A COMPARISON OF PRE-PLANT NITROGEN BEST MANAGEMENT PRACTICES ON POTATOES AND THEIR EFFECT ON NITRATE LEACHING IN THE COLUMBIA BASIN

by

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The subject of nitrates in groundwater has gained a great deal of attention in recent times. There are a number of reports indicating there has been an increase in the concentration of nitrates in groundwater, many of the reports point to agriculture as a major source of these nitrates. Some reports link areas of intensive potato production in sandy soils to high levels of nitrates in the groundwater. In Washington, much of the acreage used for potato production in the Columbia Basin involves sandy soils. To compound the problem the area between the crop rooting zone and the groundwater in these same areas is very permeable. Once the nitrates leave the crop rooting zone, the potential is high that it will eventually reach the groundwater.

Though there has been an increase in the concern over nitrates in the groundwater, little technology has been developed to help solve the problem. Studies are needed to show if there are aspects of potato production that impact the potential for nitrates to reach the groundwater. If nitrogen fertilizer practices are shown to be a potential source for nitrate leaching it needs to be determined if the potential is due to pre-season, mid-season, or late-season practices. Is the type of fertilizer being applied involved? Is there some cultural practice or practices that potato growers are using that could be modified to minimize the potential that nitrates might move below the crop rooting zone? Are there combinations of these aspects that can be utilized to minimize the potential for contributing nitrates to the groundwater?

To address some of the questions posed by these groundwater quality issues a recent project at WSU founded by the Washington State Potato Commission and the Upper Grant Soil Conservation district had the following objectives:

1) Monitor effect of different pre-plant nitrogen regimes and cultural practices used in potato production to determine if they have an effect on the movement of nitrate through the soil below the potato crop rooting zone.

2) Document the effect of pre-plant nitrogen regimes and cultural practices on potato tuber yield and quality.

3) Identify pre-plant nitrogen management practices that could be used for potato production in the sandy soils of the Columbia Basin of Washington.

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The research was performed over two growing seasons on two commercial potato production fields near Quincy, Washington. The soil types present at both locations are a Quincy sandy loam and a Timmerman sandy loam.

Both fields were intensively sampled and mapped based on a number of nutrient and textural parameters. For the purpose of these experiments, the textural composition of the soil rather than fertility was used to determine plot location. A study by Hammond, which monitored nitrate leaching under a corn crop in one of the fields used as a location for one year of this trial has shown that the textural composition of the soil was suitable for determining placement of research plots.

The grower/cooperators pre-plant nitrogen application was determined by collecting random soil samples in the field, which were composited and analyzed for nutrient content. Recommendations for nutrient applications based on this random sample take into account the soil conditions, cropping history of the field, and desired tuber yield.

In season nitrogen fertilization was uniformly applied to the research plots using a liquid form of nitrogen, Urea Ammonium Nitrate (UAN, 32-0-0), with the irrigation water. The amount of in season UAN applied to the plots was determined by comparing the nutritional status and the age of the plant against previously observed crop nutrient requirements (CNR's) for potatoes. The nutritional status of the potato plant was determined by taking representative samples of the first mature petiole from plants in the cooperators crop area outside of the research plots. The age of the plant was based on the number of days after the potato crop was planted.

The irrigation management program used by the grower/cooperator was intended to provide optimal irrigation to ensure a healthy crop throughout the growing season. The irrigation program was evaporation based and adjusted for excess or deficit soil moisture as determined by neutron probe readings.

The treatments were designed to determine the effects of different preplant rates and types of nitrogen fertilizer and cultural practices on NO_3-N levels in soil and soil water samples and tuber yield and quality. These treatments represent practices common to commercial potato production in the Columbia Basin of Central Washington (Table 1).

Treatment	Preplant N	Total N		Hill Shape
	(lbs/ac)	(lbs/ac)	(lbs/ac)	
		1995	1996	
Control	100	290	285	Square
Split N	50+50*	290	285	Square
High N Rate	150	340	335	Square
Hill Shape	100	290	285	Pointed
Slow Release N	100	290	285	Square

Table 1. Representation of treatments and respective parameters
*- 50 lbs. N/ac applied pre-plant and 50 lbs. N/ac applied at tuber initiation + 2 wks

The nitrogen control treatment represented the grower/cooperator's nitrogen fertility (100#/A) and cultural practices (flat hill) for irrigated potatoes. In the pre-plant split nitrogen treatment, the first 50 lbs. of the recommended 100#/A pre-plant nitrogen was applied prior to planting and the second 50 lbs. was applied as a top dressing two weeks after tuber initiation, approximately 60 days after planting for both years. The high nitrogen pre-plant treatment rate of 150#/A was one and one half times the 100#/A recommended pre-plant nitrogen applied to the control treatment. The hill shape treatment, involved hand shaping pointed potato hills to be compared to the square shape hills in the control treatment. Both the pointed hills and the control treatments had 100 lbs. N/ac applied pre-plant. All other treatments were square hills. The slow release nitrogen treatment used Hold-N™, a 66-0-0 fertilizer that gradually allows for the conversion of ammonium to nitrate as soil temperatures increase. The pre-plant nitrogen treatments were applied to all plots prior to planting the potato crop using a tractor mounted boom sprayer then immediately incorporated into the soil to a depth of ca. 6" using a tractor pulled disk. After the potato crop was planted, various parameters were monitored weekly or monthly during the growing season and in some cases into early winter.

