NITROGEN TEST DEVELOPMENT: SOIL N LEVELS IN 1989[1/]

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ABSTRACT

The development of a N test that can be used for fertilizer recommendations of corn in the eastern areas of Minnesota is needed for environmental and economic reasons. A multi-site project was initiated in 1989 to extensively examine soil sampling time and depth as well as N forms in the soil. This will then enable statistical models to be developed using one or more of the variables. A subset of the entire project is reported--concentrating on the sites allowing the calibration of the soil N tests and added fertilizer. Each of the 4 sites discussed had a unique N distribution before planting. The patterns of the N changes in the soil with time were not consistent across locations. The soil N forms measured did respond to fertilizer N additions but these responses were not consistent with depth, time of sampling or location.

OBJECTIVES

Throughout the academic community as well as the fertilizer industry, there is general agreement that there is a pressing need to develop a system of analytical testing procedures with correct interpretation that can be used with confidence to provide more precise, efficient, and environmentally sound nitrogen (N) rate recommendations for corn. This need is obvious in Minnesota as well as the entire Upper Midwest, where highly productive agricultural areas are susceptible to groundwater contamination by nitrates if precise rates of N are not used.

This research project is designed to meet the broad objective of developing improved crop and fertilizer management systems that provide for greater fertilizer efficiency and economic profits while minimizing potential losses of N to the groundwater. The specific objectives are to:

1) evaluate several soil analysis methods or combination of methods as indices for estimating potentially available N before or during the growing season for use in predicting fertilizer N requirements for corn.

2) determine the optimum time or times that soil samples should be collected and the appropriate analyses that sould be conducted to enable an accurate prediction of fertilizer N needs.

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3) evaluate split and sidedress N fertilizer application times compared to preplant application for improved N efficiency and reduced potential environmental consequence.

4) develop a fertilizer managment program for split or sidedress applications of N using these soil tests so that profitability is maximized and groundwater quality concerns are reduced.

MATERIALS AND METHODS

Extended research studies will be conducted at four sites in southern and eastern Minnesota. The cropping and N fertilizer history as well as some soil properties are listed in Table 1. Fourteen spring- and sidedress-applied N treatments are replicated four times. Preplant rates of N are 0, 30, 60, 90, 120, 150, and 180 lbs/A to establish a N rate calibration curve. Sidedress applications at the V6 corn growth stage consisted of 60, 90, and 120 lbs N/A. Applications of N at rates of 60+30, 60+60, and 60+90 lbs/A were split between the preplant and V6 corn growth stages. All preplant applications were broadcast applications of urea and all sidedress applications consisted of subsurface bands of urea.

Table 1. Selected soil and crop information for four sites, 1989.

Site (county)	1988 Crop and Yield	1988 N Fertilizer	Soil Texture and Parent Material
Waseca	Corn - 90 bu	50# N	Silty Clay Loam-Glacial Till
Olmsted	Soybeans - 60 bu	0# N	Silt Loam - Loess
Winona	Corn - 165 bu/A	150# N	Silt Loam - Loess
Isanti	Corn - 145 bu/A	125# N	Sandy Loam - Glacial Outwash

Soil samples were collected in 1-foot increments to a depth of five feet for preplant and post-harvest sampling times and to a depth of three feet for sampling when the corn was in the V2 and V6 stage of growth. All soil samples were taken before any fertilizer was applied at the V6 stage. All soil samples were analyzed for nitrate-N, ammonium-N, and mineralizable N using both a hot KCl extractant and a phosphate borate extractant. Except for nitrates, all tests were conducted on both dried and field moist samples. Total N in soil was measured on all samples taken before planting. Kjeldahl N analyses were conducted on ear leaf tissue, grain, and stover after physiological maturity. Grain yields were also measured.

RESULTS AND DISCUSSION

A complete report of this project would be too large for the scope of this paper. Therefore, the emphasis of the reported results will be on a portion of the soil N data that was collected in 1989.

The 1988 crop yields were relatively good considering the widespread drought that affected most of the Upper Midwest (Table 1). The inorganic--ammonium and nitrate--N status of the four sites at the beginning of the 1989 growing season ranged from 150.4 lbs N/A (assuming an acre six inch volume weighs two million pounds) in Isanti county to 319.2 lbs N/A in Winona county in the top five feet (Figure 1). The distribution of the N in the soil appears to be associated with the previous crop and fertilization program.

Figure 2 depicts the changes in the soil N measurements at the three different sampling times for the control plots. While the absolute quantities of the N forms is of lesser importance until they are correlated to crop response, the relative changes with time should be noted as it relates to what time and depth may be best for taking a soil sample for N recommendation purposes.

