TWO DAIRY WASTE HANDLING SYSTEMS: A COMPARISON OF NITROGEN BALANCES

BY

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B. Sc. Ag., University of British Columbia, 1973

A Thesis Submitted In Partial Fulfillment of
The Requirements For The Degree Of
Master Of Science

IN

The Faculty of Graduate Studies
Department of Agricultural Mechanics

We Accept This Thesis As Conforming
To The Required Standard

The University of British Columbia

March 1978

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Date April 19, 1978.

Abstract

Two dairy farms on Vancouver Island, B.C., were studied to evaluate nitrogen behavior under different handling and storage conditions. The first farm (U.B.C.) spreads slurry collected daily on a year round basis, while the second (B.M.) stores its slurry in a concrete pit to land dispose under favourable conditions. Feed analysis, slurry sampling, pit profiles and soil profiles were included in the study. Results showed that the nitrogen content of the manure can be reasonably estimated from either feed nitrogen or milk production. Losses of nitrogen during collection and storage in these systems were minimal.

Approved:

Dr. N Ross Bulley

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Acknowledgements

Special thanks to Dr. N. Ross Bulley for his guidance and support, to Dr. Mike Miko for his persistance with the large numbers of analyses in the laboratory, to Mr. Leo Kansky and Mr. Ed Smith for allowing me to use their facilities, to B.C.M.A. for funding and last but not least to my friends who helped me with sampling and moral support.

Thank you.

Niels Holbek

Introduction

Agriculture in British Columbia, long immune from pollution controls is facing increasing pressures to deal more acceptably with farm by-products. Measures to minimize pollution potential and maximize waste utilization efficiency are required.

In British Columbia, "certain plant and animal wastes may be applied to the soil as organic fertilizer to promote crop production according to traditional farming practice. Disposal by this method may be exempt under the regulations persuant to the Pollution Control Act 1967" (B.C. Pollution Control Act 1967). This clause, essentially, permits farmers to dispose of their wastes on their own recognizance. This system was not entirely satisfactory and therefore required the formation of an agency responsible to deal with complaints arising against farmers. In order to respond to complaints and at the same time avoid cumbersome anti-pollution regulations, which would have to be based on limited information, a system of Producer Environmental Committees has been established under the British Columbia Environmental Control Program (Barber, 1976). This program is structured in such a manner as to allow producers themselves to respond to complaints without the need for government interference. The British Columbia Ministry of Agriculture Engineering Branch is available in an advisory capacity and should the need arise may involve the Pollution Control Branch at a legal level. This program provides a control over serious infractions but establishes little in the way of quantitative guidelines for producers.

The single most significant factor in the utilization and disposal of farm manures is nitrogen. The significance is based on the fact that nitrogen in various molecular forms is readily lost in handling, storage, and disposal. The readily lost forms of nitrogen may be chemically or biologically bound but if they are found in sufficient quantities they may also constitute a pollution potential. The Canada Animal Waste Management Guide (C.D.A., 1974) discusses nitrogen as a basis for manure application rates, but does not attempt to carry out a nitrogen balance for a farm, or establish recommendations for land loading rates.

Required is a regional formula for the on-farm determination of animal waste disposal rates. In order to produce such a formula the nitrogen behaviour under differing conditions of species and breed, diet, climate, handling of wastes and soil type is required.

An analysis of the nitrogen content of manure is required to establish land loading rates. These analyses, however, are expensive and time consuming. If manure nitrogen could be calculated from some other input or output, recommendations for land spreading rates could be simplified.

The objective of this paper is to examine the movement of nitrogen on two Vancouver Island dairy farms in order to provide some design criteria towards establishment of British Columbia waste management guidelines.

Literature Review

Waste Management: General

There is only one well circulated document on waste disposal guidelines for farmers in B.C. The Environmental Guidelines for Dairy Producers provides a good discussion on dairy structures and various manure storage systems (B.C.M.A., 1975). However, the discussion on the land disposal of dairy manure is left to a single page with the key information provided in the following statement - "Where practical, dairy manure should be applied to the fields on a sufficient number of acres so that nutrients can be recycled through crops without the accumulation of salts or nutrients to levels that will pollute surface or groundwater supplies." Similarly, the Canada Animal Waste Management Guide (1974), although more detailed, summarizes their section on the Utilization of Manure for Crop production by suggesting that farmers "plan their manure utilization system according to provincial practice." In an unpublished British Columbia Animal Waste Management Guide (Draft 4) yields and nitrogen requirements for various crops are tabled with the assumption that these are a first guide to determining the rate of field applications (B.C.M.A., 1971). However, the only other data supplied is the fact that one 545 kg. (1200 lb.) dairy cow produces 64 kg. (140 lb.) of nitrogen per year and that 50% of the nitrogen in the manure is available in the first year of application. Needless to say this is a naive basis for land application rate guidelines and this is perhaps why the document was never published. Nevertheless, with the information that is available on farm nitrogen balances it is not unreasonable that these figures were used.

A more detailed approach has been carried out in the

Pacific Northwest United States. Turner (1975) has prepared a set of rational equations for the Pacific Northwest with related inputs in order to permit the determination of the quantity of nitrogen to be applied to land to optimize crop yields. The following factors are considered in the formula: total nitrogen excreted in fresh manure, nitrogen remaining after accounting for storage, treatment and handling losses, availability coefficients for five years, denitrification coefficients based on soil drainage and the nitrogen removed by the harvested crop as influenced by time and rate of applied nitrogen. The formula developed and the coefficients presented require further testing but there is no doubt that this type of on-the-farm determination is what farmers currently require. Turner (1975) was concerned only with the efficient use of manure for crop utilization.

In more and more operations maximum loading rates on limited areas are of concern. In a study on high rate land spreading of fresh dairy cattle manure in Georgia, U.S.A., Sund et al. (1975) found that applications of 45 t/ha (dry weight basis) incorporated into the soil produced forage of good quality while even higher yields were obtained at rates of 90 t/ha (dry weight basis). The higher rate of application produced forage with nitrate levels above 2% and it was felt that this feed could be detrimental to the health of ruminants. In another study on the maximum rates of application of fresh dairy manure in Minnesota, U.S.A., Randall et al. (1975) found that application rates of 400 t/ha (dry weight basis) could be applied and incorporated into the soil during the summer season. Corn was produced on the soil in the following year, with little sacrifice in yield. Mobile elements accumulated in the tilled layer and were expected to move downward in the profile. Fodder nitrate levels were less than 0.3%

which is below the maximum acceptable level of 0.5% recommended by Maynard and Loosli (1969). In a British Columbia study by Bomke and Lavkulich (1975) heavy applications of poultry manure were applied to an Abbotsford loam. Soil nitrate levels reached 335 ppm in the 45-60 cm depth interval.

Variation in soil types, rainfall and the resulting data accumulated make it apparent that much work is required to establish maximum permissible loading rates for British Columbia.

Although limited information is available on the waste management guidelines in British Columbia and farm nitrogen balances the same can not be said for the wealth of information on the behaviour of different forms of nitrogen in the nitrogen cycle.

Waste Management: Nitrogen Behaviour

Many volumes have been written about the behaviour of nitrogen in farm and waste management. A complete review of the material is beyond the scope of this thesis. Review will therefore be primarily concerned with current information on the effects and behaviour of input nitrogen, product nitrogen, and by-product nitrogen. Their behaviour in storage and handling and field losses as they relate to this study will also be examined.

As with almost anything there is a proportionality between inputs and outputs. A farmer anticipates a product which will be related in quality and/or quantity to the inputs he is providing. Nitrogen, comprising approximately 16% of protein weight is a critical factor in livestock feed inputs. A lactating dairy cow has a protein demand in proportion to the volume and weight of her products. According to the National Academy of Science (1971) a lactating dairy cow weighing 600 kg and producing 10 kg of 3.0% fat milk/day requires 229 g of nitrogen per day while the same cow producing 30 kg of 3.0% fat milk/day requires 453 g of nitrogen per day.

Fisher (1974) conducted a study on the influence of a feeding system, digestibility of the ration and proportion on concentrate consumed on the quantity and quality of excreta voided by lactating cows. This result shows that faeces yield fluctuated with ration dry matter digestibility. While there appeared to be a direct relationship between fecal nitrogen percent and digestible dry matter there appeared to be an inverse relationship between digestible dry matter and nitrogen in the urine.

It is presumably because of the results obtained by Fisher (1974) that there appears to be considerable fluctuations of manure criteria presented in the literature. The fresh waste characteristics most commonly of concern in dairy waste management are the volume or weight excreted, moisture content and total nitrogen content. The following data illustrates some of the values and units cited in the literature. The value and units for these criteria vary considerably. Day and Harmon (1975) determined that the average volume of waste excreted per cow per day amounted to 40 kg (wet weight basis). They stated that 9% of the excreta was solids and 4% of the solids was nitrogen. The C.D.A. (1974) expressed the daily quantity of excreta per cow as $0.38m^3$ (wet weight basis) of which 13-15% was Kjeldahl nitrogen. Foley et al. (1973) concluded that 8% of body weight (wet weight) was excreted per day and that ½% of this could be considered Kjeldahl nitrogen.

The loss of nitrogen from dairy manure begins as soon as it is voided. The degree of loss and the rates of losses are functions of storage, handling and disposal techniques employed. In a study on manure gases and air currents in livestock housing, Skarp (1975) found some cattle houses had ammonia concentrations in the order of 20-30ppm. However, no indications of the rate of gaseous ammonia loss was given. Since gaseous losses present mostly odour problems researchers have had little incentive to determine the total gaseous losses from manure. This applies to fresh manure lying on a concrete surface as well as manure in storage facilities and loss during disposal.

In a study by Lauer et al. (1976) the ammonia volatilization from dairy manure spread on the soil surface was studied. Application rates ranged from 8-45 t/ha (dry weight basis). The group found that in a time span of 5-25 days 61-99% of the total ammonia nitrogen was lost. Quantities of nitrogen volatilized ammonia ranged from 17 to 316 kg N/ha. After the initial losses the rate of volatilization slowed. The lower rates of application dried more rapidly because they were thinner resulting in an increased rate of ammonia loss from the manure.

A wealth of information is available regarding surface runoff losses as well as nitrate leaching losses. When manure is stored or fresh manure is applied to land its nitrogen constituents consist primarily of organic nitrogen and ammonia. Organic nitrogen is in time microbally converted to ammonia, ammonification.

The fate of ammonia when land spreading is four fold. On a hot day, high rates of volatilization are likely to occur from surface applied manures. This loss can be reduced by "ploughing in" the manure or spreading during periods of low temperatures. If ammonia finds its way into the soil profile it may be absorbed by micro-organisms as a nutrient source or oxidized by nitrifying organisms resulting in the formation of nitrite and nitrate molecules. Ammonium may become fixed by clay particles.

Nitrate is the singularly most important molecule in waste management studies. The formation of nitrate and its behaviour have been thoroughly documented. The reason for this concern rests with its potential to do environmental damage. Bosch et al. (1950) reported fourteen infant deaths which were attributed to nitrate contamination of well water. As a result of this potential threat to human health the U.S. Department of Health (1962) declared that potable water must not exceed 10 mg NO_3N nitrogen per litre or 45mg nitrate per litre. In other studies nitrate has been held directly responsible for the accelerated eutrophication of lakes and the depletion of oxygen for fish stocks.

In land application of dairy manure several factors are instrumental in determining the potential loss of nitrate to groundwater - loading rate, nitrogen content of manure, soil type, moisture regime, temperature, rainfall distribution, surface runoff and cropping.

It follows that the greater the application of manure the greater the potential for pollution. In the Chino-Corona dairy area of California there is a cow population of 10 animals per irrigated acre of land. This area, in response to the high cattle density,has been subject to intensive research into dairy cattle waste management. Deep drilling of soil profiles in this area showed an average nitrate concentration of 315 ppm NO_3 (70 ppm NO_3-N) in the drainage water (Adriano et al., 1971). Murphy et al. (1973) found a build up of ammonium nitrogen in some upper soil horizons to 230 ppm on heavy applications of animal wastes. This was high enough to contribute significantly to lower seed germination and depressed seedling vigour. Total yields of corn silage were increasingly depressed with increased rates of manure application.

That soil type, particularly texture, effects nitrate losses is well documented. Avinimelech (1976) studied two soils in Israel, one a clay loam and the other a sandy loam.

While the nitrogen input on the clay loam was roughly double that on the sandy loam the leaching from the sandy loam exceeded that of the clay loam by a factor greater than two under similar water regimes. Nitrification rates in soils effects the size of the nitrate pool in the soil. Nitrification rates are a function of many factors including soil type. Soulides and Clark (1958) found great variations in nitrification rates in some grassland soils. The differences in rates were attributable to different conditions such as soil carbon content, pH and texture.

Soil moisture regime effects the leaching of nitrogen in two ways. Generally the greater the moisture level the greater the loss of nitrate. Adriano et al. (1974) found a 26 and 39% loss of applied manure nitrogen at water saturation percentages of 60 and 90%, respectively. As well as increasing nitrate loss with soil moisture content there is a counteractive trend towards increased denitrification as soils become saturated. Turner (1975) has given a value of 0.0 to the denitrification for an excessive to somewhat excessively drained soil and a value of 0.50 to a very poorly drained soil. This assumes that 50% of manure applied nitrogen will be lost by denitrification in the first year, on a poorly drained soil. Gambrell et al. (1975) indicated that in a two year period 60 kg N/ha was lost by denitrification from poorly drained soil fertilized with 196 kg N/ha.

Soil temperature exerts its effects on nitrogen behaviour in soils by its influence on microbial activity as well as the changes in physical properties of frozen soil. Most microbial activity occurs in the 15^{o}C to 35^{o}C range. Above and below these temperatures we can expect significant reductions in the dynamics of microbial activities affecting nitrogen balances. Freezing conditions result in a soil surface which becomes impervious. Manure, under certain conditions, can be applied to frozen soil with minimal pollution (Klausner et al., 1976, Young and Mutchler, (1976). However, manure spread under similar conditions can also cause polluting conditions if surface runoff occurs. The Environmental Guidelines for Dairy Producers in British Columbia (1975) states that "dairy manure should not be spread on frozen or snow covered ground where runoff to open watercourses might occur."

Nitrogen is an essential nutrient for plant growth. Grass samples analysed by Staley (1976) showed nitrogen contents of 2.5% dry weight basis. A thriving crop is thus an extremely desirable method of recycling manure applied nitrogen. The British Columbia Animal Wastes Management Guide (1971) has tabled nitrogen removal by various crops in British Columbia. The highest nitrogen removal listed is 336 kg/ha for corn silage. Acceptable levels of seedling mortality and toxic plant nitrate levels can be used as indications of maximum rates of manure applications for crops, provided excessive nitrate leaching does not occur.

Materials & Methods

The Farms

Beaver Meadows Dairy Farm, Comox, B.C.* (Fig 1) and U.B.C. Farm, Campbell River, B.C.** milk Holstein herds of 250 and 150 lactating cows respectively with an average daily production of approximately 23 kg/cow. Both farms use a free stall/milking parlour system for housing and milking. The Beaver Meadows herd is divided into three production groups of approximately 128, 88 and 34 cows while the Oyster River herd is divided into two groups of 20 and 130 cows. Group numbers are given in order of decreasing production.

Beaver Meadows tractor scrapes its manure slurry from the holding area, feeding area and comfort stall area to a conveyor which deposits it in a large, open, sunken, roofed concrete pit (30.5m x 24.4m x 3.0m)(Fig 1). Storage is estimated at four to six months depending on herd size. The pit is emptied using a Liquivator and a propellor agitator. Spreading is carried out in the spring, summer and early fall as pit volume and field conditions allow. Spreading has been accomplished using a rear discharge paddle spreader and a Hawk built side delivery flail spreader. The flail spreader was used on grassland being cropped where the rear discharge paddle spreader distribution was found to be unsatisfactory. Parlour wastes are stored in a small concrete pit emptied on a regular basis by vacuum tanker.

* - 235 km NW Victoria, B.C.
**- 265 km NW Victoria, B.C.

