POTATO VARIETY RESPONSE TO IRRIGATION AND NITROGEN MANAGEMENT

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A field experiment to investigate irrigation and nitrogen management of new and traditional potato clones has been conducted at the WSU Othello research station for the past three years. The objectives of this research are to fine-tune irrigation and nitrogen management recommendations for specific potato clones and market destinations, under growing conditions as similar as possible to those being used in modern commercial production. In the Columbia Basin this requires irrigation by overhead sprinkler and in-season application of nitrogen fertilizer in the irrigation water (nitrogation). The variables in this experiment are 6 clones, 3 harvest dates, 2 irrigation schedules, and 3 nitrogen rates in all combinations.

The clones which have been included in all three years are:

Russet Burbank	The standard for both fresh market and processing uses -- late maturing.
Norgold Russet	Until recently the standard for early fresh market use.
HiLite Russet	A "new" variety used primarily for early fresh market.
Russet Norkotah	Another early fresh market variety which has been capturing an increasing share of the market.
Shepody	A new variety in this area, primarily used for early processing direct from the field- medium to late maturity.
A7411-2	An advanced selection from the Aberdeen, Idaho breeding program, very similar to Russet Burbank in yield, quality, and maturity but with fewer grade defects.

The potatoes are harvested at three dates; 100, 130 and 160 days after planting (DAP). The three harvest dates approximate the main potato market destinations of early fresh and direct processing, mid season harvest mostly for processing, and full season harvest for fresh or processing use after storage. In addition, the sequential harvesting allows observation of the pattern of growth and development of the clones as affected by the irrigation and nitrogen treatments.

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Two irrigation scheduling strategies are used. Half of the plots are irrigated when approximately 65% of the available soil moisture (ASM) remains, or 35% has been depleted (I1). The other half of the plots are irrigated at 80% ASM, or 20% depletion (I2). The 65% guideline is generally recommended for Russet Burbank, although much of the available research indicates that allowing less than 35% depletion is even better. On the silt loam soils at the research site the 65% criterion means that the potatoes are irrigated every $3\frac{1}{2}$ days during peak water use. The 80% treatment is irrigated every $2\frac{1}{2}$ days, but with a lesser amount of water applied. All irrigations are in amounts calculated to refill the root zone to field capacity without any excess. The soil moisture status is monitored by daily readings of tensiometers at four locations in each treatment. Each monitoring location has tensiometers at 6, 12, and 18 inch depths. The irrigations are scheduled based on the average of the 6 and 12 inch readings and the 18 inch reading is used to monitor any potential leaching. The treatments were chosen to investigate the optimum moisture condition for Russet Burbank and evaluate the other clones for lesser sensitivity to lower moisture status. Also, wide variations in reported responses to nitrogen (N) can be found in the research literature and we suspect most of this variation is due to leaching of nitrate below the potato root zone. We wanted to evaluate the clone's response to nitrogation at these two moisture levels without leaching a significant amount of N in either irrigation treatment.

The nitrogen variable consisted of nitrogation at two week intervals to provide 1, 2, or 3 pounds per acre per day of nitrogen (N1, N2, N3). the rates were selected to bracket the presumed optimum for Russet Burbank of about two pounds of N per day. Nitrogation treatments were started when Russet Burbank had begun tuber initiation and the last nitrogation given two weeks prior to harvest. All plots received an additional 40 lb/acre of N as a preplant broadcast application. The total amount of N applied for the combinations of rates and harvest dates are shown in Table 1.

Table 1.

TOTAL NITROGEN APPLIED IN 1989 (lb/acre)

Harvest Date	Nitrogation rate		
	1 lb/acre/day	2 lb/acre/day	3 lb/acre/day
100 DAP	95	130	165
130 DAP	125	185	250
160 DAP	165	270	375

In the first two years of this experiment nitrogation was simulated by hand sprinkling dry ammonium nitrate over each plot followed with at least one half inch of irrigation. This method was both extremely time consuming and caused an unacceptable amount of damage to the crop from foot traffic. For the 1989 season a "piggy-back" chemigation spray system was added to the linear move irrigation system. The chemigation system has a separate pump, lateral, and nozzles from the irrigation system and includes a chemical tank and metering pump. This enables chemigation with 28% UAN solution independent of the irrigation rate. Individual chemigation booms 45 feet long consist of fulljet style spray nozzles on 65 inch spacing, supplied by a rigid boom mounted 18 inches above, and $2\frac{1}{2}$ feet away from the irrigation system spray nozzles. This arrangement provides mixing of the fertilizer and irrigation water to closely simulate true chemigation, while allowing for the different nitrogation rates by turning selected booms on or off. The amount of extra water supplied by the chemigation treatments causes less then 5% variation in the irrigation rate on the one day each two weeks that nitrogation is applied.

RESULTS

Figure 1 shows the yields of the "best" treatment combination for each clone at 100 DAP. The plotted yield is for the treatment combination which produced the greatest yield of U.S. No. 1 over 4 oz. for that clone but may not have produced the highest total yield. The yield data presented for the different clones are not necessarily all of the same treatment combination. Each bar in Figure 1, and the other graphs of yield data, is the average of four replications. At 100 DAP Russet Norkotah had the highest yield followed by HiLite Russet, then Norgold Russet. The pattern of relative yields is the same as the order of tuberization, indicating that the time of tuber initiation is a determining factor of early yield. All of the early clones outyield the full season types at 100 DAP. The early clones have compact, thrifty vines and partition their dry matter into tubers earlier than the large vined, indeterminate, full season clones.