Parameters monitored weekly were soil water nitrate (NO_3-N) content, soil moisture, the amount of water that the plots received, and the NO_3-N content in the first mature petiole of the potato plants. The soil water samples were collected using vacuum lysimeters at 18 and 36 inches, and were sampled from mid May until early winter (12 January for 1995 and 12 December for 1996). Soil moisture was measured at the same depths as the vacuum lysimeters using a neutron probe. Tipping bucket rain gauges were used to measure irrigation and rain water that fell on the plots. The neutron probe and rain gauge readings were taken at the same time and for the same number of weeks as the vacuum lysimeter samples. Petiole samples were taken each week from mid June through late August.

Parameters monitored monthly were NO_3-N content of soil, whole plant, and soil water at 48 inches. Soil samples were taken at 12, 18, and 36 inch depths in each plot. All samples were analyzed for nitrate concentration, the 12 inch samples were also analyzed for ammonium concentration. Soil and soil water samples were taken from mid June until early winter. From mid June until mid August, whole plant samples were collected from each plot separated into tops, roots, stolon, and tubers and analyzed for total nitrogen to assist in developing a nitrogen budget for each treatment. As with the vacuum lysimeter samples, the monthly soil and soil water samples were taken until early winter. All samples were analyzed for nutrient concentration by Soiltest Farm Consultants Inc., a commercial laboratory located in Moses Lake, Washington.

At the end of the growing season, tubers were harvested from two twenty five foot rows in each plot to determine tuber yield, grade, specific gravity, and total N content and evaluated for the presence internal tuber defects.

In both 1995 and 1996, the soil water and soil nitrate concentrations followed a pattern of changes that seemed to be dependent on the growth stage of the potato plant.

There was a general pattern of seasonal changes for all treatments although differences between treatments were observed.

Soil water nitrate levels in the Quincy soil declined from the time sampling started in early June through early August in both 1995 (Figure 1) and 1996 (Figure 2). A similar although less uniform decline occurred in the Timmerman soil (Figures 3 & 4). Beginning in August the soil nitrate levels in the soil water increased. The time of increase in nitrate levels corresponds quite closely to the time of root declined (Figure 5) observed by Dr. Pan for plants growing in these plots.

Figure 1. 1995 soil water NO_3-N concentration in Quincy sandy loam soil at 18 and 36" sample depth. Nitrogen fertilizer rate based on 100#/A applied pre-plant the recommended rate for the soil test results. Arrows indicate nitrogation application timing, numbers with the arrows indicate nitrogation in lbs./A application rate.

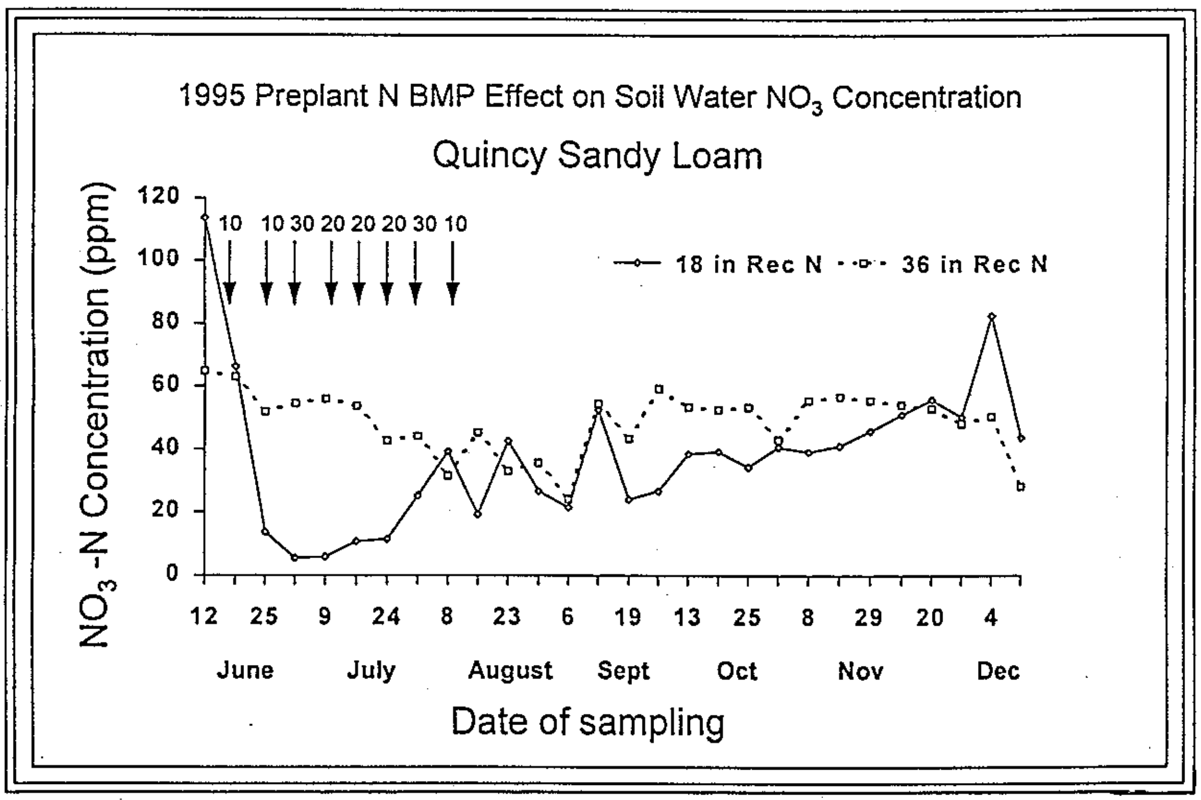


Figure 2. 1996 Soil water NO_3-N concentration in Quincy sandy loam soil at 18 and 36" sample depth. See figure 1 for additional details.