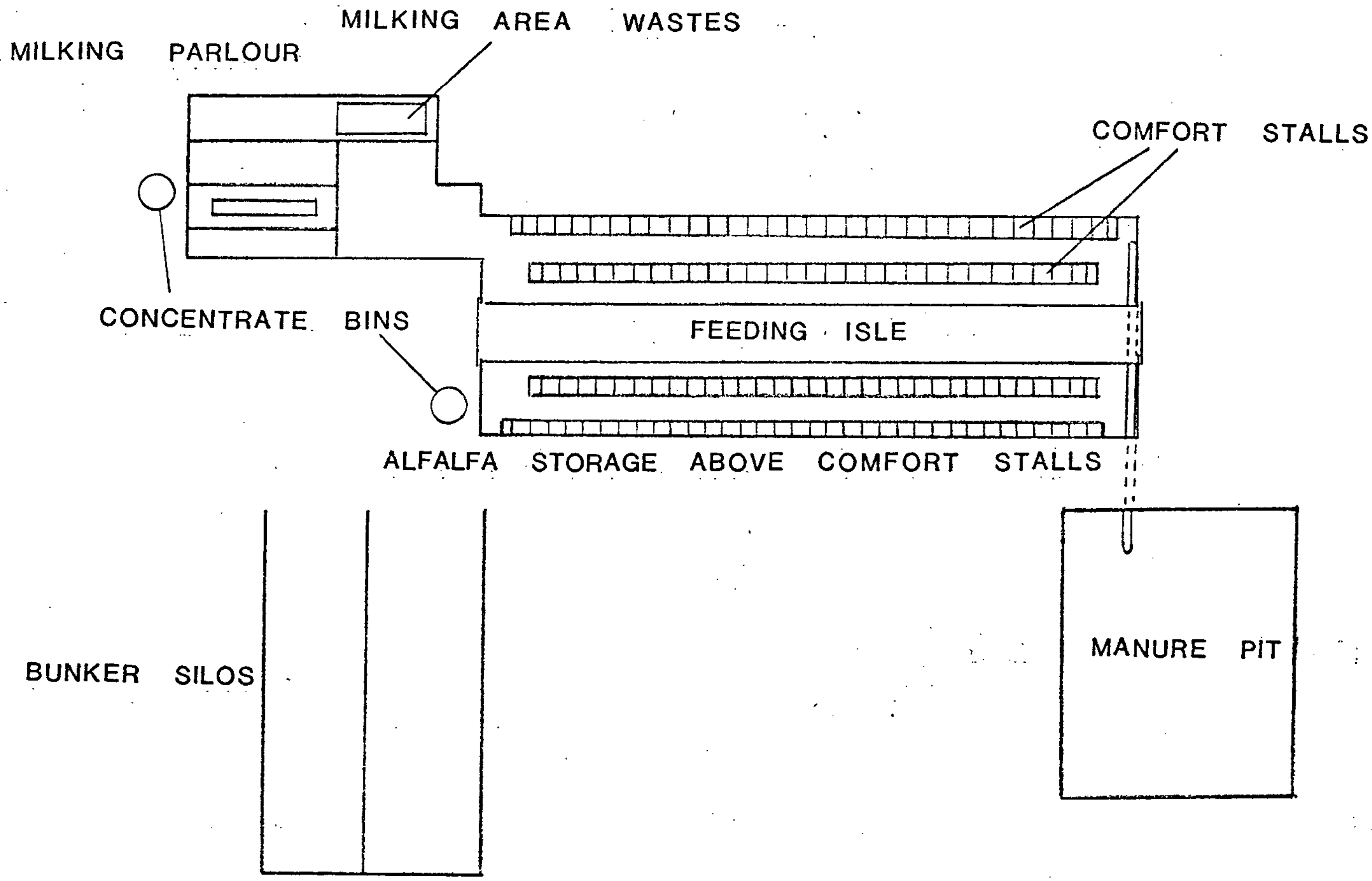

FIG 1 BEAVER MEADOW FARM BUILDING LAYOUT

Waste Management at the U.B.C. Farm involves tractor scraping of the slurry from the holding area, free stall area and feeding barn to conveyors, loading into a side delivery flail spreader and spreading on the fields on a daily basis. When field conditions do not permit, slurry is stored by mixing with drier manure from other sources, however this occurrence is rare. Parlour wastes pass through a settling tank to two facultative lagoons.

Experimental Design and Sampling Procedures

Feed Nitrogen

Samples of feed for analysis were taken at monthly intervals from Beaver Meadows and Oyster River during the Winter 1975-1976. Five individual grab samples were taken from each feed type, composited, mixed and subsampled.

Quantitative data on the feed ration at Beaver Meadows was obtained from the Herdsman. These figures were readily available as most of the feed is metered into a mixing feed wagon which incorporates a scale.

At Oyster River quantitative determinations were made by dividing the total weight of the individual feed ingredients consumed over a period of time by the period of time and the number of cows. The total weights were available from feed suppliers or calculated on the farm for farm feeds.

Milk Nitrogen

Milk production for the two herds was obtained by dividing the milk shipped by the number of cow-days milked. Shipments of milk shipped are recorded every other day at both farms. Milk produced by each cow is recorded each milking at U.B.C. Protein contents of the milk were obtained through Dairyland in Burnaby where bi-monthly analysis of milk samples are kept from all shippers. These values are also available on an individual cow basis for participants from the Record of Performance and I.R.M.A. testing facility of the B.C.M.A.

Manure Nitrogen

Fresh manure samples were collected at both farms from November 1975 until May 1976 on a monthly basis and in June 1977 during the second trial at Beaver Meadows. These samples constituted subsamples of five samples which had been composited. They were collected from the manure conveyor leading outside of the manure collection area.

During the first trial at Beaver Meadows the pit was sampled from November 1975 until May 1976 (when emptying began) at monthly intervals (location A, Fig 1). Pit samples were taken at successive 30 cm depths through the profile using a 7.6 cm diameter aluminium tube with adjustable caps at each end (Fig 2). The sampler was submerged in the slurry gently and slowly to avoid mixing. During the second trial the pit was sampled at four locations (A,B,C, & D, Fig 1) to determine variations across the pit. Samples were also collected during the emptying of the pit, when applications were being made to field plots.

Manure samples were taken from the spreaders before spreading on field plots at Beaver Meadows and Oyster River.

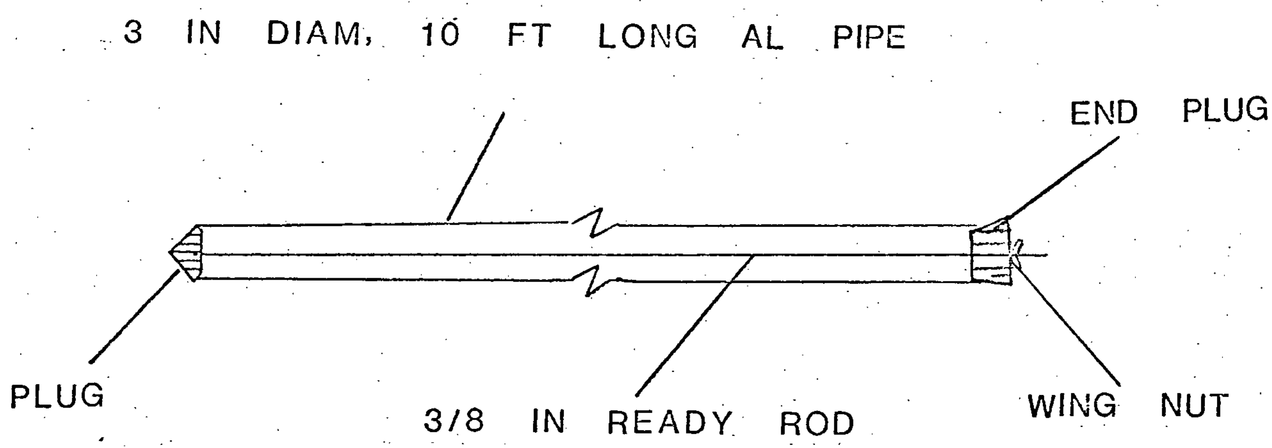

FIG 2 MANURE PIT SAMPLER

Application rates were determined by measuring weights of samples collected in three 100 cm^2 trays placed at each end of the plots. Nitrogen losses were determined by analysing composite samples collected from the trays and calculating the difference between the nitrogen content of the manure from the tank wagon before spreading and the nitrogen content of the samples collected from the trays.

Soil Nitrogen

At Beaver Meadows on June 20th, 1976 following the removal of the first crop, field plots were established to ascertain N-behaviour during the growing season for two levels of applications of pit stored slurry on a loamy sand soil (complex of a Bowser-Custer series). The experimental design consisted of a control and two different manure treatments triplicated. Plot design was as in Fig 3. The soil was sampled prior to spreading, seven days following spreading and forty-two days following spreading at which time the second crop was removed. Soil sampling was carried out diagonally across the plots to minimize the effects of variations in spreader distribution. At sampling, each plot was sampled in six locations, the samples composited and subsampled for analysis. Sampling at different soil depths was carried out at 15 cm intervals to a depth of 90 cm with the assumption that any nitrogen in the soil below 90 cm could be assumed lost to groundwater. The plots received two inches of irrigation water on June 20 and again on July 11. At the time of irrigation visual assessment indicated that there did not appear to be any saturated flow below a depth of fifteen centimetres.

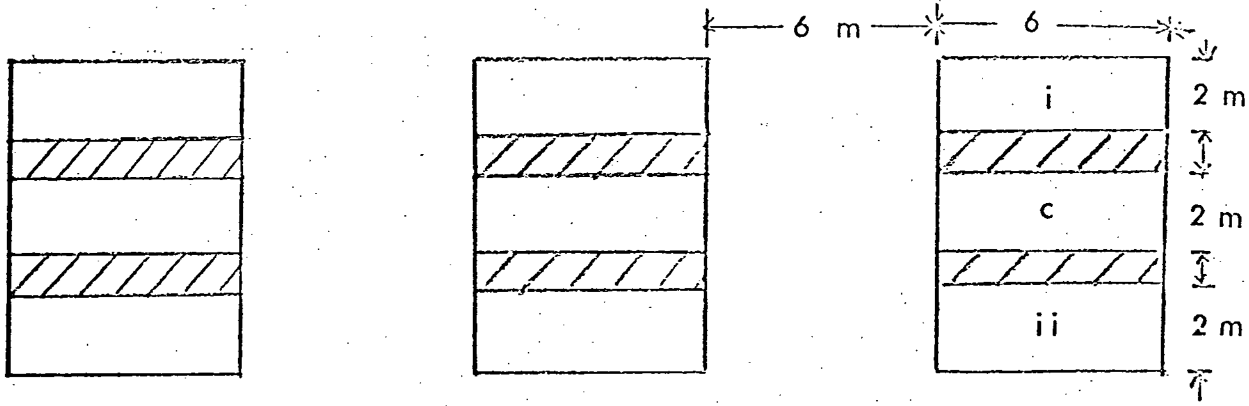

FIG 3 SOIL PLOT DESIGN FOR THE LAND APPLICATION OF DAIRY WASTES

i LIGHT APPLICATION, C CONTROL, ii HEAVY APPLICATION

This procedure was followed on a reduced scale a second time during the Summer of 1977. A single rate of application was spread on June 22, 1977. Control plots were sampled at this time with subsequent samplings on July 4 and August 1. Sampling was reduced to the top three 15 cm intervals. The results from the first trial indicated that sampling to deeper depths was unnecessary.

A plot design was established at U.B.C. Farm to ascertain nitrogen behaviour during the extended winter period (1975) of inactive biological activity. Individual soil plots (Fig 3) were arranged in a 3 x 6 matrix. The soil ranges from loamy sand to sandy loam (Cassidy Series). High and low rates of manure were applied on separate triplicated plots in November, January and March. Soil samplings were carried out, just before spreading, two months and four months after manure application to determine losses. These months were chosen as it was felt that the most significant losses of nitrogen would occur during these time periods. Application rate determination and soil sampling were carried out as at Beaver Meadows. No surface runoff was observed during the experimental period on these well drained soils.

Crop Nitrogen

In August 1976 and 1977, following the trials at Beaver Meadows, yield and crop samples were taken of the second crop. Similarly in May, 1976 samples were taken from the first crop at Oyster River. Yield was determined using a 1 m^2 frame and clippers to simulate harvesting. Samples were air dried and total yield and nitrogen recovery determined.

Analytical Techniques

All analyses, with the exception of the milk samples and crop drying were carried out in the laboratory facilities of the University of British Columbia's Agricultural Mechanics - Bio-Resource Engineering Department.

Milk samples were analysed for protein at the Dairyland laboratory in Burnaby, B.C. and the crop samples were dried in the laboratory facilities of the U.B.C. Farm.

Feed samples were analysed for total solids, organic matter and Total Kjeldahl Nitrogen (TKN). Manure samples were analysed for total solids, organic matter, pH, ammonia, and TKN. The same analyses were carried out on the soil samples as well as nitrate and some nitrite and with the exclusion of pH.

Analyses for total solids, volatile solids, and pH were carried out according to standard methods (APHA, 1971). Total Kjeldahl Nitrogen was determined using a block digestor and a Technicon AutoAnalyser II according to the method of Schummann (1973) which was checked against the standard Macro Kjeldahl technique (APHA, 1971). Ammonia, nitrate and nitrite nitrogen were extracted from soils and manure according to standard methods for soils (Methods of Soil Analysis, 1965). Nitrate, nitrite and ammonia were analysed by methods proposed by Technicon Industrial Systems (1971).

When the term ammonia is used in this text it includes ammonium where applicable.

Results and Discussion

The comparison of the standard Macro Kjeldahl Nitrogen determination (APHA, 1971) and the block digestor and Technicon AutoAnalyser can be seen in Appendix B. The experimental error was felt to be acceptable for this study.

The effect of utilizing 1N KCl solution for extracting ammonium from manure was also studied. This is the recommended extraction process for removing ammonium from soils. It was found that the KCl extraction increased the quantity of extracted ammonium by 10-40% (Appendix C). In light of this information it was decided to use the KCl extraction for both soils and manure. The increased extraction of ammonium was attributed to cation exchange sites on manure particles. Further research in this area should be carried out to confirm the cause of the large variation in apparent ammonia concentration as affected by analytical technique.

A comparison of nitrate extractions using KCl vs. $CaSO_4$ showed no significant differences (Appendix D).

The results of the analysis of the sampled feed showed crude protein levels considerably below values quoted by manufacturers, results from the B.C. Feed Analysis Service determined for U.B.C. Farm and below values in the literature. For this reason the protein levels of feeds from Beaver Meadows have been derived by utilizing the manufacturers quote for concentrate and estimates from the literature for the other constituents. The values for U.B.C. Farms are results obtained from similar samples sent to the B.C. Feed Analysis Service, Kelowna, B.C. (Appendix E, Tables I, II and III).

To determine the land application rates for dairy wastes it is necessary to know the amounts of nitrogen in the waste produced. In order to avoid extensive manure sampling and analysis for each farm in the future, we attempted to correlate nitrogen excretion to some more readily available quantity, such as feed nitrogen or milk production. The slurry produced at both farms contains small quantities of spilled feed, water and sawdust which are included in the slurry but are considered inconsequential.

Nitrogen in Manure Based on Feed

The quantity of nitrogen in the feed which is converted to milk and used for maintenance can be calculated using feed nitrogen conversion efficiency (FNCE) of 0.29 (Foley et al., 1973; National Academy of Sciences,1971; Turner, 1975; Yeck at al., 1975) and the formula:

$$\text{Manure Nitrogen} = \text{Feed Nitrogen} \times (1 - \text{FNCE}).$$

The FNCE of 0.29 used in this study is in close agreement with the National Academy of Sciences (1971) for the weight and production of cattle in this study. However, as production decreases and increases so does the FNCE in relation to protein requirements. Taking the two identical animals described in the Literature Review (p. 6), one milking 10 kg/day and the other 30 kg/day the resulting FNCEs calculated from the National Academy of Sciences (1971) tables results in calculated FNCEs of 0.22 and 0.34, respectively.

In the 1976 study at Beaver Meadows the farm was feeding 420 g of nitrogen/cow/day (Table I) and in the 1977 study they were feeding 396 g of nitrogen/cow/day (Table II). U.B.C. Farm was feeding 496 g of nitrogen/cow/day (Table III).

Applying the formula results in a calculated manure N output of 298 g/cow/day for Beaver Meadows in 1976 and 281 g/cow/day in 1977 (Table IV). The measured value of fresh manure for Beaver Meadows on a per cow basis was determined from the average weight of waste excreted per day (9.7 kg/day, dry weight basis) and the nitrogen content 2.9% N dry weight basis (Table V) in 1975 and 2.7% N dry weight basis in 1977. This is equivalent to 283 and 262 g N/cow/day for the two studies (Table IV).

The nitrogen in the manure at U.B.C. Farm based on feed was calculated to be 352 g/cow/day (Table IV). The measured value was determined using the weight excreted per day at Beaver Meadows (9.7 kg/day, dry weight basis) and the nitrogen content at the U.B.C. Farm (3.5% N, dry weight basis, Table V) and equal to 340 g/cow/day.

The percentage difference between the literature FNCE values for calculated manure N and the actual measured values of manure N were 5%, 7% and 4%, respectively for three trials (Table IV).

