mentioned earlier occurred in all three fertilizers between 224 kg N/ha and 336 kg N/ha. While the swine and inorganic fertilizer treatments again increased, the beef treatments continued to decrease in growth response up to and including the 560 kg N/ha rate, at which time it increased to a comparative level with the inorganic fertilizer. In most cases the growth response was higher at every rate when the inorganic fertilizer was used.

The amount of response in growth was significantly dependent on the rate of nitrogen application and the cut of hay ($p \leq .01$). Each rate had a higher response in growth for the first cut of hay than the second cut.

Significant dependence was evident in the fertilizer by soil by cut interaction ($p \leq .01$) which can best be explained by Figure 13.

Figure 13

F x S x C Interaction



The four way interaction (FxSxRxC) was significant to the 5% level which provides some indication that there is much dependence from one factor to another in determining the response in growth. This is substantiated by the fact that all four 3-way interactions were significant (Appendix 9).

Dry Matter Yield

The clay soil had a significantly higher dry matter production than the sand soil ($p \leq .01$). Dry matter production on the clay increased from 9909, 8933 and 9238 kg/ha at 0 kg N/ha to 10305, 10732, and 9970 kg/ha at 672 kg N/ha for the beef, swine and inorganic fertilizer respectively. Production on the sand increased from 7318, 7348 and 7622 kg/ha at 0 kg N/ha to 8933, 9360 and 8658 kg/ha at 672 kg N/ha for the beef, swine and inorganic fertilizer respectively.

The inorganic fertilizer was significantly higher in total dry matter production than the organic fertilizers ($p \leq .05$) while swine manure produced more dry matter than beef manure ($p \leq .01$). The average total DM production was 8811, 9120, and 9155 kg/ha for beef, swine and inorganic fertilizer respectively.

The amount of dry matter production was significantly dependent on the rate of nitrogen applied ($p \leq .01$). The greater the rate of application, the greater DM production ($r = 0.85$). Average yield increased from 8394 kg DM/ha at 0 kg N/ha to 9659 kg DM/ha at 672 kg N/ha. A fall-off response occurred in yield between 224 and 336 kg N/ha.

Dry matter production was significantly dependent on the soil type and the kind of fertilizer used ($p \leq .05$). Swine manure produced the highest total yield on the clay soil followed by the inorganic fertilizer while the inorganic fertilizer had the highest total DM yield on the sand soil followed by swine and beef manure respectively. The exact same results occurred in the fertilizer by cut interaction ($p \leq .01$). Swine manure had the highest total yield for the first cut and the inorganic fertilizer had the highest total yield for the second cut.

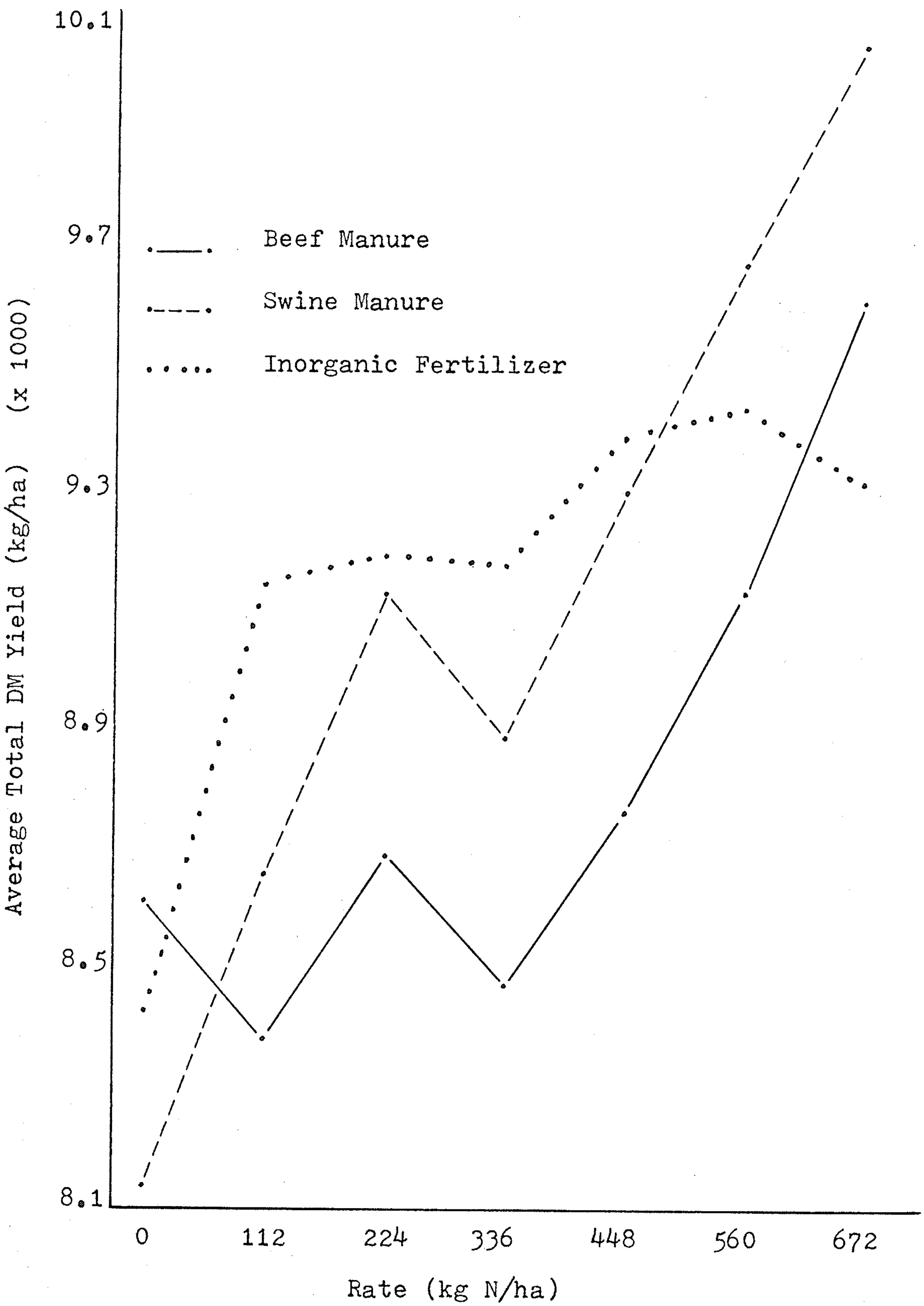
The fertilizer by rate interaction (Figure 14) was significant ($p \leq .01$), and clearly illustrates that the inorganic fertilizer produced higher yields at the lower levels of nitrogen application up to 448 kg N/ha than either beef or swine manure. Swine manure produced the highest yields of all fertilizers at 560 and 672 kg N/ha while beef manure outyielded the inorganic fertilizer at 672 kg N/ha. As can be seen in Figure 14, each fertilizer shows a fall-off response between 224 and 336 kg N/ha. The beef manure also has a fall-off response between 0 and 112 kg N/ha while the inorganic fertilizer treatment had a decrease in yield between 560 and 672 kg N/ha.

Crude Protein Content

The inorganic fertilizer produced significantly higher crude protein levels in the reed canarygrass than the animal manures ($p \leq .01$). The CP content for the swine treatments was significantly higher than in the beef manure treatments ($p \leq .01$).

Figure 14

Fertilizer x Rate Interaction



Reed canarygrass grown on clay soil had a higher CP content than grass grown on sandy soil ($p \leq .01$). Also, the first cut of reed canarygrass was higher in crude protein than the second cut ($p \leq .01$).

The crude protein level in reed canarygrass increased as the rate of nitrogen fertilization increased ($r = 0.86$). Each rate increase produced a significant increase in crude protein ($p \leq .01$). The average crude protein ranged from 14.77, 14.80 and 14.24 % at 0 kg N/ha to 18.01, 20.55, and 20.66% at 672 kg N/ha for the beef, swine and inorganic treatments respectively. A breakdown of average crude protein levels for each treatment is listed in Appendix 11. Crude protein levels were greater than 21% at the higher rates of fertilization for some treatments.

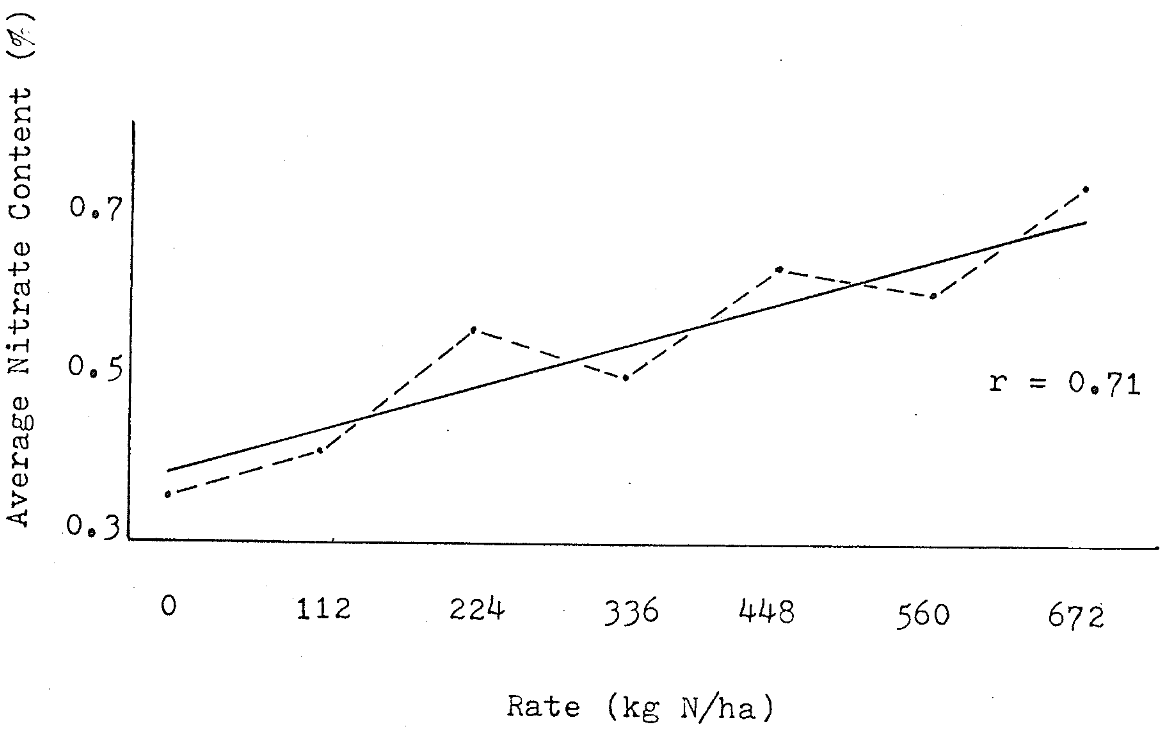
Nitrate Content of Plant Tissue

The nitrate content of the reed canarygrass fertilized with the inorganic fertilizer was significantly higher than nitrate levels in either of the manures ($p \leq .01$). Furthermore, plants fertilized with swine manure were significantly higher in nitrate than plants treated with beef manure ($p \leq .01$). Plants grown on the clay were significantly higher in nitrate than plants grown on the sandy soil ($p \leq .01$). The nitrate content of the first cut hay was significantly higher than the nitrate content of the second cut hay ($p \leq .01$).

Nitrate content increased as the rate of nitrogen application increased ($r = 0.71$) although, as Figure 15 verifies, considerable fluctuation occurred.