For Norkotah, the combination of irrigation at 65% ASM and 130 lb/acre of nitrogen applied as 14 lb/acre every two weeks (I1,N2) gave the greatest yield of U.S. No. 1 over 4 oz. (Figure 2). The lower rate of nitrogation (1 lb/acre/day) tended to give lower total yields but a high percentage of U.S. No. 1 potatoes. The higher nitrogation rate (3 lb/acre/day) did not give a yield increase with the 65% ASM irrigation rate. When combined with the wetter irrigation regime (80% ASM), the higher nitrogation rate resulted in an increase in total yield, but not marketable yield, relative to the I1,N2 combination. The pattern of early yield response to the treatments for all of the early clones was similar to that for Russet Norkotah (Figure 2). At 100 DAP the best Russet Burbank yield was only 70% of Norkotah's (Figure 1) and approximately 1/3 of the total yield of Burbank were tubers under 4 oz. in size. Yield of Burbank tended to decrease with increasing nitrogation rate and the wetter irrigation schedule gave slightly better yields, in contrast to the response of the early clones (Figure 3).

At 130 days after planting differences in total yield between the early and late clones are at a minimum (Figure 4). As in Figure 1, the bars indicate the highest yield of U.S. No. 1 tubers over 4 oz. for each variety, and the yields displayed are not necessarily all of the same treatment combinations.

For marketing of potatoes harvested in the middle of the season, size and maturity considerations become more important than yield in choosing between clones. All three of the early clones were mature enough for normal harvesting and storage by this date. Norgold and Norkotah vines were completely dead, while HiLite had more than 75% dead plants with all remaining plants showing signs of advanced senescence. Shepody vines were in various stages of senescence depending on the treatment and the late clones A7411-2 and Burbank were still completely green and vigorous. Russet Norkotah had the largest average size of tubers at about 10 oz. for the U.S. No. 1-over 4 oz. class. These tubers were also the most mature as all of the Norkotah vines had died at least two weeks before this harvest. HiLite had the highest yield of U.S. No. 1-over 4 oz. tubers, the highest percentage of U.S. No. 1's, and a narrower size distribution than any other clones. While the average size of U.S. No. 1-over 4 oz. HiLite was only 8.5 oz., this clone had the least amount of undersize tubers. The variation between treatments at 130 DAP is presented for Shepody in Figure 5. The relationship between the treatments is representative of the other full season clones. The wetter irrigation schedule (80% ASM) combined with the lowest nitrogation rate (1 lb/acre/day) produced the best yields of U.S. No. 1-over 4 oz. for this clone at 130 DAP. For this, or any other medium- to late-maturing clones, the lowest nitrogation rate would be expected to do well because it encourages earliness. The higher N rates would be expected to cause a delay in tuber bulking, and apparently cannot bulk at enough faster rate to have caught up by 130 DAP. The "dryer" irrigation regime (65% ASM) had slightly lower yields and a much greater proportion of U.S. No. 2's in contrast to the situation at the earlier harvest. It seems likely that the 80% ASM scheduling criterion (I2) becomes superior once the high temperatures of July and August arrive.

At the 160 DAP harvest the late clones Russet Burbank and A7411-2 have the highest total yields (Figure 6). At this harvest one treatment combination of HiLite was competitive, even though it had been completely dead for at least two weeks prior to this harvest. The bulking rate of HiLite appears to be faster than any of the other clones in this trial. Shepody, A7411-2, and Burbank all showed a substantial delay in vine death with increasing nitrogation rates, but the increase in duration of green vines did not give an increase in U.S. No. 1 yield. This observation agrees with the results from 1988 where higher rates of N increased green vine duration but not marketable yield. The wetter irrigation regime (80% ASM) with the middle nitrogation rate (2 lb/acre/day) proved to be the best combination for Russet Burbank in terms of both U.S. No. 1-over 4 oz. yield and total yield (Figure 7). The higher rate of nitrogation depressed the yield with either irrigation rate, presumably because of a delay of tuber initiation or reduction in the tuber bulking rate early in the season. A7411-2 produced the highest total yield at 160 DAP, but had fewer U.S. No. 1's than the best yield of HiLite (Figure 6). In the previous two years A7411-2 has produced a higher percentage of U.S. No. 1 tubers than was seen in 1989.

PETIOLE NITRATE PROFILES

Large clonal differences in the level of petiole nitrate, rate of decline, and shape of the petiole nitrate (NO_3) curve are evident in the data for all clones when given the wetter irrigation schedule with nitrogation at 2 lb/acre/day (Figure 8).