If the actual feed nitrogen conversion efficiencies are calculated (milk nitrogen divided by feed nitrogen) the resulting factors are 0.28, 0.29 and 0.23 for Beaver Meadows I, Beaver Meadows II and Oyster River respectively. Recalculating the anticipated nitrogen in the manure results in differences of 7%, 7% and 11%, in the three studies.

TABLE I

AVERAGE DAILY FEED CONSUMPTION AND MILK PRODUCTION
PER COW AT BEAVER MEADOWS - TRIAL I

FEED CONSUMPTION	FEED(WET) (G)	CRUDE PROTEIN % (WET)	CRUDE PROTEIN (G) (DRY)	NITROGEN CONTENT (G)
ALFALFA HAY	2,300	14.5*	333.5	53.4
CONCENTRATE	9,900	16.0**	1584.0	253.4
CORN & GRASS SILAGE	22,700	3.1*	703.7	113.5
TOTAL	34,900		2,621.2	420.3

* - NATIONAL ACADEMY OF SCIENCES (1969)

** MANUFACTURERS QUOTATION

MILK PRODUCTION PER COW

MILK	CRUDE PROTEIN %	NITROGEN CONTENT
22.7 KG	3.2	116 G

TABLE II

AVERAGE DAILY FEED CONSUMPTION AND MILK PRODUCTION PER COW AT BEAVER MEADOWS - TRIAL II

FEED CONSUMPTION	FEED(WET)	CRUDE PROTEIN % (WET)	CRUDE PROTEIN (G) (DRY)	NITROGEN CONTENT (G)
GRASS-LEGUME HAY	2,300	8.0%*	184.0	29.4
CONCENTRATE	9,900	16.0%**	1584.0	253.4
SILAGE	22,700	3.1%	703.7	113.5
TOTAL	34,900		2471.7	396.3

* - NATIONAL ACADEMY OF SCIENCES (1969)

** - MANUFACTURERS QUOTATION

MILK PRODUCTION PER COW

MILK	CRUDE PROTEIN %	NITROGEN CONTENT
22.5 KG	3.2	115 G

TABLE III

AVERAGE DAILY FEED CONSUMPTION AND MILK PRODUCTION
PER COW AT U.B.C. FARM

FEED CONSUMPTION	FEED (WET)	CRUDE PROTEIN *% (WET)	CRUDE PROTEIN (G) (DRY)	NITROGEN CONTENT (G)
CONCENTRATE	4,548	15.5	705	113
ALFALFA CUBES	4,831	17.8	860	138
ALFALFA HAY	6,027	14.7	886	142
CORN SILAGE	12,000	1.4	168	27
GRASS SILAGE	18,231	2.6	474	76
TOTAL	45,637		3,093	496

* - B.C. FEED ANALYSIS SERVICE, KELOWNA

MILK PRODUCTION PER COW

MILK	CRUDE PROTEIN %	NITROGEN CONTENT
22.7 KG	3.2	116 G

TABLE IV

MANURE NITROGEN BASED ON FEED NITROGEN

GRAMS N/COW/DAY

	FEED	CALCULATED MANURE N* LITERATURE FNCE: FNCE	CALCULATED MANURE N* LITERATURE FNCE: MANURE N	CALCULATED MANURE N* MEASURED FNCE: FNCE	CALCULATED MANURE N* MEASURED FNCE: MANURE N	MEASURED MANURE N	% DIFFERENCE BETWEEN LITERATURE FNCE MANURE AND MEASURED MANURE	% DIFFERENCE BETWEEN MEASURED FNCE MANURE AND MEASURED MANURE
BEAVER MEADOWS I	420	0.29	298	0.28	304	283	5%	7%
BEAVER MEADOWS II	396	0.29	281	0.29	281	262	7%	7%
OYSTER RIVER	496	0.29	352	0.23	380	340	4%	11%

* FEED NITROGEN x (1 - FNCE)

TABLE V

NITROGEN CONTENT OF FRESH MANURE
(% DRY WT. BASIS)

DATE	BEAVER MEADOWS I	U.B.C.
NOV. 75	-	4.9
JAN. 76	2.4	2.8
FEB. 76	3.4	3.3
MAR. 76	3.3	3.1
APR. 76	-	3.3
MAY 76	2.6	-
MEAN	2.9	3.5
S^2	0.75	0.6725
S	0.87	0.82

These values do not represent an improvement in accuracy (Table IV).

In the area of waste management where variability appears to be the rule these values would indicate this to be a satisfactory method of calculating manure nitrogen levels from cows.

Nitrogen in Manure Based on Milk

Both farms had a recorded daily average milk production of 22.7 kg of milk per cow in 1976 and 22.5 kg per cow per day in 1977 for Beaver Meadows II. At 3.2% protein, wet weight basis (Table VI) the nitrogen content of the milk at the two levels is 116 and 115 g N/cow/day. Using a $\frac{(1 - 0.29)}{(0.29)}$ nitrogen conversion efficiency value the resulting calculated manure nitrogen levels would be 284, 284 and 282 g N/cow/day excreted in the three studies (Table VI). Comparing this to the three measured values of 283, 262 and 340 g N/cow/day gives discrepancies of 0%, 7% and 16% in each case. If the nitrogen conversion efficiencies are calculated, (milk nitrogen divided by feed nitrogen) the conversion efficiencies become 0.28, 0.29 and 0.23, for Beaver Meadows I, Beaver Meadows II and Oyster River, respectively. Recalculating the anticipated nitrogen in the manure using the calculated nitrogen conversion efficiencies results in differences of 5%, 7% and 11% in the three studies. This an improvement in agreement for Oyster River but not for Beaver Meadows I.

It appears from the above determinations that manure nitrogen based on milk production could be used in waste

TABLE VI

AVERAGE PROTEIN CONTENT OF MILK * (WET WEIGHT BASIS)

DATE	FARM	
	BEAVER MEADOWS	U.B.C.
JAN 1, 1976	3.16	3.08
JAN 15, 1976	3.00	3.10
FEB 1, 1976	3.23	3.21
FEB 15, 1976	3.22	3.25
MAR 1, 1976	3.14	3.14
MAR 15, 1976	3.21	3.21
APR 1, 1976	3.24	3.18
APR 15, 1976	3.19	3.11
MAY 1, 1976	3.17	3.21
MAY 15, 1976	3.11	3.18
JUNE 1, 1976	3.15	3.16
JUNE 15, 1976	3.18	3.16
JULY 1, 1976	3.16	3.21
MEAN	3.2	3.2

* DAIRYLAND, BURNABY.

TABLE VII

MANURE NITROGEN BASED ON MILK PRODUCTION

GRAMS N/COW/DAY

	MILK	CALCULATED MANURE N*				MEASURED MANURE N	% DIFFERENCE BETWEEN	
		LITERATURE FNCE		MEASURED FNCE			LITERATURE FNCE MANURE AND MEASURED MANURE	MEASURED FNCE MANURE AND MEASURED MANURE
		FNCE	MANURE N	FNCE	MANURE N			
BEAVER MEADOWS I	116**	0.29	284	0.28	298	283	0%	5%
BEAVER MEADOWS II	115***	0.29	282	0.29	282	262	7%	7%
OYSTER RIVER	116**	0.29	284	0.23	380	340	16%	11%

* NITROGEN CONTENT OF MILK X $\frac{1 - FNCE}{FNCE}$

** 22.7 KG MILK PER DAY AT 3.2% CRUDE PROTEIN

***22.5 " " " " " " " "

disposal formulations. It appears that this method is best utilized on farms which are feeding close to an optimal level. Knowledge of the feed nitrogen conversion efficiency or knowing that a farm is feeding close to the optimal level of conversion make this a more useful tool.

The high conversion efficiency at Beaver Meadows can be in part attributed to the rational division of production groups which their facilities allow.

Nitrogen Losses in Storage

During the first trial at Beaver Meadows a profile of the manure in the pit at 0.3 m depth intervals was taken using a core sampler previously described (Fig 2). The core samples were taken approximately 2 m from the manure imput. The results show a general decrease in ammonia, TKN and moisture concentration with depth (Table VIII). During the second trial at Beaver Meadows four sets of cross sectional samples were taken from the pit. The samples were taken at different locations around the pit, approximately 1.0 m from the edge of the pit (A,B,C and D, Fig 1). The study confirmed that TKN decreased with depth; an average of 25,200 ppm at the surface to 19,900 ppm (dry weight basis) at the bottom (Table IX). The results also showed a decrease in TKN, from an average of 26,900 to 20,300 (dry weight basis), as the sampling distance fron the imput incresed (Table IX). The concentration of ammonia did not change greatly across the pit but decreased with depth at all points, from an average of 13,800 ppm at the top to 8,400 (dry weight basis) at the bottom (Table X). The pH of all

TABLE VIII

CONCENTRATION OF NH_3-N, TKN AND MOISTURE CONTENT AFTER FOUR MONTHS PIT STORAGE AT BEAVER MEADOWS

TRIAL I.

DEPTH (METRES)	NH_3-N (PPM)*	TKN (PPM)*	M.C.%**
TOP	11,200	32,533	85.0
.3	14,123	37,714	86.0
.6	16,757	34,759	85.5
.9	13,226	36,126	84.5
1.2	14,121	30,545	83.5
1.5	13,667	31,030	83.5
1.8	9,086	18,757	71.0
2.1	7,754	13,046	67.5
MEAN	12,492	29,314	81.5

* DRY WEIGHT BASIS

** WET WEIGHT BASIS

TABLE IX

BEAVER MEADOWS II, PIT STUDY - 1977, TKN PPM*

		PIT SAMPLING LOCATION				
		A	B	C	D	MEAN
	0 - 0.3	30,724	26,541	21,981	21,626	25,218
	0.3 - 0.6	31,492	31,525	24,482	19,277	26,694
DEPTH (M)	0.6 - 0.9	24,865	25,663	25,432	19,061	23,755
	0.9 - 1.2	23,613	26,673	22,102	20,922	23,328
	1.2 - 1.5	26,556	24,354	18,705	20,671	22,574
	1.5 - 1.8	24,200	19,007	16,291	20,123	19,905
		------	------	------	------	------
	MEAN	26,908	25,627	21,499	20,280	23,579

DISTANCE FROM INPUT

* DRY WEIGHT BASIS

TABLE X

BEAVER MEADOWS II, PIT STUDY - 1977. NH_3 PPM*

		PIT SAMPLING LOCATION				
		A	B	C	D	MEAN
DEPTH (M)	0 - 0.3	14,274	15,358	12,638	12,896	13,792
	0.3 - 0.6	14,616	16,059	14,491	10,726	13,973
	0.6 - 0.9	10,969	13,744	13,393	10,722	12,207
	0.9 - 1.2	11,063	13,807	11,880	11,743	12,123
	1.2 - 1.5	10,928	10,767	7,534	11,755	10,246
	1.5 - 1.8	8,879	8,840	6,398	9,496	8,403
		------	------	------	------	------
	MEAN	11,788	13,096	11,055	11,223	11,791

DISTANCE FROM INPUT

* DRY WEIGHT BASIS

samples showed a slight increase with depth. The pH ranged from 7.4 - 7.8 with an average of 7.7 (Table XI). Moisture content decreased with depth but not as significantly as in the first study (Table XII).

The first study at Beaver Meadows appeared to show an unexpectedly low loss of nitrogen when pit input was compared to a sample taken during the emptying of the pit. The second trial, however, revealed the discrepancies which occur from the input end of the pit to the opposite side. The difference between TKN at the input and the pit mean TKN showed a decrease of 12% in 1977 (Table IX). Observation of the pit during filling showed a level rise across the pit with the exception of the period following sawdust bedding of the comfort stalls. During this time a mound, approximately 1.0 m high, formed below the conveyor but disappeared in a few days.

The pit appeared to meet its storage capacity with the daily volume of 0.061 cu m of slurry per cow added per day. This volume appears to be higher than that in the literature (Canada Waste Management Guide, 1974; Loehr, 1974) but in agreement with a study on another British Columbia farm (Luymes, 1976).

Nitrogen Losses During Spreading

The rates of applied nitrogen for Beaver Meadows I and Oyster River can be seen in Tables XIII and XIV. Comparing the nitrogen content of the manure before spreading to the nitrogen collected in the trays after spreading showed that spreading at Beaver Meadows resulted in a loss of

TABLE XI

BEAVER MEADOWS II, PIT STUDY - 1977. pH.

PIT SAMPLING LOCATION

DEPTH (M)	A	B	C	C	MEAN
0 - 0.3	7.4	7.6	7.7	7.7	7.6
0.3 - 0.6	7.7	7.7	7.7	7.7	7.7
0.6 - 0.9	7.7	7.7	7.6	7.8	7.7
0.9 - 1.2	7.8	7.7	7.7	7.8	7.8
1.2 - 1.5	7.7	7.8	7.7	7.8	7.8
1.5 - 1.8	7.8	7.9	7.8	7.7	7.8
	---	---	---	---	---
MEAN	7.7	7.7	7.7	7.8	7.7

DISTANCE FROM INPUT

TABLE XII

BEAVER MEADOWS II, PIT STUDY - 1977, % MOISTURE CONTENT*

		PIT SAMPLING LOCATION				
		A	B	C	C	MEAN
DEPTH (M)	0.0 - 0.3	83.7	85.3	82.6	84.6	84.0
	0.3 - 0.6	84.5	86.0	84.0	82.4	84.2
	0.6 - 0.9	81.4	83.7	84.8	82.0	83.0
	0.9 - 1.2	81.2	84.4	83.7	83.3	83.2
	1.2 - 1.5	83.0	83.3	82.2	83.1	82.9
	1.5 - 1.8	84.0	82.0	81.9	86.6	83.1
		----	----	----	----	----
	MEAN	83.0	84.1	83.2	83.3	83.4

DISTANCE FROM INPUT

* WET WEIGHT BASIS

5% of total applied nitrogen in one trial. In three trials at Oyster River the losses were 4%, 6% and 9% of the applied manure nitrogen. The loss during spreading is attributed to the volatilization of ammonia.

Nitrogen Recovery

The quantities of nitrogen removed by the grass-clover crops are shown in Tables XIII and XIV. At Beaver Meadows the light manure application increased crop yield by 30% over the control while the heavy application decreased the yield by 50%. The data collected from U.B.C. Farm shows higher yields on all the plots receiving manure. The January and March heavy applications show a reduced yield over the light applications. This effect has presumably not occurred in the November heavy application due to the increased time for leaching of nitrate, volatilization of ammonia, and a lower application rate of manure.

It should be remembered that these values apply only to the crop harvested immediately following the application. At Beaver Meadows at least one additional crop would be expected to be harvested and at Oyster River two additional cuttings would be made. The effect of manure on the subsequent harvests from the treated plots need not necessarily follow those of the previous harvest.

Nitrogen Movement in Soil: Applied During the Growing Season

At Beaver Meadows, changes in Total Kjeldahl, ammonia and nitrate nitrogen were determined for all plots. In

TABLE XIII

GRASS-CLOVER YIELD AND NITROGEN RECOVERY FROM PLOTS RECEIVING LIGHT AND HEAVY MANURE APPLICATIONS

BEAVER MEADOWS

	MANURE APPLICATION: JUNE 1976		CROP YIELD: AUG. 1976	
	DRY WT.*	NITROGEN	DRY WT.	NITROGEN**
PLOT	t/ha	kg/ha	t/ha	Kg/ha
CONTROL	0	0	2.7	68
LIGHT APPLICATION	16	450	3.6	89
HEAVY APPLICATION	28	785	1.4	35

* MOISTURE CONTENT OF MANURE 81% (WET WEIGHT BASIS).

** BASED ON 2.5% N (DRY WEIGHT BASIS) FOR CROP (STALEY, 1976).

TABLE XIV

GRASS-CLOVER YIELD AND INITIAL NITROGEN RECOVERY FROM PLOTS RECEIVING LIGHT AND HEAVY MANURE APPLICATIONS DURING THE WINTER.

U.B.C. OYSTER RIVER FARM

DATE MANURE APPLIED		MANURE APPLICATION DRY WT.* t/ha	MANURE APPLICATION NITROGEN Kg/ha	CROP YIELD: MAY 1976 DRY WT. t/ha	CROP YIELD: MAY 1976 NITROGEN** Kg/ha
NOV. 75	CONTROL	0	0	0.58	14.5
	LIGHT	4.6	161	1.10	27.5
	HEAVY	13.9	486	1.22	30.5
JAN. 76	CONTROL	0	0	0.59	14.8
	LIGHT	5.9	206	1.25	31.3
	HEAVY	17.6	616	0.99	25.0
MAR. 76	CONTROL	0	0	0.96	24.0
	LIGHT	5.5	192	1.20	30.0
	HEAVY	16.5	577	0.74	18.5

* MOISTURE CONTENT OF MANURE 85% (NET WEIGHT BASIS).