Nitrate concentrations decreased with time at Waseca and Winona whereas they increased at Olmsted and Isanti. The mineralization potential measurements (Nm1 representing the phosphate borate extractant and Nm2 representing the hot KCl extractant) also showed the same inconsistency over time in the control plots. The phosphate borate test had elevated concentrations at the V6 sampling date compared to the previous sampling times at Winona and Isanti while the V2 stage sampling was the highest value at the Waseca and Olmsted sites. The hot KCl mineralization test fluctuated less and rose appreciably only at the V6 stage in Isanti county.

Each site had preplant N applications at rates ranging from 30-180 lbs/A. These N applications should, therefore, be reflected in the V2 and V6 soil sample analyses. For the sake of brevity, data regarding the effect of added fertilizer will be presented for the Olmsted location. This site is in southeast Minnesota, where soils are primarily loess-derived and situated on a karst topography--making them especially sensitive to groundwater pollution.

At the V2 stage of growth, almost all of the elevated N concentrations from the added fertilizer are measured in the top foot of soil (Figure 3). Both nitrate-N and ammonium-N increased with additional increments of N fertilizers. For all four N forms reported, concentrations appeared to increase in a linear, if not exponential, manner. At the higher N rates, the increase in soil N concentrations--when compared to the control--was greater than the amount of added N.

Nitrate-N concentrations increased at all depths (including the control) at the V6 corn growth stage compared to the V2 growth stage for all rates of N applied (Figure 4). While the ammonium-N concentrations were a function of fertilizer N rates at V2, the concentrations at the V6 stage were all quite similar to the control plots' values. The hot KCl-extractable mineralizable N data followed the same trend as the ammonium-N. The phosphate borate extractant for mineralizable N had much more variability across the N rates and appeared less correlated to N rate. However, in all measurements, the phosphate borate extractant resulted in higher values, with higher variability, for mineralizable N than the hot KCl extractant. Again, the addition of crop response data to these two tests will be of high importance.

The data reported is only a subsample of the data collected from this N calibration/correlation study. It is clear, however, that all N analyses are dependent on site-specific conditions and are a function of time and depth of analysis.