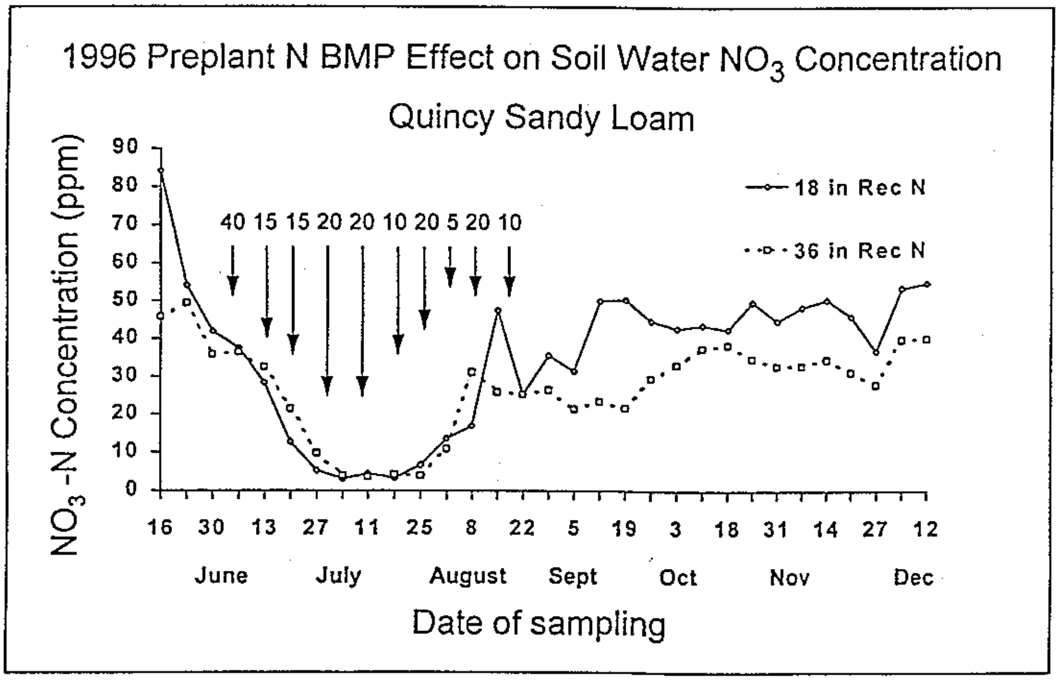


Figure 3. 1995 Soil water NO_3-N concentration in Timmerman sandy loam soil at 18 and 36" sample depth. See figure 1 for additional details.

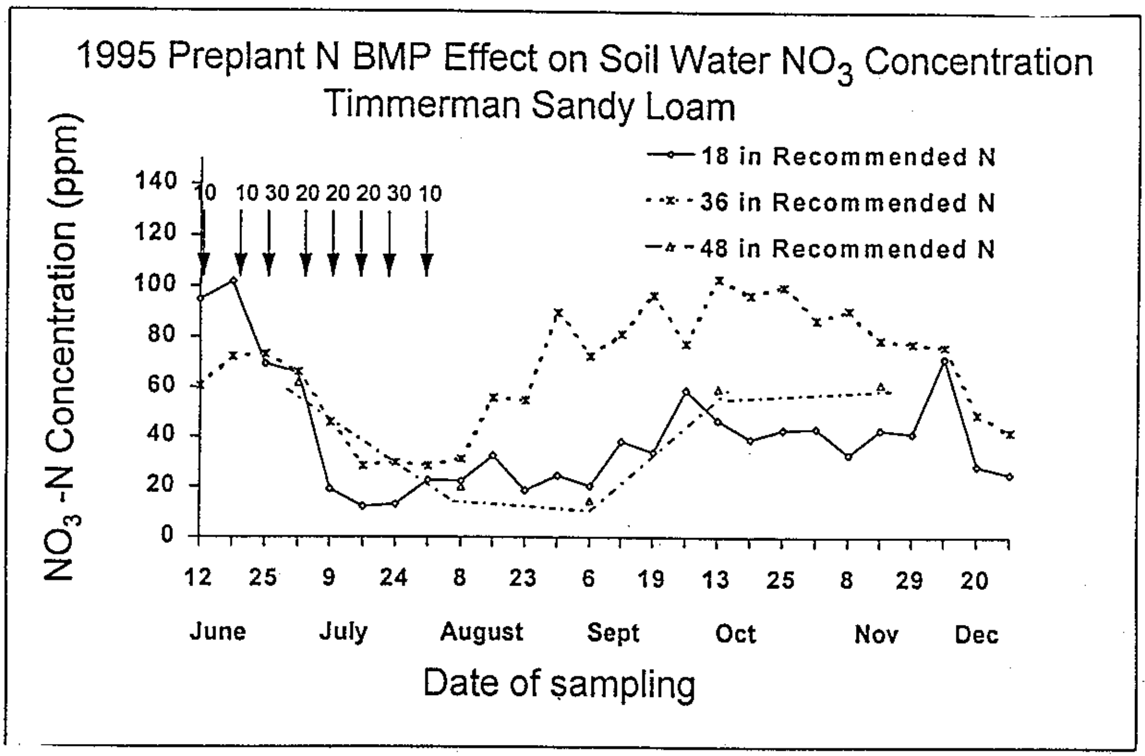


Figure 4. 1996 Soil water NO3-N concentration in Timmerman sandy loam soil at 18 and 36" sample depth. See figure 1 for additional details.