** BASED ON 2.5% N (DRY WEIGHT BASIS) FOR CROP (STALEY, 1976).

both trials the control plots were sampled just prior to application. Soils from the plots receiving light and heavy applications of manure were sampled seven and forty-two days after application. Results for the ammonia nitrogen behaviour through the profile are shown in Fig 4. All points in these figures constitute the mean of three samples, each of the three composited from six individual samples. This is equivalent to eighteen samples. The heavily manured plots (Fig 4) show an average of 60 ppm NH_3-N (dry weight basis) in the 0-15 cm profile (June 27). This value dropped to 19 ppm by August 1, presumably through nitrification. There is no apparent increase or movement below the 30 cm depth.

The nitrate nitrogen profiles (Fig 5) show that one week after manure application the nitrate levels in all the plots in the 0-15 cm depth interval rose in the first week after spreading. The increase in the manured plots was greater than in the control plots. An increase of 41 ppm NO_3-N was measured on the heavily manured plots in the 0-15 cm depth interval. By August 1, the nitrate levels in all the plots had dropped. Only the heavily manured plot exceeded the original level in the top 15 cm. There appears to be a relation between an increased ammonia concentration leading to an increase in nitrate concentration and a concurrent drop in both. This is understandable since nitrification is in part a function of ammonification. During the time period studied, there were no significant differences among treatments below the 15 cm level. All the plots decreased gradually in nitrate concentration from approximately 10 ppm NO_3-N (dry weight basis) at the 30-45 cm level to approximately 2 ppm at the 75-90 cm level. There did not appear to be any excessive movement of nitrogen

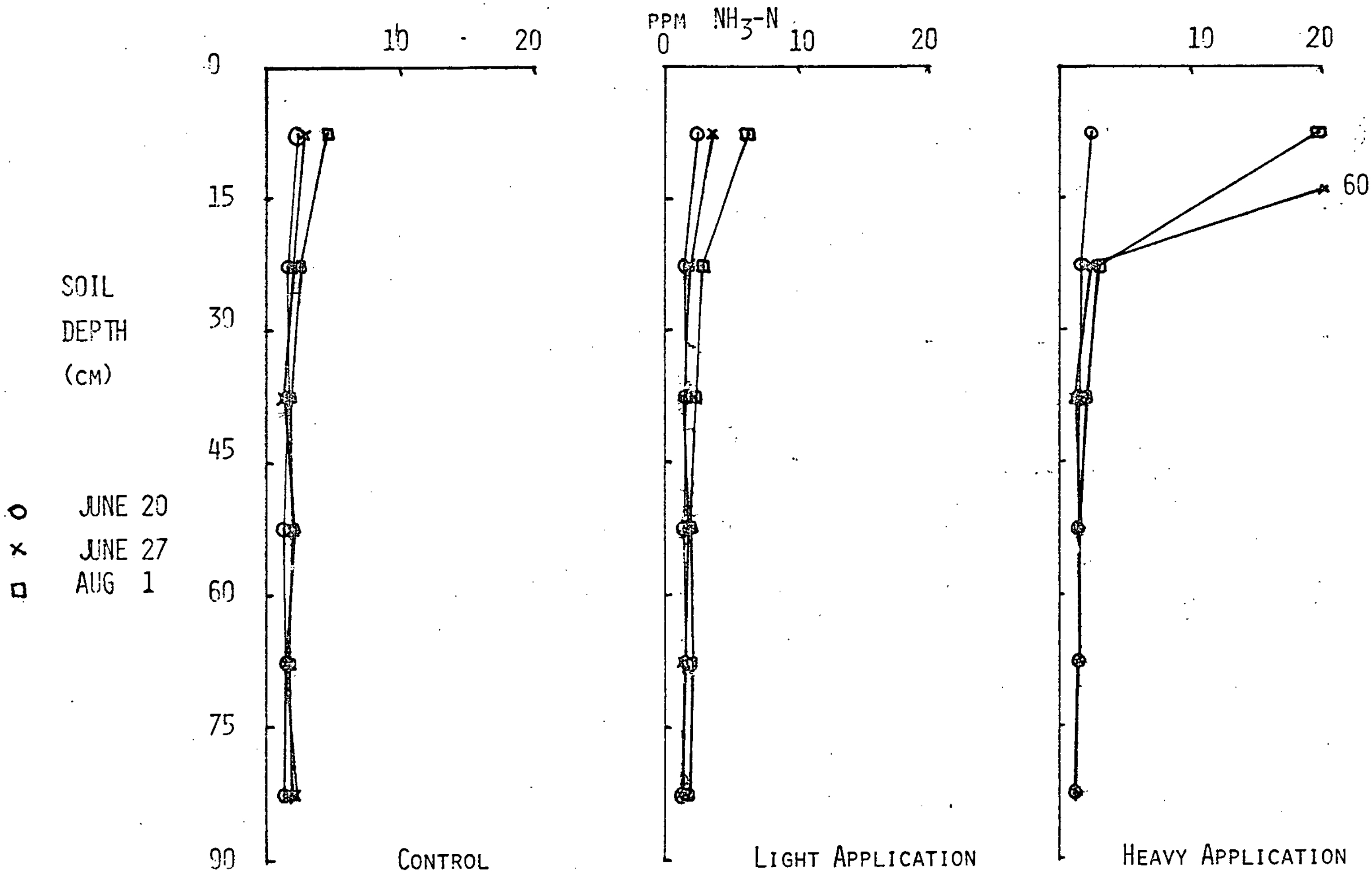

FIG 4 BEAVER MEADOWS TRIAL I AMMONIA NITROGEN PROFILES: CHANGES IN NH_3N CONCENTRATION WITH TIME FOR A SOIL (BOWSER-CUSTER SERIES) RECEIVING 0, 16 AND 28 T/HA (DRY WEIGHT BASIS) DAIRY MANURE ON JUNE 20, 1976

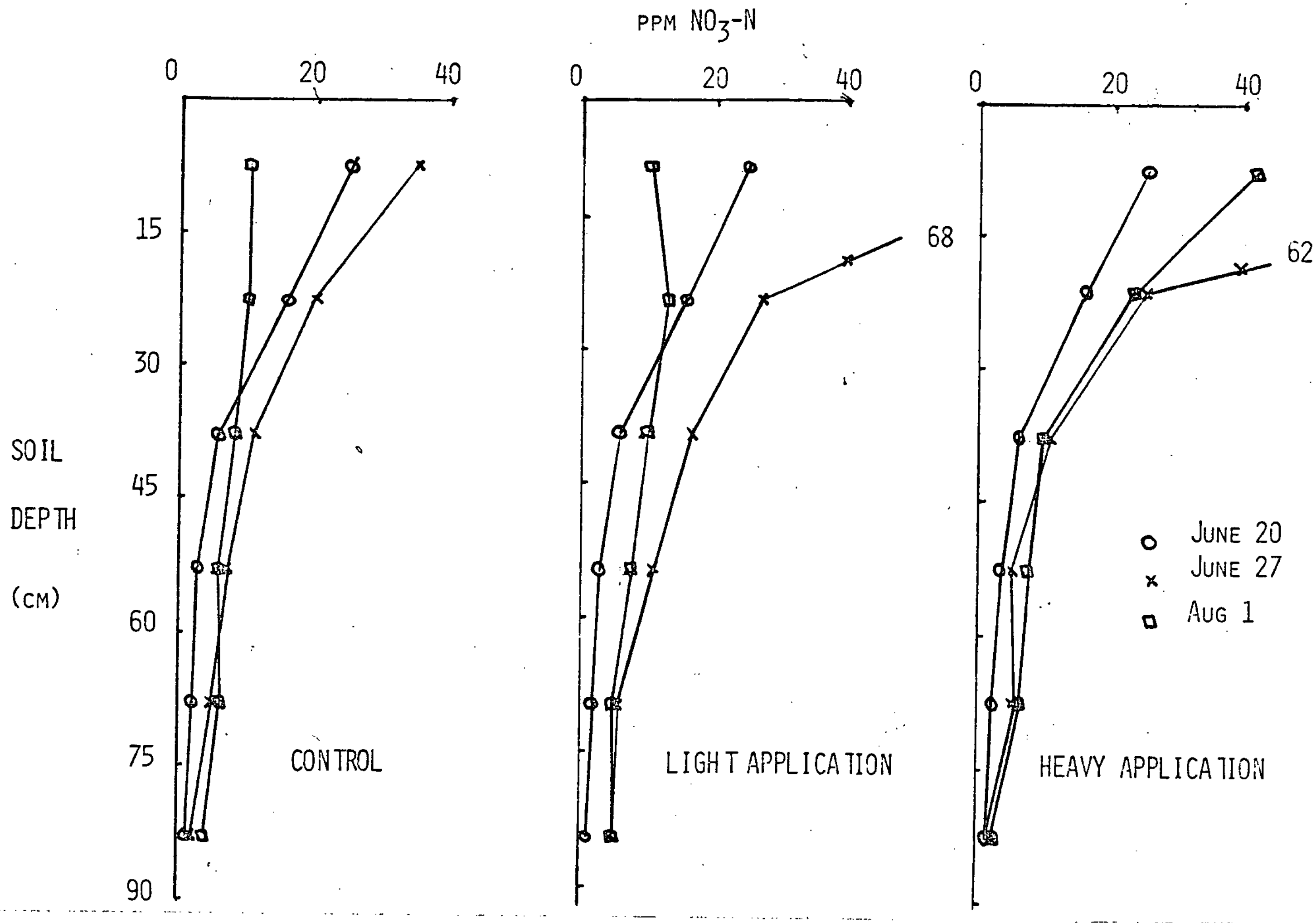

FIG 5 BEAVER MEADOWS TRIAL I NITRATE NITROGEN PROFILES: CHANGES IN NO_3N CONCENTRATION WITH TIME FOR A SOIL (BOWSER-CUSTER SERIES) RECEIVING 0, 16 AND 28 T/HA (DRY WEIGHT BASIS) DAIRY MANURE ON JUNE 20, 1976

down the profile based on the ammonia and nitrate analyses.

Large unexplained decreases in TKN were observed over the growing season for Beaver Meadows Trial I (Fig 6). No major differences were observed among the control, light and heavily manured plots, but the pooled data gave strong support to the apparent large decreases in TKN (Fig 7). The large decrease is not suspected to be a sampling error as each point represents the average of fifty-four points and nine analyses.

The second summer trial at Beaver Meadows (Beaver Meadows II, 1977) was conducted to verify the soils data obtained in the first trial, particularly TKN results. A control and one light manure application were studied. The plots were triplicated and sampled to a depth of 45 cm as the first study revealed that any major fluctuations occurred in the upper horizons. Manure was applied and control plots sampled on June 22, 1977. Subsequent samplings were carried out July 4 and August 1.

In both the control and the treated plots ammonia decreased from June 22 to July 4 (Fig 8). Ammonia then increased substantially in the August 1 sampling but not to the original concentration. No outstanding differences occurred between the control and treated plots.

Nitrate concentration increased dramatically in the treated plots from 6 to 20 ppm NO_3-N (dry weight basis) in the 15-30 cm depth interval (Fig 9). It subsequently decreased to 9 ppm by August 1. The control plots showed a similar but much smaller increase and subsequent decrease. This appeared to confirm the relationship between ammonia

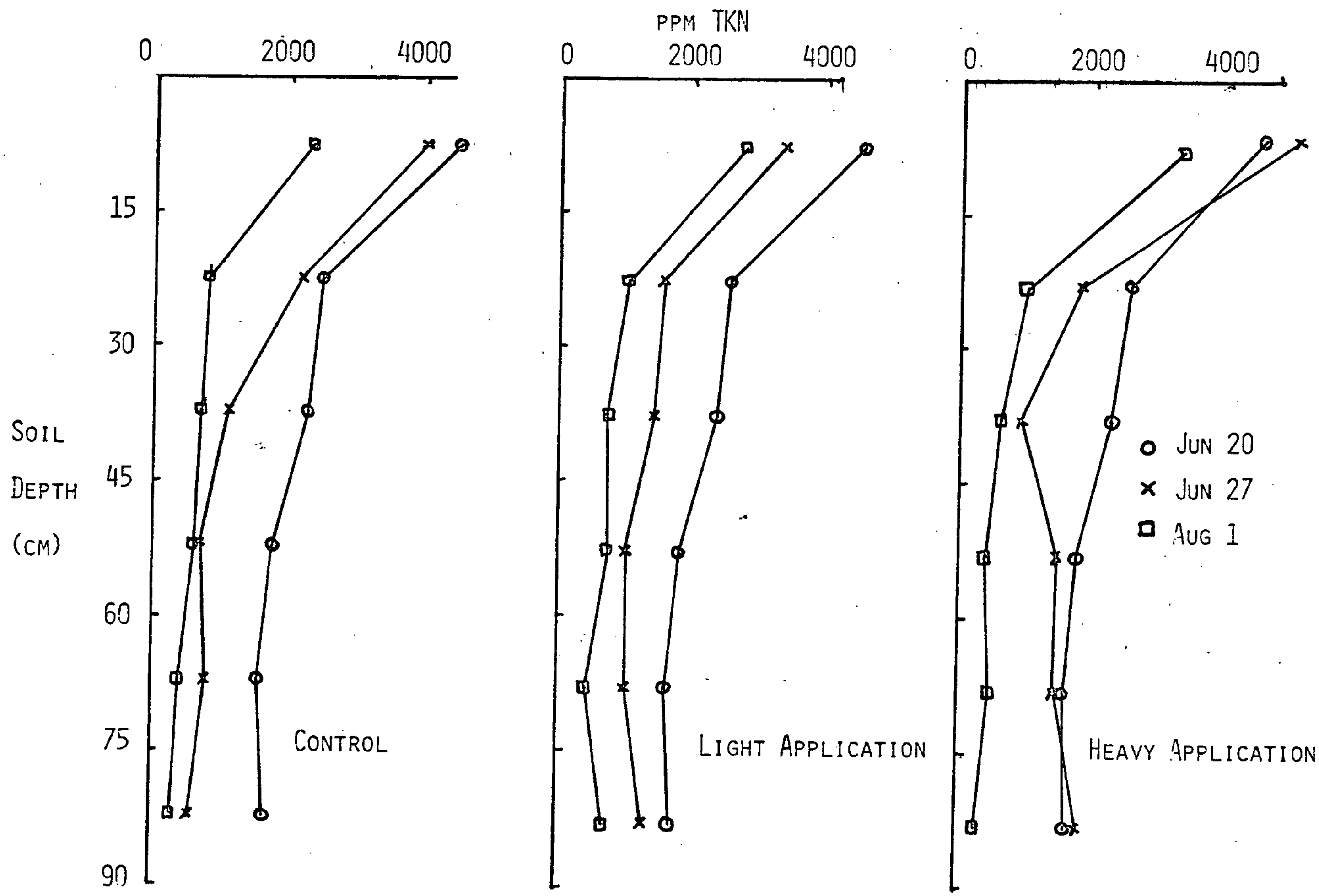

FIG 6 BEAVER MEADOWS TRIAL I TKN PROFILES: CHANGES IN TKN WITH TIME FOR A SOIL (BOWSER-CUSTER SERIES) RECEIVING 0, 16 AND 28 T/HA (DRY WEIGHT BASIS) DAIRY MANURE ON JUNE 20, 1976