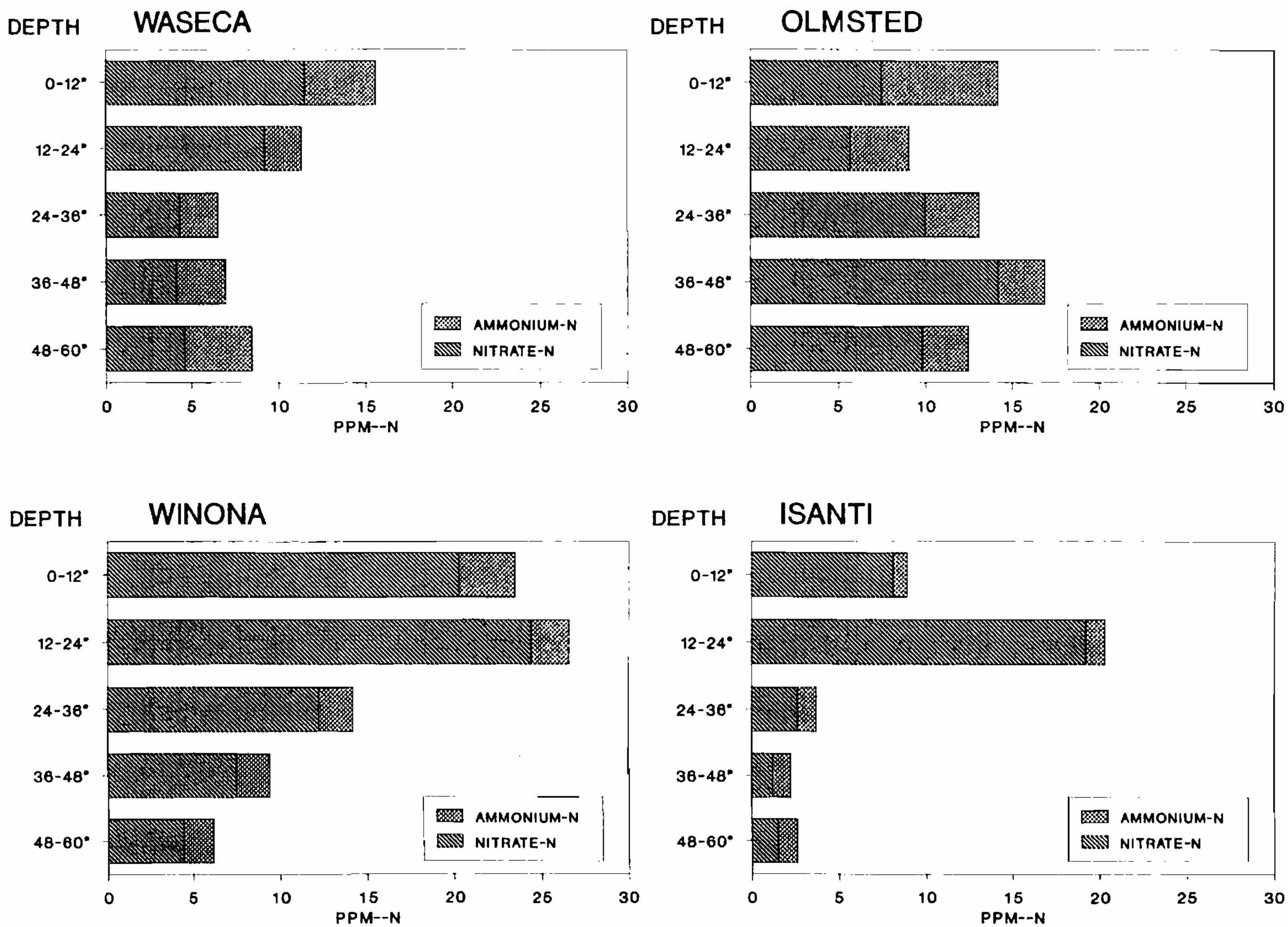

Figure 1. Soil ammonium-N and nitrate-N concentrations as a function of sampling depth, 1989.