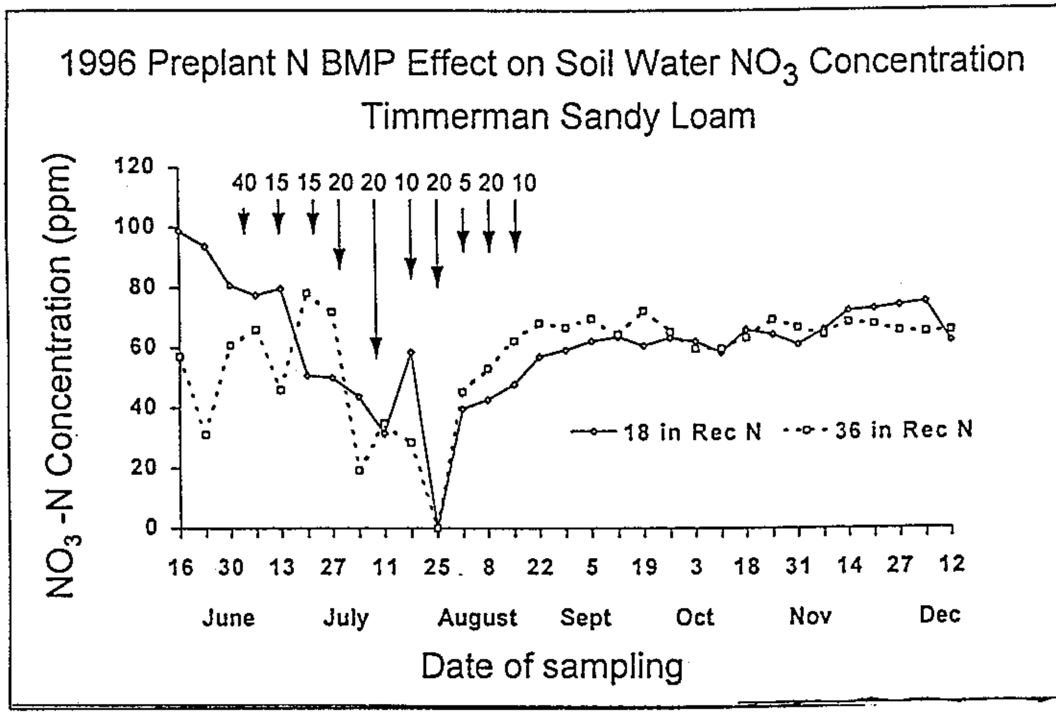
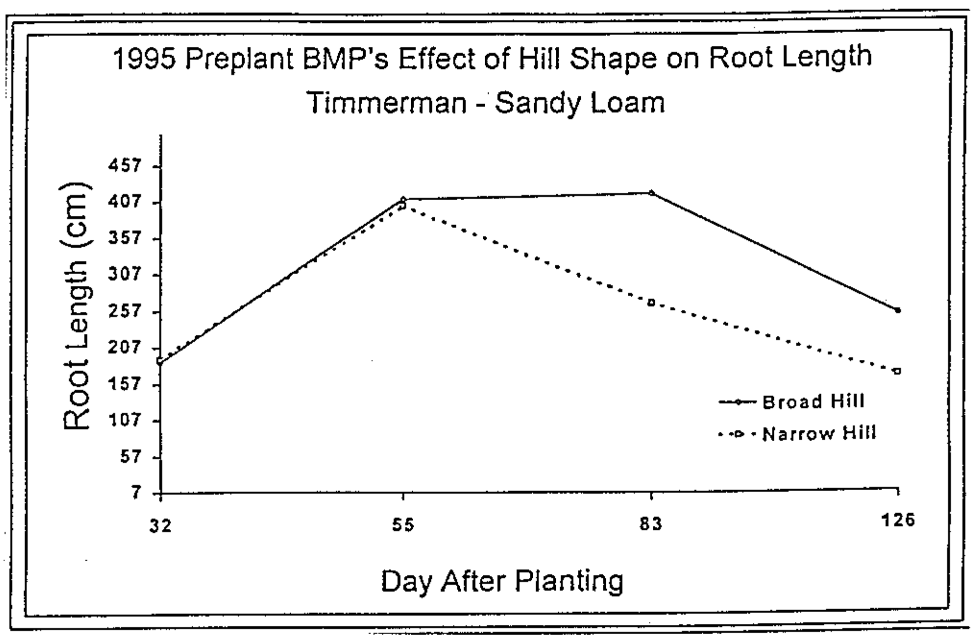


Figure 5. Root length of potato plants grown in Timmerman sandy loam soil using flat and pointed hill shapes.



The application of nitrogen as a split treatments of 50#/A pre-plant and 50#/A top dressed 60 days after planting compared to the 100#/A pre-plant resulted in a higher nitrate level in the soil water in the Timmerman soil from late June at 18" in 1995 (Figure 6) but not in 1996 (data not shown). The soil water nitrate level at 36" was similar for both the split and 100# pre-plant application until mid August (Figure 7). Thereafter the 100#/A pre-plant treatment had lower soil water nitrate levels at 18" and higher at 36". There was no difference in the soil water nitrate levels in the Quincy soil due to these nitrogen treatments (data not shown).

Figure 6. 1995 soil water nitrogen concentration in Timmerman sandy loam soil sampled at 18" depth from the 100#/A (check) and the split nitrogen treatments.

