Effect Of Different Rates Of Nitrogen and Potassium on Drip Irrigated Beauregard Sweetpotatoes

FREP Contract # 00-0507

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Introduction

The use of drip irrigation for sweetpotatoes in California has increased every year since its inception back in the late 80's, and is now used on an estimated 65-75% of the production acreage. Some of the reasons for this continued growth include irrigation convenience, uniformity of application, the ability to irrigate rolling land, and the ability to spoon feed nutrients with the system through the growing season.

Drip irrigation is just one of many agronomic changes that have contributed to substantial average yield increases in the past 20 years. Since 1982, average county yields have increased > 35% (from 9.5 to 13 tons per acre). Despite the widespread adoption of drip irrigation, however, no fertilizer trials have been performed with this system to determine optimal rates of N and K for maximum economic production. Based on old fertilizer trials performed in furrow irrigated fields, current N and K recommendations are 80 – 120 lbs N/A and 0 – 100 lbs K_2O/A. Increased yields certainly imply that increased nutrients are required, but because nitrogen is metered into the system during the growing season, nitrogen use efficiency may be improved to the extent that increased fertilizer rates (especially for nitrogen) are not necessary.

The judicial use of nitrogen fertilizer has more than just economic implications for sweetpotato production in Merced county as well: almost the entire industry is situated in an area with deep, well drained loamy sands where water and nutrients can easily leach out of the root zone.

Objectives

In 2001, we initiated a study to evaluate the nitrogen and potassium requirements for Beauregard sweetpotatoes. The objectives of this trial were:

- Determine the optimal rates of N and K fertilizer for best yield and quality in drip irrigated Beauregard sweetpotatoes.
- Determine the effect of different rates of potash and nitrogen on moisture loss in storage.
- Re-evaluate current fertilizer application tissue analysis guidelines.
- Determine if applications of N with the drip system results in substantial leaching of nitrate beyond the root zone.

Project Description
A trial was initiated with a commercial sweetpotato grower beginning in the spring of 2001 and again in 2002. Nitrogen rates were 0, 50, 100, and 200 lbs N per acre, and potash rates were 0, 75, 150, and 300 lbs K_2O per acre. Part of the field was sectioned off from the main irrigation assembly so that nutrient inputs could be applied independent of the grower's fertilization schedule. No preplant incorporated fertilizers were applied. Plots were 2 rows wide by 45 feet long and replicated four times.

Granular potassium sulfate and phosphorous were applied to the beds under the drop lines at transplanting. Phosphorous rates were 60 lbs P_2O_5 uniformly applied to all plots. Nitrogen treatments began in late June or early July. CAN17 was injected on a 5 to 7 day schedule for a total of 7 - 8 applications. All nitrogen was applied through the drip tubes using a small battery operated piston pump. The nitrogen rate injection schedule is shown in Table 1.

Sampling: Soil samples were taken in April and late August. The August soil sampling occurred after all nitrogen treatments had been applied. Samples were taken in each plot to three feet and divided into one-foot increments, then analyzed for N (as NO_3-N) and K. Leaf and petiole samples were taken three times during the growing season. A sub sample of harvested roots were also analyzed for N and K to determine nutrient removal rates. Moisture loss in storage measured each month from November to May on 40 lb samples from each plot. Plots were harvested using a commercial harvester on October 31 and November 1, 2001.

Results
Since not all data for 2002 has been collected, results presented here are for 2001 to early 2002. Spring soil test results are shown in Table 2. Nitrate levels in the top foot were moderate, averaging 13.7 ppm (~ 54 lbs NO_3-N), and fairly low at the lower depths. Potassium was below 100 ppm at all depths, indicating that a response to potash fertilizer would be expected.

Leaf and petiole sample results for July and September, 2001, are shown in Tables 3 and 4. In July, the plants in the 150 and 300 lbs K_2O treatments had significant greater potassium in the petioles than the lower rates. Late season (September) results showed significantly higher nitrate levels as the N rate increased. Tissue results from August after all fertilizer treatments were finished are shown in Figures 1 and 2. Tissue NO_3-N and K were significantly increased as fertilizer rate increased. There was no significant nitrogen by potassium interaction.