The petiole nitrate interpretive guidelines which have been developed for Russet burbank may not apply to other cultivars. All of the other clones have higher petiole NO_3 levels than Burbank early in the season. Petiole NO_3 readings in excess of 25,000 ppm indicate a potential for delayed tuber initiation and reduced early bulking rate in Burbank, but NO_3 levels of up to 35,000 ppm occurred with the other clones with their best yielding treatment combinations. The late season, indeterminate clones show a pattern of gradual decline in petiole nitrate status early which levels off in mid-season if the nitrogation rate is adequate. The early, determinate clones show a much more rapid and continuous decline in petiole nitrate without a steady period at mid season. For all of the clones, the difference in petiole NO_3 status due to irrigation treatment at a single N rate is frequently greater than the difference between nitrogation rates within an irrigation treatment. The "wetter" irrigation strategy (80% ASM) tended to give higher petiole NO_3 readings at a given nitrogation rate than the "drier" treatment (65% ASM).

The generally recommended guidelines for petiole nitrate in Russet Burbank call for a target of between 15,000 and 25,000 ppm during the tuber bulking period. As shown in Figure 9, both 3 lb/acre/day nitrogation treatments fell within the guidelines all season. However, the high nitrogation rate did not provide improved yield of U.S. No. 1 potatoes over the 2 lb/acre/day rate. The high irrigation rate with 2 lb/acre/day nitrogation, which proved to be the best combination at final harvest, was clearly below the guideline for the first three weeks of June when management adjustments to the nitrogation rate are commonly made. The 1 lb/acre/day nitrogation rate was insufficient with either irrigation regime judging by the final yields, but these treatments show petiole NO_3 readings above or the same as the best N rate for late harvest (N2) until the 10 August sample. If the 1 lb/acre/day treatments were to benefit from increased nitrogation, the change would have to be made before the petiole data gave any indication of a problem. The difference in petiole nitrate between irrigation regimes with the 2 lb/acre/day nitrogation rate on 1 July, 10 August, and 30 August are as large as the differences between these treatments and some of the other nitrogation rates. The graph in Figure 9 illustrates several pitfalls of petiole nitrate monitoring programs. First, the only N treatments that are clearly separable from the rest are for the 3 lb/acre/day nitrogation treatments, which were clearly excessive as judged by final yield. The optimum combination (80% ASM and 2 lb/acre/day nitrogation) cannot be distinguished from the insufficient nitrogation treatments (N1) until after 10 August which is probably to late to start an effective recovery program. Also the impact of relatively subtle differences in irrigation regime is clear in this graph. It is apparently critical to know the irrigation history and current condition to be able to interpret the petiole data correctly.

The petiole data for A7411-2 show a different suite of problems for interpretation (Figure 10). All treatments start out at higher levels than Russet Burbank's and decline more slowly. The middle nitrogation gave the best yields at the late harvest but the petiole NO_3 curve for this treatment is not distinct from the curves for less desirable combinations of irrigation and nitrogation rates.

Only the low irrigation with low nitrogation treatment (I-1,N-1) is obviously lower in petiole NO_3 than the other treatments, but even this treatment stayed close to or above the minimum guidelines value established for Burbank. The highest nitrogation rate treatments (3 lb/acre/day, N3) give the highest readings, at least at the beginning and end of the season, but through the early to mid summer period when changes in nitrogation rate would be made, these curves provide no indication of an excessive nitrogation rate.

Petiole NO_3 data for Shepody are graphed in Figure 11. These curves appear to provide some useable data but once again there are serious problems. Only the 3 lb/acre/day nitrogation treatments maintained petioles NO_3 levels above the Burbank guidelines. Furthermore this cultivar is usually grown for early direct processing and for this harvest date (H1 or H2) the lowest nitrogation rate produced the best yields. A possible interpretive guideline for Shepody in early processing use would be to start out at 20,000 ppm in early July and then let the petiole NO_3 level fall as rapidly as possible. This would mean no nitrogation after 1 July. This strategy however was not tested in this research and cannot be endorsed at this time.

The early clones present a different set of curves and different requirements for useable information. If an early clone is to be harvested between 1 August and 15 August, nitrogation should be completed by about 15 July to 1 August. This means that petiole data needs to indicate the crop nitrogen status from mid June to mid July if it is to have value as an in-season management tool.

The curves for Norgold Russet (Figure 12) do not show a useable differentiation between treatments until 9 August which is about the time of harvest for this cultivar. With the exception of two anomalous data points, all of the curves decline continuously until 18 July, which is typical of the early, determinate clones. At the final sampling on 9 August, the highest nitrogation rates (N3) become clearly separated from the others but it is to late to help with scheduling nitrogation.

For Russet Norkotah (Figure 13) the 65% ASM with 2 lb/acre/day nitrogation treatment (I-1,N-2) gives petiole NO_3 readings which are observably lower than the other treatments. This treatment (I1-N2) did give the best yield in an early harvest use so petiole monitoring may be useful with this clone, although the interpretation is completely different from the Burbank guidelines.

The curves for petiole NO_3 status of HiLite would be alarming to anyone used to the Russet Burbank interpretations. The readings start out extraordinarily high and decline precipitously regardless of treatment. In spite of the apparent difference between these curves and those of a typical Burbank crop, applying the Burbank guidelines might have led to correct decisions with this cultivar. Only the 3 lb/acre/day nitrogation treatments (N3) stayed above the 15,000 mark through August and the 3 lb/acre/day N rate combined with the 80% ASM irrigation schedule proved to be the best for harvest in late August or September.

