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## Manure Nutrient Management Research in Southern Alberta

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### Introduction

The animal sector is a significant part of Alberta's agricultural industry. The number of cattle in Alberta has increased by more than 50 percent in the last 25 years (CAESA 1998). Opportunities may support continued expansion of Alberta's animal sector. Favourable climate and good access to feed and water have resulted in concentrations of intensive feedlot operations in certain regions of Alberta. The effects of manure disposal on soil and water quality are a major concern. Over application of manure can cause surface water contamination from nitrogen, phosphorus, and pathogens. Groundwater can be at risk from nitrate-N, which is very soluble and can leach through soil. Soil quality can be adversely affected by excess nutrients and salts from repeated, heavy applications of manure.

The purpose of this paper is to describe the findings of two research studies that examined the environmental effects of cattle manure on soil and groundwater quality in southern Alberta.

### Lethbridge Long-term Manure Study

**Method.** This study was started by the Agriculture and Agri-Food Canada Lethbridge Research Centre in **1973**. The site was divided into two blocks: nonirrigated and irrigated. Cattle feedlot manure has been applied and incorporated each fall since 1974. The manure rates were 0, 30, 60, and 90 tonne  $\text{ha}^{-1}$  (wet weight) for the nonirrigated block, and 0, 60, 120, and 180 tonne  $\text{ha}^{-1}$  for the irrigated block. The site has been continuously cropped since 1974.

**Results.** Chang et al. (1991) reported that the accumulation of organic matter, total N,  $\text{NO}_3^-$ , total P, available P, soluble Na, Ca+Mg, Cl,  $\text{SO}_4^{2-}$ ,  $\text{HCO}_3^-$ , and Zn in the soil increased with increasing rates of manure applied. They also reported a decrease in soil pH and an increase in electrical conductivity with increasing manure rates.

Nitrogen balances were calculated after 19 annual manure applications. Crop N, soil organic N, and extractable nitrate-N accounted for all of the N added in the manure on the

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nonirrigated plots (Chang and Janzen 1996). However, a significant amount of N was leached and volatilized under irrigation. Chang and Janzen (1996) estimated that about 56 percent of the N applied was mineralized after 19 years of manure application.

Nitrate-N accumulated significantly in the root zone in the nonirrigated plots, but leaching below the root zone was minimal except in a year when precipitation was well above normal (Chang and Entz 1996). However, under irrigated conditions, nitrate-N leached below the root zone and contaminated the shallow groundwater. The long-term average loss of nitrate-N by leaching was 93,224, and 34 1 kg  $\text{ha}^{-1}\text{yr}^{-1}$  for the 60, 120, and 180 tonne  $\text{ha}^{-1}$  manure treatments, respectively, for the irrigated plots (Chang and Entz 1995). The average nitrate-N loss by leaching was linearly correlated with the annual rate of manure application. They estimated that a maximum annual application rate of 13.77 tonne  $\text{ha}^{-1}$  would result in zero leaching of nitrate-N.

The general recommendation from this study is that the original recommended manure rates, 30 tonne  $\text{ha}^{-1}$  for nonirrigated land and 60 tonne  $\text{ha}^{-1}$  for irrigated land, are too high for annual application (Chang et al. 199 1; Chang and Entz 1996).

### **New Manure Study**

**Method.** Two field sites, located about 25 km northeast of Lethbridge, Alberta, were started in 1993. One site was established on sandy-loam soil (coarse-textured site), and the other site was established on a loam to clay-loam soil (medium-textured site). Treatments included a control, three N-fertilizer rates (60, 120, and 180 kg  $\text{ha}^{-1}$  of urea-N), and four manure rates (20, 40, 60, and 120 tonne  $\text{ha}^{-1}$ , wet weight basis). Treatments were replicated five times in a randomized, complete block design. Manure was applied in the fall of 1993 to 1997. The sites were seeded to silage barley in 1994 to 1997, and irrigated when required. Soil samples were collected each fall to a depth of 150 cm, and groundwater samples were collected monthly from April to October.

**Results.** Nitrate-N content was high in the lower soil profile at the coarse-textured site at the beginning of the study (Fig. 1a). During the four crop years, nitrate-N content decreased in the lower soil profile (Fig 1b-e). This decrease may have been caused by crop uptake and leaching below the measured depth (0 to 150 cm). Nitrate-N increased in the top soil layer (0 to 15 cm) with increasing manure rate (Fig. 1a-e).