Yield results are shown in Table 5. At the 90% confidence level, nitrogen significantly increased #1's, jumbos, and total marketable yield as compared to the treatments that did not receive any N. However, there was no significant difference between the rate of N applied. Potash did not have any significant effect on yield, and the N x K interaction was not significant for any size (Figure 3). The lack of potassium response in this trial probably occurred because the whole test site was accidentally top dressed with 150 lbs K_2O per acre mid-way through the growing season.

Soil samples taken in August after the last irrigation with fertilizer application showed increased amounts of NO_3-N and K as fertilizer rates increased for all depths (Figures 4 & 5). The 200 lb N rate significantly increased soil NO_3 in the first and second foot as compared to the other treatments. Greatest K was found at the 12-24" depth, while most of the N was at the surface. The amount of NO_3-N in the profile, however, was very low for the amount applied. Even at 200 lbs of N per acre, less than 4 ppm N as NO_3-N was found at a depth of 3 feet. This suggests that most of the N applied was not being leached past the root zone during the growing season. However, spring 2002 soil samples from the 200 lbs N/A plots showed levels of 9.6 ppm NO_3-N at 3 feet, suggesting that some movement of N had occurred over the winter.

Because of the lack of a yield response to potassium fertilizer, correlation and calibration curves comparing fertilizer K to soil K and yield show no clear association. Regression analysis comparing potash fertilizer rate to cumulative soil test K showed a significant positive linear response ($p = 0.001$, $r^2 = 39.1\%$) in soil test K as fertilizer K increased (Figure 6). However, there was no correlation between fall soil test K and total marketable yield (Figure 7). There may be two reasons as to why this occurred. One, there was simply more potassium in the soil, either as indigenous soil K or from applied fertilizer, than was needed by the crop. On the other hand, the lack of a response may be because there was not enough difference between low and high soil test values to cause a significant yield response. Average soil K values ranged from 25 to 62 ppm, which basically classifies the soil as low K for all treatments (below 100 ppm K).

Very little relationship was found between the leaf and petiole analyses in August and yield. There was a slight positive relationship with plant NO_3-N and total marketable yield ($r^2 = 12\%$), with highest yields occurring when nitrate levels in the tissue were around 3000 ppm (Figure 8). For tissue K, a slightly *negative* ($r^2 = 10\%$) relationship was found (yield decreased as K% increased). The data suggest that there is no clear association between tissue test levels taken during root bulking and yield, but that tissue NO_3-N concentrations greater than 3000 ppm are clearly sufficient.

Weight loss in storage was measured at 6, 12, and 18 weeks. There was no significant effect from either N or K fertilizer rate on moisture loss until 18 weeks. On average, the roots lost 8.2% of their weight over 4 months, with 3.5% of that occurring in the first 6 weeks (initial losses are higher because of curing).

To help explain the lack of yield response to additional N fertilizer, a simple nitrogen balance was calculated using soil, crop, and tissue N analyses (Table 6). About 165 lbs N/A was found in the treatments receiving 50 and 100 lbs of N, and 310 lbs N/A at the 200 lb N rate. While the high rate of N only marginally increased yield as compared to the other two rates, it also resulted in increased vine weight, leaf N, root N, and the amount of NO_3-N in the soil. Based on this data, optimal rates of N appear to be at least 100 lbs per acre, but less than 200.

In summary, we saw a significant yield response to N, but there was no significant difference between 50 to 200 lbs of N. However, as N rates increased, more N accumulated in the leaves and roots, and vine weight also increased as N rates increased. Thus, one of the effects of the 200 lb rate of N was thick, green vine growth. There was no significant yield response to potassium fertilizer, but all treatments received at least 150 lbs K_2O per acre, and thus no conclusions can be made. Varying N and K fertilizer rates had little effect on weight loss in storage. Regression analysis on leaf and petiole results showed a plant response to increased rates of N and K, however, this response was not correlated to yield. Mid-season nitrate levels in excess of 3000 ppm are more than sufficient; no conclusions can be drawn from the K tissue analyses. On a positive note, our research suggests that using drip irrigation in sweetpotatoes results in little build up of soil N or leaching beyond the root zone, even at high fertilizer rates.

Table 1. N fertilizer injection schedule for 2001 and 2002.