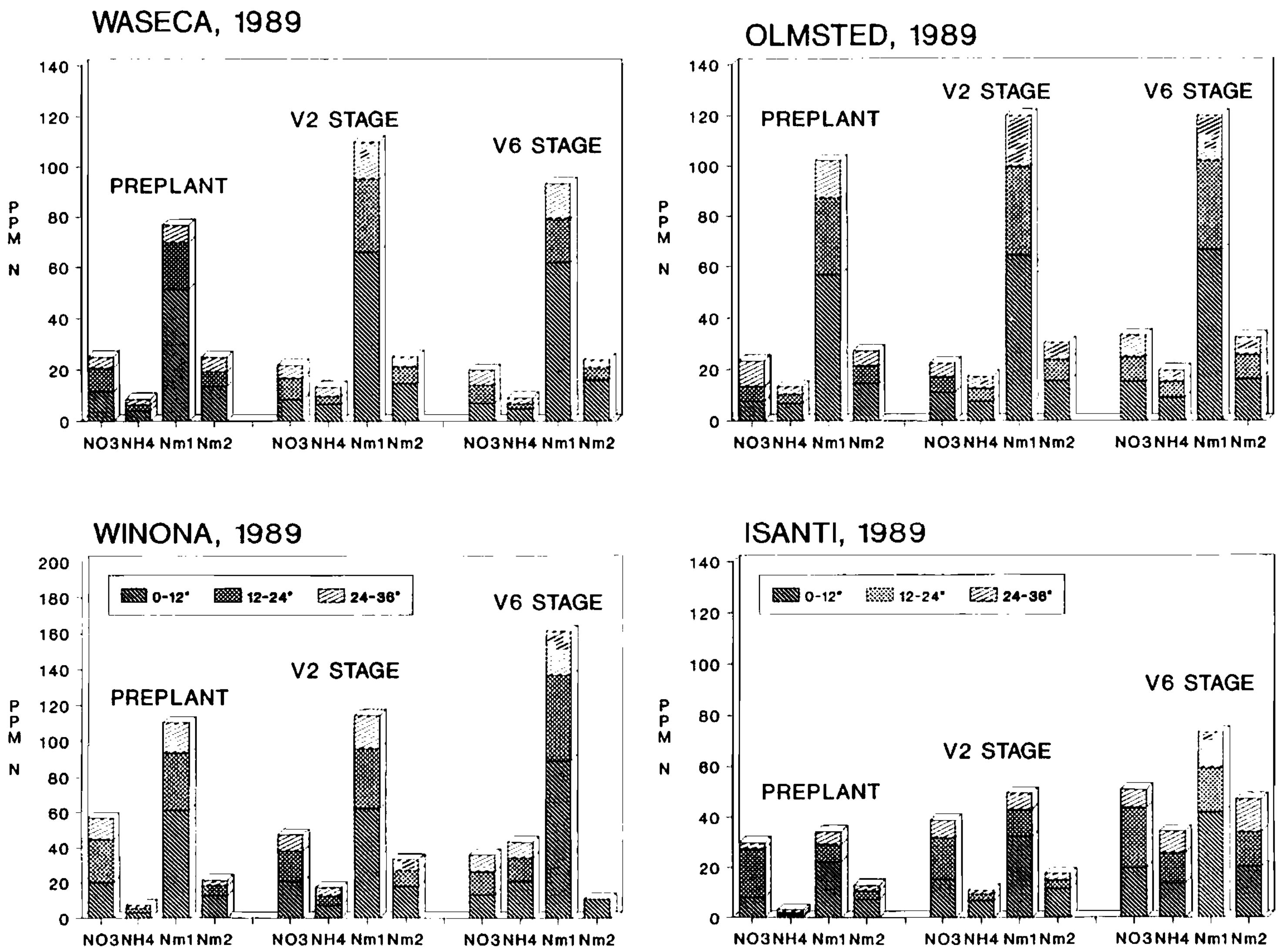

Figure 2. Selected soil N quantities as a function of soil sampling time at a 3-foot depth, 1989.

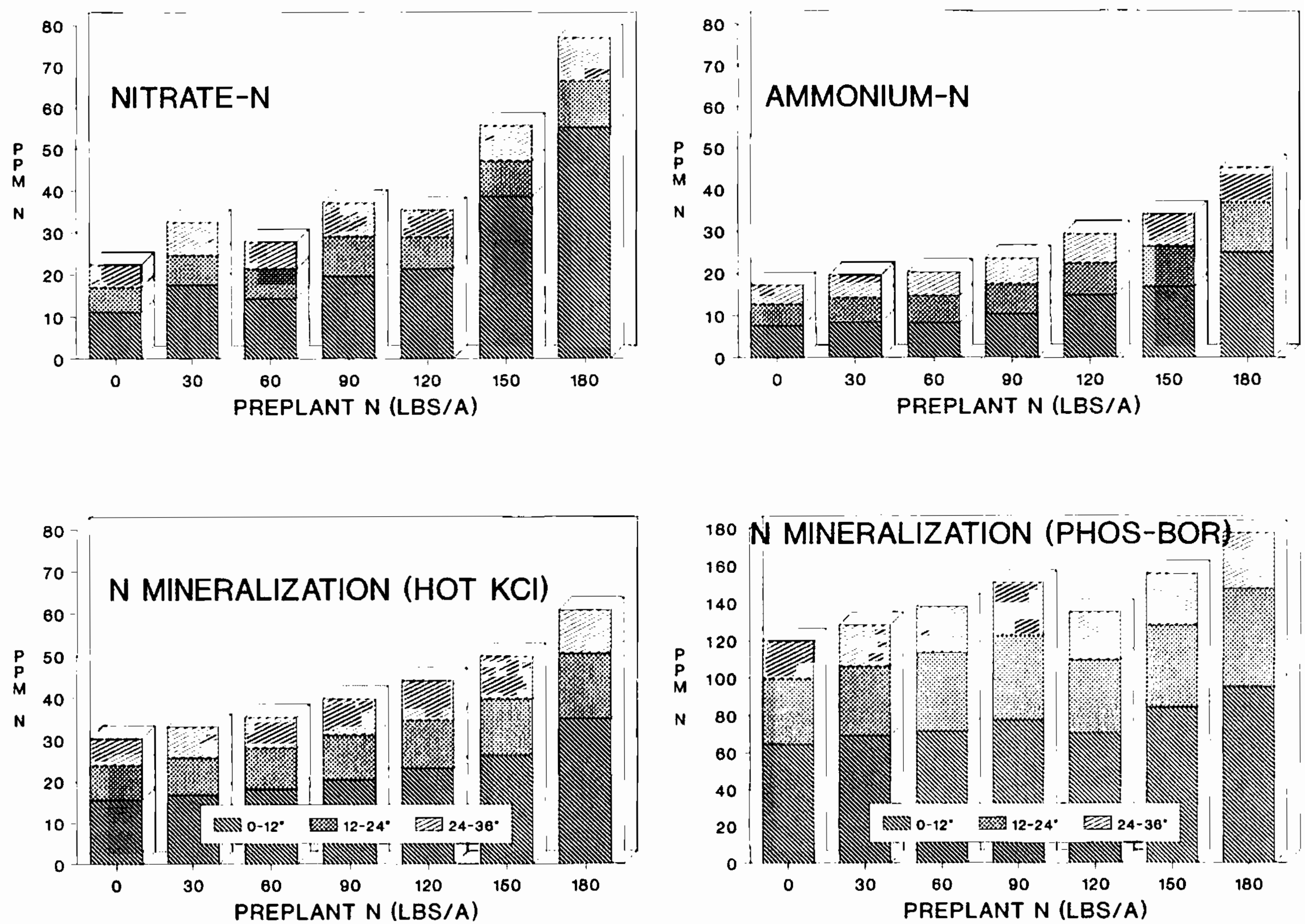

Figure 3. Selected soil N quantities effected by preplant N rates at a 3-foot depth at the corn's V2 growth stage, Olmsted, 1989.

