Final Report
ODA Groundwater Research and Development Grants
Category 1 - 1998-99

PROJECT TITLE Missing Links in Wheat Nitrogen Uptake

FUNDING: $1940

LEADERS Ernie Marx, Dept. of Crop and Soil Science, OSU, Corvallis, OR
Russ Karow, Dept. of Crop and Soil Science, OSU, Corvallis, OR

PROJECT RATIONALE FROM ORIGINAL PROPOSAL

Management of nitrogen for crop use and use of crops to manage soil nitrogen requires detailed knowledge of nitrogen uptake patterns by crops. While a great deal of work has been done on managing nitrogen for and with wheat crops, we discovered that we do not have a complete picture of wheat uptake patterns. Our previous studies as well as those of others in the Willamette Valley have used Feekes 5 (late tillering) as the initial point in pattern determination. Most reports in the literature also either deal with spring crops or winter crops that go dormant during the winter months due to cold temperatures. We do not have data on earlier growth stage nitrogen uptake by wheat across a range of soil nitrogen levels. Such data are important as we try to determine how nitrogen uptake may interact with fall-mineralized nitrogen and residual soil nitrogen from previous crops. Do wheat plants take up nitrogen at a constant rate as tissue develops? Do plants accumulate nitrogen just prior to late tillering? We do not know but this information is important to know, especially as we think about using wheat and other cereals as residual nitrogen scavengers.

PROJECT OBJECTIVES:

To determine full-season dry matter and nitrogen uptake patterns for winter wheat grown under three different nitrogen fertility treatments.

PROCEDURES

A randomized complete block design study with three nitrogen treatments (0N, 100 lb./a fall N, 100 lb./a spring N) and three replications was planted on Hyslop Farm in fall 1998. Starting at the two-leaf stage, four one-foot row samples were harvested from each plot, dried, weighed for dry matter determination and submitted for total nitrogen determination. Samples were collected at intervals of 200-300 GDD until crop maturity.

FINDINGS

Dry matter accumulation curves are shown in Figure 1. Total dry matter production was 12 tons per acre with nitrogen applied at late-tillering. Dry matter production was 6 tons per acre when zero nitrogen was applied and 7 tons per acre when all nitrogen was applied at planting.

Nitrogen accumulation curves are shown in Figure 2. Total N uptake was 220 lb N/acre with nitrogen applied at late-tillering. N uptake was 120 lb N/acre and 100 lb N/acre with N applied at planting or zero N applied, respectively. The similarity in N uptake between the zero N and N applied at planting treatments implies that most of the N applied at planting was leached from the soil and was not available to the crop when spring growth occurred. The N uptake rate peaked at 2.5 lb N/a per day in late April (Figure 3).

Prior to this project, dry matter and nitrogen accumulation curves for winter wheat in the Willamette Valley were derived from data that began with sampling at the late tillering stage. We thought the curves may have been biased by the late initial sampling date. Our intent in this project was to sample throughout the season, beginning in the fall, to determine if the sampling window affects the resulting uptake and accumulation curves.

To determine the affect of the sampling period, we truncated the 1998-99 data to simulate a scenario where sampling was initiated at late-tillering. A comparison of the truncated curves and the complete curves shows a striking similarity (Figure 3). The curves are nearly identical. This suggests the late initial sampling date in previous studies is not a problem.

We also compared N uptake rate curves based on growing degree days (GDD) or calendar date (Figure 4). The data peaks at similar dates using both approaches. There is much more scatter in the GDD data than we anticipated, however. By looking only at N uptake rate curves, we would expect a maximum rate of about 2.5 lb N/acre per day. The GDD data, however, suggests rates may be as high as 4.5 lb N/acre per day on warm spring days. This may be an artifact of the method of data analysis, as the GDD uptake rates are from model equations. We do not know how long a period of warm temperatures is needed for the plants to respond metabolically. Also, air temperature is used to calculate GDD but soil temperature may be more important in plant response. Soil temperatures do not fluctuate as widely as air temperatures and the calculated uptake rates may be more stable if soil temperature data is used.

In general, GDDs are preferred to the calendar date because temperature patterns vary among years. The variation in GDD accumulation from year-to-year probably explains the difference in N uptake patterns in our data as compared to the winter wheat data shown by Sullivan et al. in *Nitrogen Uptake and Utilization of Pacific Northwest Crops* (PNW 513, Oregon State University Extension). Sullivan's data shows maximum N uptake in mid-March, but our data shows maximum uptake in mid-April. If we assume a planting date of October 15, maximum N uptake rate at 1250 GDD, and use 30-year averages for weather data, then N uptake will peak in mid- to late-April. This approach gives the best generalization of N uptake.