App.	*2001 Date*	*2002 Date[1]*	*Rate*	*50*	*100*	*200*
				*Lbs N per week**		
1	7/5	6/26	½ x	3.5	7.0	14.0
2	7/13	7/5	1 x	7.0	14.0	28.0
3	7/18	7/10	1 x	7.0	14.0	28.0
4	7/23	7/16	1.5 x	10.5	21.0	42.0
5	7/30	7/23	1.5 x	10.5	21.0	42.0
6	8/3	7/29	1 x	7.0	14.0	28.0
7	8/8	8/2	½ x	3.5	7.0	14.0
8	8/13		½ x	3.5	7.0	14.0

* Due to rounding, actual total N applied was 5% greater than target rate.
1. The 8th application was not made in 2002; instead rates were increased on the 7th application.

Table 2. Spring initial soil samples, 2001 and 2002.

Year	*Sample depth*	*pH*	*EC*	*CEC*	*NO_3-N ppm*	*P ppm*	*Sol K ppm*
2001	0 – 12”	5.8	0.79	6.8	13.7	58.1	51.0
	12–24”	5.2	0.64	9.0	8.6	23.8	23.1
	24–36”	5.5	0.53	8.4	6.2	15.8	11.9
2002	0 – 12”	4.7	0.89		21.5	68.6	86
	12 – 24”	5.0	0.44		6.2	27.9	50
	24 – 36”	5.5	0.62		9.4	19.2	52

EC = electrical conductivity in mmhos/cm.
CEC = cation exchange capacity in meq/100 g (not determined in 2002)

Table 3. Leaf and petiole samples taken July 6, 2001.

K rate, lbs/A	*N rate, lbs/A**	*K %*	*NO_3-N, ppm*
0	0	5.19	2537
75	0	5.52	3297
150	0	6.11	5627
300	0	5.95	3602
	LSD 0.10	**0.53**	**NS**

* At time of sampling nitrogen treatments had not started.

LSD 0.10 = Least Significant Difference at the 90% confidence level. Means separated by less than this amount are not significantly different.

Table 4. Leaf and petiole analyses from samples taken September 17, 2001.

K rate, lbs/A[1]	*K %*	*N rate, lbs/A*	*NO_3-N, ppm*
0	2.56	0	1375
150	2.72	50	4210
		100	2858
		200	7433
LSD 0.10	**NS**		**1935**

1. Only 0 and 150 lb rates were sampled at this time.
LSD = Least Significant Difference at the 90% confidence level. Means separated by less than this amount are not significantly different.

Table 5. Main effect of nitrogen and potash rate on yield and grade of Beauregard sweetpotatoes in 2001.

Treatment	*#1's*	*Jumbos*	*Mediums*	*Market Yield*	*#1's %*	*Culls Boxes/A*
N Rate	40 lb Boxes/A					
0	328	206	158	685	48.1	107
50	420	208	156	784	54.0	95
100	463	209	159	830	56.0	126
200	459	279	177	915	50.1	121
LSD 0.10	**122**	**59**	**NS**	**159**	**6.8**	**NS**
K Rate	437	219	171	828	53.2	105
0						
75	409	212	168	788	51.9	116
150	431	251	158	833	51.4	102
300	393	219	152	764	51.7	126
LSD 0.10	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
N x K LSD	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

US #1's: Roots 2 – 3.5" in diameter, 3 – 9" in length, must be well shaped and free of defects.
Mediums: Roots 1 – 2" diameter, 3 – 7" in length.
Jumbos: Roots that exceed the diameter and length requirements of the above two grades, but are of marketable quality.
% US #1's: Wt. of US #1's divided by the total marketable wt (culls not included).
Culls: Roots >1" in diameter and so misshapen or unattractive as to be unmarketable.
LSD 0.10: Least significant difference at the 90% probability level. NS = not significant.
CV Coefficient of variation, a measure of variability in the experiment.

Table 6. Partial soil N balance based on vine weight, root yields, and soil NO_3-N in the upper three feet of the profile.