Figure 15

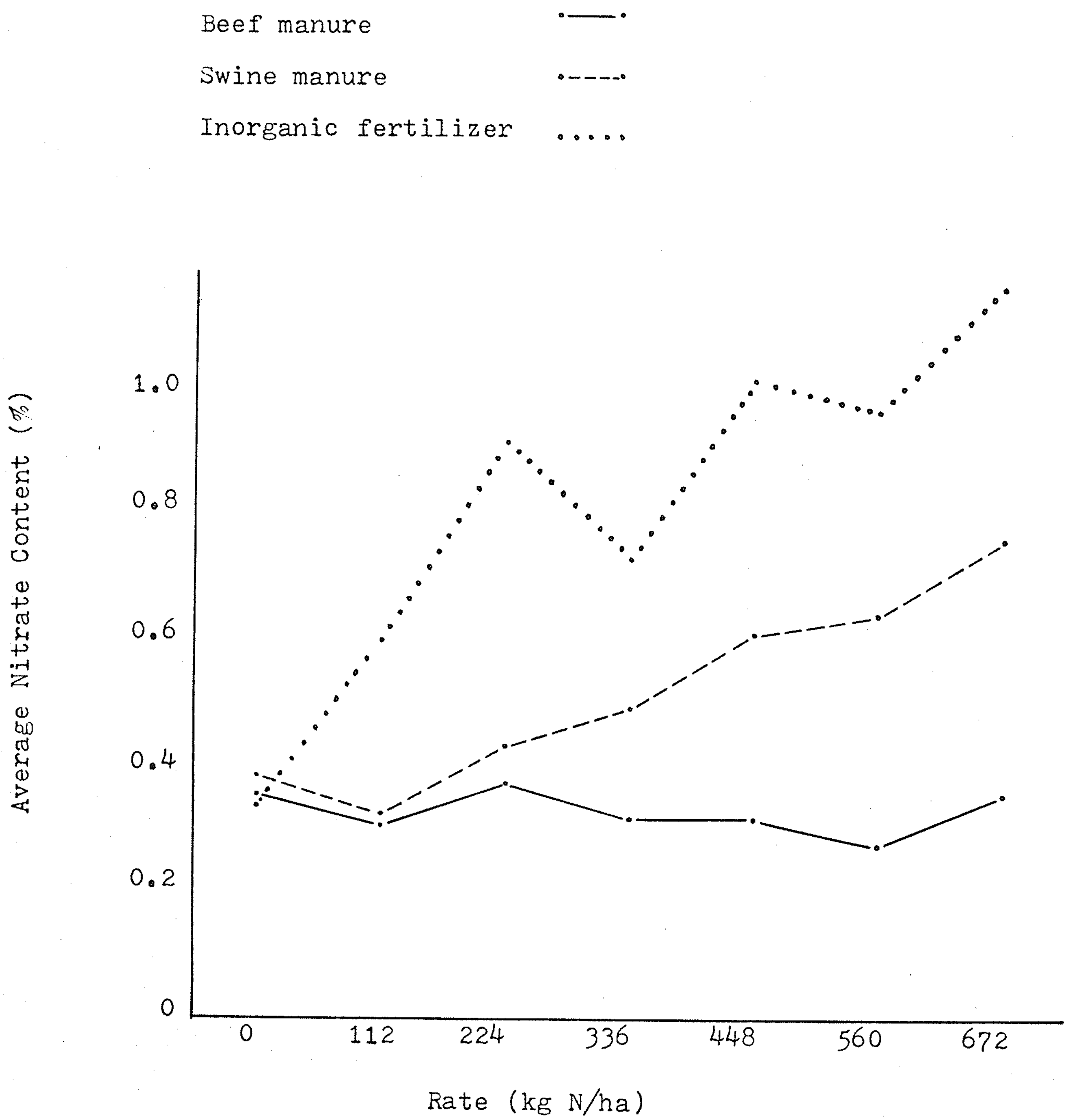
% Nitrate in Plant Tissue as Affected
by Rate of Nitrogen Application



Nitrate accumulation in plant tissue was significantly dependent on the kind of fertilizer and the rate at which the fertilizer was applied ($p \leq .01$). Figure 16 demonstrates how much more nitrate the plants on the inorganic fertilizer treatment accumulated than the plants treated with manure. An interesting point brought by Figure 16 is that nitrate content of plants treated with beef manure remained relatively constant whereas the other two fertilizers continually increased nitrate content of the plants.

Figure 16

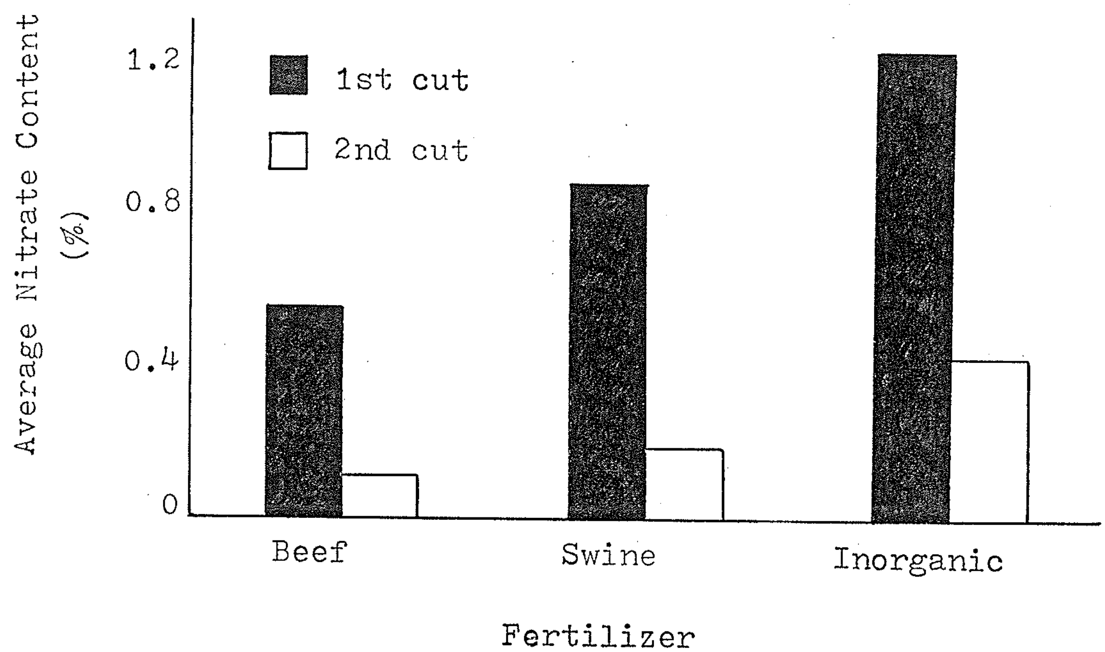
Fertilizer x Rate Interaction



There was a significant decrease in nitrate content for each fertilizer from the first cut to the second cut. This decrease is clearly demonstrated in Figure 17.

Figure 17

Fertilizer & Cut Interaction



The same kind of decrease in nitrate seen in Figure 17 was also apparent in the rate by cut interaction ($p \leq .01$). Average nitrate decreased from 0.63 to 0.10% at 0 kg N/ha and from 1.15 to 0.38% at 672 kg N/ha from the first cut to the second cut respectively.

There were three three-way interactions that were significant; namely FxSxC, FxRxC and SxRxC. These interactions did not bring forth any new points of interest; only those already discussed in earlier interactions.

Mineral Content of Plant Tissue

For the most part, mineral element content of the reed canarygrass remained unchanged between fertilizers on each soil within each cut. Decreases in P, K and B were apparent in the second cut from the first cut. Ca and Mg remained relatively unchanged between cuts. Increases or decreases in element content between rates were negligible in most cases with the exception of Mn. Increases in Zn content between rates were slight. Table 6 is a condensed form of the raw data for mineral content. Original data for both cuts is listed in Appendix 16.

Table 6

Average Mineral Content of Plant Tissue

	%				ppm			
1st cut	P	K	Ca	Mg	Fe	Mn	B	Zn
Clay								
Beef manure	0.28	3.3	0.34	0.27	126	48	6.69	48
Swine manure	0.29	3.3	0.35	0.26	120	(54)	6.99	47
Inorg. fert.	0.26	3.3	0.38	0.26	118	54	6.28	48
Sand								
Beef manure	(0.30)	(2.2)	0.38	0.42	99	(73)	8.95	30
Swine manure	(0.29)	1.9	0.39	0.43	122	(78)	9.65	(33)
Inorg. fert.	0.24	1.8	(0.52)	0.49	99	(109)	7.93	(38)
2nd cut								
Clay								
Beef manure	0.24	2.8	0.36	0.25	124*	36	8.40	31
Swine manure	0.23	2.7	0.37	0.25	116	37	7.61	32
Inorg. fert.	0.22	3.0	0.38	0.25	136*	(44)	8.64	(35)
Sand								
Beef manure	0.36	(1.8)	0.38	(0.37)↓	108	(98)	10.03	26
Swine manure	0.29	1.6	0.40	0.43	109	(86)	10.79	(25)
Inorg. fert.	0.24	1.5	0.44	0.45	111	(113)	11.71	(29)

( ) - concentration increased from 0 to 672 kg N/ha
( )↓ -concentration decreased from 0 to 672 kg N/ha

* - high Fe concentration at one rate due to possible contamination from the drum.

V. DISCUSSION

The total amount of moisture received during the experiment, including additional water given, was 20.8 inches (52.81 cm). This figure is 7.79 inches (19.76 cm) greater than the annual average rainfall as seen in Table 4. This high moisture value might be viewed as bringing forth data representative of an area of a higher rainfall rather than southern Manitoba. This is considered a wrong evaluation of the experiment. Rainfall was higher this year than average but the additional water making up the greatest increase of the moisture difference was given for two reasons; 1) to stave off retardation of plant growth due to severe dry weather conditions even though reed canarygrass is considered to be drought resistant and, 2) to make up the difference of moisture loss due to greater soil temperature in the drums. It was a known fact that even painting the drums white would not completely eliminate greater temperatures in the soils studied (especially the clay) as compared to soil temperature of the enclosure. The greater soil temperature did not affect plant growth since reed canarygrass is reported to have a 20% decrease in net photosynthesis at 38°C from the optimum temperature of 20°C (26) but it would have caused a greater loss of soil moisture than is normal. The extra water given eliminated this problem and kept soil moisture conditions near normal and representative of the area.

The general behaviour of nitrate-nitrogen in the soil conforms to what other researchers have already found namely; as nitrogen fertilization increased NO_3-N in the soil increased; NO_3-N decreased in soil as the time period after application increased, and the highest concentrations of NO_3-N accumulated at the 30 cm depth of the soil profile. (51, 62). However, deviation from the general rule of behaviour did exist in the results. The fall-off response in NO_3-N between 336 and 448 kg N/ha rate is such a deviation. By looking at the various interactions, this deviation mainly occurred on the clay soil treated with the inorganic fertilizer at the 15 cm depth at the above said rate. All possibilities for this occurrence have been carefully considered but no supporting evidence was found in order to attain a solution (65). Therefore, no explanation can be given as to why it happened.

Another deviation in behaviour was the increase in soil NO_3-N concentration from August to September. Here, the explanation appears logical. As mentioned in the Literature Review, water on a nitrogen source will aid in the formation of nitrates. The addition of the remaining extra water to stave off severe drought effects on the reed canarygrass in August caused a release of nitrate-nitrogen in high concentrations which would have not normally occurred. If the addition of the extra water had been applied according to schedule, more than likely there would have been no increase in soil NO_3-N for September. This also would have improved the correlation coefficient between NO_3-N concentration and time period after fertilization.

As the results indicate, the contamination threat to ground water of high NO_3-N concentrations came not from the animal manures but from the inorganic fertilizer. This is most clearly illustrated in Figure 9. The threat of environmental contamination is continuously decreasing in both manures but becoming an ever-increasing problem at dangerously high levels in the inorganic fertilizer. This problem is even more serious when it is realized the NO_3-N levels from the inorganic fertilizer are so much higher than the animal manures to begin with.

If the average of the control replications for each fertilizer at the 60 cm depth are converted to zero by subtracting their true value and this same value is subtracted from the average of each rate in the respective fertilizer, it is apparent that at even the highest rates of nitrogen application the NO_3-N in the soils from the animal manure is less than 10 ppm for each month of the growing season thereby eliminating the chance of groundwater pollution. This, however, is not the case for the inorganic fertilizer. At rates higher than 224 kg N/ha, the levels of NO_3-N in the soil exceed 10 ppm and consequently present an environmental problem. It is quite evident that farmers using commercial fertilizer will probably never apply it at such rates higher than 224 kg N/ha but an error in calculation for application rates for a commerical fertilizer presents a greater possibility of an environmental hazard since the margin for error is much smaller than with animal manure.

Conductivity increase in the soil is highly correlated with NO_3-N increase in the soil. This fact is quite apparent in this experiment when one considers the same interactions were significant for both and the general behaviour of conductivity was similar to that of NO_3-N. As expected the beef manure treatments had the highest cumulative salt content. What was not expected was how high the values for the inorganic fertilizer were. In some cases salt contribution from the inorganic fertilizer were greater than contributions from the beef manure. The salt content of the soil treated with swine manure was low. Sows in the farrowing barn at the Glenlea Research Station are not fed recycled wastewater as are the boars and guilts. Because of the piglets, the water supply is ordinary tap water. If the swine manure had been taken from the pit of the barn housing the boars and guilts, the high salinity content of the wastewater would probably have resulted in a higher salinity content in the swine treated soils. As stated earlier, the inorganic fertilizer and beef manure were very close in conductivity levels especially on the clay soil. The difference between the two was greatest on the sand soil where salt content of the beef treatment was significantly higher in most cases than where inorganic fertilizer was applied.

At no time during the course of the experiment did the salinity content of either soil present a problem in terms of growth retardation of the reed canarygrass.

Although salt content did reach fairly high levels in some instances, the fact that the moisture the soil received distributed the salts throughout the soil profile helping to eradicate high concentrations at various depths. The highest concentrations of salt, like NO_3-N, accumulated at the 30 cm depth. The salts that are added when beef manure is applied could present a problem in an area of lesser rainfall. The salts would then be brought near to the surface and a serious problem could arise. From the results obtained in this experiment, a salinity problem does not seem possible in this area of Manitoba as long as the normal pattern of rainfall occurs.