Soil nitrate-N content was low throughout the soil profile at the medium-textured site in 1993 (Fig. 2a). Nitrate-N content increased with time as manure rate increased (Fig. 2b-e). Greatest accumulation of nitrate-N occurred with the two highest manure rates. Accumulation was greatest in the upper soil profile and decreased with depth. The nitrate-N leaching front in the 120 tonne  $\text{ha}^{-1}$  manure treatment advanced downward each year. The accumulated nitrate-N advanced about 30 cm  $\text{yr}^{-1}$ , and by 1997 the nitrate-N had reached the 120 cm depth.

Groundwater nitrate-N content at the coarse-textured site was well above the maximum Canadian water quality guideline of 10 mg  $\text{L}^{-1}$  (TFWQG 1987) for human consumption (Fig.

3a). This was not surprising considering the coarse soil texture, the high soil nitrate-N content at the start of the study, and the shallow depth (about 2 m) of the water table. Nitrate-N content in the groundwater increased annually during the July-October period. Groundwater below the 120 tonne  $\text{ha}^{-1}$  manure treatment contained the highest nitrate-N content, and the concentration increased each successive year.

Groundwater nitrate-N content was lower at the medium-textured site, but was often above  $10 \text{ mg L}^{-1}$  (Fig. 3b). None of the manure treatments affected groundwater nitrate-N after four annual applications.

This study clearly showed that repeated applications of manure (60 to 120 tonne  $\text{ha}^{-1}$ ) caused nitrate-N to accumulate in the soil profile and to leach through the root zone.

### **Other Research Activities and Management Approaches**

Other research activities in southern Alberta include manure composting, reclaiming eroded land with manure, measuring volatile gases from manure, and applying solid and liquid manure on forages.

Manure is often treated as a waste disposal problem, and without education, this approach can lead to repeated over application on farm land. Attempts are underway to promote manure as a valuable soil amendment and nutrient resource for crop growth. However, managing manure as a fertilizer poses several challenges. These challenges include maximizing the nutrient value of manure, application and incorporation technology, and nutrient imbalances in manure relative to crop requirements.

Research has clearly shown that over application of manure can lead to environmental problems. Additional research is needed to effectively integrate manure usage into an agronomic and nutrient-cycling management strategy. The animal sector is an important part of Alberta's agricultural industry, however, current practices and future expansion of this sector must not compromise our soil and water resources.

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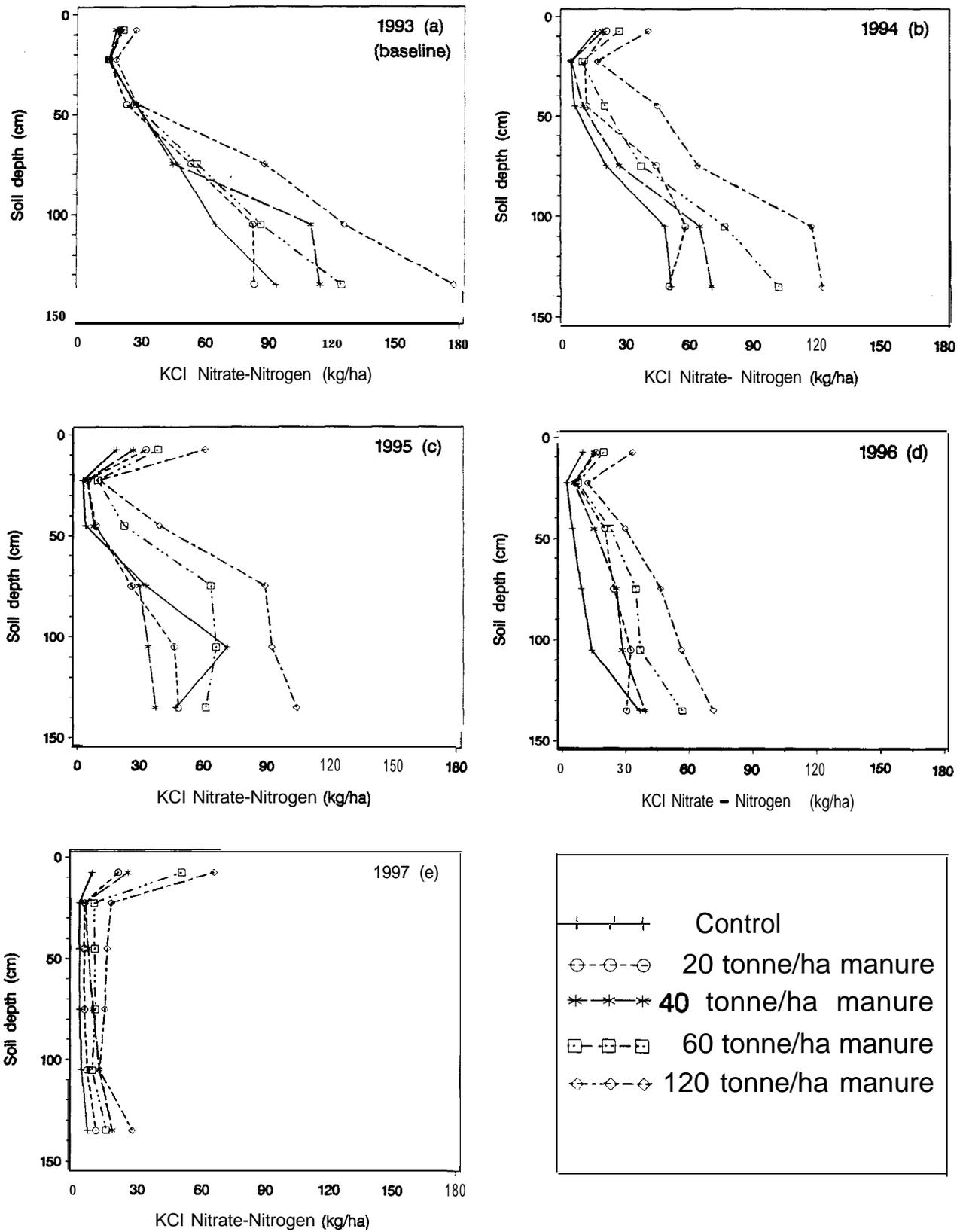