N rate	*Vine wt[1] Lbs/A*	*Vine N ppm NO_3*	*Vine N Lbs/A[2]*	*Root wt Lbs/A*	*Root N %*	*Root N[3] Lbs/A*	*Soil N[4] Lbs/A*	***TOTAL N Lbs/A***
1. 0 lbs/A	868	1375	30.6	27,400	0.85	48.0	18.5	**97.1**
2. 50 lbs/A	1309	4210	63.9	31,360	1.15	74.3	27.0	**165.2**
3. 100 lbs/A	1437	2858	59.9	33,200	1.01	69.1	37.3	**166.3**
4. 200 lbs/A	1589	7433	103.0	36,600	1.52	114.6	93.2	**310.8**
Average	1301	3969	64.3	32,200	1.13	---	44.0	**---**
LSD 0.05	426	2388	25.2	6360	0.25	---	26.8	**---**

1. Vine weight is the total dry weight (6% D.M.) of the vine plus leaves by the end of the season (September sampling).
2. Vine N estimated by converting NO_3-N values to total N% and multiplying by dry weight.
3. Root nitrogen is total dry weight of roots using total marketable yield (D.M. = 20.6%) multiplied by N% in roots.
4. Soil N is the sum of NO_3-N in the upper 3 feet of soil based on soil bulk density of 1.7, 1.6, and 1.5 g cm^{-3} for the 1^{st}, 2^{nd}, and 3^{rd} foot in the profile, respectively (soil BD values based on USDA NRCS soil survey data).

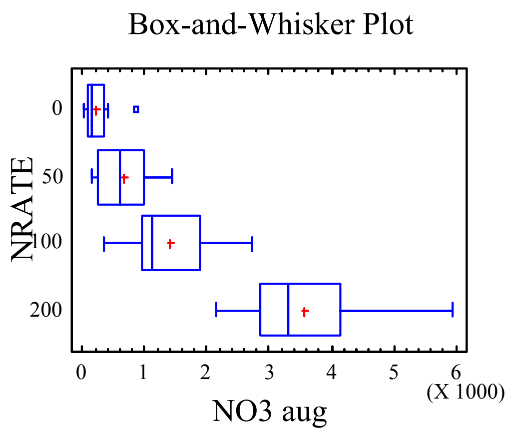

Figure 1. August leaf and petiole tissue N (as NO_3) as affected by N fertilizer rate. LSD 0.90 = 502 ppm.

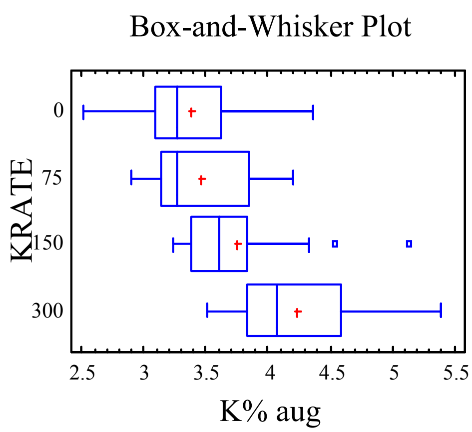

Figure 2. August leaf and petiole tissue K as affect by potash rate. LSD 0.90 = 0.29%.