TENTATIVE CONCLUSIONS

The data presented here covers only one year of the experiment and cannot be used for reliable conclusions. It does appear that we have confirmed some previous research information and gained insight into some areas needing further research. For full season Russet Burbank a wetter irrigation strategy than is currently recommended may be beneficial if leaching and disease problems can be controlled. Also a moderate 2 lb/acre/day nitrogation rate is at least as good as the 3 lb/acre/day rate if there is no leaching of nitrogen. The management guidelines for irrigation and nitrogation of other clones need to be different from those developed for Burbank. The drier 65% irrigation regime seems to work best for harvests before extreme hot weather; crops for later harvesting appear to benefit from a wetter soil moisture regime. Petiole NO_3 monitoring programs seem to work well in some fields and years but not in others. Irrigation management can cause a very substantial variation in the petiole NO_3 status of a potato crop. Interpreting petiole NO_3 curves of other clones using the guidelines developed for Russet Burbank does not lead to correct decisions, while developing new guidelines for the new clones will be difficult because the petiole NO_3 status is not sufficiently responsive to the nitrogation rate.

FIGURE 1.
Best Yields of U.S.No.1 over 4 oz.
Harvested 100 days after planting

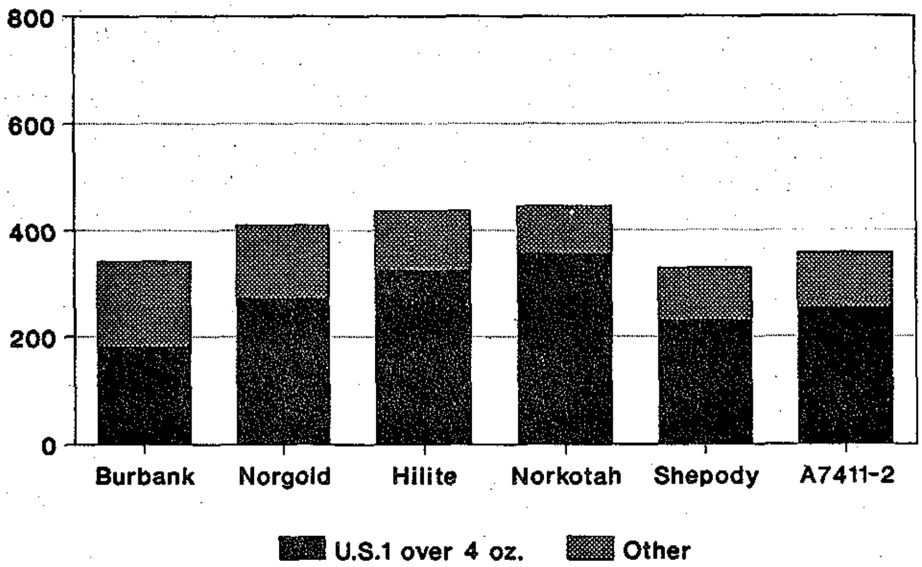

FIGURE 2. NORKOTAH
Yields by treatments
Harvested 100 days after planting

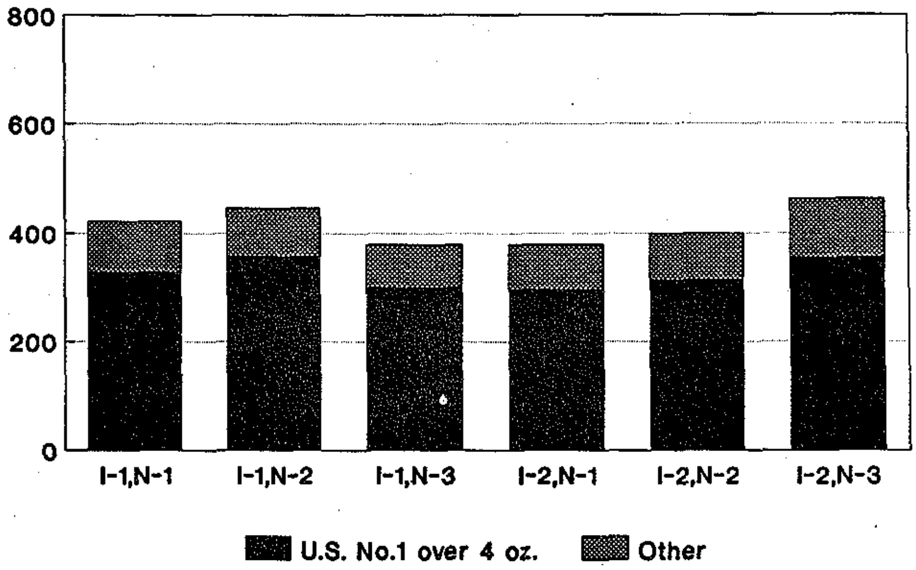

FIGURE 3. BURBANK
Yields by treatments
Harvested 100 days after planting