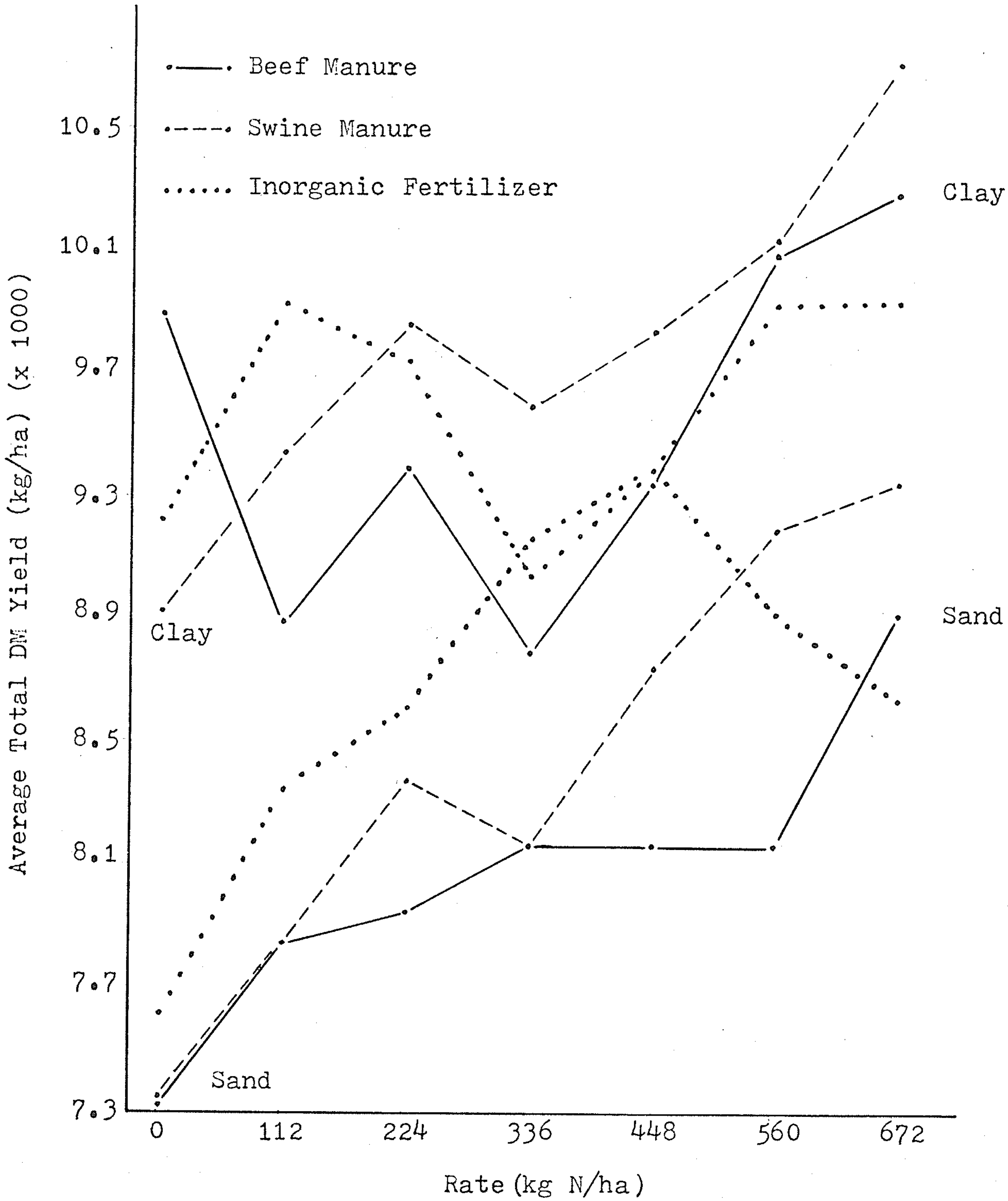
The amount of growth in terms of height was not significantly different from one fertilizer to another but the values for the inorganic fertilizer were slightly higher than values for the other two. The results obtained from the single factors studied were as expected; growth was greater on the clay soil and the first cut of hay and the height of plants grown increased in accordance with increasing rates of nitrogen application. The diminishing returns curve between 224 and 336 kg N/ha was also expected since a fall-off response has been reported by many workers in terms of dry matter yield (4, 8, 11, 17, 19, 55). Although height of plant growth is a good indication of plant productivity, more validity can be placed and is placed on the results obtained for DM yield.

Dry-matter production was greatest on the inorganic fertilizer treatment on an overall basis. As can be seen in Figure 18, swine manure had greater yields at the higher rates on both soils and was the highest yielding treatment on the clay when application rates exceeded 112 kg N/ha. Yields were good on both soils and the second cut was not significantly less than the first cut. The fall-off response expected occurred between the same rates as reported by Dean and Clark (17) and Ramage et al. (55) for reed canarygrass on a clay soil.

The results for DM yield illustrated in Figure 18 might possibly be used as a guide for anyone who wants to know what fertilizer is best at what rate for what soil. The farmer who has land on a clay type soil with a low animal production will consequently have a low waste production not adequate enough to meet his fertilizer requirements. As long as application rates do not exceed 224 kg N/ha, the farmer's best bet is to use a commercial fertilizer to maximize yields. For a farmer or a commercial feedlot operator who has a large animal production and a large amount of waste to handle, maximum yields of hay will be obtained if animal manure is used at rates of 448 kg N/ha or higher. Even though the commercial fertilizer is higher producing than the beef manure between 224 and 448 kg N/ha, the cost of commercial fertilizer would probably not warrant its use at higher rates because the economic return would be small.

Figure 18

Fertilizer x Rate x Soil Interaction



For an animal producer on a sandier type of soil, it is recommended that inorganic fertilizer be used only at very low rates. Economic returns would probably not justify high rates of inorganic fertilizer but as shown in Figure 9, NO_3-N in the soil continues to increase after application while animal manure NO_3-N does not. For a sandy soil the recommendation is simply if inadequate manure exists, use an inorganic fertilizer at low rates and if adequate manure exists apply at 672 kg N/ha or higher to maximize DM yield.

There is another alternative that can be used to obtain maximum DM production from the land and that is a combination of inorganic and organic fertilizer. Hubbard and Nicholson (28) finalized a report on reed canarygrass versus grass-legume mixtures by saying:

> When all factors were taken into account the bromegrass-orchardgrass-ladino clover gave the most satisfactory results followed closely by the reed canarygrass-ladino clover mixture. Reed canarygrass alone produced the lowest number of sheep days over a three year period and the lowest actual gains per hectare. The reed canarygrass plus 300 kg N/ha produced the highest actual weight gain, 640 kg/ha and the greatest number of sheep days, 2240. However the nitrogen fertilizer cost $84/ha which cannot be justified in terms of additional T.D.N. produced.

It is in a situation like this that one of two courses can be taken. From the aforementioned report, it is evident that with fertilization, reed canarygrass the highest yields of all grasses and grass-legume mixtured studied. To maximize yields, animal manure, preferably swine manure, can be applied in place of the inorganic fertilizer in order to equal 300 kg N/ha or the inorganic fertilizer can be applied to an economic rate and the animal manure can be applied with it to make up the difference in nitrogen required. In that way the inorganic fertilizer would cost less than $84/ha, weight gains and sheep days would be maximized, and all it would cost the farmer other than the inorganic fertilizer would be a little more time taken to apply the animal manure. The economic returns from the latter method would probably justify the use of such a method.

Crude protein content for the reed canarygrass was very good for both cuts and both soils. Levels at 224 kg N/ha were higher than Chalupa's (13) 21.64% especially on the swine and inorganic fertilizer treatments on the clay soil. The inorganic fertilizer was significantly better than the animal manure ($p \leq .01$). This was mainly due to the fact that CP levels for the inorganic treatment on the sand were much higher than CP levels for the beef treatment on the sand. The three fertilizers were fairly equal on the clay soil for both the first and second cut in terms of CP content. The linear response of crude protein to nitrogen fertilization occurred as expected. The response was similar to reports by other workers (12, 20, 27, 53). Although crude protein levels were best from the inorganic treatments, swine manure is recommended for fertilizer use at high rates not only because it had significantly better CP levels than beef manure but because it presents less of a chance of environmental contamination than the commercial fertilizer.

The level of NO_3-N in the plant tissue that was considered potentially toxic to animal health was 0.30%. This figure is based on the reports by Wright and Davison (77) who regarded levels of 0.34 to 0.45% NO_3-N as potentially toxic and Hanway et al. (25) who concluded nitrate poisoning of livestock would occur if levels exceeded 0.30%. The figure of 0.3% NO_3-N is equal to 1.33% total nitrate in the plant tissue.

The inorganic fertilizer had the highest nitrate levels on both soils and both cuts of hay. Toxic levels were reached for all rates of the inorganic fertilizer (except for the control) on the clay soil and the highest rates on the sand soil for the first cut. Toxic levels were never reached in either of the animal manures. Nitrate levels had a tendency to decrease for beef treatments in the first cut of hay. Although high application rates of the inorganic fertilizer will probably never be applied to the land due to economic reasons, the results clearly show how potentially lethal a commercial fertilizer can be to livestock if misused. From the results obtained in this experiment, high application rates of animal manure on land appear to pose a lesser threat to the environment and/or farm livestock than inorganic fertilizer. Cattle manure treatments had the lowest nitrate levels in the reed canarygrass which is quite important since the cattle population and the amount of manure produced per animal far exceed equivalent values for other farm livestock. Values for NO_3-N and total NO_3^- in the plant tissue are listed in Appendix 14.

The mineral content of the reed canarygrass was comparable to values set down by the National Academy of Sciences (48) for P, Ca, Mg; higher in K but lower in Fe and Mn. In comparing the nutrient values for the inorganic fertilizer with the values obtained by Dean and Clark (Table 7), only P, Mg and B were approximately equal. Values for Ca and K in this experiment were twice as much as values obtained in Dean's experiment. Zinc values were lower in the Dean experiment and Mn was higher than in this experiment. Dean's values for iron fluctuated considerably as can be seen in Table 7. The Ca:Mg ratio in Dean's values was 1:1 while the Ca:P ratio fluctuated considerably as compared to a 3:2 and 3:4 ratio for Ca:Mg and Ca:P in this experiment.

Table 7

Mineral Content of Reed Canarygrass Fertilized With an Inorganic Fertilizer (17)

Experiment 1		%				ppm		
1st Cut	P	K	Ca	Mg	Fe	Mn	B	Zn
0 kg N/ha	0.28	1.02	0.19	0.22	61	32	6	17
112 kg N/ha	0.23	1.47	0.14	0.19	63	21	5	15
2nd cut								
0 kg N/ha	0.45	1.74	0.19	0.22	100	40	7	18
112 kg N/ha	0.31	1.69	0.19	0.21	70	44	6	16
Experiment 2								
1st cut								
0 kg N/ha	0.19	0.91	0.20	0.20	237	44	10	20
112 kg N/ha	0.18	2.09	0.20	0.19	122	24	8	21
2nd cut								
0 kg N/ha	0.51	2.34	0.18	0.29	269	37	11	35
112 kg N/ha	0.41	3.46	0.16	0.25	170	34	7	36

Separate tests on reed canarygrass fertilized with animal waste were conducted by Clark (14) at Glenlea Research Station. The mineral values for Clark's experiment compared to values of this experiment were relatively the same for P, K, Mg, Mn, and Zn. No values for B were given in Clark's data. Clark's values for Ca were ½ the levels in this experiment and the Fe levels were extremely higher than Fe levels in this experiment (Table 8). The Ca:Mg ratio in Clark's data was approximately 2:3 for the controls and 1:2 for the treated plots while the Ca:P was 1:2 throughout the data.

In comparing the four sets of data, it would appear the mineral content of the reed canarygrass for this experiment is comparable to similar data from the other experiments. The reed canarygrass would probably meet the majority of requirements for feed for farm livestock. Some mineral supplement would probably be needed in most cases but the amount and kind of supplement would depend largely on the type of animal being fed.

Table 8

Mineral Content of Reed Canarygrass
in Animal Waste Experiments,
Glenlea Research Station, 1973 (14)

Rate	P (%)	K (%)	Ca (%)	Mg (%)	Fe (ppm)	Mn (ppm)	B (ppm)	Zn (ppm)
control								
0 lbs.N/acre	0.27	2.5	0.17	0.26	379	25	-	25
(0 kg N/ha)	0.28	2.2	0.16	0.24	386	33	-	20
	0.26	2.4	0.16	0.26	1465	48	-	25
	0.22	2.2	0.19	0.23	1305	42	-	23
Beef Manure								
30 lbs.N/acre	0.25	2.2	0.16	0.26	1465	43	-	26
(33.6 kgN/ha)	0.27	2.4	0.24	0.26	365	21	-	24
180 lbs.N/acre	0.32	2.2	0.19	0.24	158	65	-	24
(202 kgN/ha)	0.39	2.1	0.19	0.21	99	48	-	21
Swine Manure								
60 lbs.N/acre	0.33	2.4	0.15	0.28	1585	54	-	35
(67 kg N/ha)	0.34	2.6	0.16	0.30	1200	50	-	32
180 lbs.N/acre	0.44	3.0	0.23	0.36	665	59	-	42
(202 kgN/ha)	0.44	2.9	0.21	0.40	3235	100	-	63
Inorganic Fertilizer								
60 lbs.N/acre	0.23	2.0	0.16	0.35	4810	114	-	41
(67 kg N/ha)	0.31	3.1	0.18	0.30	560	43	-	39
	0.28	2.7	0.18	0.32	1825	48	-	40
	0.29	2.9	0.18	0.31	9795	51	-	30

VI. SUMMARY AND CONCLUSIONS

The experiment was conducted in the summer of 1973 to determine various effects of heavy rates of beef and swine manure compared to an inorganic fertilizer on the production of reed canarygrass grown on two Manitoba soils; a sand and a clay. Seven rates of fertilizer were applied ranging from 0 to 672 kg N/ha.