By sampling from the beginning of the growing season, we were able to examine N uptake in the fall and early winter. N uptake in the plots receiving nitrogen at planting preceded N uptake in the zero N and N at late-tillering plots (Figure 5). This suggests the plants will accumulate nitrogen prior to late-tillering if nitrogen is available. From an applied perspective, however, a more important question is whether *yield* is affected if nitrogen is not abundant prior to late-tillering. The design of this experiment does not allow us to make yield comparisons. The question may be addressed, however, by looking at yields in nearby experiments.

In 1998 and 1999, Madsen was planted with and without 20 lb N/a at planting as part of the Oregon Statewide Variety Trials at Hyslop Farm. The fields had been summer fallowed following a clover cover crop. Nitrogen at planting had no effect on yield in either year. In a separate study, Neil Chistensen looked at the effect of fall applied N as part of a long-term wheat rotation project at Hyslop in 1998 and 1999. Nitrogen applied at planting resulted in increased yield for wheat following oats (N deficient soils) but not for wheat following clover in both years. To summarize, nitrogen at planting will increase yields on N deficient soils. If N is not deficient, nitrogen at planting will result in luxury consumption prior to late-tillering but will have no effect on yield.

General Conclusions:

1. Rapid nitrogen uptake by wheat begins at late-tillering and peaks at 1250 GDD, which usually occurs in mid- to late-April.

2. Nitrogen and dry matter accumulation curves for winter wheat derived from limited data sets in previous experiments are sufficiently accurate.

3. Maximum N uptake rates in spring may be higher than the 2.5 lb N/acre indicated by curves.

4. In high nitrogen environments, rapid N uptake by wheat may begin prior to late-tillering. This may be luxury consumption and does not always result in increased yields.