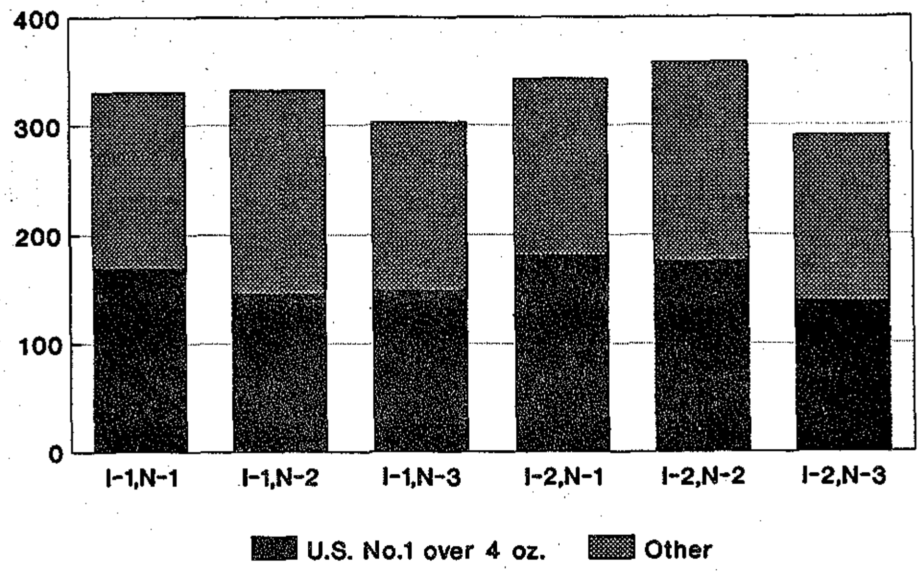

FIGURE 4.
Best yields of U.S.No.1 over 4 oz.
Harvested 130 days after planting

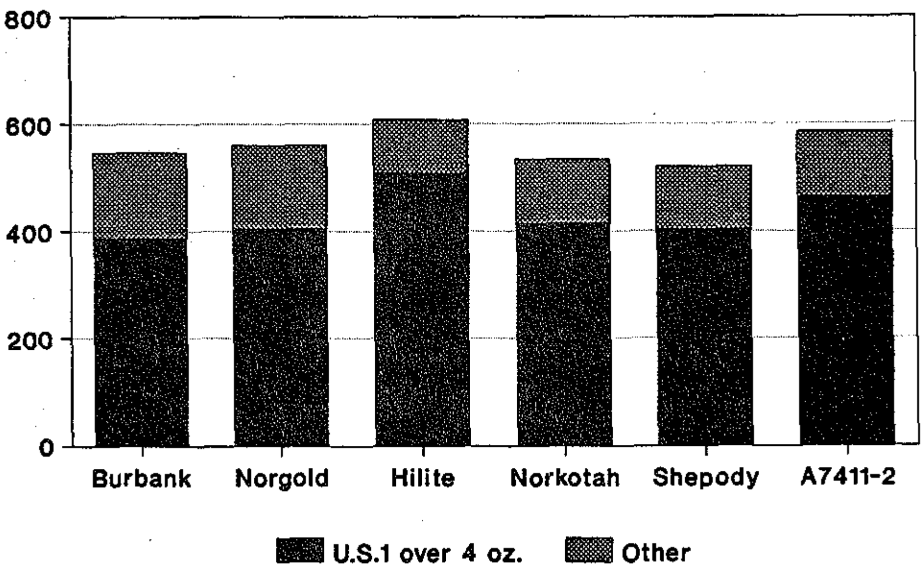

FIGURE 5. SHEPODY
Yields by treatments
Harvested 130 days after planting

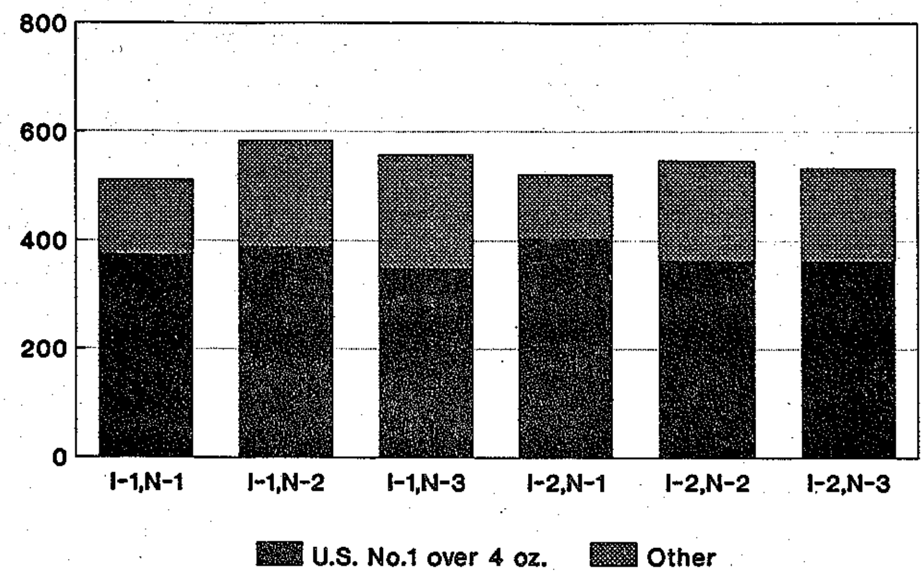

FIGURE 6.
Best Yields of U.S.No.1 over 4 oz.
Harvested 160 days after planting

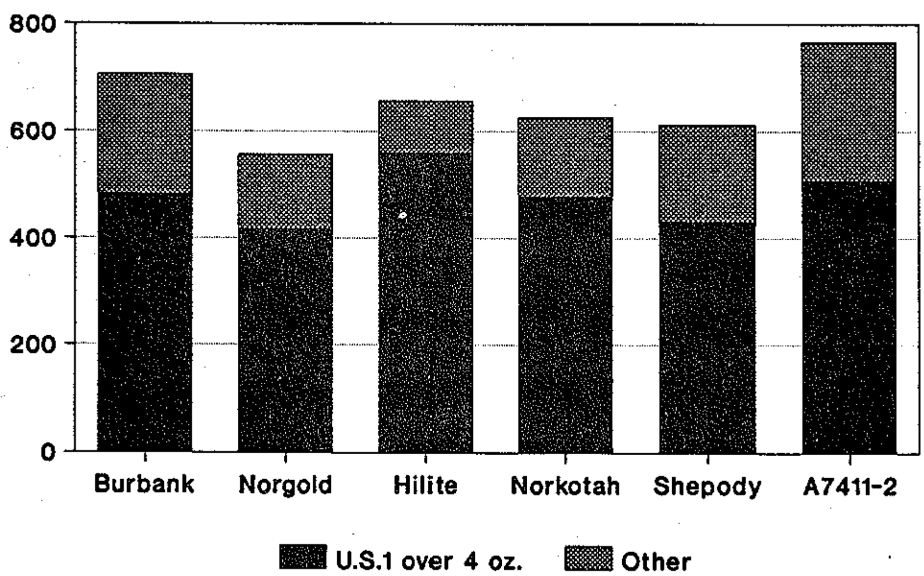

FIGURE 7. BURBANK
Yields by treatments
Harvested 160 days after planting

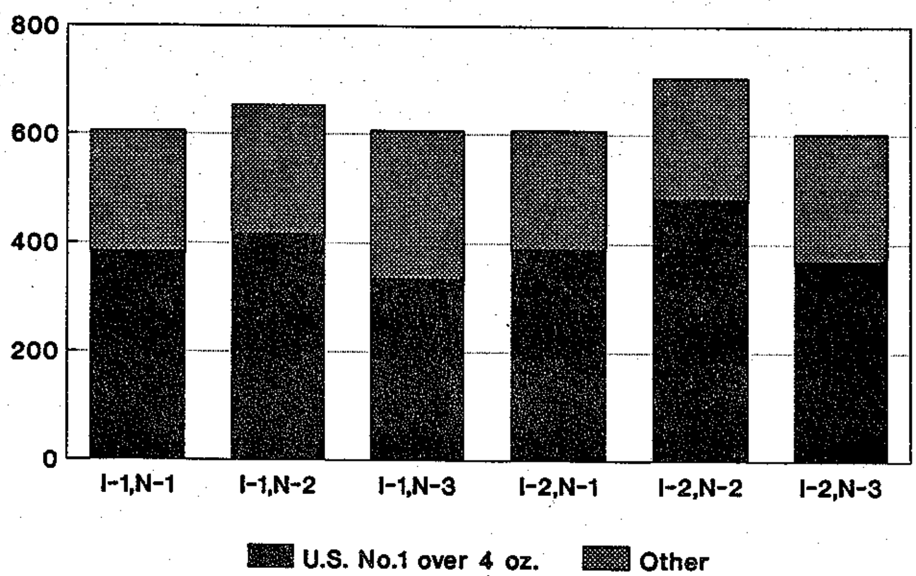

FIGURE 8. 1989 PETIOLE COMPARISON