Twenty-five gallon oil drums were used to contain the soils under investigation and grow the reed canarygrass. Each drum had holes drilled in the side in order that soil sampling could be carried out during the course of the experiment. The inside of each drum was lined with plastic in order to prevent metal contamination of the soil from the drum. Soil samples were taken once every four weeks from the 15, 30 and 60 cm depth in the drum and analysed for nitrate-nitrogen and conductivity. Two cuts of hay were taken, the first at the end of July and the second at the end of September. Dry-matter yield, crude protein, % nitrate, and mineral content of the plant tissue was then determined.

Heavy concentrations of nitrate-nitrogen were contributed from all three sources of nitrogen at the beginning of the experiment. These high concentrations never accumulated lower in the soil profile than 30 cm. Nitrate-nitrogen from the manures decreased as the experiment progressed but increased in concentration from the inorganic treatments. As the experiment progressed NO_3-N concentrations from the inorganic fertilizer continued to increase and posed an ever-increasing threat of environmental contamination.

Salinity content of the soil rose and fell in accordance with the levels of NO_3-N. As expected, the clay soil treated with beef manure had the highest conductivity. Adequate moisture aided in preventing high concentrations of salts from building up near the surface. There were no harmful effects on the growth of the reed canarygrass from salt concentrations. Growth of reed canarygrass was good on all treatments of both soils.

Dry-matter yield from all fertilizers was very good. The inorganic fertilizer had the highest yields at the lower rates while the animal manures had the greatest production in the highest nitrogen application rates. Swine manure had the highest yields on the clay soil at all rates except 112 kg N/ha. There was only a slight decrease in yield for the second cut of hay as compared to the first.

Crude protein content was very good in all treatments especially for the first cut on the clay soil. The average CP content was over 21% on the clay soil and over 18% on the sand for the first cut. A linear increase in CP level as nitrogen rates increased was always apparent.

Total nitrate in plant tissue reached potentially toxic levels from most rates of the inorganic fertilizer only. The level at which nitrate-nitrogen was considered potentially harmful was 0.30%. The animal manures were always lower in nitrate concentration, with the exception of one or two instances, than what was considered harmful to livestock.

Mineral content of the fertilized grass was comparable to data of a similar nature from other experiments. Slight increases in some element concentrations were apparent on treated grass as compared to the controls. There was also slight fluctuation in Ca:K and Ca:P ratios in this experiment as compared to ratios in similar experiments.

It is the opinion of the writer that this experiment brings forth the possibility that heavy rates of animal manure might possibly be applied to Manitoba soil without endangering the environment or causing toxic levels of nitrate to accumulate in a forage crop. This does not mean the chances of environmental contamination are nil. The threat of such contamination is still present but under careful management and a watchful eye, farmers and feedlot operators who have a waste disposal problem can apply heavier rates to land growing a suitable crop with greater confidence in that neither the environment or livestock will be harmed.

Reed canarygrass has proven it can utilize the nutrients from animal waste without becoming toxic. In the past, this forage has proven better than other forages for this purpose. There is great potential in the fact that reed canarygrass can produce very high yields from organic fertilizer. This grass can be fed back to animals on farms and feedlots thereby producing a cyclical operation where most of the nutrients of the manure are re-utilized by indirectly converting them to grass and refeeding the grass. A process like this could cut down on the amount of hay a feedlot operation would have to bring in for the animals.

The swine manure proved the best in terms of crop production but beef manure contributed less nitrate-nitrogen to the soil profile. When applying animal manures to the land, incorporation into the soil would probably be the best method for maximum utilization of nutrients and minimum odor problems. When applying heavy rates of beef manure, another factor that should be considered is the type of climate. Heavy rates of beef manure would probably cause a salinity problem on the soil surface in areas where annual moisture is not enough to effectively distribute the salts throughout the soil profile.

Research in this area is only beginning. More extensive research will have to be carried out so that the effects of animal and human waste recycled back into the environment are completely known in order that the possibility of environmental contamination is reduced to almost nil. The nutrients in manures, both anaimal and human, are a great resource that has not been utilized in the most useful and economic way. Proper recycling of these nutrients will mean greater forage production on existing land space and cheaper food sources for greater livestock production.

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APPENDIX

Appendix 1

Table 9. Daily Air Temperature (°C) from May 19, 1973, to September 30, 1973 *

Date	°C	Date	°C	Date	°C	Date	°C	Date	°C
May		June		July		Aug.		Sept.	
19	18.9	15	28.3	12	25.6	8	20.6	4	15.6
20	24.4	16	23.3	13	15.6	9	20.6	5	17.2
21	23.3	17	17.2	14	21.1	10	22.8	6	17.8
22	16.1	18	16.7	15	22.2	11	26.1	7	18.9
23	18.3	19	13.9	16	26.1	12	20.6	8	23.9
24	13.9	20	13.3	17	23.3	13	23.3	9	25.0
25	10.0	21	20.6	18	17.2	14	27.8	10	20.0
26	19.4	22	23.9	19	22.8	15	28.9	11	21.1
27	25.6	23	28.3	20	24.4	16	27.8	12	20.6
28	22.2	24	24.4	21	26.1	17	25.6	13	14.4
29	23.3	25	20.6	22	26.1	18	30.6	14	8.9
30	19.4	26	18.9	23	25.6	19	21.1	15	10.0
31	20.0	27	19.4	24	23.3	20	22.2	16	15.6
June		28	11.7	25	22.8	21	21.7	17	17.8
1	22.2	29	21.1	26	22.8	22	23.9	18	19.4
2	27.2	30	24.4	27	19.4	23	23.9	19	8.3
3	20.6	July		28	22.2	24	20.0	20	11.1
4	15.0	1	27.2	29	19.4	25	27.8	21	7.8
5	16.7	2	22.2	30	16.1	26	26.7	22	12.2
6	12.2	3	18.9	31	22.2	27	31.1	23	14.4
7	15.6	4	24.4	Aug.		28	26.1	24	12.2
8	13.3	5	23.3	1	23.9	29	30.0	25	17.2
9	24.4	6	25.6	2	27.2	30	28.3	26	16.7
10	17.2	7	24.4	3	26.1	31	30.0	27	20.6
11	18.3	8	25.6	4	22.8	Sept.		28	21.7
12	19.4	9	25.0	5	21.7	1	23.9	29	18.9
13	26.7	10	23.9	6	26.7	2	16.7	30	21.7
14	22.8	11	26.7	7	23.9	3	16.7		

* Temperatures recorded at 3 p.m. daily.

Appendix 2

Table 10. Weekly Soil Temperatures (^{o}C) in the Drums and the Enclosure

Date	Drum		Enclosure	
	Clay	Sand	a	b
May 23	14.5	14.5	12.2	12.2
30	18.8	16.3	12.8	12.8
June 6	14.4	12.2	12.8	12.2
13	15.0	12.8	13.1	13.3
20	14.4	13.3	14.4	14.4
27	18.9	15.6	18.9	18.9
July 4	17.8	15.6	17.8	17.8
11	22.2	20.0	20.0	20.0
18	18.9	16.7	18.9	18.9
25	22.2	22.2	20.0	20.0
Aug. 1	17.8	16.7	18.9	18.9
8	21.1	20.0	20.0	20.0
15	21.1	20.6	20.6	20.6
22	17.8	16.7	18.1	17.8
29	18.9	16.1	18.9	18.9
Sept. 5	14.4	12.2	17.8	16.7
12	12.8	8.9	15.0	15.0
19	11.1	9.4	14.4	14.4
26	11.7	9.4	11.7	11.7

Appendix 3

Table 11. Additional Watering Dates

Date	Amount (mls)	Date	Amount (mls)
June 6	650	August 1	1300
7	650	7	2600
12	650	10	1300
14	650	17	1300
July 11	1300	21	1300
16	650	22	1300
19	650	27	5200
30	1300		

Appendix 4

Table 12. Nitrate-Nitrogen Concentrations (ppm) in the Soils for the Month of June

	Depth (cm)				Depth (cm)		
Drum	15	30	60	Drum	15	30	60
CB-0a	4.0	39.0	34.2	SB-0a	1.0	0.4	5.2
0b	2.4	17.2	47.8	0b	0.4	1.0	8.0
1a	5.0	31.4	42.2	1a	1.2	1.6	4.4
1b	20.8	32.8	47.8	1b	3.6	5.4	6.4
2a	6.6	32.4	49.8	2a	2.4	1.2	5.4
2b	19.4	32.4	36.4	2b	1.0	3.0	15.0
3a	4.4	19.4	84.0	3a	9.6	11.0	8.2
3b	13.0	40.0	38.4	3b	10.6	2.4	9.4
4a	12.2	19.6	23.0	4a	2.0	2.8	8.8
4b	20.2	36.4	47.8	4b	6.4	13.4	6.8
5a	23.4	37.2	57.8	5a	10.0	6.2	8.6
5b	11.2	40.2	50.8	5b	7.4	11.4	6.8
6a	8.4	28.2	26.2	6a	14.8	20.2	4.0
6b	18.8	35.6	50.2	6b	11.2	23.2	6.8
CS-0a	2.4	14.0	40.4	SS-0a	1.4	1.6	14.4
0b	1.8	19.8	27.0	0b	0.8	0.8	5.0
1a	6.4	23.0	14.4	1a	1.8	4.2	7.6
1b	20.4	30.4	18.4	1b	4.0	5.8	10.2
2a	38.8	56.4	37.4	2a	9.4	6.8	7.0
2b	12.2	40.2	22.6	2b	28.8	17.2	11.6
3a	33.4	38.6	24.8	3a	5.0	16.2	13.4
3b	33.4	45.0	37.4	3b	24.0	12.2	10.6
4a	37.4	113.0	1.6	4a	16.0	25.8	4.6
4b	4.2	73.0	18.0	4b	7.6	17.0	7.8
5a	19.4	53.8	28.0	5a	11.4	25.0	13.2
5b	155.0	86.0	27.4	5b	4.2	15.2	6.2
6a	330.0	61.0	9.0	6a	14.2	22.8	5.2
6b	280.0	145.0	21.0	6b	43.8	29.2	7.0
CI-0a	3.8	25.4	36.4	SI-0a	1.2	0.6	7.2
0b	8.0	27.4	68.0	0b	0.8	1.2	15.4
1a	36.0	83.0	47.4	1a	13.4	7.0	2.4
1b	7.2	54.4	40.0	1b	3.0	6.4	12.0
2a	4.6	33.6	79.0	2a	22.6	52.0	14.4
2b	50.2	121.0	58.0	2b	12.6	39.0	16.4
3a	11.0	195.0	82.0	3a	19.4	15.4	10.4
3b	265.0	103.0	96.0	3b	4.0	22.8	9.2
4a	32.0	64.0	115.0	4a	5.2	16.6	7.4
4b	6.6	57.8	54.8	4b	13.4	57.0	15.0
5a	15.4	132.0	68.0	5a	15.4	38.6	11.8
5b	58.0	275.0	72.0	5b	2.2	33.0	9.0
6a	127.0	195.0	48.4	6a	18.6	37.0	12.0
6b	250.0	265.0	47.4	6b	16.2	49.4	17.8

Appendix 4 (cont'd)

Table 13. Nitrate-Nitrogen Concentrations (ppm) in the Soils for the Month of July