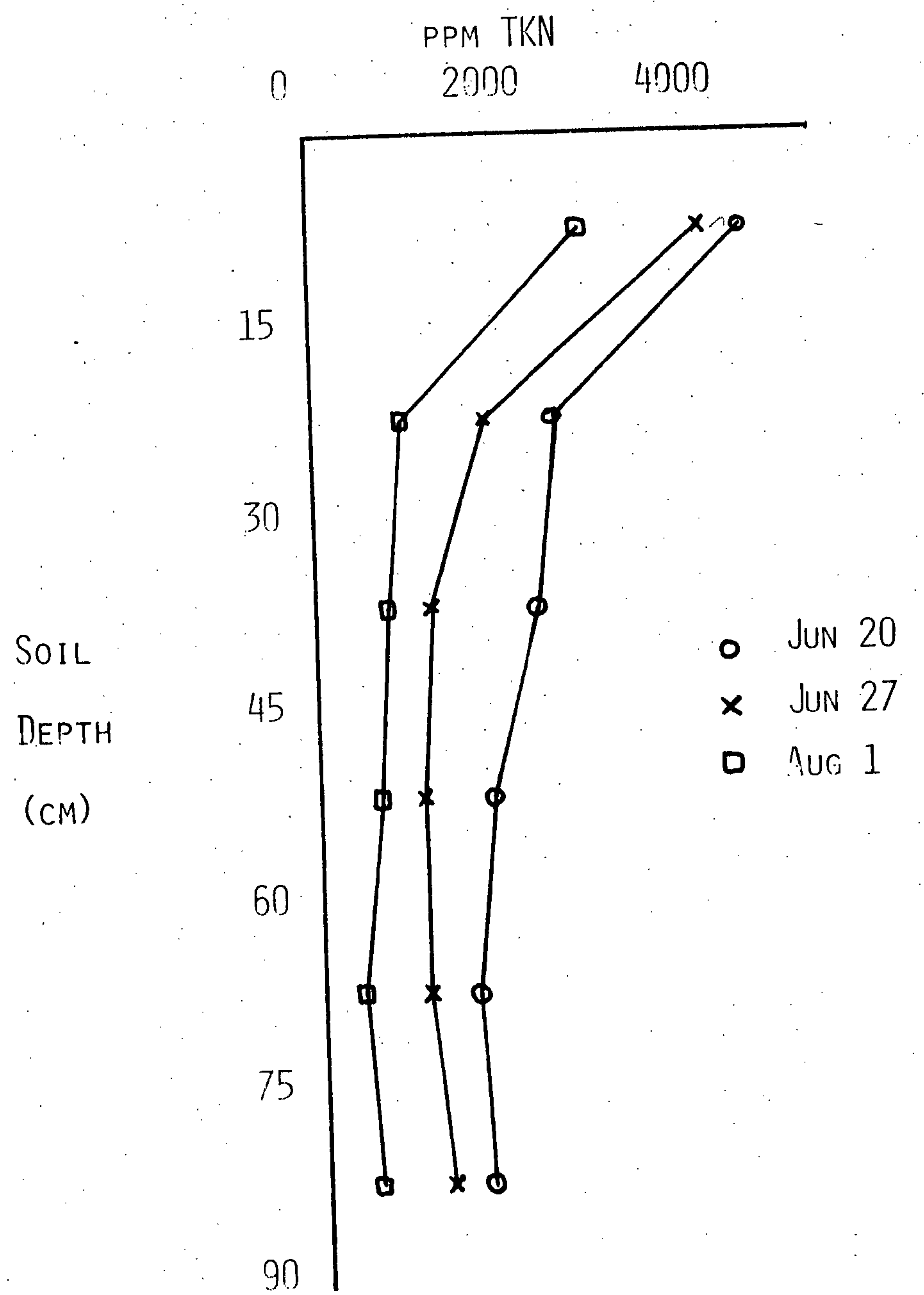

FIG 7 BEAVER MEADOWS TRIAL I COMPOSITED TKN

(CHANGES IN TKN WITH TIME)

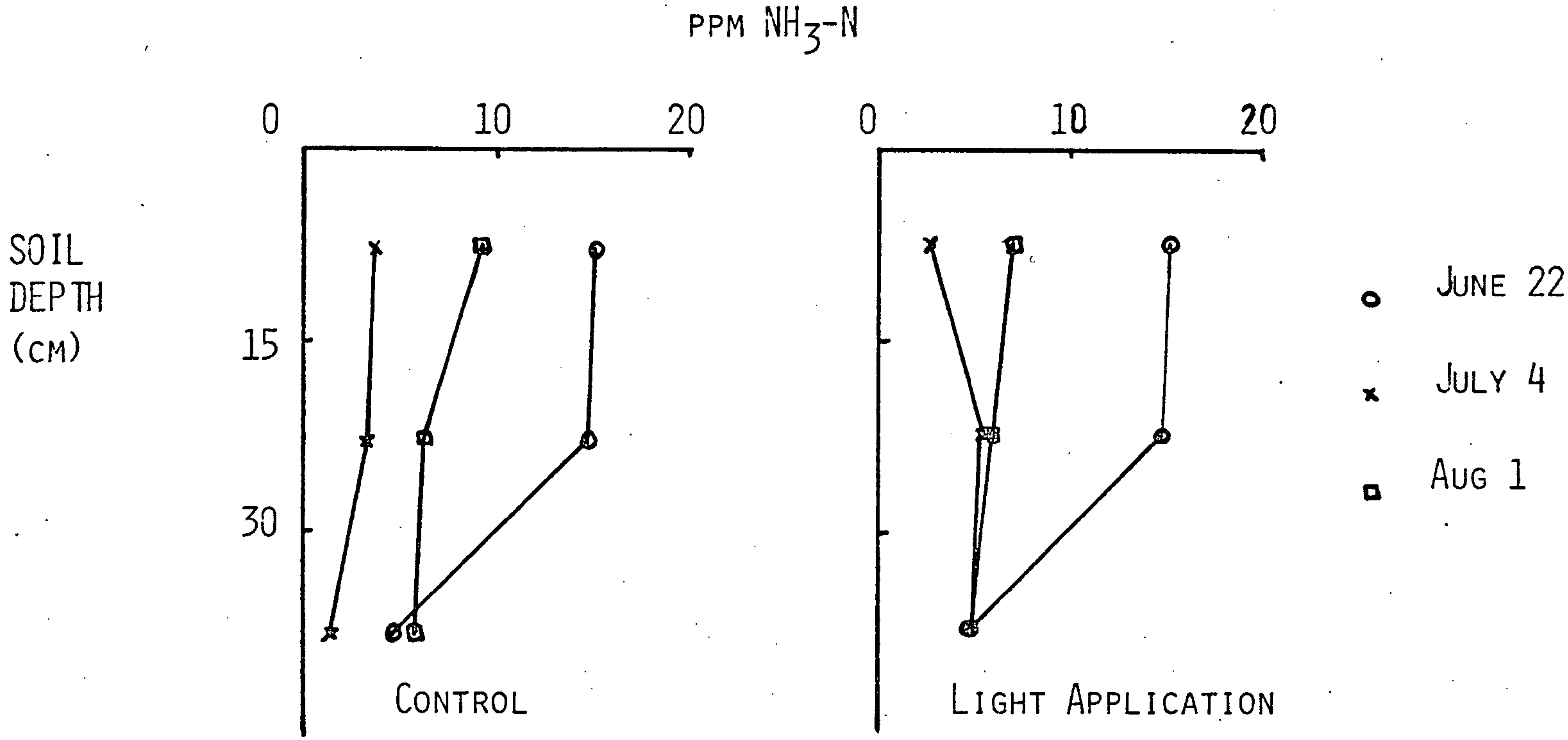

FIG 8 BEAVER MEADOWS TRIAL II AMMONIA NITROGEN PROFILES: CHANGES IN NH_3N CONCENTRATION WITH TIME FOR A SOIL (BOWSER-CUSTER SERIES) RECEIVING NO MANURE AND A SOIL RECEIVING A LIGHT APPLICATION OF DAIRY MANURE ON JUNE 22, 1977

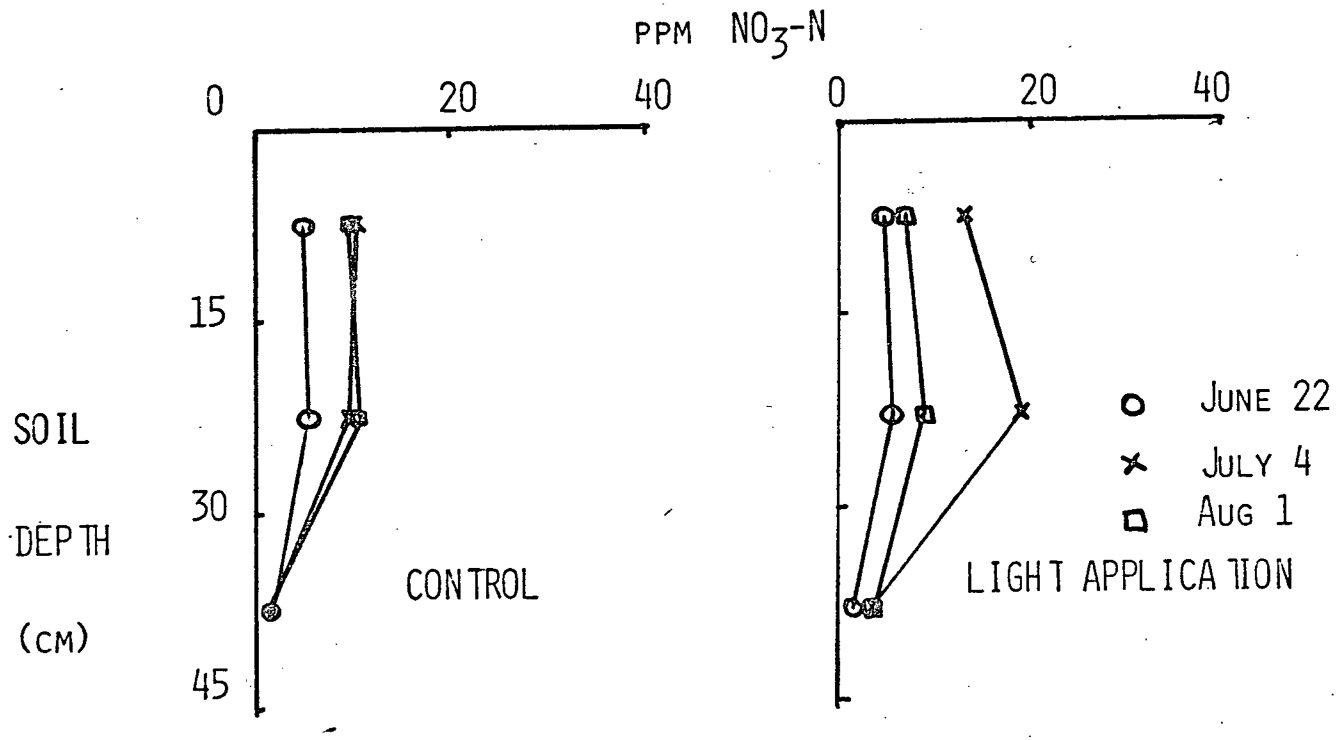

Fig 9 Beaver Meadows Trial II Nitrate Nitrogen Profiles: changes in NO_3N concentration with time for a soil (Bowser-Custer series) receiving no manure and a soil receiving a light application of dairy manure on June 22, 1977

and nitrate in the earlier study. At no time did the 30-45 cm intervals show nitrate nitrogen levels above 10 ppm.

TKN showed large fluctuations again in this study (Fig 10). There is no doubt that some of the changes are due to soil variability. Nevertheless, there again appears to be a decrease in TKN concentration with time. The magnitude of this decrease from July 4 to August 1 in the 15-30 cm interval of the lightly manured plots amounted to approximately 75 kg/hectare furrow slice (15cm x 100m x 100m). Similar losses occurred in the control plots. These losses are difficult to explain at this time.

Nitrogen Movement in Soil:Applied Before the Growing Season

At the U.B.C. Farm changes in ammonia, nitrate and Total Kjeldahl Nitrogen for plots receiving heavy and light manure applications before the growing season were determined. Applications of manure were made in November 1975, January and March, 1976.

The ammonia profiles at U.B.C. Farm exhibited similar behaviour to those at Beaver Meadows with generally lower increases in ammonia concentration in the 0-15 cm interval (Figs 11, 12, 13). The largest increase in ammonia concentration occurred on the heavily manured January plots where the May sampling reached an average level of 14 ppm NH_3-N (dry weight basis). Below the 0-15 cm horizon, with one exeption, all profiles showed no concentrations exceeding 5 ppm NH_3-N (dry weight basis) and decreasing to 2-3 ppm NH_3-N at the 75-90 cm depth.

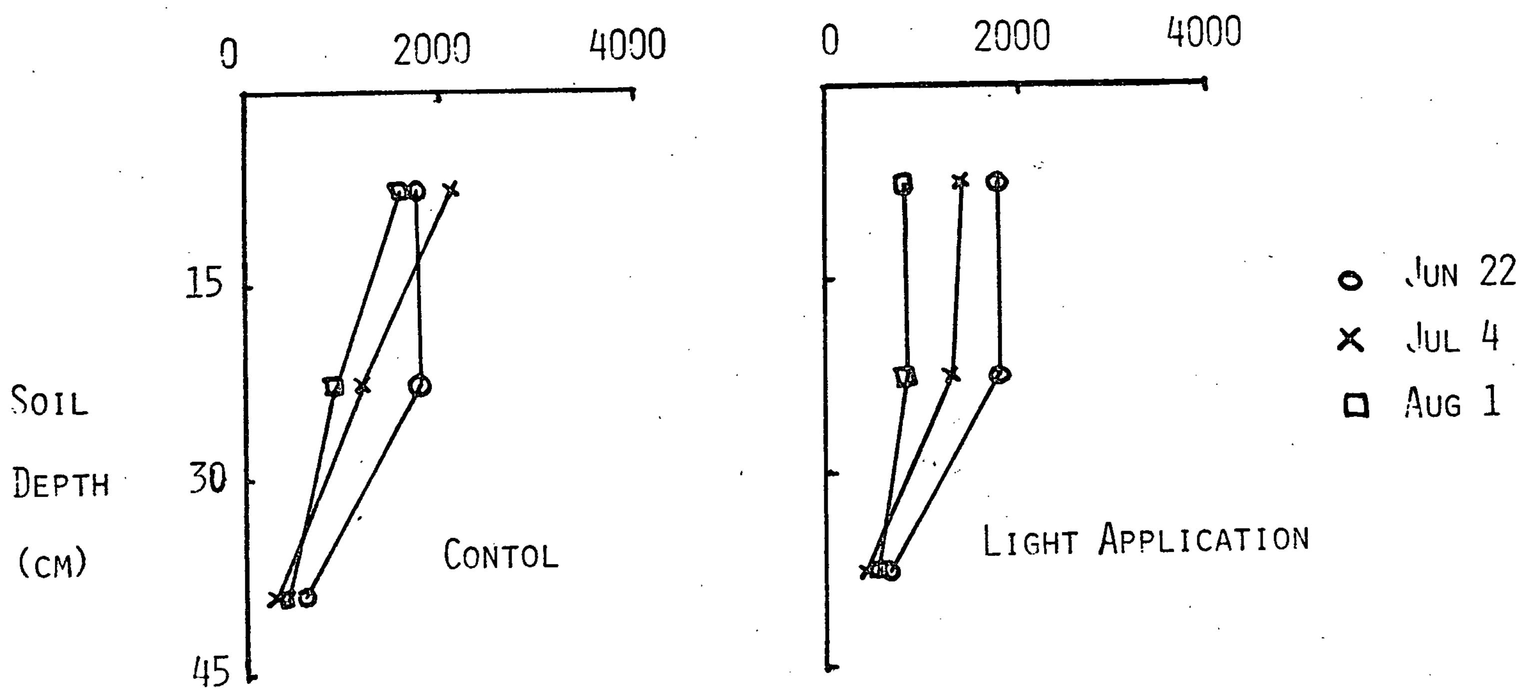

Fig 10 Beaver Meadows Trial II TKN Profiles: changes in TKN concentration with time for a soil (Bowser-Custer series) receiving no manure and a soil receiving a light application of dairy manure on June 22, 1977