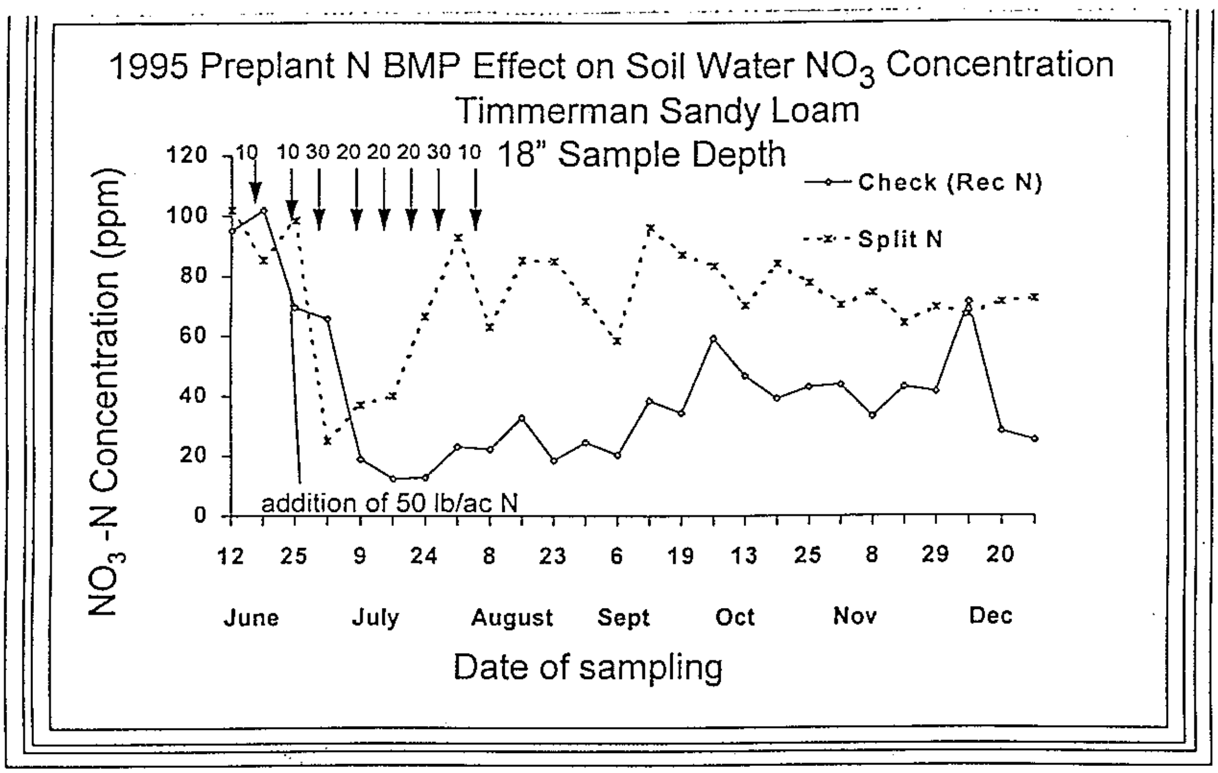
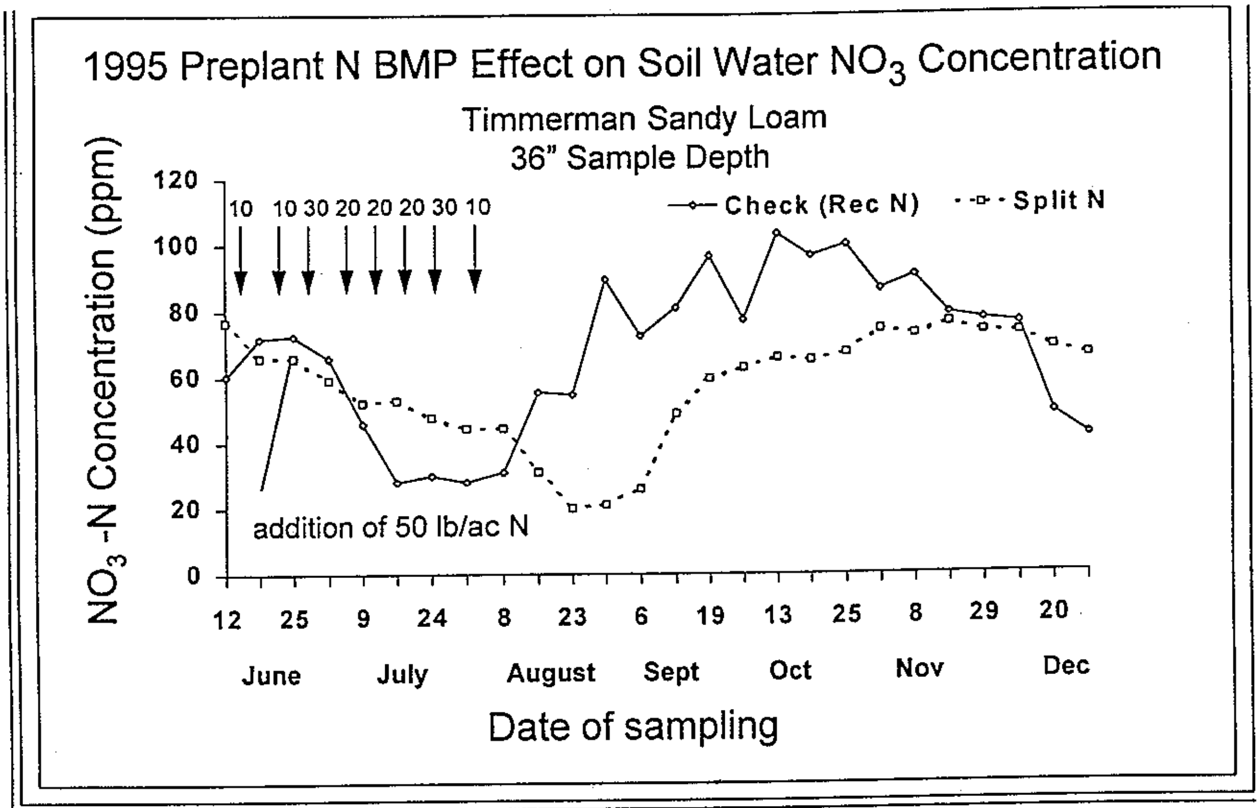


Figure 7. 1995 soil water nitrogen concentration in Timmerman sandy loam soil sampled at 36" depth from the 100#/A (check) and the split nitrogen treatments.