	Depth (cm)				Depth (cm)		
Drum	15	30	60	Drum	15	30	60
CB-0a	3.2	2.6	20.4	SB-0a	2.6	2.6	2.6
0b	2.6	4.0	46.6	0b	2.4	0.4	2.8
1a	1.4	4.2	46.6	1a	1.2	2.6	2.4
1b	3.0	2.8	54.6	1b	2.4	2.4	2.6
2a	4.4	4.4	41.0	2a	2.6	1.2	2.8
2b	3.8	3.6	30.0	2b	2.6	2.8	5.4
3a	4.6	3.2	44.6	3a	2.6	2.8	3.8
3b	3.2	3.4	38.0	3b	00.8	1.2	2.0
4a	2.6	7.6	41.6	4a	2.8	2.6	6.4
4b	3.6	5.0	44.0	4b	2.6	2.8	2.8
5a	3.4	8.6	34.6	5a	2.0	2.6	4.6
5b	4.6	5.0	29.6	5b	2.8	2.4	1.0
6a	4.4	3.2	31.6	6a	1.0	0.8	3.2
6b	5.0	6.6	39.0	6b	1.0	2.8	3.2
CS-0a	2.6	2.2	29.2	SS-0a	0.0	0.6	2.0
0b	3.0	3.0	21.2	0b	1.8	1.4	3.8
1a	5.2	5.8	18.6	1a	1.0	1.2	2.8
1b	3.4	5.6	28.0	1b	1.2	0.0	1.8
2a	7.2	33.4	43.6	2a	0.6	0.0	2.8
2b	3.4	14.6	26.0	2b	7.2	2.8	6.2
3a	3.4	28.4	37.2	3a	3.0	4.8	6.8
3b	4.6	20.6	36.2	3b	13.4	9.2	2.0
4a	4.0	108.0	26.4	4a	4.2	3.8	2.6
4b	5.0	67.0	23.8	4b	39.2	12.6	6.8
5a	7.6	40.4	39.8	5a	3.8	5.0	8.4
5b	41.4	64.0	24.6	5b	6.0	0.8	3.6
6a	157.0	155.0	26.2	6a	64.0	31.6	11.4
6b	5.0	107.0	30.0	6b	1.6	8.2	5.4
CI-0a	2.8	8.6	7.2	SI-0a	6.2	1.4	1.0
0b	4.4	3.6	38.0	0b	1.2	0.4	1.2
1a	4.8	54.4	57.4	1a	0.4	3.6	4.8
1b	4.6	33.4	39.4	1b	21.6	42.4	10.4
2a	3.6	45.2	46.4	2a	1.6	2.0	7.0
2b	19.0	132.0	80.0	2b	3.4	165.0	14.2
3a	270.0	17.0	89.0	3a	16.4	63.0	0.8
3b	19.6	54.0	56.0	3b	2.8	42.6	8.4
4a	5.6	9.4	74.0	4a	25.8	31.0	13.6
4b	5.6	124.0	43.4	4b	9.4	58.4	15.6
5a	144.0	200.0	48.0	5a	9.4	124.0	7.6
5b	44.2	110.0	20.4	5b	4.6	139.0	44.8
6a	255.0	121.0	50.4	6a	125.0	134.0	18.4
6b	75.0	270.0	43.2	6b	82.0	127.0	20.8

Appendix 4 (cont'd)

Table 14. Nitrate-Nitrogen Concentrations (ppm) in the Soils for the Month of August

	Depth (cm)				Depth (cm)		
Drum	15	30	60	Drum	15	30	60
CB-0a	4.0	4.4	12.0	SB-0a	1.6	2.0	1.6
0b	1.6	9.0	18.4	0b	1.6	1.0	1.6
1a	3.0	3.2	22.0	1a	0.8	1.0	2.6
1b	2.0	6.0	18.0	1b	4.0	1.6	2.6
2a	2.0	3.4	22.0	2a	4.0	0.8	3.6
2b	2.0	4.0	29.4	2b	4.0	1.0	4.6
3a	2.0	3.0	22.0	3a	1.0	1.0	1.6
3b	1.8	5.0	47.0	3b	3.6	3.6	2.0
4a	2.0	5.0	18.4	4a	0.4	2.6	1.0
4b	3.0	3.2	10.4	4b	1.0	1.0	2.0
5a	2.4	4.4	37.0	5a	3.2	1.0	1.6
5b	1.8	2.0	19.0	5b	1.0	1.0	2.6
6a	2.0	2.0	32.0	6a	1.6	1.6	2.0
6b	3.0	6.4	37.0	6b	1.0	1.6	1.6
CS-0a	1.0	2.4	12.4	SS-0a	0.4	0.4	0.8
0b	3.0	3.0	3.4	0b	1.6	0.2	0.8
1a	3.0	3.0	8.0	1a	0.2	0.4	0.4
1b	4.6	9.0	13.4	1b	0.0	1.0	0.2
2a	5.6	18.4	13.4	2a	0.8	1.0	1.0
2b	3.4	22.6	34.0	2b	1.0	1.6	2.0
3a	4.0	30.0	26.0	3a	1.0	1.0	4.0
3b	3.4	37.0	22.0	3b	1.0	0.6	3.0
4a	2.4	13.4	22.0	4a	0.8	0.6	2.4
4b	2.4	31.0	30.6	4b	1.0	0.4	4.4
5a	5.6	73.0	25.0	5a	0.2	0.8	7.0
5b	9.0	118.0	27.0	5b	1.6	1.0	2.6
6a	4.0	39.0	21.6	6a	0.4	6.4	8.0
6b	3.4	70.0	35.4	6b	1.0	23.0	6.6
CI-0a	3.6	5.6	4.6	SI-0a	0.2	0.0	0.2
0b	4.0	4.6	29.6	0b	0.4	0.4	0.4
1a	3.6	32.6	31.0	1a	0.4	17.4	4.4
1b	4.0	130.0	34.0	1b	4.0	21.0	1.8
2a	4.6	145.0	33.0	2a	6.0	18.4	4.4
2b	4.0	105.0	48.6	2b	0.2	27.0	11.6
3a	10.0	245.0	60.0	3a	35.0	20.4	1.0
3b	170.0	180.0	75.0	3b	0.0	125.0	3.0
4a	38.6	270.0	22.6	4a	36.4	102.0	11.0
4b	8.6	245.0	48.6	4b	0.4	17.4	8.0
5a	63.0	245.0	63.0	5a	26.0	157.0	27.6
5b	170.0	345.0	33.6	5b	0.4	27.0	52.0
6a	170.0	230.0	58.0	6a	82.0	115.0	13.6
6b	11.0	145.0	42.6	6b	115.0	145.0	14.0

Appendix 4 (cont'd)

Table 15. Nitrate-Nitrogen Concentrations (ppm) in the Soils for the Month of September

Drum	Depth (cm) 15	30	60	Drum	Depth (cm) 15	30	60
CB-0a	4.6	10.0	3.0	SB-0a	0.4	0.8	0.4
0b	6.2	18.0	5.0	0b	1.0	0.6	0.4
1a	6.4	14.4	8.0	1a	0.0	0.0	0.0
1b	10.4	14.4	14.4	1b	0.4	0.6	1.4
2a	9.0	14.4	5.0	2a	0.8	0.4	0.6
2b	3.0	6.2	2.4	2b	0.8	1.0	1.0
3a	8.4	11.0	7.0	3a	0.8	1.0	1.4
3b	8.4	19.0	7.0	3b	0.4	0.8	1.0
4a	7.0	8.4	4.0	4a	0.6	0.6	3.0
4b	12.4	19.0	4.4	4b	0.0	0.4	1.4
5a	4.4	13.6	3.8	5a	0.4	1.8	1.6
5b	8.2	7.4	4.6	5b	0.6	0.6	1.8
6a	3.6	6.2	3.6	6a	0.6	0.2	1.4
6b	17.0	22.4	7.0	6b	0.4	0.4	1.8
CS-0a	6.4	12.4	3.6	SS-0a	0.6	1.0	1.2
0b	5.0	11.4	4.6	0b	1.2	0.8	1.0
1a	3.6	10.0	5.0	1a	0.6	0.8	0.6
1b	9.0	18.4	13.4	1b	0.6	1.0	1.0
2a	6.4	11.0	10.0	2a	0.6	1.6	1.0
2b	4.6	35.0	15.0	2b	1.0	1.0	1.6
3a	4.0	37.4	7.4	3a	0.6	1.4	3.4
3b	9.4	47.0	9.0	3b	1.0	1.4	2.0
4a	11.0	28.0	7.0	4a	1.0	1.2	7.4
4b	8.0	37.0	5.4	4b	0.6	0.6	4.4
5a	5.0	35.0	14.0	5a	2.0	1.4	1.4
5b	41.0	108.0	13.0	5b	1.0	5.4	1.0
6a	10.0	35.0	7.4	6a	3.4	8.8	10.2
6b	10.0	105.0	26.4	6b	17.0	12.0	7.0
CI-0a	4.6	6.2	3.8	SI-0a	1.0	0.0	1.0
0b	3.2	10.6	6.2	0b	0.0	1.0	1.6
1a	10.0	45.4	9.0	1a	3.0	1.0	3.6
1b	6.6	196.0	6.4	1b	3.0	6.0	5.6
2a	8.2	142.0	19.0	2a	4.4	105.0	6.0
2b	11.2	20.0	12.0	2b	14.4	90.0	8.4
3a	37.0	276.0	16.4	3a	37.4	31.0	4.2
3b	178.0	188.0	30.4	3b	0.2	230.0	1.0
4a	30.0	176.0	7.4	4a	34.0	124.0	12.0
4b	262.0	244.0	11.2	4b	14.0	113.0	22.4
5a	270.0	274.0	27.0	5a	115.0	180.0	13.4
5b	32.4	200.0	5.0	5b	4.0	130.0	42.4
6a	206.0	166.0	29.6	6a	140.0	230.0	22.4
6b	33.8	148.0	15.6	6b	260.0	290.0	39.0

Appendix 5

Table 16. Factorial Analysis for NO_3-N in the Soil

	Degrees of Freedom	Mean Square	F Value	
Total	1007			
Fertilizer (F)	2	205250.14	222.41	**
Soil (S)	1	185510.60	201.02	**
Rate (R)	6	36449.93	39.50	**
Month (M)	3	3055.34	3.31	*
Depth (D)	2	61824.41	66.99	**
F x S	2	20802.64	22.54	**
F x R	12	15043.84	16.30	**
F x M	6	7238.61	7.84	**
S x M	3	7441.23	8.06	**
R x M	18	827.70	0.90	n.s.
R x S	6	5024.40	5.44	**
D x M	6	5292.37	5.73	**
D x F	4	47859.82	51.86	**
D x R	12	8324.75	9.02	**
D x S	2	6977.31	7.56	**
M x F x R	36	1269.75	1.38	n.s.
M x F x S	6	1692.80	1.83	n.s.
F x R x S	12	3318.01	3.60	**
M x R x S	18	2059.36	2.23	**
D x M x F	12	4187.92	4.54	**
D x M x R	36	806.19	0.87	n.s.
D x M x S	6	2442.41	2.65	*
D x F x R	24	3272.23	3.55	**
D x F x S	4	4469.81	4.84	**
D x R x S	12	1610.31	1.75	n.s.
Sub-total	251			
Error	756	922.83		

* = ($p \leq .05$) ** = ($p \leq .01$) n.s. = not significant

Appendix 6

Table 17. Conductivity (mmhos) of the Soils for the Month of June

	Depth (cm)				Depth (cm)		
Drum	15	30	60	Drum	15	30	60
CB-0a	0.8	1.2	1.1	SB-0a	0.3	0.3	0.4
0b	0.7	0.8	1.2	0b	0.3	0.4	0.4
1a	0.9	1.2	1.3	1a	0.4	0.6	0.3
1b	1.4	1.3	1.3	1b	1.0	0.8	0.4
2a	1.4	1.4	1.4	2a	0.6	0.5	0.4
2b	1.4	1.4	1.4	2b	1.0	0.5	0.4
3a	1.1	1.2	1.6	3a	1.3	1.3	0.4
3b	1.4	1.8	1.4	3b	1.1	0.5	0.4
4a	1.6	1.4	1.1	4a	0.7	0.8	0.4
4b	1.6	1.6	1.6	4b	1.7	1.4	0.4
5a	2.1	1.9	1.5	5a	1.3	1.2	0.4
5b	1.5	1.9	1.9	5b	1.3	1.2	0.4
6a	1.4	1.8	1.6	6a	2.0	1.5	0.3
6b	1.9	1.9	1.5	6b	2.3	1.4	0.4
CS-0a	1.1	1.1	1.5	SS-0a	0.3	0.4	0.4
0b	1.1	1.3	1.4	0b	0.2	0.2	0.2
1a	1.2	1.4	1.4	1a	0.2	0.4	0.2
1b	1.2	1.4	1.4	1b	0.2	0.3	0.2
2a	1.4	1.8	1.5	2a	0.3	0.4	0.2
2b	1.2	1.4	1.4	2b	0.7	0.6	0.4
3a	1.4	1.4	1.4	3a	0.3	0.5	0.3
3b	1.4	1.6	1.7	3b	0.6	0.6	0.3
4a	1.4	2.3	1.4	4a	0.4	0.7	0.2
4b	1.1	1.9	1.2	4b	0.3	0.6	0.2
5a	1.2	1.6	1.3	5a	0.4	0.7	0.3
5b	1.7	2.0	1.4	5b	0.2	0.4	0.2
6a	3.7	1.9	1.1	6a	0.8	0.7	0.2
6b	3.3	2.7	1.2	6b	1.3	0.7	0.3
CI-0a	1.0	1.3	1.3	SI-0a	0.2	0.3	0.2
0b	1.1	1.3	1.7	0b	0.2	0.2	0.3
1a	1.2	1.6	1.4	1a	0.3	0.6	0.2
1b	1.0	1.3	1.0	1b	0.2	0.3	0.3
2a	1.0	1.2	1.6	2a	0.4	0.7	0.3
2b	1.3	1.8	1.6	2b	0.3	0.7	0.2
3a	1.1	2.4	1.8	3a	0.6	0.4	0.3
3b	2.3	1.7	1.8	3b	0.3	0.5	0.2
4a	1.2	1.5	1.5	4a	0.2	0.4	0.2
4b	1.1	1.4	1.4	4b	0.4	0.8	0.3
5a	1.1	1.8	1.5	5a	0.4	0.7	0.3
5b	1.5	2.7	1.5	5b	0.2	0.6	0.3
6a	1.7	2.0	1.4	6a	0.4	0.6	0.3
6b	2.2	2.5	1.4	6b	0.4	0.7	0.3

Appendix 6 (cont'd)