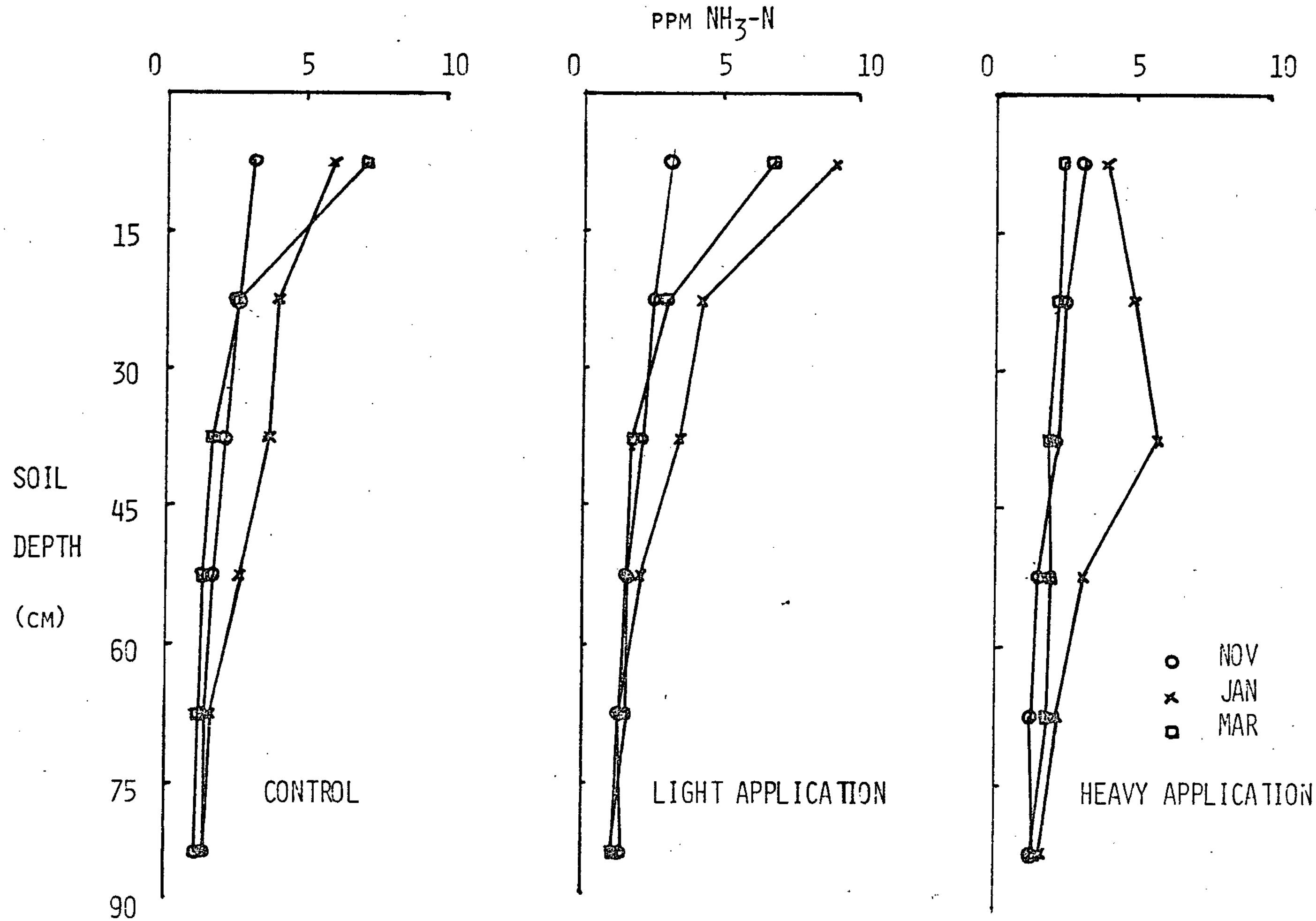

FIG 11 UBC AMMONIA NITROGEN PROFILES NOVEMBER SERIES: CHANGES IN NH_3N CONCENTRATION WITH TIME, FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 4.6 AND 13.9 T/HA OF DAIRY MANURE (DRY WEIGHT BASIS) IN NOVEMBER 1975

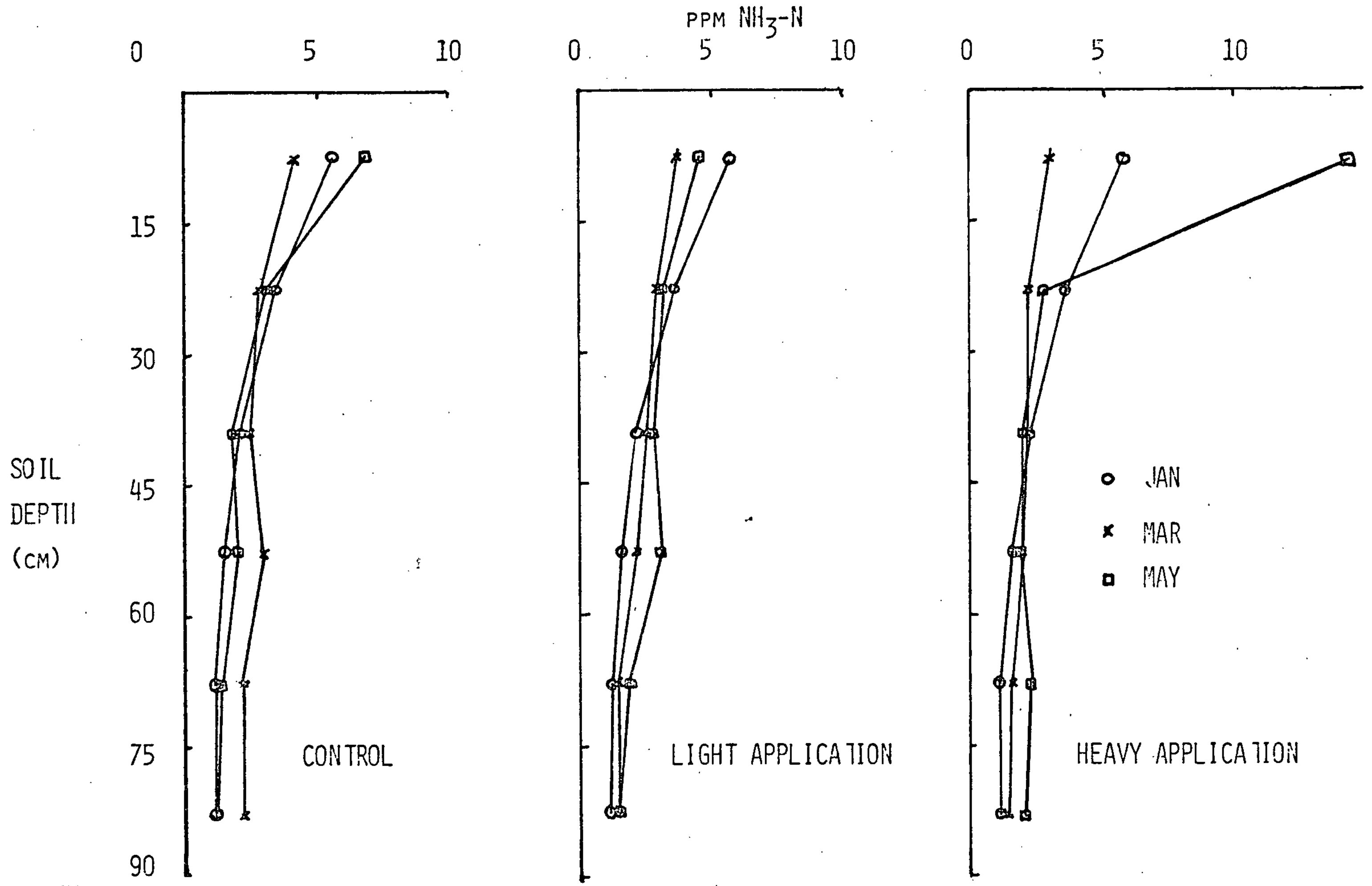

FIG 12 UBC AMMONIA NITROGEN PROFILES JANUARY SERIES: CHANGES IN NH_3 N CONCENTRATION WITH TIME FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 5.9 AND 17.6 T/HA DAIRY MANURE (DRY WEIGHT BASIS) IN JANUARY 1976

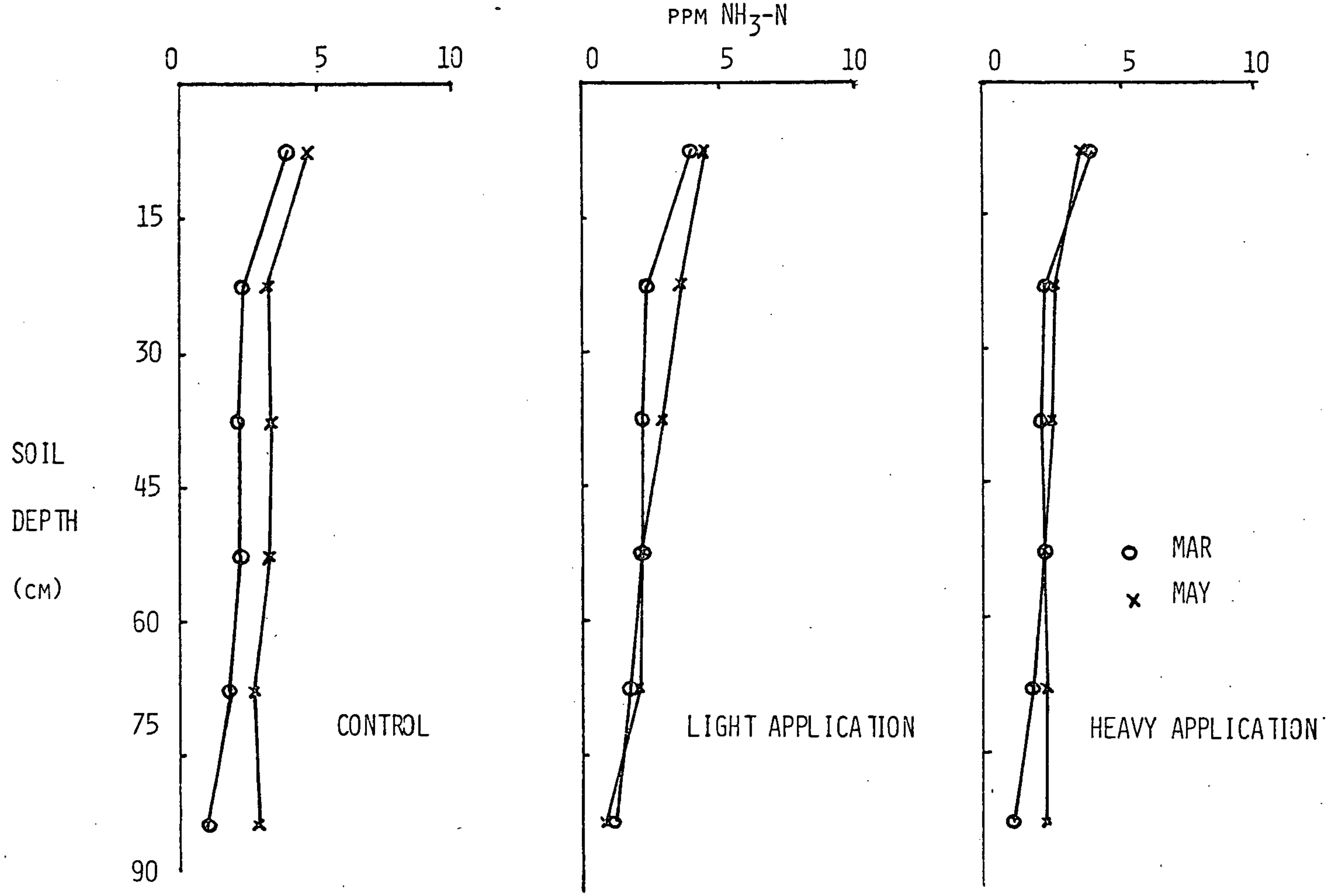

FIG 13 UBC AMMONIA NITROGEN PROFILES MARCH SERIES: CHANGES IN NH_3N CONCENTRATION WITH TIME FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 5.5 AND 16.5 T/HA DAIRY MANURE (DRY WEIGHT BASIS) IN MARCH 1976

Nitrate nitrogen distributions in the soils are shown in Figs 14, 15 and 16. The heavily manured plots showed nitrate concentrations in excess of 10 ppm NO_3-N (dry weight basis) above 45 cm for the sampling in the month following application. Below 45 cm in depth the concentration decreased to 4-5 ppm NO_3-N (dry weight basis). The January heavy application showed indications of substantial downward nitrate movement in the March sampling.

The TKN showed general fluctuations with time (Figs 17, 18, 19, and 20). As experienced with other trials the magnitudes and sometimes the directions of these changes appear inexplicable.

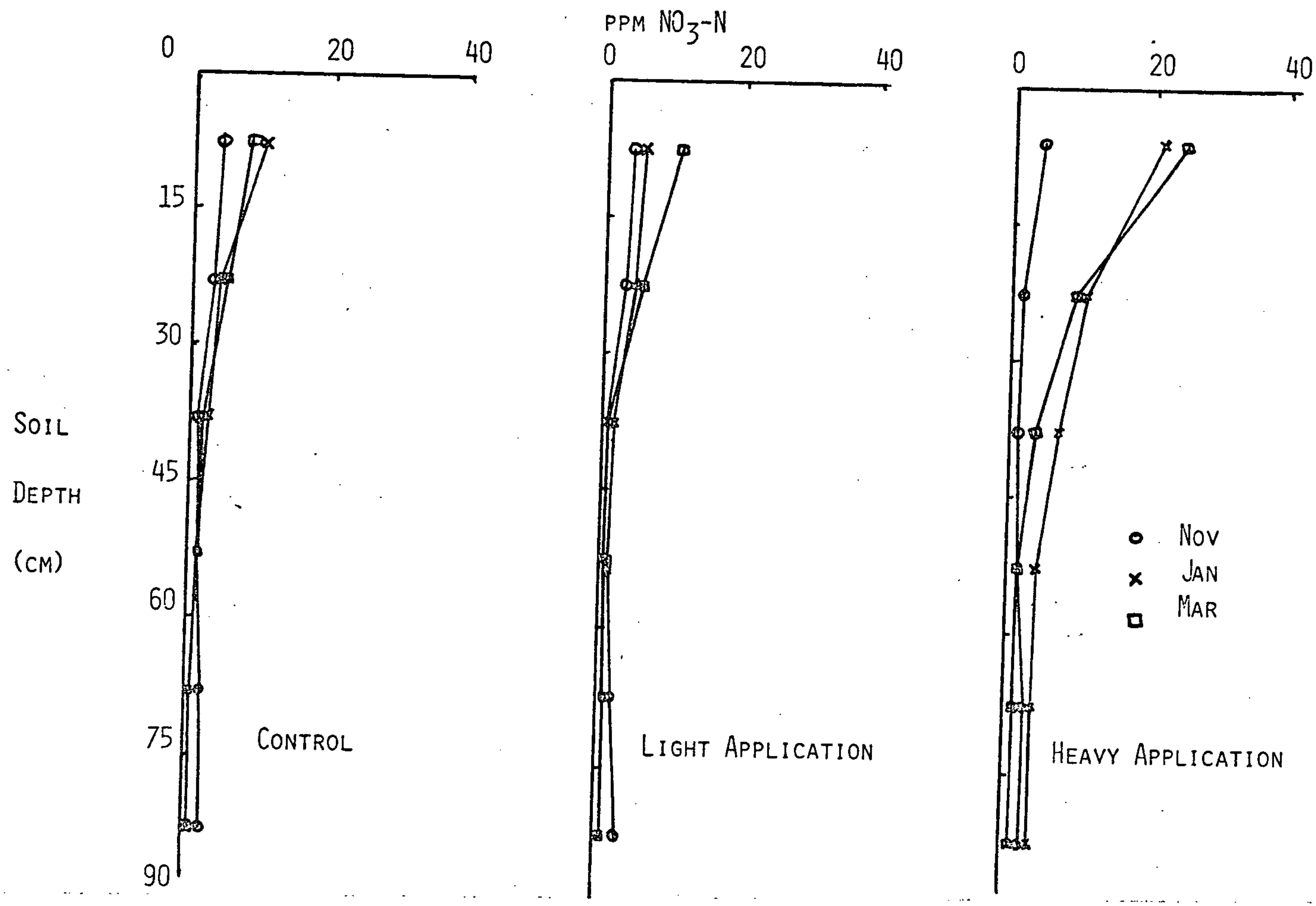

FIG 14 UBC NITRATE NITROGEN PROFILES NOVEMBER SERIES: CHANGES IN NO_3N CONCENTRATION WITH TIME FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 4.6 AND 13.9 T/HA DAIRY MANURE (DRY WEIGHT BASIS) IN NOVEMBER 1975