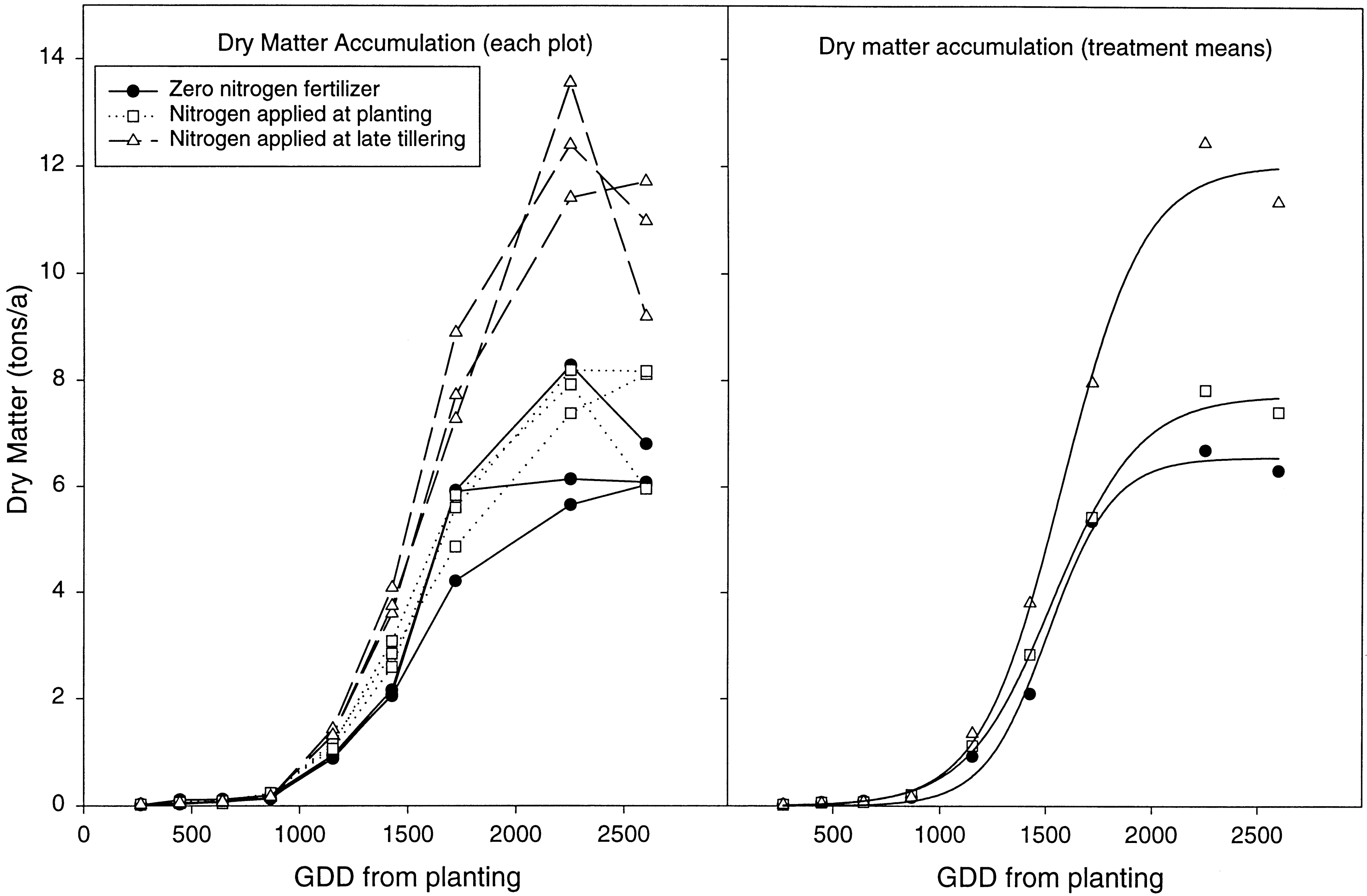

Figure 1. Winter wheat dry matter accumulation as a function of growing degree days (GDD) from planting.