Table 18. Conductivity (mmhos) of the Soils

For the Month of July

Drum	Depth (cm) 15	30	60	Drum	Depth (cm) 15	30	60
CB-0a	1.1	1.1	1.2	SB-0a	0.5	0.5	0.3
0b	1.1	1.0	1.5	0b	0.4	0.5	0.2
1a	1.2	1.2	1.5	1a	0.5	0.5	0.4
1b	1.2	1.2	1.6	1b	0.4	0.5	0.5
2a	1.3	1.6	1.5	2a	1.1	0.7	0.5
2b	1.5	1.6	1.4	2b	1.3	1.2	0.4
3a	1.6	1.7	1.5	3a	0.5	0.9	0.4
3b	2.0	1.7	1.4	3b	1.0	0.3	0.2
4a	1.8	1.6	1.4	4a	1.2	2.0	0.4
4b	1.8	1.8	1.3	4b	0.5	0.8	0.5
5a	1.7	2.3	1.4	5a	1.5	2.1	0.6
5b	1.8	2.3	1.4	5b	0.7	1.3	0.8
6a	2.1	2.3	1.5	6a	1.0	1.0	0.4
6b	1.8	2.3	1.5	6b	0.7	1.3	0.6
CS-0a	1.1	1.2	1.4	SS-0a	0.2	0.2	0.3
0b	1.1	1.2	1.2	0b	0.2	0.2	0.2
1a	1.1	1.3	1.4	1a	0.2	0.2	0.3
1b	1.1	1.3	1.5	1b	0.2	0.3	0.2
2a	1.1	1.5	1.5	2a	0.2	0.8	0.2
2b	1.1	1.3	1.4	2b	0.4	0.5	0.3
3a	1.3	1.4	1.6	3a	0.2	0.6	0.3
3b	1.2	1.6	1.5	3b	0.6	0.8	0.2
4a	1.2	1.9	1.8	4a	0.3	0.4	0.2
4b	1.1	1.5	1.4	4b	1.1	0.5	0.2
5a	1.3	1.6	1.6	5a	0.3	0.6	0.2
5b	1.6	1.9	1.4	5b	0.4	0.3	0.2
6a	2.8	2.7	1.4	6a	1.8	0.8	0.2
6b	1.3	2.1	1.2	6b	0.2	0.4	0.3
CI-0a	1.1	1.3	1.3	SI-0a	0.4	0.2	0.2
0b	1.2	1.2	1.5	0b	0.2	0.2	0.2
1a	1.2	1.5	1.4	1a	0.2	0.2	0.2
1b	1.1	1.3	1.6	1b	0.5	0.6	0.2
2a	1.2	1.4	1.5	2a	0.2	0.3	0.2
2b	1.2	1.9	1.8	2b	0.2	1.9	0.3
3a	2.5	1.2	1.8	3a	0.5	0.8	0.2
3b	1.2	1.6	1.6	3b	0.2	0.7	0.2
4a	1.1	2.2	1.8	4a	0.5	1.7	0.3
4b	1.2	1.8	1.4	4b	0.3	0.7	0.3
5a	2.0	2.2	1.4	5a	0.3	1.5	0.2
5b	1.3	1.8	1.4	5b	0.3	1.5	0.6
6a	2.2	1.8	1.5	6a	1.5	1.5	0.4
6b	1.5	2.7	1.4	6b	1.0	1.5	0.5

Appendix 6 (cont'd)

Table 19. Conductivity (mmhos) of the Soils

For the Month of August

Drum	Depth (cm) 15	30	60	Drum	Depth (cm) 15	30	60
CB-0a	1.0	1.0	1.0	SB-0a	0.4	0.4	0.3
0b	0.9	1.0	1.1	0b	0.3	0.3	0.3
1a	1.0	1.2	1.4	1a	0.3	0.4	0.4
1b	1.0	1.3	1.3	1b	0.3	0.4	0.5
2a	2.0	1.8	1.2	2a	0.5	0.7	0.5
2b	0.8	1.0	1.2	2b	0.8	0.5	0.4
3a	2.1	1.8	1.2	3a	0.6	1.3	0.5
3b	1.7	1.5	1.3	3b	0.6	0.9	0.3
4a	1.8	1.8	1.1	4a	0.6	0.5	0.3
4b	2.0	2.0	1.1	4b	0.6	1.1	0.4
5a	1.7	1.5	1.3	5a	0.8	0.5	0.4
5b	1.5	1.7	1.2	5b	1.5	1.1	0.9
6a	1.8	2.3	1.4	6a	1.0	1.4	0.4
6b	2.1	2.5	1.2	6b	0.8	1.1	0.6
CS-0a	1.0	0.9	0.9	SS-0a	0.3	0.3	0.3
0b	0.8	0.9	0.9	0b	0.3	0.3	0.3
1a	1.0	1.1	1.1	1a	0.3	0.3	0.3
1b	1.1	1.1	1.1	1b	0.3	0.3	0.3
2a	0.9	1.2	1.2	2a	0.3	0.3	0.3
2b	1.0	1.4	1.3	2b	0.3	0.3	0.3
3a	1.3	1.3	1.3	3a	0.4	0.4	0.3
3b	1.0	1.5	1.1	3b	0.3	0.3	0.3
4a	1.1	1.0	1.1	4a	0.3	0.3	0.3
4b	1.0	1.3	1.3	4b	0.3	0.4	0.4
5a	1.1	1.8	1.2	5a	0.3	0.3	0.4
5b	1.4	2.5	1.3	5b	0.4	0.3	0.2
6a	0.9	1.3	1.3	6a	0.3	0.7	0.4
6b	1.1	1.7	1.2	6b	0.5	0.8	0.3
CI-0a	1.0	1.1	1.2	SI-0a	0.3	0.3	0.3
0b	1.0	1.2	1.4	0b	0.2	0.2	0.3
1a	1.1	1.3	1.4	1a	0.3	0.5	0.3
1b	1.0	1.8	1.5	1b	0.3	0.5	0.3
2a	1.1	1.9	1.4	2a	0.4	0.6	0.4
2b	1.0	1.7	1.4	2b	0.3	0.7	0.4
3a	1.0	2.7	1.5	3a	0.6	0.5	0.3
3b	2.1	2.3	1.5	3b	0.3	1.6	0.3
4a	1.2	2.8	1.1	4a	0.6	1.2	0.3
4b	0.9	2.4	1.5	4b	0.3	0.5	0.3
5a	1.4	2.5	1.5	5a	0.4	1.6	0.4
5b	2.1	2.8	1.4	5b	0.3	0.5	0.7
6a	2.1	2.7	1.2	6a	1.1	1.4	0.4
6b	1.0	2.0	1.3	6b	1.2	1.5	0.4

Appendix 6 (cont'd)

Table 20. Conductivity (mmhos) of the Soils

For the Month of September

	Depth (cm)				Depth (cm)		
Drum	15	30	60	Drum	15	30	60
CB-0a	1.1	1.1	1.1	SB-0a	0.4	0.3	0.3
0b	1.2	2.2	1.1	0b	0.6	1.3	0.3
1a	1.1	1.4	1.3	1a	0.3	0.3	0.4
1b	1.8	1.2	2.1	1b	0.6	0.7	0.4
2a	1.6	1.7	1.1	2a	0.6	0.7	0.5
2b	1.4	1.7	1.0	2b	0.4	1.1	0.3
3a	1.9	1.6	2.2	3a	0.7	1.1	0.6
3b	1.1	1.4	1.1	3b	0.7	1.1	0.3
4a	2.4	1.8	1.2	4a	0.7	0.6	0.4
4b	1.0	2.1	1.1	4b	0.4	0.9	0.5
5a	2.1	2.1	1.1	5a	1.0	2.2	0.6
5b	1.8	1.9	1.2	5b	0.9	0.9	0.9
6a	2.3	2.2	1.2	6a	1.2	2.4	0.4
6b	1.1	1.1	1.9	6b	1.9	1.3	0.9
CS-0a	1.2	1.2	1.1	SS-0a	0.3	0.4	0.4
0b	1.2	1.2	1.1	0b	0.3	0.3	0.4
1a	1.0	1.3	1.2	1a	0.4	0.5	0.4
1b	1.2	1.2	1.4	1b	0.4	0.3	0.4
2a	1.2	1.2	0.3	2a	0.4	0.4	0.3
2b	1.1	1.3	1.2	2b	0.4	0.9	0.4
3a	1.4	1.5	1.3	3a	0.4	0.5	0.4
3b	1.4	1.5	1.2	3b	0.4	1.2	0.4
4a	1.2	1.4	1.2	4a	0.4	0.4	0.4
4b	1.2	1.5	1.1	4b	0.3	0.5	0.4
5a	1.4	1.5	1.4	5a	0.4	0.3	0.6
5b	1.6	2.1	1.1	5b	0.4	0.6	0.3
6a	1.2	1.1	1.1	6a	0.7	0.7	0.4
6b	1.3	1.9	1.3	6b	0.7	0.7	0.3
CI-0a	1.0	1.2	1.2	SI-0a	0.3	0.4	0.3
0b	1.1	1.2	1.3	0b	0.3	0.3	0.3
1a	1.1	1.4	1.2	1a	0.3	0.4	0.3
1b	1.0	1.9	1.2	1b	0.4	0.4	0.3
2a	1.1	1.3	1.1	2a	0.4	0.8	0.4
2b	1.2	1.1	1.3	2b	0.4	1.0	0.3
3a	1.2	2.3	1.1	3a	0.6	0.6	0.3
3b	1.9	2.0	1.4	3b	0.3	1.3	0.3
4a	1.3	1.6	1.2	4a	0.5	1.3	0.4
4b	1.7	2.0	1.3	4b	0.6	0.8	0.4
5a	2.3	2.5	1.2	5a	0.8	2.4	0.4
5b	1.3	2.0	1.3	5b	0.3	2.1	0.6
6a	2.0	1.8	1.3	6a	1.4	1.2	0.5
6b	1.3	1.9	1.3	6b	2.0	1.5	0.6

Appendix 7

Table 21. Factorial Analysis for Soil Conductivity

	Degrees of Freedom	Mean Square	F Value	
Total	1007			
Fertilizer	2	4.54	64.85	**
Soil	1	207.55	2965.00	**
Rate	6	5.72	81.71	**
Month	3	0.39	5.57	**
Depth	2	10.37	148.14	**
F x S	2	1.38	19.71	**
F x R	12	0.19	2.71	**
F x M	6	0.44	6.28	**
S x M	3	0.49	7.00	**
R x M	18	0.08	1.14	n.s.
R x S	6	0.17	2.42	*
D x M	6	0.15	2.14	*
D x F	4	1.09	15.57	**
D x R	12	1.17	16.71	**
D x S	2	0.55	7.85	**
M x F x R	36	0.10	1.42	n.s.
M x F x S	6	0.38	5.42	**
F x R x S	12	0.16	2.28	**
M x R x S	18	0.13	1.85	*
D x M x F	12	0.12	1.71	n.s.
D x M x R	36	0.09	1.28	n.s.
D x M x S	6	0.26	3.71	**
D x F x R	24	0.12	1.71	*
D x F x S	4	0.14	2.00	n.s.
D x R x S	12	0.07	1.00	n.s.
Sub-total	251			
Error	756	0.07		

Appendix 8

Table 22. Height (cm) of Reed Canarygrass after Transplanting and Before Each Harvest

	Height				Height		
Drum	after trans-planting	before 1st cut	before 2nd cut	Drum	after trans-planting	before 1st cut	before 2nd cut
CB-0a	13	52	43	SB-0a	17	44	34
0b	17	53	41	0b	18	47	28
1a	11	46	42	1a	11	39	30
1b	15	54	41	1b	8	38	31
2a	18	52	42	2a	13	41	33
2b	12	45	45	2b	15	42	35
3a	20	46	42	3a	12	44	39
3b	19	43	38	3b	12	45	39
4a	24	45	39	4a	16	42	33
4b	19	50	44	4b	10	33	28
5a	20	44	43	5a	12	38	33
5b	21	47	42	5b	12	42	36
6a	24	52	44	6b	10	40	37
6b	18	50	44	6b	14	43	41
CS-0a	24	45	39	SS-0a	20	38	39
0b	23	48	44	0b	23	41	36
1a	12	55	43	1a	18	42	35
1b	14	46	38	1b	16	44	29
2a	13	48	45	2a	22	42	30
2b	6	52	42	2b	20	41	38
3a	10	47	39	3a	15	38	34
3b	12	49	39	3b	14	40	37
4a	16	50	42	4a	16	41	36
4b	15	48	40	4b	14	41	36
5a	12	45	43	5a	14	44	42
5b	18	49	38	5b	16	42	40
6a	22	54	42	6a	19	48	42
6b	21	53	44	6b	19	46	44
CI-0a	20	52	44	SI-0a	12	43	29
0b	16	48	36	0b	13	39	25
1a	15	48	38	1a	17	42	37
1b	13	44	40	1b	14	42	39
2a	12	51	43	2a	18	39	38
2b	9	47	42	2b	16	46	42
3a	14	46	37	3a	24	43	41
3b	8	46	36	3b	25	38	35
4a	10	45	43	4a	14	40	41
4b	12	48	43	4b	17	43	44
5a	10	48	41	5a	16	43	37
5b	18	49	48	5b	18	46	40
6a	16	50	42	6a	15	39	40
6b	16	52	47	6b	16	38	38

