Effect of Growing Season Soil Temperature on Nitrification

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This study is part of a program of research into the complex interactions between weather variables and soil processes affecting the level of plant available nutrients. Through laboratory simulation and field experimentation the program attempts to elucidate and quantify the aforementioned interactions.

One of our main objectives is to provide researchers and soil fertilitists with some type of equation or equations whereby they can, with the aid of a few key soil measurements and detailed meteorological data calculate the amount of nitrification which has taken place during a certain period.

Dr. Biederbeck in his paper on the effect of rainfall on nitrification reported that we had obtained a good relationship whereby the daily change in NO_3-N (ΔNO_3) in the 0 to 2.5 cm. segment of soil = -0.56-1.11 M; (Δ = daily change; M = moisture, % O.D. wt. and NO_3-N = ppm.).

$$\Delta NO_3 = -0.56-1.11\Delta M \qquad (1)$$

S.E. coef. = 0.16

r = 0.94**

This relationship was obtained by intensive sampling (*in situ*) over a 6-week period of relatively rainy weather. It indicates that an increase in moisture caused a decrease in NO_3-N; this we ascribed to leaching. It also indicates that a large daily decrease in moisture (e.g. near field capacity) caused an increase in NO_3-N while a small daily decrease in moisture (e.g. near wilting percentage) caused little change in nitrification. When soil temperature was included as a variable it did not improve the above relationship. This was probably because in the short sampling period (6 weeks) there was not sufficient variability in temperature to allow a proper assessment of this factor.

In a complimentary study carried out under simulated conditions in the laboratory the effect of temperature on nitrification was assessed. Disturbed soil was wetted to 20, 15 and 10% moisture (by weight) while adding 0, 25 and 50 ppm NH_4-N. These soils were placed in plastic bags and incubated throughout the growing season in a specially constructed soil incubator (1). This incubator was adjusted each day so that it operated at the max-min temperatures measured at a depth of 2.5 cm. in the field the previous day. Duplicate samples per treatment were taken every 7 days for NO_3- and exchangeable NH_4-N analysis.

The results of this study are shown in Fig. 1. Cumulative nitrification was plotted versus cumulative degree-days (D). Degree-days = (the mean temperature for a period less 5°C) x the number of days in the period. The 5°C was assumed to be the threshold below which nitrification approaches zero (2). Generally, the relationships obtained were not surprising. There was an increase in nitrification with increase in moisture content, fertility level and degree-days. Although the points on each line could probably be fitted with a sigmoid curve it appeared that two approximately linear lines with different slopes could be used to represent the period 0 to 4, and 4 to 16 weeks of incubation. When data for these two periods were analyzed factorially we obtained a significant 3rd order interaction between D x F x M (F = initial NH_4-N) during the first 4 weeks, while D x F and D x M were significant in the 4- to 16-week period. We then calculated equations (2) and (3) for the first 4, and the 4- to 16-week periods respectively using a stepwise multiple regression program (3). We included the interactions as independent variables in the appropriate equations.

<u>First 4 weeks</u>

$$NO_3 = -0.75 + 0.00016\,D \times M \times F + 0.21\,F + 0.033\,D + 0.18\,M \qquad (2)$$