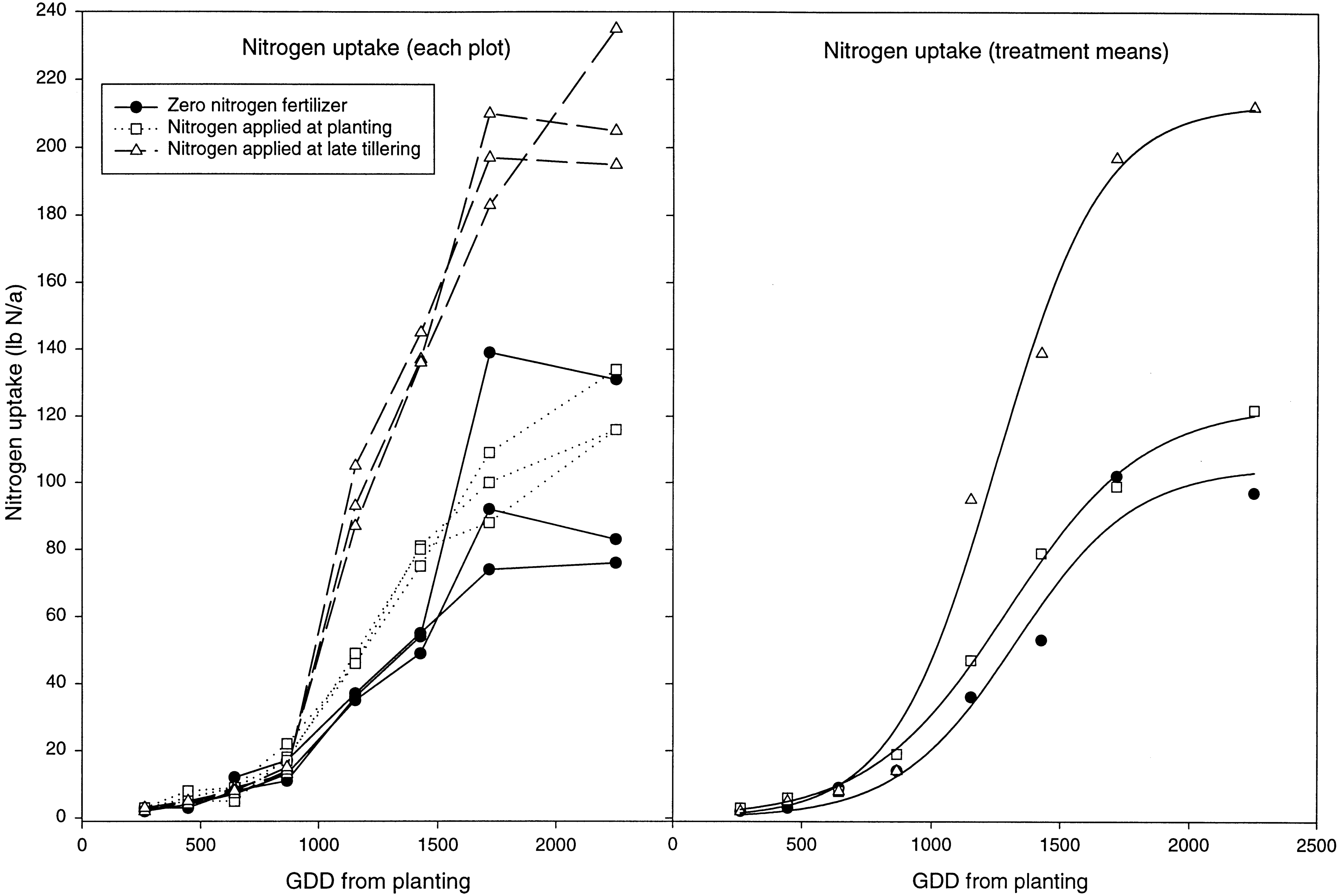

Figure 2. Winter wheat nitrogen accumulation as a function of growing degree days (GDD) from planting.