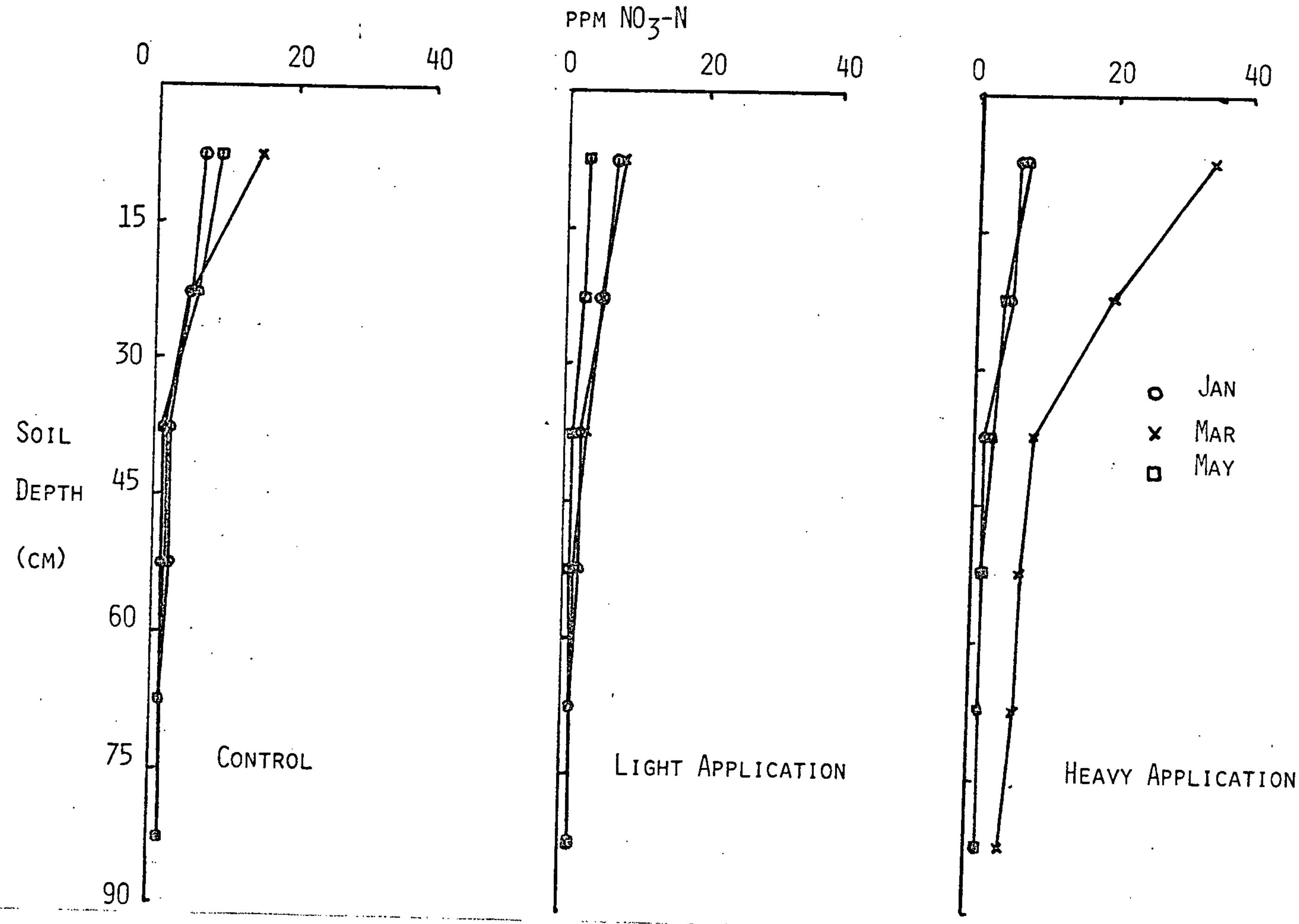

FIG 15 UBC NITRATE NITROGEN PROFILES JANUARY SERIES: CHANGES IN NO_3N CONCENTRATION WITH TIME FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 5.9 AND 17.6 T/HA OF DAIRY MANURE (DRY WEIGHT BASIS) IN JANUARY 1976

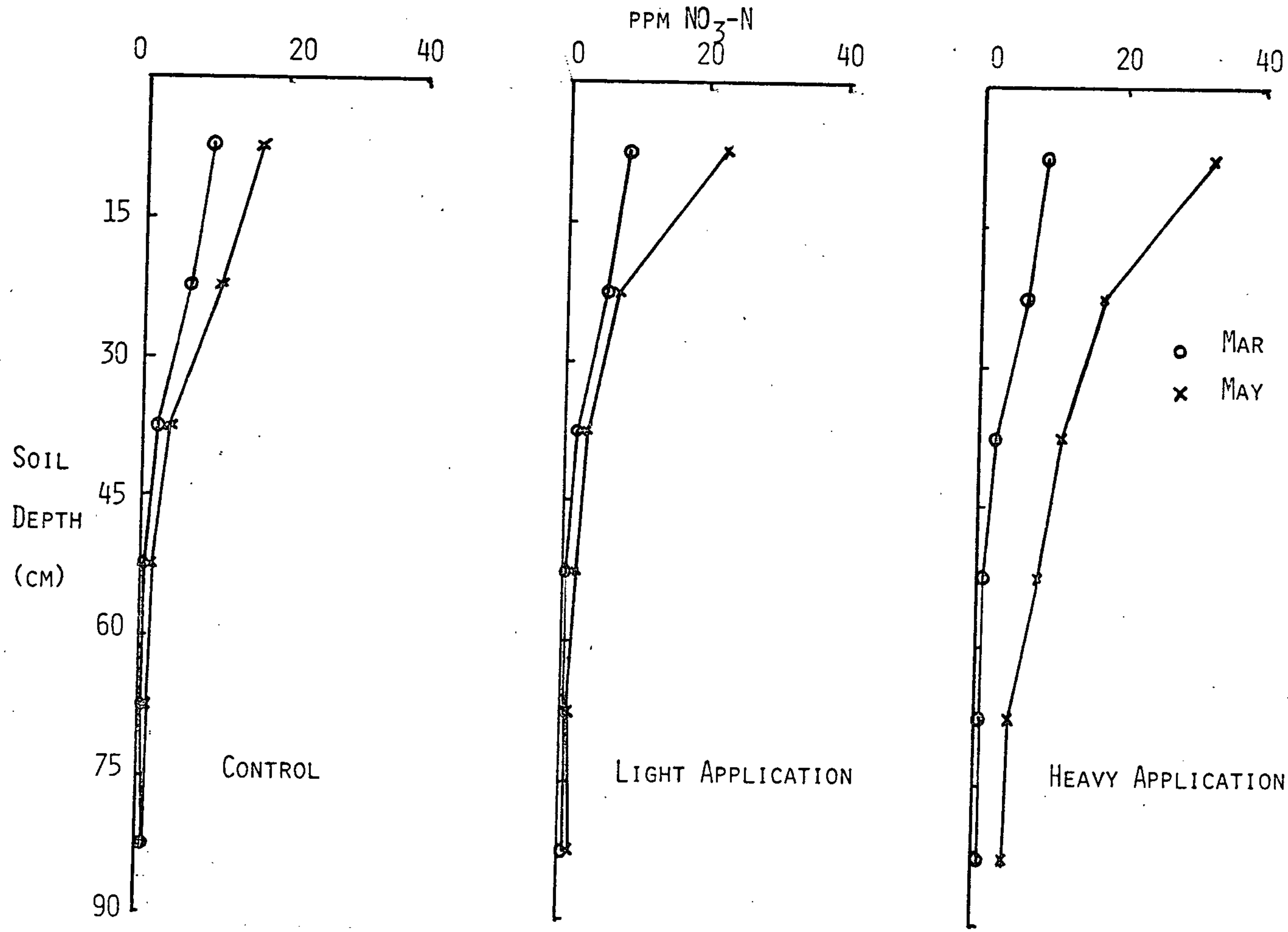

FIG 16 UBC NITRATE NITROGEN PROFILES MARCH SERIES: CHANGES IN NO_3N CONCENTRATION WITH TIME FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 4.6 AND 13.9 T/HA OF DAIRY MANURE (DRY WEIGHT BASIS) IN MARCH 1976

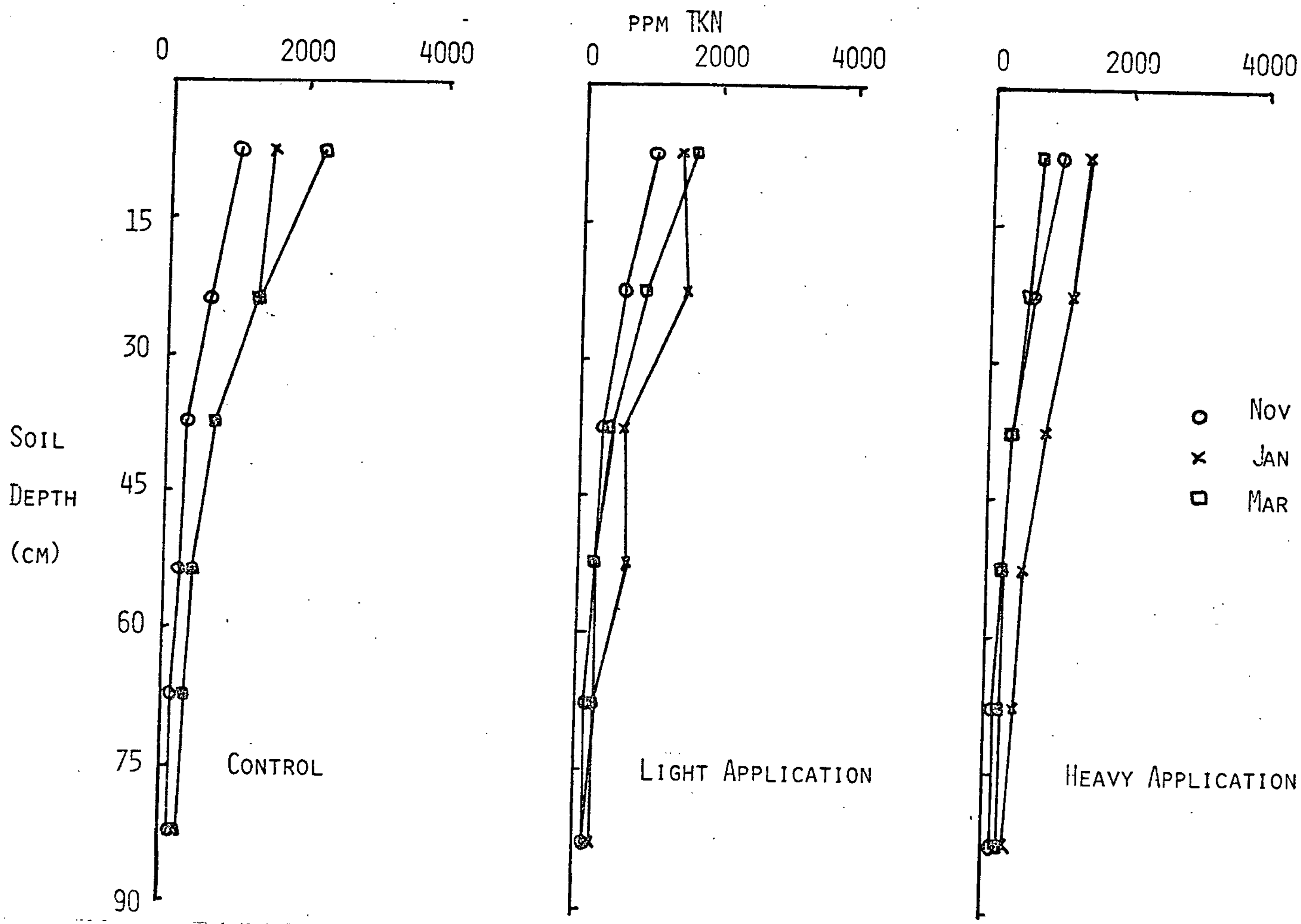

FIG 17 UBC TKN PROFILES NOVEMBER SERIES: CHANGES IN TKN CONCENTRATION WITH TIME FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 4.6 AND 13.9 T/HA (DRY WEIGHT BASIS) OF DAIRY MANURE IN NOVEMBER 1975

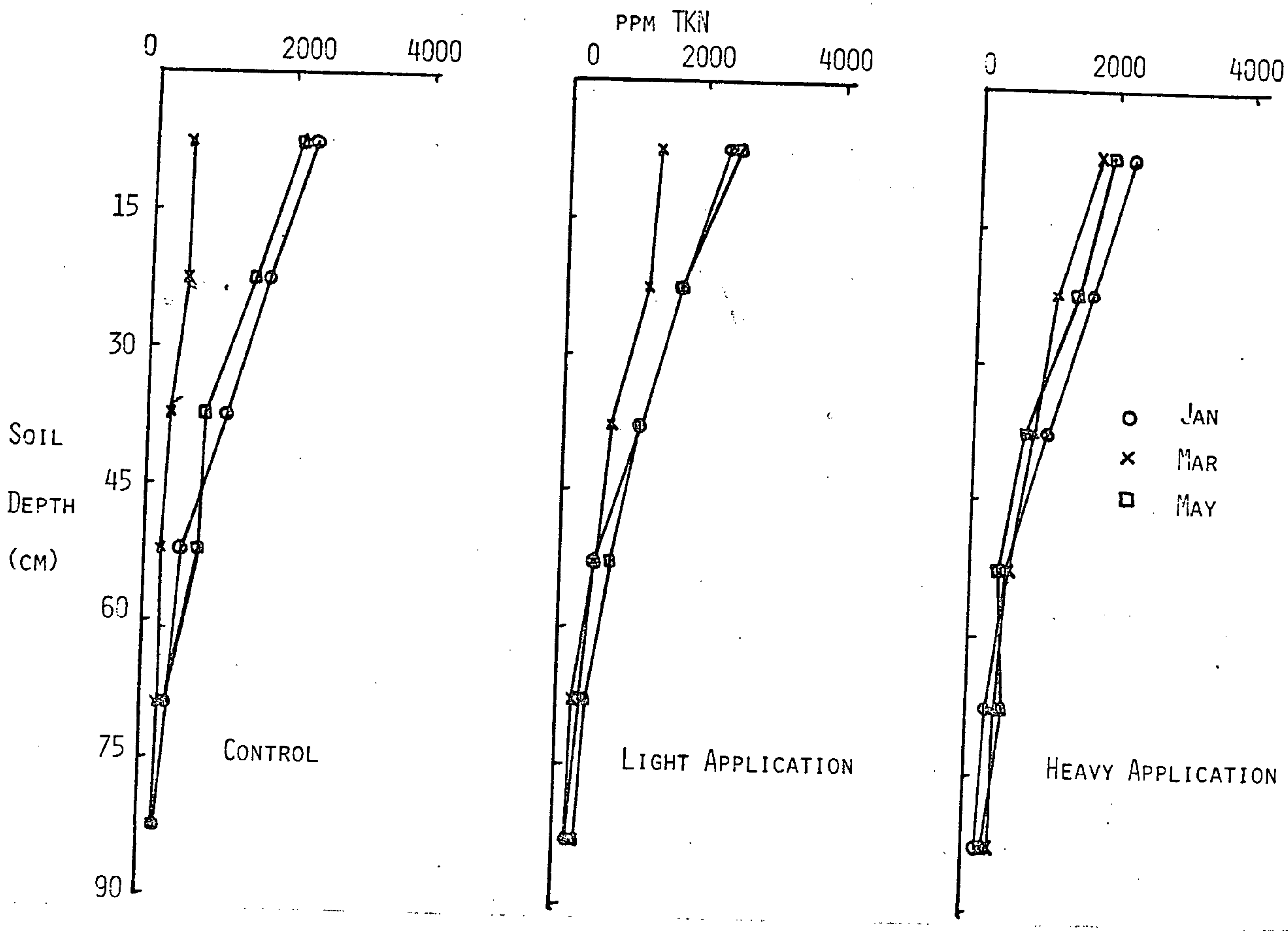

FIG 18 UBC TKN PROFILES JANUARY SERIES: CHANGES IN TKN CONCENTRATION WITH TIME FOR A SOIL (CASSIDY SERIES) RECEIVING 0, 5.9 AND 17.6 T/HA (DRY WEIGHT BASIS) OF DAIRY MANURE IN JANUARY 1976