Appendix 9

Table 23. Factorial Analysis for Height of Growth

	Degree of Freedom	Mean Square	F Value	
Total	167			
Fertilizer (F)	2	4.09	0.49	n.s.
Soil (S)	1	1506.00	179.07	**
Rate (R)	6	38.51	4.58	**
Cut (C)	1	260.00	30.92	**
F x S	2	29.24	3.48	*
F x R	12	21.54	2.56	*
F x C	2	8.58	1.06	n.s.
S x R	6	36.29	4.32	**
S x C	1	28.35	3.37	n.s.
R x C	6	29.28	3.48	**
F x S x R	12	33.09	3.93	**
F x S x C	2	157.35	18.71	**
S x R x C	6	20.70	2.46	*
F x R x C	12	32.82	3.90	**
F x S x R x C	12	17.51	2.08	*
Sub-total	83			
Error	84	8.41		

Appendix 10

Table 24. Dry Matter Yield (kg/ha) for the First and Second Cut

Drum	Yield 1st cut	Yield 2nd cut	Drum	Yield 1st cut	Yield 2nd cut
CB-0a	5061	5000	SB-0a	4024	3415
0b	5000	4756	0b	3598	3598
1a	4146	4817	1a	3902	3598
1b	4512	4329	1b	4085	4146
2a	5000	4634	2a	4085	3902
2b	4573	4634	2b	3841	4085
3a	4390	4390	3a	4024	4085
3b	4573	4207	3b	4207	4024
4a	4878	4390	4a	3476	4085
4b	4512	4939	4b	4207	4573
5a	5183	4878	5a	4207	4085
5b	5183	4939	5b	4024	4024
6a	5122	5061	6a	4512	4573
6b	5244	5183	6b	4512	4268
CS-0a	4512	4390	SS-0a	3780	3415
0b	4634	4329	0b	4085	3415
1a	5244	4817	1a	3963	4085
1b	4695	4146	1b	4146	3537
2a	4756	5488	2a	4207	4207
2b	4939	4573	2b	4146	4207
3a	5122	4634	3a	3780	4329
3b	5000	4451	3b	4146	4085
4a	5122	4695	4a	4512	4268
4b	4817	5061	4b	4634	4085
5a	4878	5122	5a	4695	4451
5b	5488	4817	5b	4695	4573
6a	5610	5305	6a	4756	4695
6b	5610	4939	6b	4878	4390
CI-0a	4756	5061	SI-0a	4329	3658
0b	4085	4573	0b	3780	3476
1a	5122	5183	1a	4146	3902
1b	4939	4634	1b	4329	4329
2a	4756	5244	2a	4085	4146
2b	4451	5061	2b	4390	4634
3a	4634	4695	3a	4817	4756
3b	4329	4512	3b	4085	4878
4a	4207	5244	4a	4451	4939
4b	4573	4756	4b	4268	5122
5a	5000	5061	5a	4024	4512
5b	4756	5061	5b	4756	4573
6a	4817	5183	6a	4329	4268
6b	4756	5183	6b	4085	4634

Appendix 11

Table 25. Factorial Analysis for DM Yield

	Degree of Freedom	Mean Square	F Value	
Total	167			
Fertilizer	2	502256.64	8.44	**
Soil	1	16299549.05	274.11	**
Rate	6	1088579.45	18.30	**
Cut	1	14878.34	0.25	n.s.
F x S	2	280699.79	4.72	*
F x R	12	159757.69	2.68	**
F x C	2	716439.21	12.04	**
S x R	6	286439.62	4.81	**
S x C	1	775.72	0.01	n.s.
R x C	6	130528.38	2.19	n.s.
F x S x R	12	108264.25	1.82	n.s.
F x S x C	2	84625.16	1.08	n.s.
F x R x C	12	54585.81	0.91	n.s.
S x R x C	6	92628.98	1.55	n.s.
F x S x R x C	12	44617.15	0.75	n.s.
Sub-total	83			
Error	84	59462.68		

Appendix 12

Table 26. Crude Protein Content (%)

for the First and Second Cut

	CP Content			CP Content	
Drum	1st cut	2nd cut	Drum	1st cut	2nd cut
CB-0a	21.19	14.69	SB-0a	14.00	8.88
0b	20.63	16.88	0b	14.31	7.63
1a	23.31	15.00	1a	14.81	9.00
1b	21.69	14.50	1b	15.88	10.50
2a	21.88	18.13	2a	15.19	9.81
2b	21.63	17.88	2b	19.31	13.38
3a	21.13	16.81	3a	17.31	13.00
3b	22.19	18.31	3b	17.50	13.31
4a	20.50	17.88	4a	19.13	12.38
4b	21.63	17.13	4b	18.38	12.13
5a	20.88	18.00	5a	18.31	12.88
5b	21.63	18.00	5b	18.00	11.38
6a	21.63	16.88	6a	18.38	12.88
6b	20.88	17.63	6b	20.50	15.31
CS-0a	21.13	16.00	SS-0a	17.38	8.38
0b	21.81	14.13	0b	11.81	7.81
1a	20.31	16.38	1a	15.38	8.81
1b	21.19	16.81	1b	16.81	8.31
2a	24.19	16.69	2a	16.81	10.38
2b	21.31	17.31	2b	20.31	13.50
3a	21.31	17.13	3a	21.00	14.00
3b	22.31	17.50	3b	20.81	14.19
4a	21.50	16.81	4a	20.81	15.69
4b	22.00	18.63	4b	20.31	16.38
5a	22.00	17.69	5a	21.31	16.69
5b	22.19	18.88	5b	21.19	15.63
6a	21.88	19.19	6a	22.81	18.63
6b	21.19	18.38	6b	21.38	21.00
CI-0a	20.88	12.88	SI-0a	12.31	8.81
0b	21.13	15.88	0b	13.38	8.69
1a	21.81	16.50	1a	19.69	14.69
1b	22.50	16.31	1b	20.81	14.88
2a	22.81	19.81	2a	20.31	13.88
2b	23.38	18.69	2b	20.88	18.00
3a	23.00	20.31	3a	20.81	16.00
3b	22.81	18.31	3b	22.0	14.69
4a	26.63	15.13	4a	22.63	17.88
4b	23.69	18.63	4b	21.88	16.19
5a	23.13	20.38	5a	24.31	18.13
5b	22.00	18.81	5b	21.19	18.81
6a	23.50	18.00	6a	24.00	18.31
6b	22.00	16.63	6b	24.50	18.31

Appendix 13

Table 27. Factorial Analysis for CP Content[1]

	Degrees of Freedom	Mean Square	F Value	
Total	167			
Fertilizer	2	1.92	64.00	**
Soil	1	12.19	406.33	**
Rate	6	1.99	66.33	**
Cut	1	27.87	929.00	**
F x S	2	0.66	22.00	**
F x R	12	0.14	0.004	n.s.
F x C	2	0.00	0.00	n.s.
S x R	6	0.75	25.00	**
S x C	1	0.13	4.33	*
R x C	6	0.07	2.33	*
F x S x R	12	0.06	2.00	*
F x S x C	2	0.05	1.67	n.s.
F x R x C	12	0.06	2.00	*
S x R x C	6	0.03	1.00	n.s.
F x S x R x C	12	0.03	1.00	n.s.
Sub-total	83			
Error	84	0.03		

[1] Values used here for statistical analysis were those of % nitrogen in the plant tissue. These values obtained by multiplying CP content by 0.16.

Appendix 14

Table 28a. Percent Nitrate and Nitrate-Nitrogen in 1st Cut Reed Canarygrass

Drum	NO_3^-	NO_3-N	Drum	NO_3^-	NO_3-N
CB-0a	1.01	0.23	SB-0a	0.21	0.05
0b	1.24	0.28	0b	0.05	0.01
1a	0.85	0.19	1a	0.05	0.01
1b	1.02	0.23	1b	0.09	0.02
2a	0.96	0.22	2a	0.19	0.04
2b	1.04	0.23	2b	0.33	0.07
3a	0.76	0.17	3a	0.18	0.04
3b	0.85	0.19	3b	0.29	0.06
4a	0.94	0.21	4a	0.16	0.04
4b	0.75	0.17	4b	0.29	0.07
5a	0.78	0.18	5a	0.17	0.04
5b	0.71	0.16	5b	0.13	0.03
6a	0.78	0.18	6a	0.21	0.05
6b	0.79	0.18	6b	0.54	0.12
CS-0a	1.04	0.23	SS-0a	0.28	0.06
0b	1.27	0.29	0b	0.12	0.03
1a	1.02	0.23	1a	0.23	0.05
1b	0.89	0.20	1b	0.12	0.03
2a	1.03	0.23	1b	0.21	0.05
2b	0.96	0.22	2b	0.66	0.15
3a	1.06	0.24	3a	0.55	0.12
3b	1.18	0.27	3b	0.61	0.14
4a	1.20	0.27	4a	0.89	0.20
4b	1.30	0.29	4b	0.85	0.19
5a	1.15	0.26	5a	1.05	0.24
5b	1.28	0.29	5b	0.82	0.18
6a	1.40	0.32	6a	1.11	0.25
6b	1.10	0.25	6b	1.17	0.26
CI-0a	1.12	0.25	SI-0a	0.13	0.03
0b	0.91	0.20	0b	0.14	0.03
1a	1.36	0.31	1a	0.58	0.13
1b	1.38	0.31	1b	0.62	0.14
2a	1.83	0.41	2a	0.93	0.21
2b	1.45	0.33	2b	1.06	0.24
3a	1.23	0.28	3a	0.84	0.19
3b	1.40	0.32	3b	0.90	0.20
4a	1.61	0.36	4a	1.40	0.32
4b	1.51	0.34	4b	1.49	0.34
5a	1.70	0.38	5a	1.57	0.35
5b	1.57	0.35	5b	0.99	0.22
6a	1.46	0.33	6a	2.03	0.46
6b	1.69	0.38	6b	1.55	0.35

Appendix 14 (Cont'd)

Table 28b. Percent Nitrate and Nitrate-Nitrogen in 2nd Cut Reed Canarygrass

Drum	NO_3^-	NO_3-N	Drum	NO_3^-	NO_3-N
CB-0a	0.09	0.02	SB-0a	0.01	0.002
0b	0.24	0.05	0b	0.03	0.007
1a	0.17	0.04	1a	0.05	0.011
1b	0.23	0.05	1b	0.01	0.002
2a	0.20	0.05	2a	0.03	0.007
2b	0.24	0.05	2b	0.03	0.007
3a	0.13	0.03	3a	0.03	0.007
3b	0.26	0.06	3b	0.01	0.005
4a	0.17	0.04	4a	0.04	0.009
4b	0.21	0.05	4b	0.02	0.005
5a	0.22	0.05	5a	0.02	0.005
5b	0.18	0.04	5b	0.01	0.002
6a	0.16	0.04	6a	0.04	0.009
6b	0.26	0.06	6b	0.03	0.007
CS-0a	0.19	0.04	SS-0a	0.03	0.007
0b	0.12	0.03	0b	0.04	0.009
1a	0.15	0.03	1a	0.03	0.007
1b	0.18	0.04	1b	0.02	0.005
2a	0.33	0.07	2a	0.01	0.002
2b	0.33	0.07	2b	0.02	0.005
3a	0.30	0.07	3a	0.01	0.002
3b	0.28	0.06	3b	0.03	0.007
4a	0.25	0.06	4a	0.03	0.007
4b	0.39	0.09	4b	0.05	0.011
5a	0.35	0.08	5a	0.07	0.016
5b	0.41	0.09	5b	0.06	0.014
6a	0.58	0.13	6a	0.17	0.038
6b	0.37	0.08	6b	0.22	0.050
CI-0a	0.14	0.03	SI-0a	0.05	0.011
0b	0.18	0.04	0b	0.03	0.007
1a	0.42	0.09	1a	0.03	0.007
1b	0.44	0.10	1b	0.06	0.014
2a	0.94	0.21	2a	0.04	0.009
2b	0.74	0.17	2b	0.42	0.095
3a	0.49	0.11	3a	0.29	0.065
3b	0.63	0.14	3b	0.14	0.031
4a	0.79	0.18	4a	0.34	0.077
4b	0.68	0.15	4b	0.40	0.090
5a	0.74	0.17	5a	0.21	0.047
5b	0.81	0.18	5b	0.23	0.052
6a	0.92	0.21	6a	0.39	0.088
6b	0.77	0.17	6b	0.64	0.144

Appendix 15

Table 29. Factorial Analysis for Nitrate in the Plant Tissue

	Degrees of Freedom	Mean Square	F Value	
Total	167			
Fertilizer	2	3.53	353.0	**
Soil	1	6.90	690.0	**
Rate	6	0.48	48.0	**
Cut	1	17.53	1753.0	**
F x S	2	0.01	1.0	n.s.
F x R	12	0.19	19.0	**
F x C	2	0.49	49.0	**
S x R	6	0.10	10.0	**
S x C	1	0.79	79.0	**
R x C	6	0.06	6.0	**
F x S x R	12	0.01	1.0	n.s.
F x S x C	2	0.20	20.0	**
F x R x C	12	0.04	4.0	**
S x R x C	6	0.16	16.0	**
F x S x R x C	12	0.01	1.0	n.s.
Sub-total	83			
Error	84	0.01		