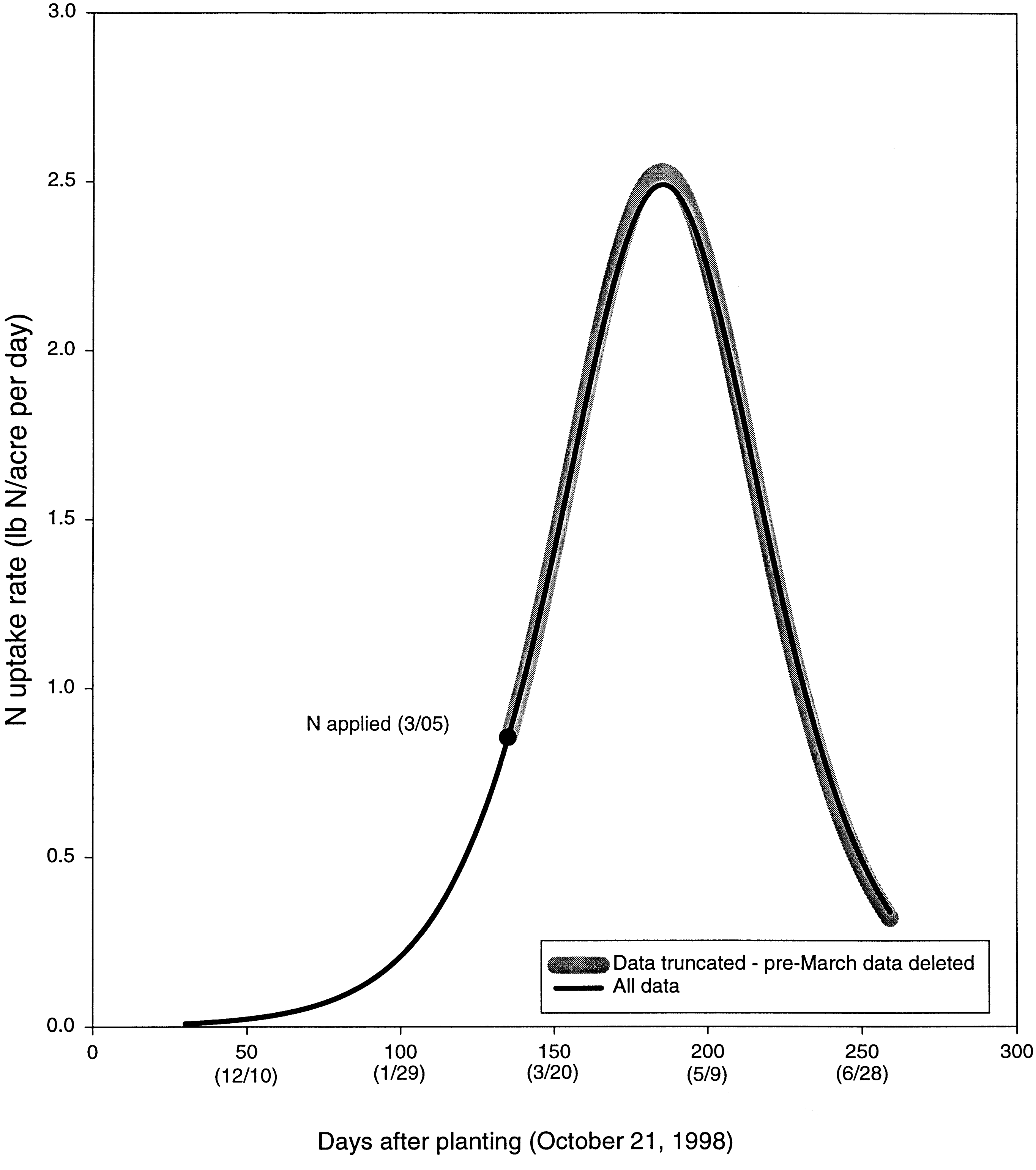

Figure 3. Nitrogen uptake rate as a function of days after planting. Data was modeled using the entire data set and also using only data collected after March 1. Truncating the data had little effect on the curve. The N uptake rate peaked in late April.

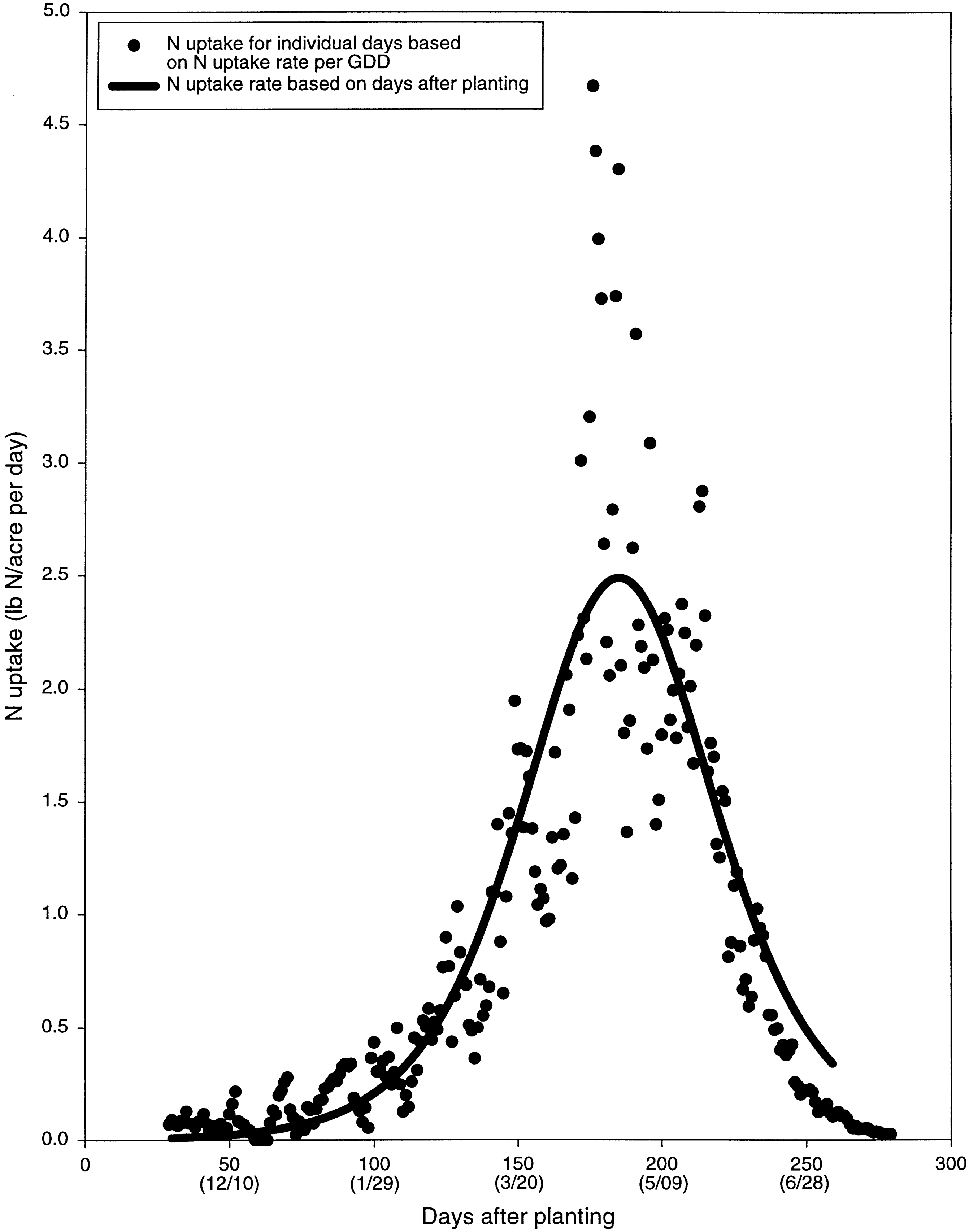

Figure 4. Nitrogen uptake rate as function of days after planting and growing degree days. The curve is fitted to days after planting data. The points are calculated N uptake based on growing degree days for individual days.