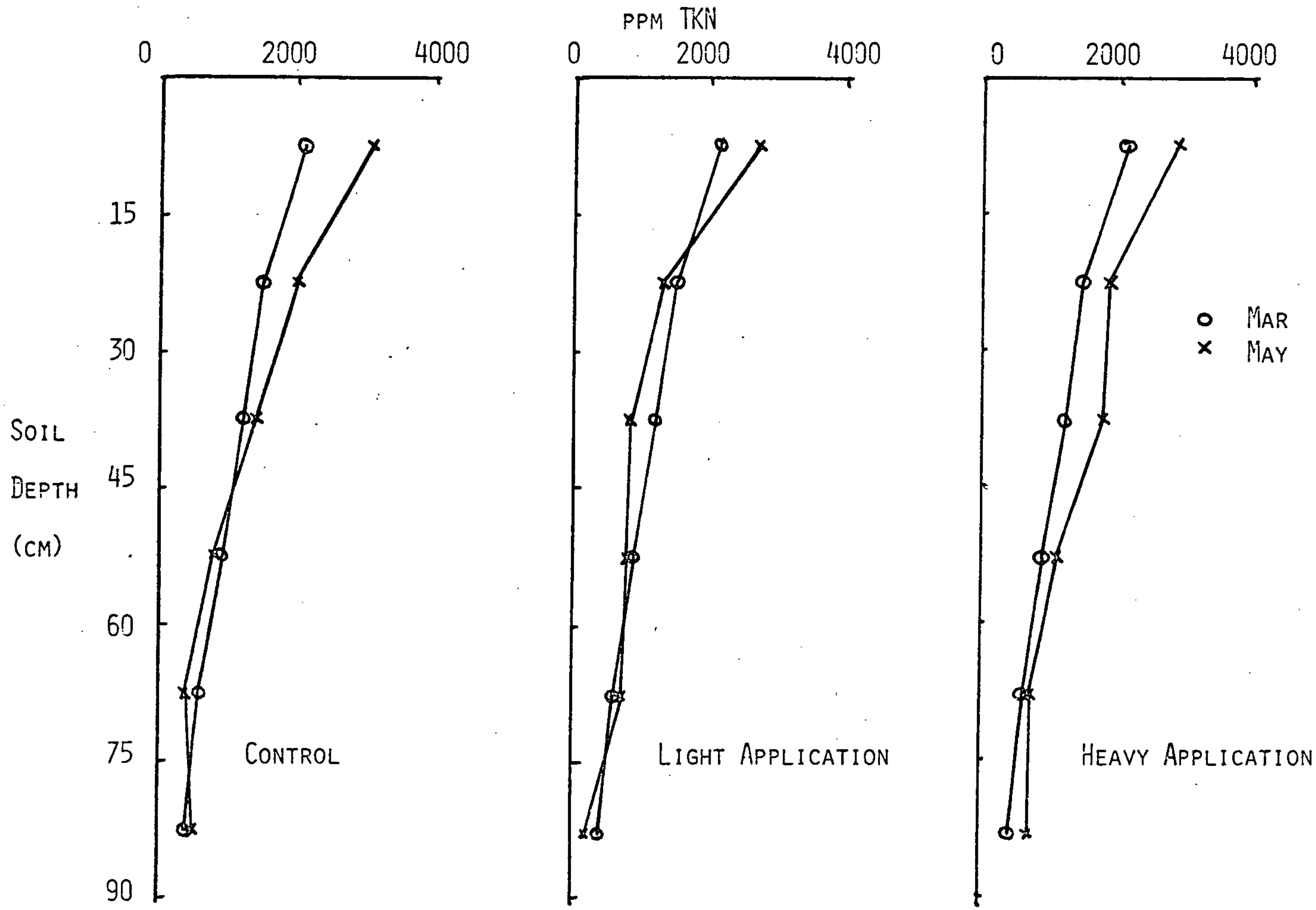

Fig 19 UBC TKN Profiles March Series: changes in TKN concentration with time for a soil (Cassidy series) receiving 0, 5.5 and 16.5 t/ha (dry weight basis) of dairy manure in March 1976

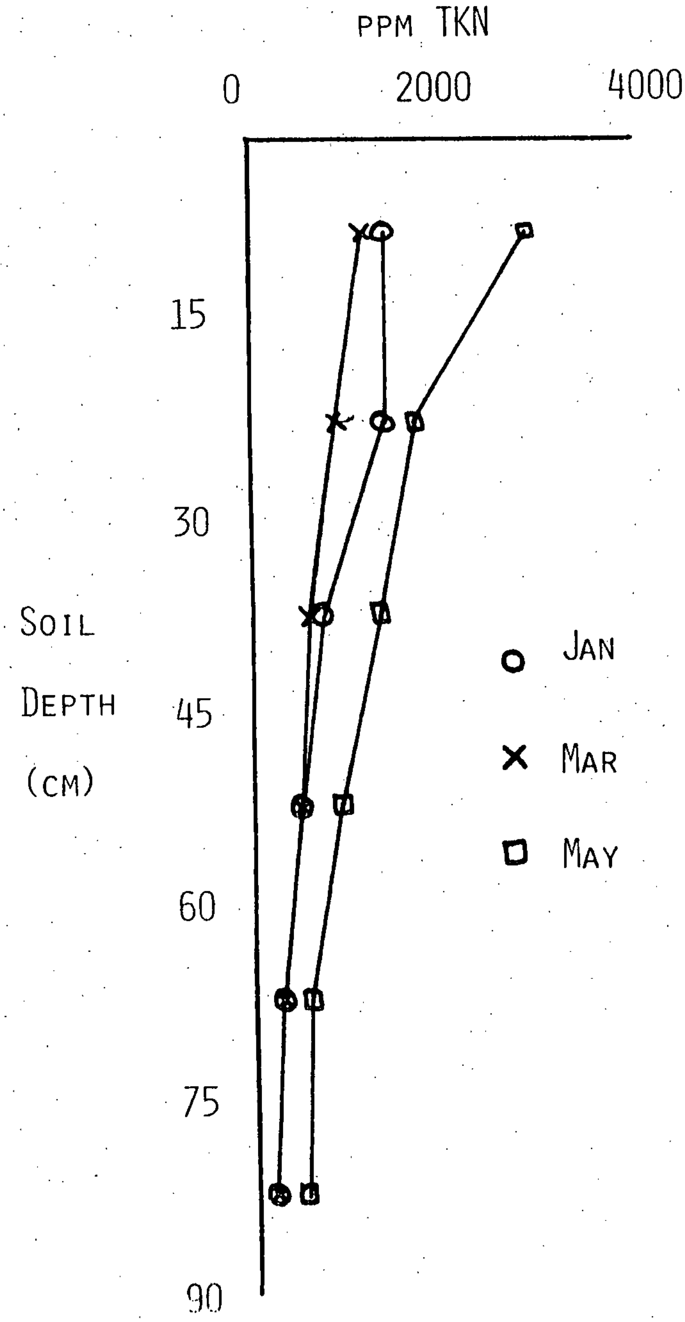

FIG 20 UBC COMPOSITED TKN

(CHANGES IN TKN WITH TIME)

Summary and Conclusions

Attempting to establish criteria for waste management guidelines is an enormous task. In this study of two dairy farms on Vancouver Island we feel we have established some principles which should improve future studies.

As an alternative to repetitive analyses of manure for nitrogen content, it was found that a knowledge of the total nitrogen content of the feed provided a good basis for calculating the amount of nitrogen which could be found in the waste.

The nitrogen content of the manure could also be calculated knowing the nitrogen content and the average total milk produced per cow over a given length of time. This method is more rapid and easier than the above.

Both of these methods work well for a farm herd which is feeding at close to optimal rates and has a genetic potential approaching the anticipated feed nitrogen conversion efficiencies.

The closer a farm is feeding to the optimum rates and the closer the herd is to achieving its' genetic potential of an anticipated feed nitrogen conversion efficiency the greater will be the accuracy of these two methods. Large errors in estimating the manure nitrogen are possible if excess nitrogen is being fed or if the efficiency with which the herd is converting the feed nitrogen to milk nitrogen is significantly below average.

Nitrogen losses in pit storage were small in the 1976 trial. More significant losses had been expected. The pit cross section study (1977) showed that these losses were likely greater due to the variability in nitrogen content found in the pit at different locations. The difference between nitrogen at the input and the pit mean nitrogen level in this study was 12%.

Spreading losses ranged from 4-9% of applied manure nitrogen in four trials.

Nitrogen recovery showed higher yield in all the treated plots. With the exception of the November U.B.C. trial, the yield of the light applications exceeded that of the heavy applications. Based on this data it is unlikely that a farmer wishing to ensure high crop yields and efficient use of manure would land spread at a rate resulting in environmental damage. However, the data collected at Beaver Meadows was only for the second of three crops and that at the U.B.C. Farm an early harvest in May to allow field work which would be followed by at least two subsequent cuttings. Thus far more extensive yield data is required before conclusions on application rate vs. yield can be made.

The ammonia profiles showed some build-up in the upper horizons, but little downward movement as expected.

Observations of the nitrate profiles showed levels exceeding 10 ppm in the upper horizons but never in the lower horizons. It is unlikely that the loading rates shown would cause environmental damage.

TKN soil profiles at Beaver Meadows and U.B.C. Farms showed unexplained fluctuations.

It is reasonable to conclude that in most farming operations in British Columbia undesirable environmental impacts from waste management will be generated principally from poor manure handling and storage. The land base limited operations are the obvious exceptions and will require study into maximum permissible loading rates.

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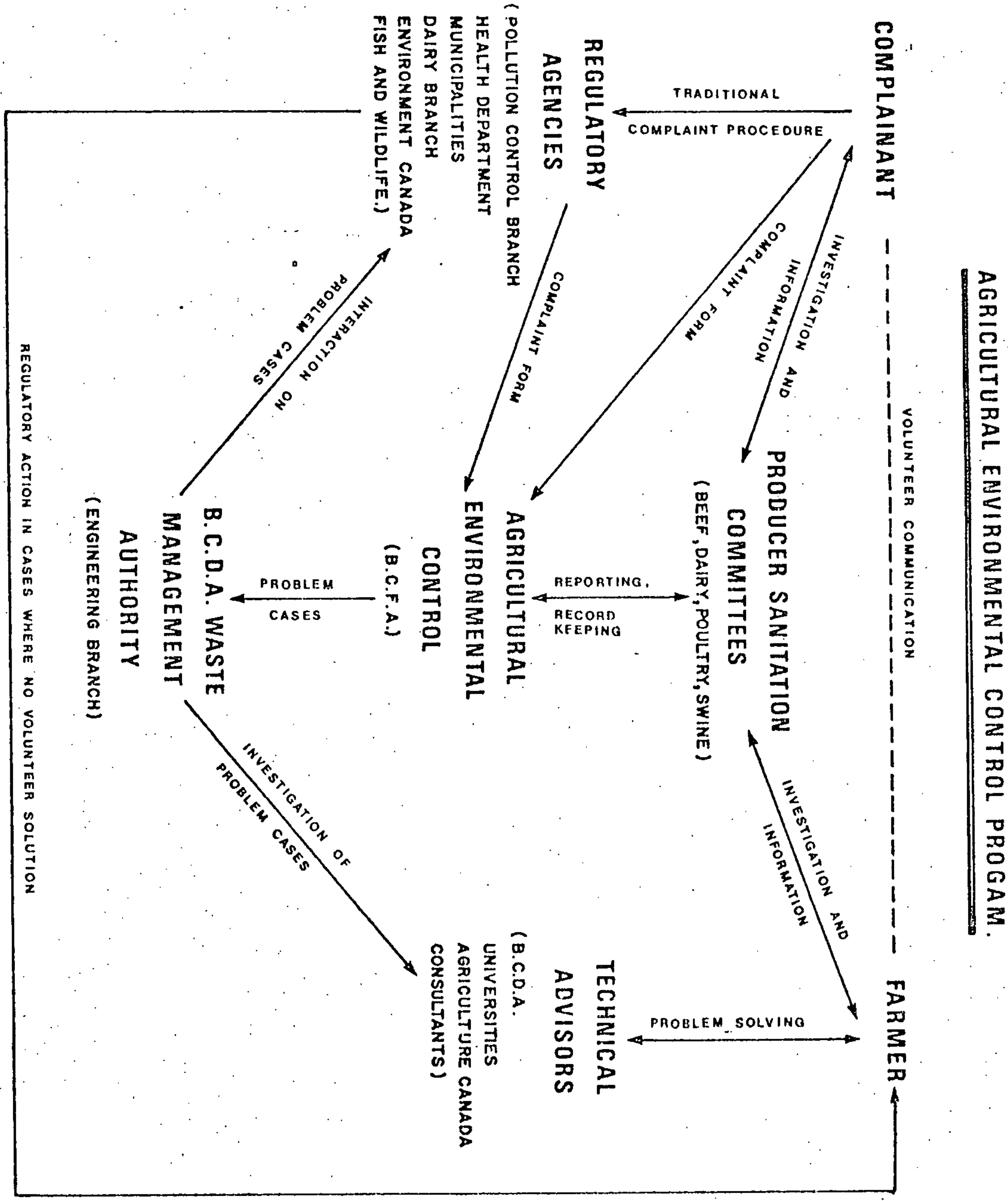
Appendix A



Operation of the Agricultural Environmental Control Program

APPENDIX B

COMPARISON OF TOTAL NITROGEN DETERMINATION OF SOILS

Determination of TKN by two methods;

a) Block digestion/AutoAnalyser

b) Macro Kjeldahl determination

Short Description of Analytical Procedures:

A. BLOCK DIGESTION/AUTOANALYSER

i. Soil sample size - approximately 1.0 g

ii. Digestion catalyst: 3 g of premix catalyst 97% K_2SO_4 + 3% $CuSO_4$ + 10 ml of concentrated H_2SO_4

iii. The mixture in digestion tube is digested at 700^{o}F after cooling and diluted into 500 ml and analysed on Technicon AutoAnalyser for NH_4+ by alkaline phenol-hypochloride reaction

B. MACRO KJELDAHL DETERMINATION

i. Soil sample - approximately 6 g

ii. Digestion catalyst: Official KEL PAK POWDER BAG(10 g K_2SO_4 + 0.3 g $CuSO_4$, Canlab-Curtis Matheson Scientific Inc. 50 ml of concentrated H_2SO_4 is added and mixture is digested for approximately 2-3 hours on Kjeldahl Digester Rack. Add 200 ml of H_2O after digestion

iii. After cooling add 150 ml of 10 N NaOH and distill about 75 ml into 300 ml flask containing 75 ml of Boric Acid Indicator Solution using Kjeldahl Distillation Rack

iv. Titrate the distillate with standardised HCl.

v. Calculation;

$$\%n = \frac{\text{N of HCl} \times 14.007 \times \text{ml HCl} \times 100}{\text{g soil} \times 10^3}$$

Normality of HCl = 0.104

NOTES

Due to violent bumping during distillation(even with excess of boiling chips)only two samples were distilled at a time on a 12 place Distillation Rack, and volume of distillate was cut to 40-50 ml. With all precautions one Macro-Kjeldahl flask cracked but distillate was recovered.

RESULTS

Six soil samples, from two field plots on Vancouver Island, were analysed in duplicate by both methods. Soil sampling was carried out diagonally across the field plots as 15 cm intervals to a depth of 45 cm, thus giving four determination of TKN for each depth by both methods.

Results are as follows:

	Macro Kjeldahl			Block Digestion/ AutoAnalyzer		
Depth cm	Sample Size g	TKN ppm	TKN Average ppm	Sample Size g	TKN	TKN Average
0-15	6.14 6.47	1922 1848	1884	1.01 1.03	1866 1479	1672
15-30	6.21 6.11	2064 2122	2093	1.01 1.03	2250 2091	2170
30-45	7.45 7.52	626 639	632	1.08 1.03	608 459	533
0-15	6.32 5.34	1751 1664	1707	1.04 1.04	1568 1265	1416
15-30	6.31 6.15	1108 1090	1099	1.04 1.02	860 1082	971
30-45	7.44 7.42	274 314	294	1.03 1.03	434 459	446

At the 0.05 level of signifigance a t-test shows that there is not a signifigant difference between the two methods of analysis.

APPENDIX C

NH_4 - N ANALYSES -- PRERUN (WATER AND 1N KCl EXTRACTIONS)

Sample Code	Water ppm	1.N KCl ppm	Difference ppm	Difference %
1	1,340	1,480	140	10.4%
2	1,240	1,450	210	16.9%
3	1,060	1,480	420	39.6%
4	1,340	1,510	170	12.7
5	1,340	1,520	180	13.4

At the 0.05 level of signifigance a t-test shows that there is a signifigant difference between the two methods of analysis

APPENDIX D

DETERMINATION OF NO_3 - N IN SOIL

EXPERIMENTAL CONDITIONS:

A - 5g of soil extracted by 25 ml 1N KCl

B - 5g of soil extracted by 25 ml of $H_2O/CaSO_4$(1g/1)

STD - 2 ppm = 62.5 Div.

NO_3 - N ppm	
A	B
4.80	4.80
4.55	4.80
4.80	4.80
4.12	4.80
4.35	4.58
4.58	4.58
4.58	4.58
4.80	4.80
4.58	4.80
4.80	5.03
Avg. 4.60	4.76

At the 0.05 level of signifigance a t-test shows that there is not a signifigant difference between the two methods of analysis.

APPENDIX E

COMPARISON OF FEED RESULTS AT BEAVER MEADOWS AND U.B.C. FARMS.

FEED	% CRUDE PROTEIN (WET WEIGHT BASIS)			
	MEASURED*	FEED ANALYSIS SERVICE	MANUFACTURERS QUOTATION	LIT
ALFALFA (B.M.)	12.3	-	-	14.5
SILAGE (B.M.)	2.5	3.0	-	3.1
CONCENTRATES (B.M.)	9.8	-	16%	-
ALFALFA (U.B.C.)	9.7	14.7	-	14.5
GRASS SILAGE (U.B.C.)	2.8	2.6	-	-
CORN SILAGE (U.B.C.)	2.2	1.4	-	-
CONCENTRATE (U.B.C.)	10.6	15.5	16%	-

* Measured Values are an average of 6 samples taken at monthly intervals. These samples showed considerable fluctuations.