The pre-plant application of 150#/A of nitrogen compared to 100#/A had little effect on the soil water nitrate level in 1996 in either soil type (data not shown). In the Timmerman soil in 1995 (Figure 8), the 150#/A treatment resulted in higher soil water nitrate levels in July at 18" and during June, July and early August at 36" depth (Figure 9).

Figure 8. 1995 soil water nitrogen concentration in Timmerman sandy loam soil sampled at 18" depth from 100#/A (check) and the 150#/A pre-plant nitrogen treatments.

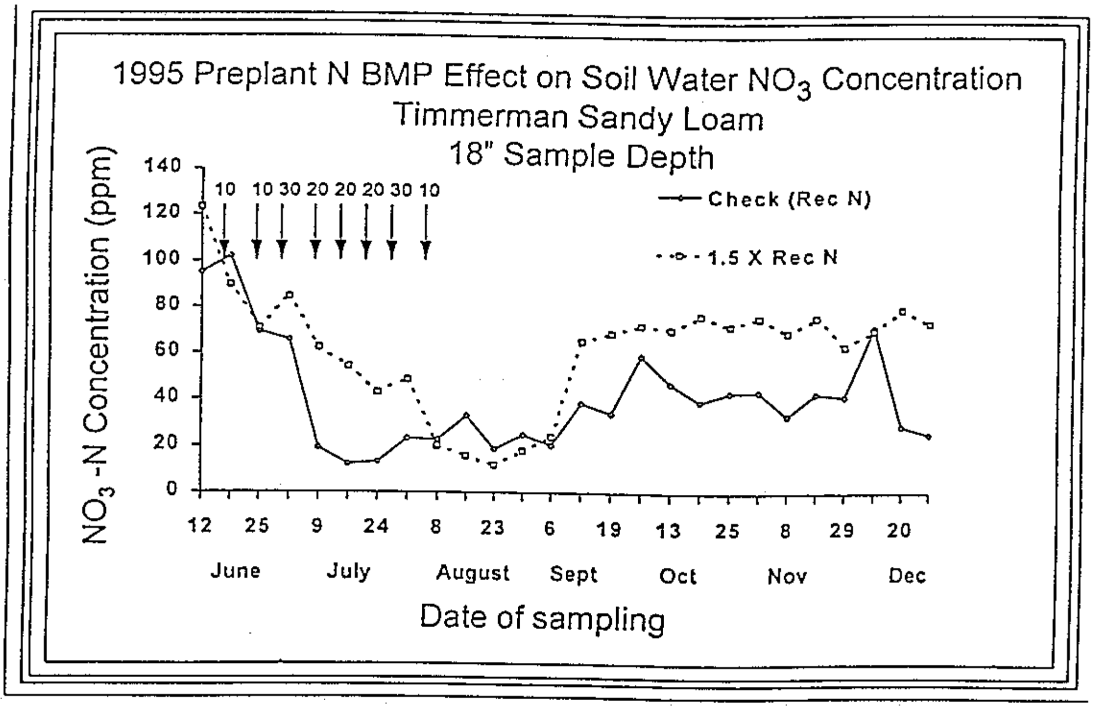
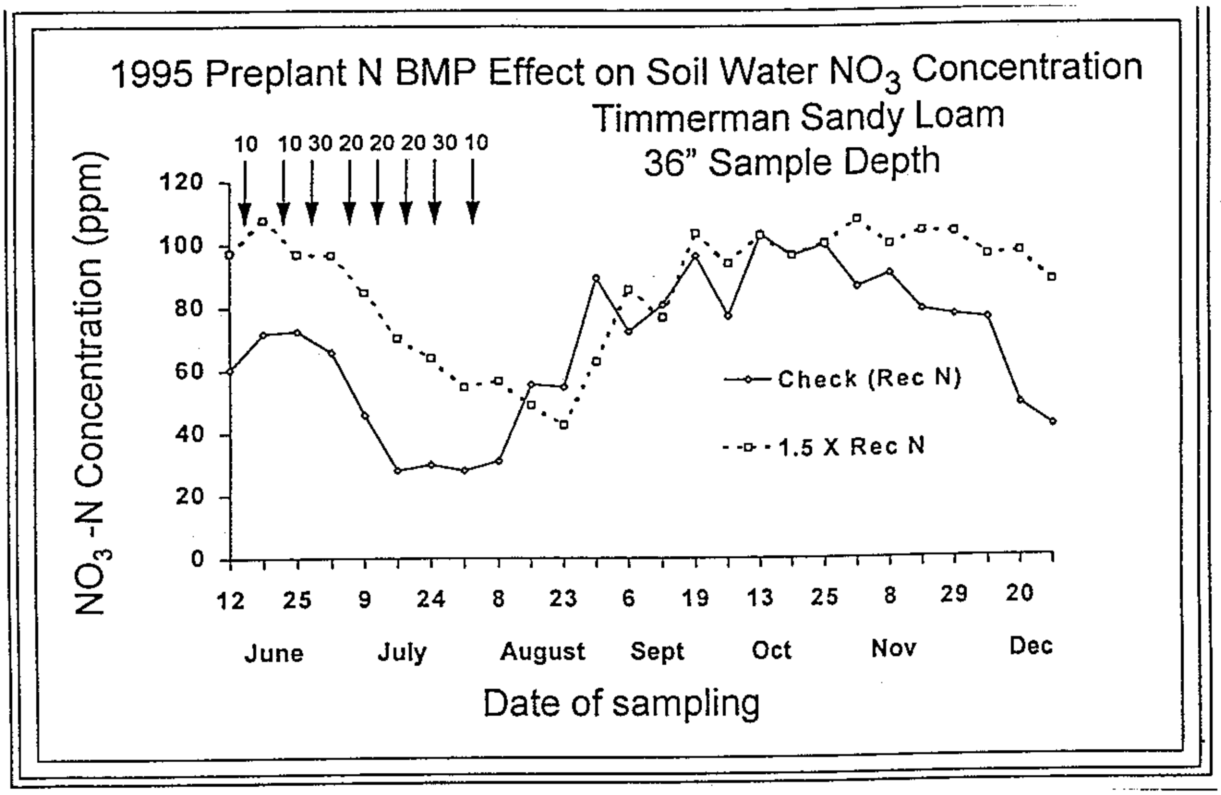