Fig. 1. Soil nitrate-N content at the coarse -textured site.

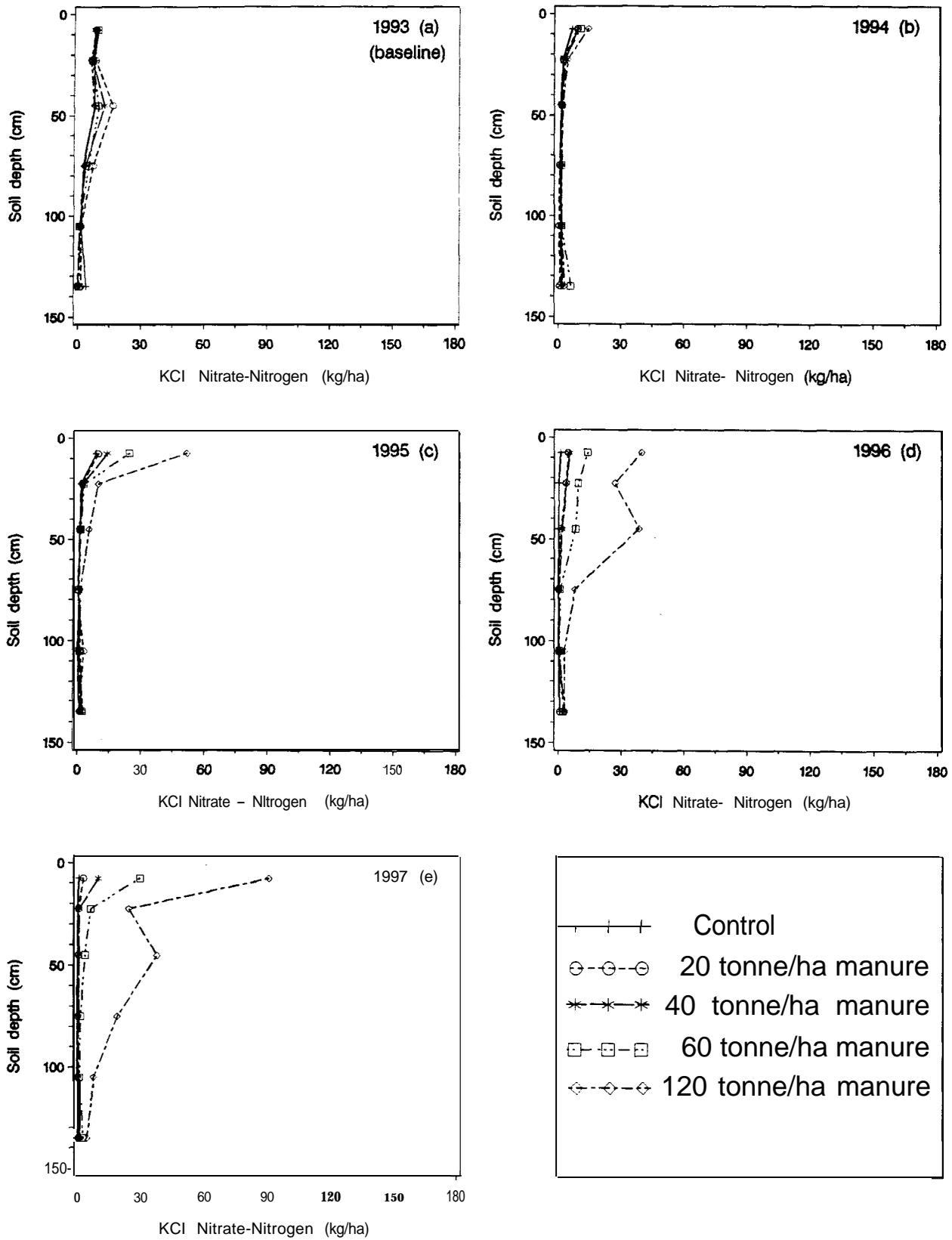


Fig. 2. Soil nitrate-N at the medium- textured site.