Appendix 16

Table 30a. Mineral Content of 1st Cut Reed Canarygrass Grown on the Clay Soil

Drum	%				ppm			
	P	K	Ca	Mg	Fe	Mn	B	Zn
CB-0a	0.26	3.4	0.35	0.26	113	50	9.44	52
0b	0.23	3.5	0.38	0.25	119	41	5.15	53
1a	0.29	3.3	0.32	0.29	114	42	8.29	50
1b	0.28	3.2	0.31	0.25	107	35	15.73	47
2a	0.26	3.2	0.34	0.23	101	39	8.87	43
2b	0.26	3.5	0.36	0.29	120	44	1.72	60
3a	0.25	3.3	0.36	0.25	113	45	5.72	39
3b	0.26	3.2	0.30	0.24	122	44	8.01	44
4a	0.29	3.4	0.34	0.26	104	49	0.00	52
4b	0.29	2.8	0.33	0.28	107	51	6.01	41
5a	0.28	3.3	0.38	0.27	128	59	3.72	63
5b	0.28	2.9	0.31	0.26	320	64	7.15	41
6a	0.33	3.2	0.31	0.27	100	46	11.44	34
6b	0.31	3.4	0.38	0.28	95	54	2.29	54
CS-0a	0.26	3.2	0.32	0.24	107	38	8.58	40
0b	0.24	3.4	0.36	0.25	135	40	8.29	50
1a	0.31	3.2	0.29	0.25	110	40	8.01	47
1b	0.28	3.2	0.34	0.26	110	45	1.43	45
2a	0.29	2.9	0.29	0.25	106	51	17.16	42
2b	0.29	3.4	0.33	0.27	107	49	9.15	50
3a	0.26	3.4	0.36	0.27	113	56	4.00	43
3b	0.29	3.1	0.31	0.25	114	55	4.58	38
4a	0.27	3.3	0.40	0.28	144	55	1.43	47
4b	0.28	3.2	0.35	0.24	135	62	5.14	44
5a	0.32	3.2	0.36	0.27	115	64	14.30	57
5b	0.30	3.3	0.36	0.27	108	61	2.86	45
6a	0.32	3.4	0.43	0.30	93	75	5.72	58
6b	0.28	3.1	0.37	0.26	172	64	7.15	47
CI-0a	0.27	3.3	0.40	0.27	104	59	3.15	47
0b	0.23	3.3	0.33	0.23	105	40	11.15	40
1a	0.28	3.4	0.37	0.26	112	40	5.72	45
1b	0.28	3.2	0.33	0.24	115	55	9.15	42
2a	0.29	3.1	0.34	0.27	107	58	5.15	57
2b	0.25	3.2	0.36	0.26	120	48	4.86	47
3a	0.26	3.3	0.41	0.27	102	56	10.58	45
3b	0.26	3.4	0.40	0.26	136	52	2.86	46
4a	0.31	3.3	0.34	0.27	177	64	6.29	69
4b	0.26	3.5	0.41	0.27	165	57	13.44	42
5a	0.25	2.9	0.34	0.25	105	53	4.01	47
5b	0.25	3.3	0.41	0.27	90	49	0.00	43
6a	0.25	3.2	0.38	0.26	109	66	2.29	44
6b	0.24	3.3	0.41	0.25	107	57	9.15	49

Appendix 16 (Cont'd)

Table 30b. Mineral Content of 1st Cut

Reed Canarygrass Grown on the Sand Soil

Drum	%				ppm			
	P	K	Ca	Mg	Fe	Mn	B	Zn
SB-0a	0.25	1.6	0.33	0.49	83	54	13.16	25
0b	0.21	1.6	0.36	0.45	109	58	14.59	23
1a	0.23	1.9	0.40	0.48	86	64	5.72	30
1b	0.21	1.9	0.38	0.46	93	56	2.86	32
2a	0.31	2.1	0.30	0.39	92	80	11.44	21
2b	0.28	2.3	0.40	0.43	95	67	8.29	35
3a	0.29	2.2	0.39	0.42	101	71	11.44	28
3b	0.32	2.1	0.37	0.40	116	81	5.72	40
4a	0.33	2.5	0.41	0.38	89	78	8.87	33
4b	0.34	2.1	0.34	0.35	121	71	15.16	26
5a	0.35	2.4	0.44	0.40	99	86	5.72	28
5b	0.35	2.4	0.39	0.39	101	86	8.87	23
6a	0.37	2.6	0.35	0.35	102	86	5.15	27
6b	0.39	2.9	0.37	0.43	92	81	8.29	44
SS-0a	0.23	1.5	0.38	0.50	113	58	3.43	26
0b	0.18	1.5	0.39	0.43	88	54	11.15	20
1a	0.25	1.6	0.30	0.47	91	59	9.15	26
1b	0.25	1.6	0.34	0.49	83	54	10.58	22
2a	0.24	1.8	0.43	0.49	94	68	4.86	35
2b	0.29	2.2	0.43	0.46	117	71	10.87	40
3a	0.29	1.7	0.32	0.40	125	79	5.43	32
3b	0.31	2.0	0.41	0.40	104	83	11.73	38
4a	0.32	1.7	0.30	0.40	147	76	10.01	29
4b	0.30	2.0	0.41	0.43	112	82	14.30	32
5a	0.33	2.1	0.38	0.40	103	88	17.45	37
5b	0.32	2.0	0.40	0.39	130	86	12.30	43
6a	0.37	2.1	0.48	0.37	205	117	5.43	36
6b	0.36	2.3	0.44	0.38	192	115	7.44	44
SI-0a	0.22	1.7	0.37	0.49	78	53	3.72	32
0b	0.26	1.7	0.34	0.48	105	69	8.01	23
1a	0.21	1.8	0.45	0.43	106	86	12.58	32
1b	0.25	1.7	0.48	0.53	85	104	7.72	30
2a	0.25	1.4	0.36	0.45	113	98	9.15	37
2b	0.24	1.9	0.63	0.52	87	119	8.87	55
3a	0.23	1.4	0.43	0.51	135	103	4.86	34
3b	0.21	1.9	0.54	0.53	85	103	8.01	44
4a	0.26	1.7	0.48	0.48	95	119	5.72	35
4b	0.24	2.0	0.64	0.50	88	108	6.58	44
5a	0.24	1.8	0.66	0.45	100	150	14.01	41
5b	0.20	1.9	0.60	0.46	102	124	4.29	45
6a	0.29	1.6	0.57	0.48	110	145	8.29	39
6b	0.25	1.9	0.75	0.58	98	138	9.15	40

Appendix 16 (Cont'd)

Table 30c. Mineral Content of 2nd Cut Reed Canarygrass Grown on the Clay Soil

	%				ppm			
Drum	P	K	Ca	Mg	Fe	Mn	B	Zn
CB-0a	0.21	2.6	0.34	0.24	102	31	11.73	29
0b	0.23	3.1	0.36	0.23	114	33	9.15	36
1a	0.20	2.7	0.33	0.25	117	26	8.29	37
1b	0.20	2.6	0.34	0.23	113	29	11.44	27
2a	0.25	3.0	0.34	0.24	127	34	5.15	28
2b	0.22	2.8	0.35	0.24	110	36	7.15	32
3a	0.19	2.5	0.35	0.24	111	31	12.87	24
3b	0.24	2.6	0.37	0.26	120	39	6.29	34
4a	0.24	2.7	0.35	0.25	115	38	6.86	31
4b	0.23	2.8	0.37	0.26	115	37	8.01	31
5a	0.29	3.0	0.36	0.26	142	40	2.86	29
5b	0.28	2.8	0.36	0.25	113	43	7.72	26
6a	0.23	2.8	0.38	0.25	117	36	11.44	32
6b	0.26	2.8	0.34	0.26	210	41	8.58	30
CS-0a	0.22	2.9	0.36	0.25	105	34	3.43	33
0b	0.20	2.9	0.37	0.24	92	29	8.87	28
1a	0.22	2.9	0.38	0.24	106	34	6.01	32
1b	0.22	2.8	0.35	0.25	170	37	10.30	27
2a	0.22	2.5	0.34	0.23	107	35	5.43	33
2b	0.23	2.5	0.37	0.25	114	31	10.01	29
3a	0.22	2.8	0.36	0.25	117	37	10.58	38
3b	0.22	2.6	0.36	0.23	109	32	9.15	29
4a	0.22	2.6	0.37	0.25	132	35	10.01	32
4b	0.23	2.6	0.36	0.24	119	38	6.86	35
5a	0.23	2.8	0.37	0.24	119	44	8,58	36
5b	0.23	2.7	0.36	0.24	110	40	4.86	31
6a	0.24	2.8	0.36	0.25	110	51	6.29	36
6b	0.24	2.5	0.37	0.24	104	42	7.15	30
CI-0a	0.20	2.8	0.37	0.23	118	38	20.02	25
0b	0.20	2.9	0.37	0.24	335	40	10.01	29
1a	0.23	3.1	0.40	0.25	109	37	11.73	32
1b	0.22	2.9	0.36	0.23	108	41	6.29	30
2a	0.21	3.0	0.38	0.25	102	40	9.44	33
2b	0.22	3.0	0.39	0.24	107	35	6.58	36
3a	0.23	3.0	0.41	0.28	128	42	8.58	33
3b	0.22	2.9	0.38	0.24	132	41	8.87	35
4a	0.18	3.3	0.38	0.27	117	54	8.58	38
4b	0.21	2.9	0.38	0.25	118	40	2.86	37
5a	0.23	2.9	0.38	0.25	108	49	11.15	42
5b	0.23	2.8	0.38	0.24	118	43	6.01	41
6a	0.23	3.1	0.41	0.28	155	64	7.72	39
6b	0.22	3.1	0.37	0.24	140	48	3.15	41

Appendix 16 (Cont'd)

Table 30d. Mineral Content of 2nd Cut Reed Canarygrass Grown on the Sand Soil

	%				ppm			
Drum	P	K	Ca	Mg	Fe	Mn	B	Zn
SB-0a	0.34	1.2	0.46	0.48	80	64	15.16	23
0b	0.25	1.0	0.40	0.41	86	53	6.29	22
1a	0.33	1.2	0.39	0.46	92	76	12.01	20
1b	0.27	1.4	0.37	0.38	105	80	10.58	31
2a	0.31	1.6	0.35	0.36	116	113	9.15	22
2b	0.31	1.7	0.37	0.37	117	90	8.01	25
3a	0.41	2.2	0.36	0.34	111	101	10.01	30
3b	0.38	1.8	0.35	0.35	104	91	14.01	24
4a	0.39	1.8	0.41	0.37	135	113	8.87	25
4b	0.37	1.9	0.36	0.31	134	94	11.73	29
5a	0.42	1.9	0.37	0.33	105	118	9.15	24
5b	0.38	1.9	0.38	0.32	102	135	10.58	24
6a	0.42	2.3	0.37	0.32	119	132	6.29	35
6b	0.37	2.5	0.32	0.31	103	114	8.58	27
SS-0a	0.25	1.2	0.40	0.44	77	68	8.29	20
0b	0.26	1.1	0.41	0.42	99	64	10.58	21
1a	0.27	1.6	0.34	0.40	105	73	11.73	23
1b	0.27	1.1	0.41	0.46	74	71	8.01	19
2a	0.31	1.6	0.37	0.43	86	103	8.58	22
2b	0.29	1.6	0.34	0.41	101	83	11.44	20
3a	0.27	1.6	0.35	0.40	110	84	14.01	23
3b	0.34	1.8	0.38	0.41	96	84	11.73	31
4a	0.29	1.7	0.40	0.43	145	97	8.87	30
4b	0.28	1.7	0.39	0.44	118	84	10.87	19
5a	0.30	1.8	0.45	0.46	131	89	17.45	26
5b	0.32	1.8	0.42	0.45	114	90	10.58	26
6a	0.30	1.7	0.43	0.41	140	109	10.01	36
6b	0.34	1.9	0.44	0.42	130	99	8.87	35
SI-0a	0.28	1.4	0.37	0.42	76	67	8.29	17
0b	0.30	1.3	0.39	0.43	78	81	17.16	17
1a	0.23	1.5	0.43	0.48	122	101	12.58	23
1b	0.27	1.8	0.44	0.46	105	132	12.01	31
2a	0.22	1.7	0.42	0.47	115	108	11.44	30
2b	0.23	1.5	0.43	0.43	112	102	11.44	32
3a	0.22	1.3	0.41	0.44	108	129	8.58	31
3b	0.21	1.3	0.44	0.46	101	102	10.87	29
4a	0.22	1.6	0.44	0.44	115	113	11.44	33
4b	0.20	1.5	0.43	0.41	120	116	11.15	36
5a	0.19	1.2	0.48	0.45	129	116	8.58	31
5b	0.19	1.4	0.48	0.44	116	113	12.01	29
6a	0.26	1.4	0.54	0.48	125	149	9.15	28
6b	0.25	1.5	0.46	0.44	123	152	19.16	44