S.E. coef. = 0.000015   0.05   0.009   0.15

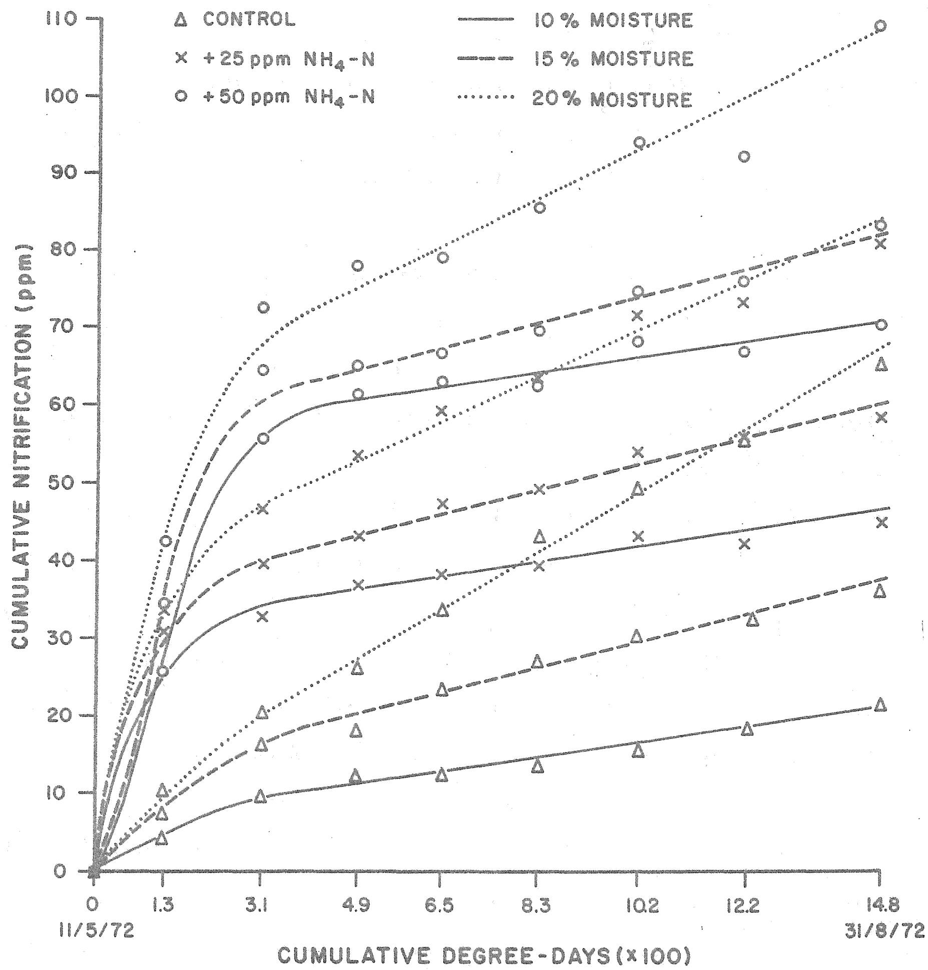

Figure 1. Effect of temperature x time, initial NH_4-N and moisture content on nitrification in 0.5 mil polyethylene bags.

Reduction in S.S. due to variables: 93% 1.5% 1% <1%

$R = 0.97^{**}$

4- to 16-week period

$$NO_3 = 0.70 + 0.00207\ D \times M - 0.0092\ D - 0.000077\ D \times F \qquad (3)$$

S.E. coef. = 0.00012 0.0023 0.000025

Reduction in S.S. due to variables: 80% 4% 1%

$R = 0.92^{**}$

If we differentiate $(\frac{dNO_3}{dD})$ we obtain for the first 4 weeks

$\frac{dNO_3}{dD} = 1.6 \times 10^{-4}\ MxF + 0.033$, and for the 4- to 16-week period

$$\frac{dNO_3}{dD} = 2.07 \times 10^{-3}\ M - (8 \times 10^{-5}\ F + 9.2 \times 10^{-3}).$$

Using these relationships it is possible to calculate NO_3-N production during a specified time interval if the mean temperature change during that period is known and if the moisture content and fertility level are known. An example of the results obtained from these types of calculations is shown in Table 1.

It should be stressed here that equations (2) and (3) only calculate the changes due to time, temperature, moisture and fertility. *In situ* changes would be much larger because of the effect of wetting and drying on nitrification (as shown by equation 1).

Our next step will be to set up a model in which we use equations (1), (2) and (3) to test field results.

References

1. Dyck, F. G., C. A. Campbell, J. F. Weinberger, and V. O. Biederbeck. 1972. An inexpensive versatile incubator for soil biological research. Can. J. Microbiol. 18:1513-1517.

2. Schrodter and Tietjen. 1971. Statistical studies on the relation between nitrification and soil temperature and soil moisture. Agric. Meteorol. 9:77-91.

3. Thompson, B. and K. Price. 1970. Computer program SOO4B Regression. Statistical Research Service, Canada Department of Agriculture, Ottawa, Canada.

Table 1. Calculated[+] effect of temperature change, moisture content and initial NH_4-N on NO_3-N production in a loam soil during the growing season

Treatments	Av NO_3-N produced/5 C increase/week (ppm)	
	During 1st 4 weeks	During 4 to 16 weeks
Initial NH_4-N = 5 ppm (control)		
M 10%	1.33	0.39
M 15%	1.54	0.75
M 20%	1.68	1.11
Initial NH_4-N = 30 ppm		
M 10%	2.52	0.32
M 15%	3.16	0.68
M 20%	3.92	1.04
Initial NH_4-N = 55 ppm		
M 10%	3.92	0.25
M 15%	5.26	0.61
M 20%	6.76	0.97

[+]Calculated from equations 1 and 2 shown elsewhere.