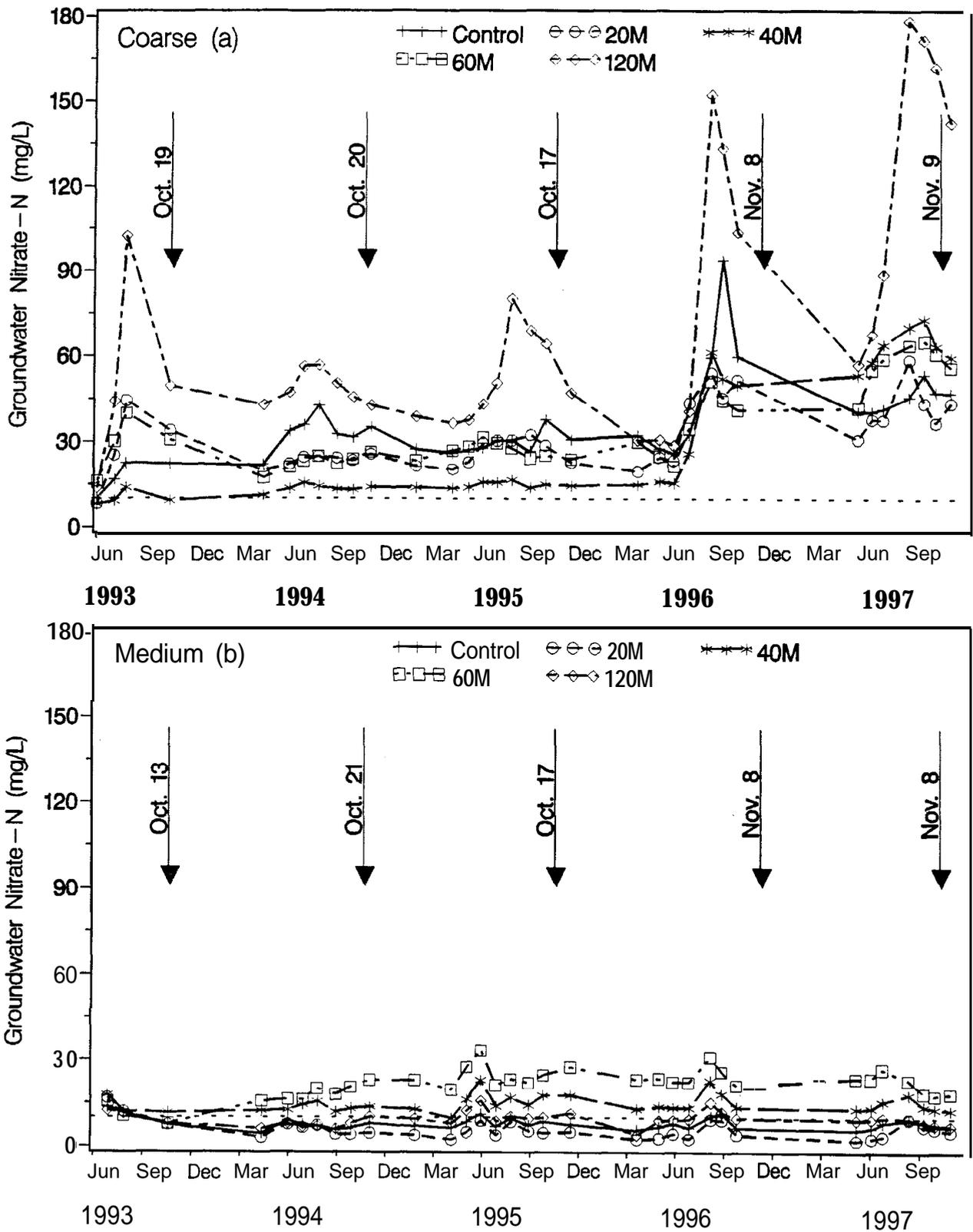


Fig. 3. Groundwater nitrate -N at the coarse-textured site (a) and the medium- textured site (b). The vertical arrows indicate dates when manure was applied. The horizontal dotted lines indicate the Canadian water quality guideline for maximum concentration of 10 for human consumption.