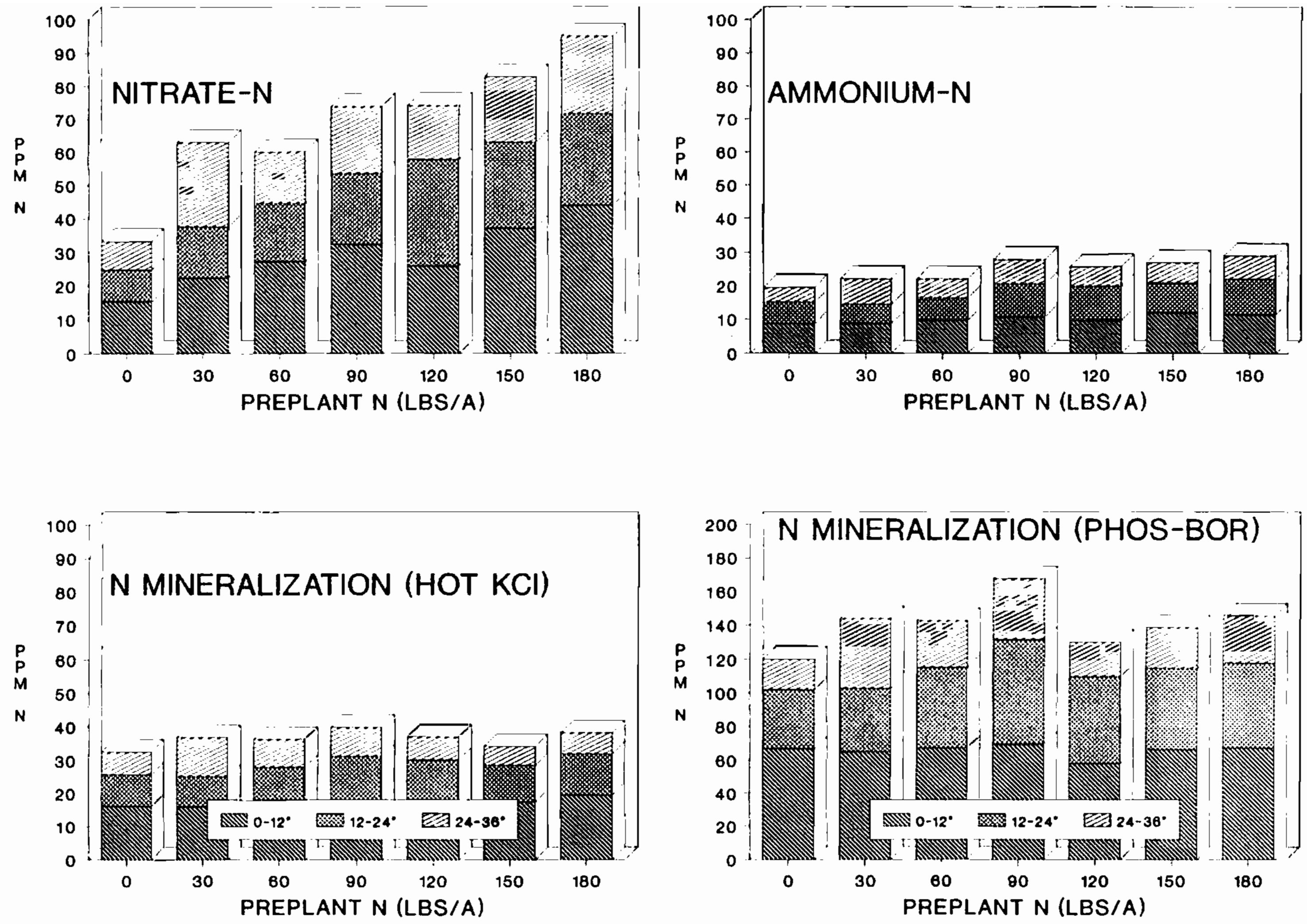

Figure 4. Selected soil N quantities effected by preplant N rates at a 3-foot depth at the corn's V6 growth stage, Olmsted, 1989.

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