Figure 9. 1995 soil water nitrogen concentration in Timmerman sandy loam soil sampled at 36" depth from the 100#/A (check) and the 150#/A pre-plant nitrogen treatments.



Soil nitrate levels in the Quincy soil in 1995 (Figure 10) remained uniform and similar at the 18" and 36" sampling depths throughout the sampling period. Late June through early July and from September on NO_3-N levels at 12" depth were elevated. Soil nitrate levels and profile in the Timmerman soil were similar to those shown for the Quincy soil (data not shown). Soil nitrate levels in the Quincy soil in 1996 (Figure 11) were higher in May at all three depths. The seasonal profile throughout the remainder of the season at the three depths was similar to that in 1995. Soil nitrate levels and seasonal profiles were not substantially changed by any of the nitrogen treatments in either soil type (data not shown).

Figure 10. 1995 Quincy sandy loam soil NO_3-N concentration from 100#/A pre-plant nitrogen treatment at 3 sample depths.

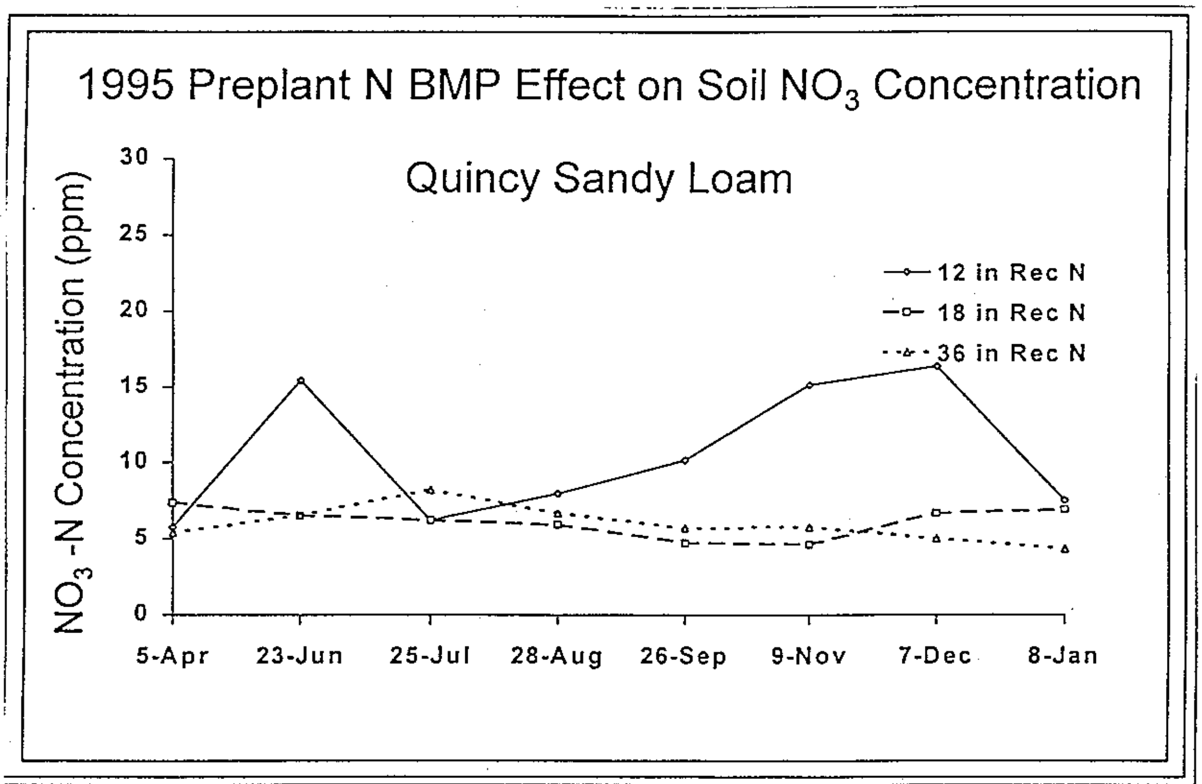
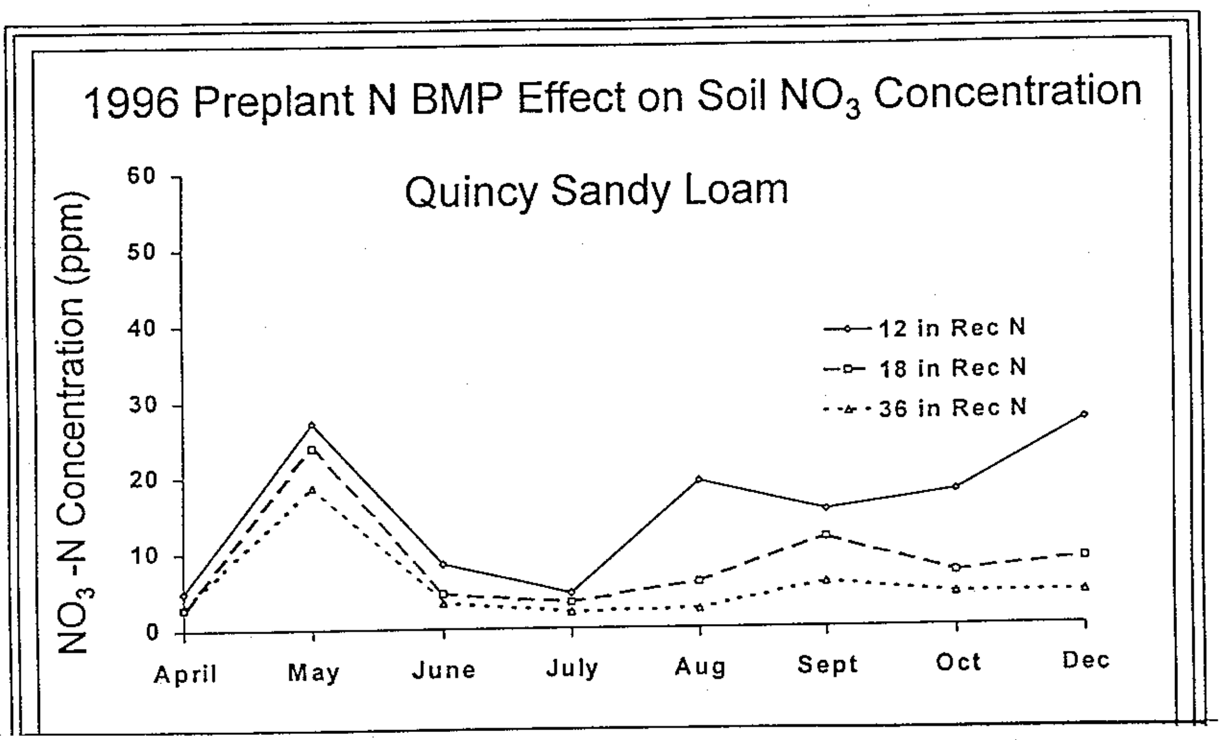