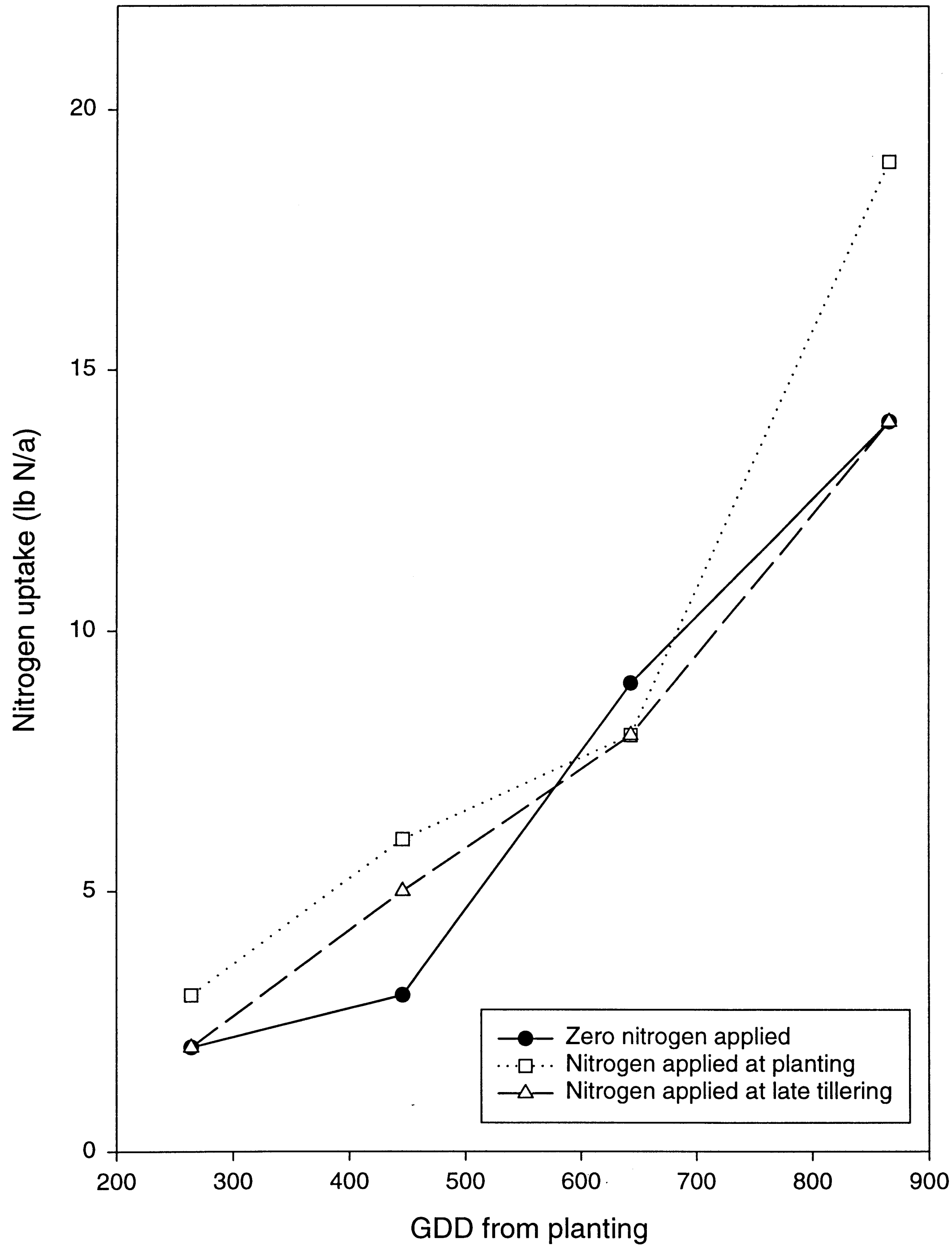

Figure 5. Nitrogen accumulation during the early growing season. During the period represented in this graph, only the "nitrogen applied at planting" treatment had received nitrogen fertilizer.