ALL AT I-2, N-2

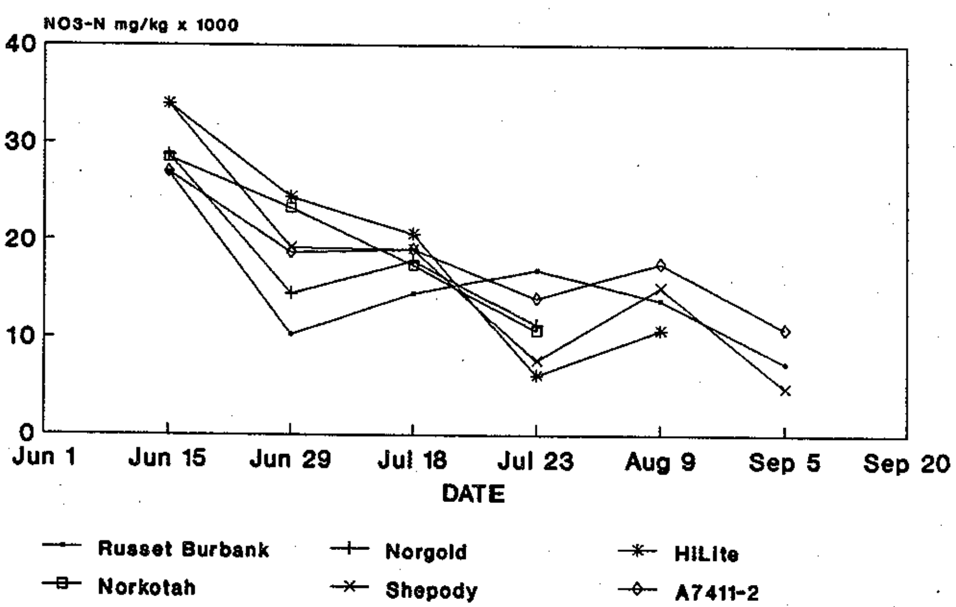

FIGURE 9. RUSSET BURBANK
1989 Petiole Nitrate

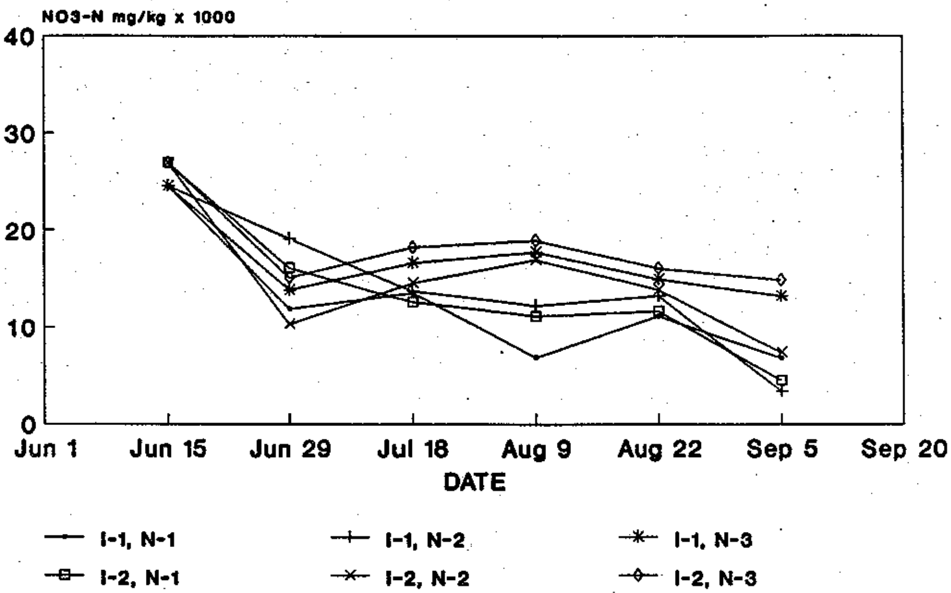

FIGURE 10. A7411-2
1989 Petiole Nitrate

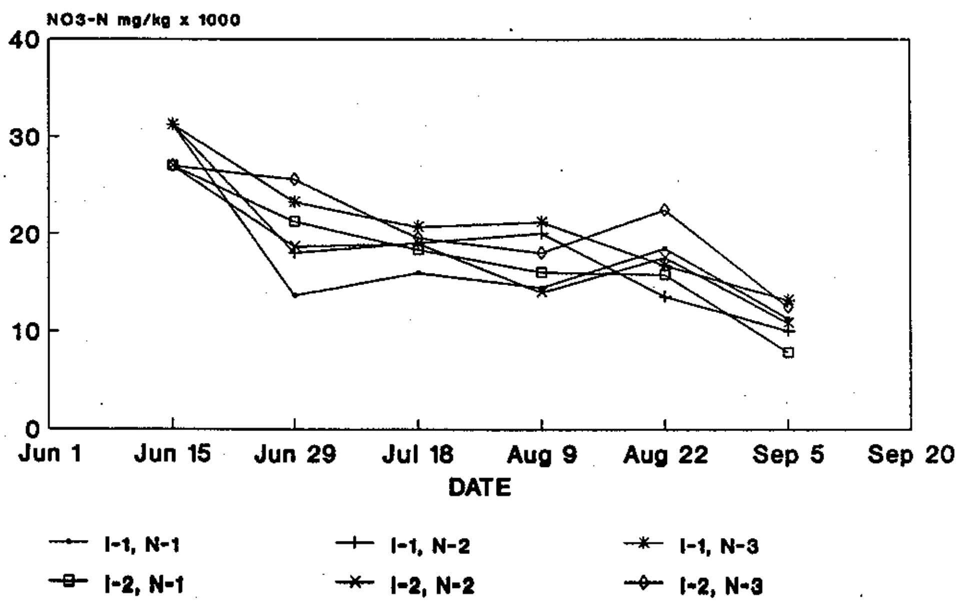

FIGURE 11. SHEPODY
1989 Petiole Nitrate

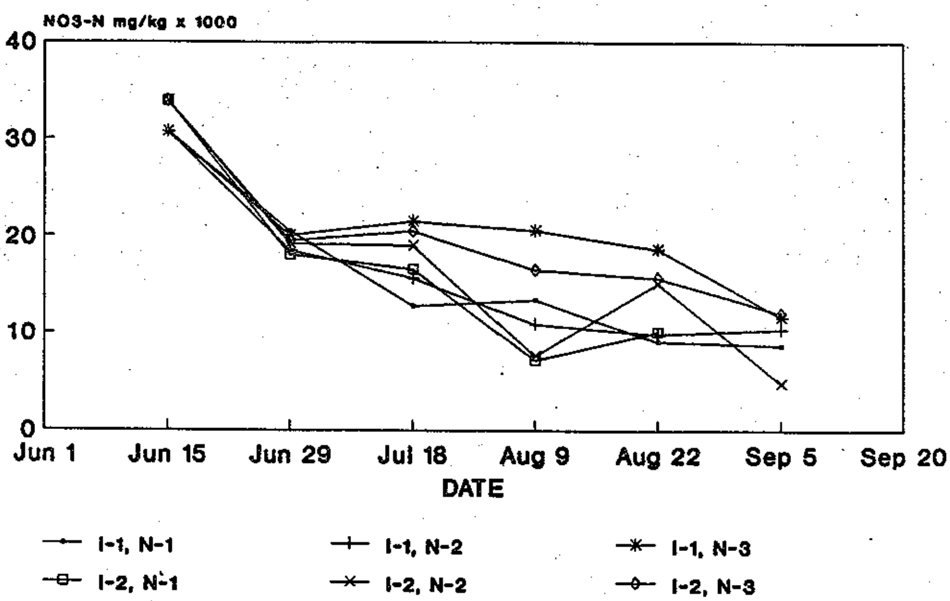

FIGURE 12. NORGOLD RUSSET
1989 Petiole Nitrate

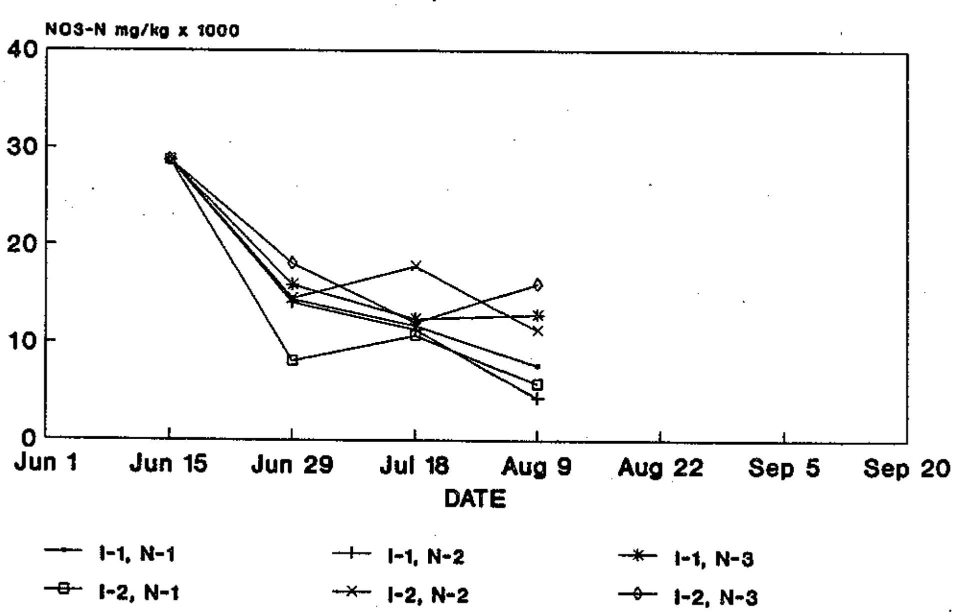

FIGURE 13. RUSSET NORKOTAH
1989 Petiole Nitrate

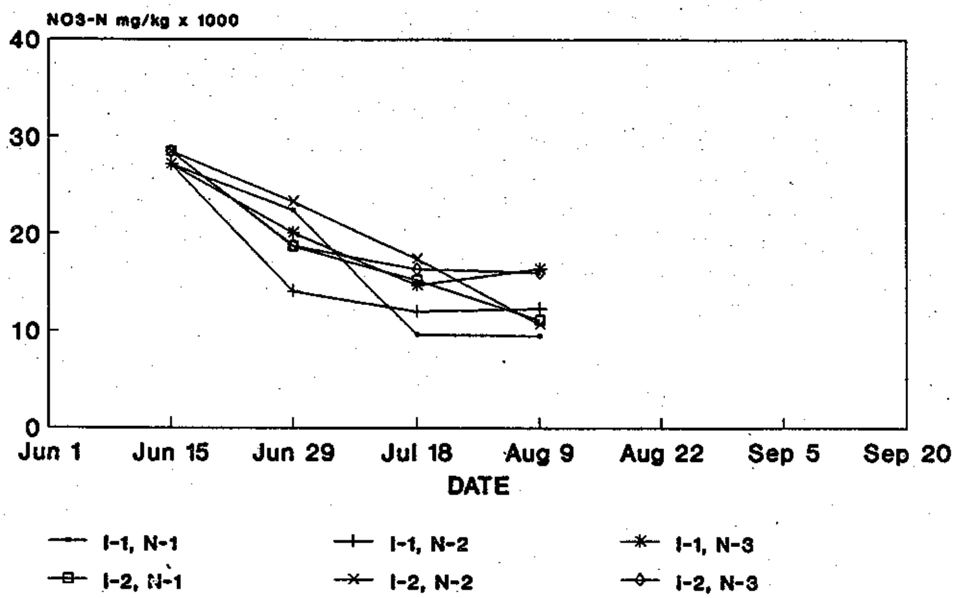

FIGURE 14. HILITE RUSSET
1989 Petiole Nitrate