Figure 11. 1996 Quincy sandy loam soil NO3-N concentration from 100#/A pre-plant nitrogen treatment at 3 sample depths.



In 1995 tuber yield and quality was affected by the nitrogen treatments in the Quincy soil but not in the Timmerman soil (Table 2). Pointed hill shape resulted in a lower total yield and US No. 1 yield than all other treatments. The 50#/A pre-plant plus 50#/A nitrogen following tuber initiation had lower total yield but there was no effect on US No. 1 yield. Tuber specific gravity was not affected by the treatments. 1996 tuber yield was slightly lower over all then the 1995 yield but treatments affects were similar (data not shown).

Treatment	Yield	#1's	#2's	S.G. >4oz
Quincy				
Rec N	633.5ab	470.8ab	162.7	1.083
Split N	631.1b	448.4ab	182.6	1.083
1.5 X Rec N	648.8ab	509.7a	139.1	1.081
Pointed Hill	563.8c	418.6c	145.2	1.085
Slow Release	683.6a	488.2b	195.4	1.083
Timmerman				
Rec N	634.1	483.9	150.2	1.081
Split N	637.1	449.9	187.1	1.080
1.5 X Rec N	558.5	427.1	131.4	1.081
Pointed Hill	592.1	464.9	127.2	1.082
Slow Release	602.3	413.4	188.9	1.081

Table 2

Summary of tuber yield and quality from 1995 pre-plant nitrogen study.

CONCLUSIONS/RECOMMENDATIONS

1. Although differences between these pre-plant nitrogen treatments occurred, these pre-plant N treatments resulted in minimal differences in NO_3-N levels in the soil and soil water later in the season but must be considered as a part of the N available and have potential to be moved beyond the root zone late in the season.

2. Applications of nitrogen rather than ca. 90 days after planting (for these trials, late July or early August) appears to impact late season soil and soil water NO_3 -N levels. This may be due primarily to the fact that there is less root area to take up nitrogen so any applications of nitrogen during this part of the season cannot be taken up by the plant as efficiently as pre-plant and early season nitrogen applications.

3. The late season rise in nitrate concentrations in the soil and soil water samples are due, in part, to the onset of senescence of the potato plant. Senescence is most notable in the above ground structures of the plant i.e., laying down of the vines, yellowing of the plants, etc. One factor associated with senescence that is not easily observed is the reduction of potato plant root length. Starting shortly after 45 days after planting (tuber initiation), when the roots are at their maximum length, the roots begin to decrease in length until ca. 90 days after planting when the lengths of roots are significantly reduced. This decrease in length of the potato roots means that there is less root area available to take up nutrients (including nitrogen) from the soil.

4. The treatments in general had little effect on potato yield, grade, specific gravity and internal tuber defects. Tuber yield and quality from the treatments were not greatly different from the tubers harvested from the grower/cooperators production field.

5. Cover crops should be considered as a means to recapture any nitrogen left in the soil after the harvest of the potato crop. The cover crop should be selected on the basis of its ability to establish its root system quickly and should be planted as soon as possible after harvesting the potato crop.

6. Proper irrigation management is essential in any potato best management practice. Adequate water provides both a healthy plant, which ensures proper uptake of nutrients, and conditions in the soil where movement of highly mobile nutrients are minimized. Irrigation management in these trials were considered optimum, if this were not the case the different pre-plant nitrogen treatments might have had more impact on the late season soil and soil water NO_3-N levels.