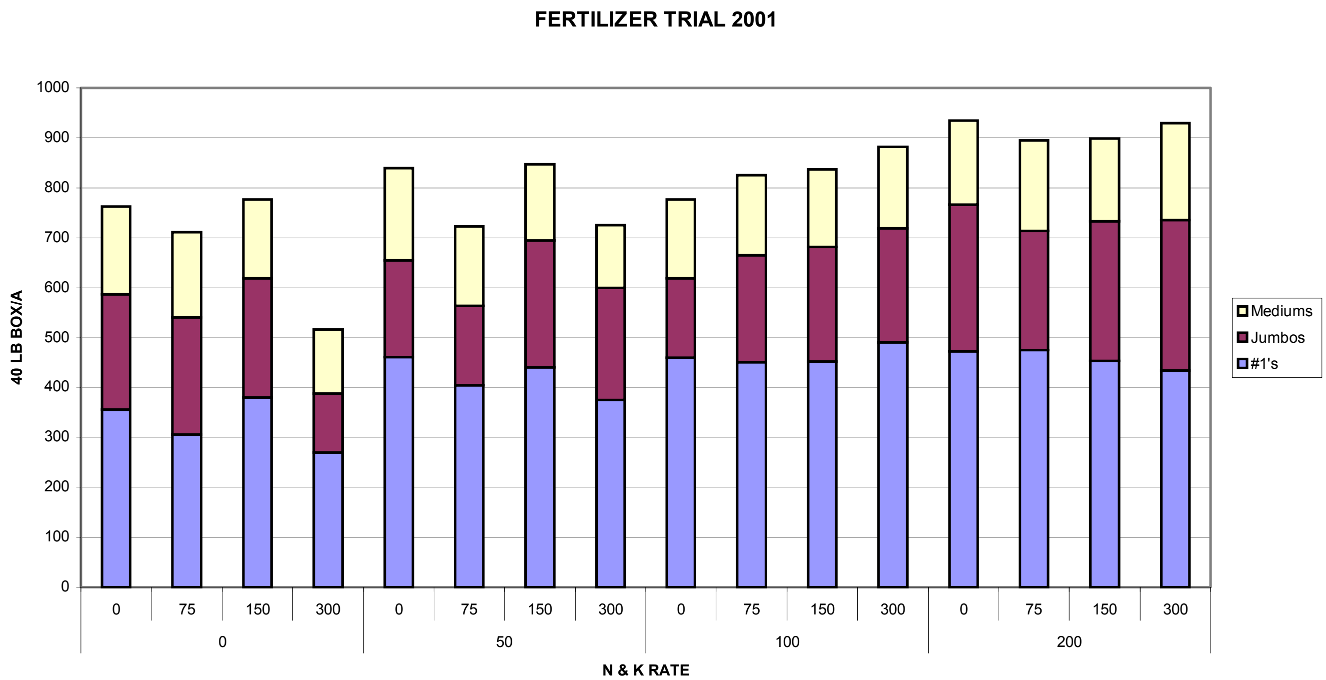

Figure 3. Sweetpotato yield and grade as affected by nitrogen (0 – 200 lbs/A) and potash (0 – 300 lbs K_2O/A) rate.

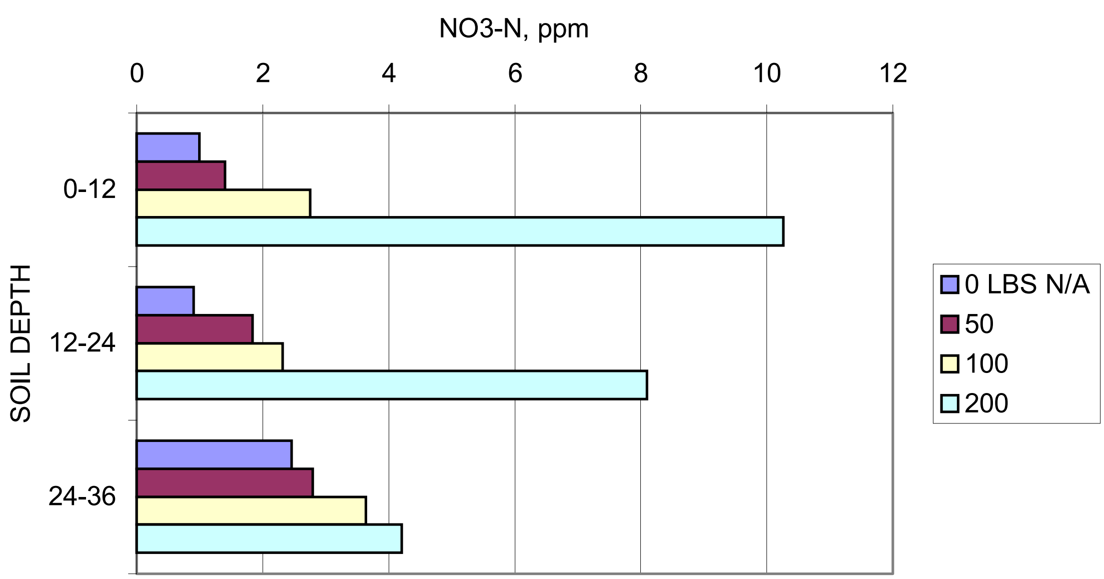

Figure 4. Average soil nitrate-nitrogen (NO_3-N in ppm) at the end of the summer for different depths and nitrogen fertilizer treatments. LSD (0.90) for 12, 24, and 36" depths are 2.41, 2.28, and 1.15 ppm respectively.

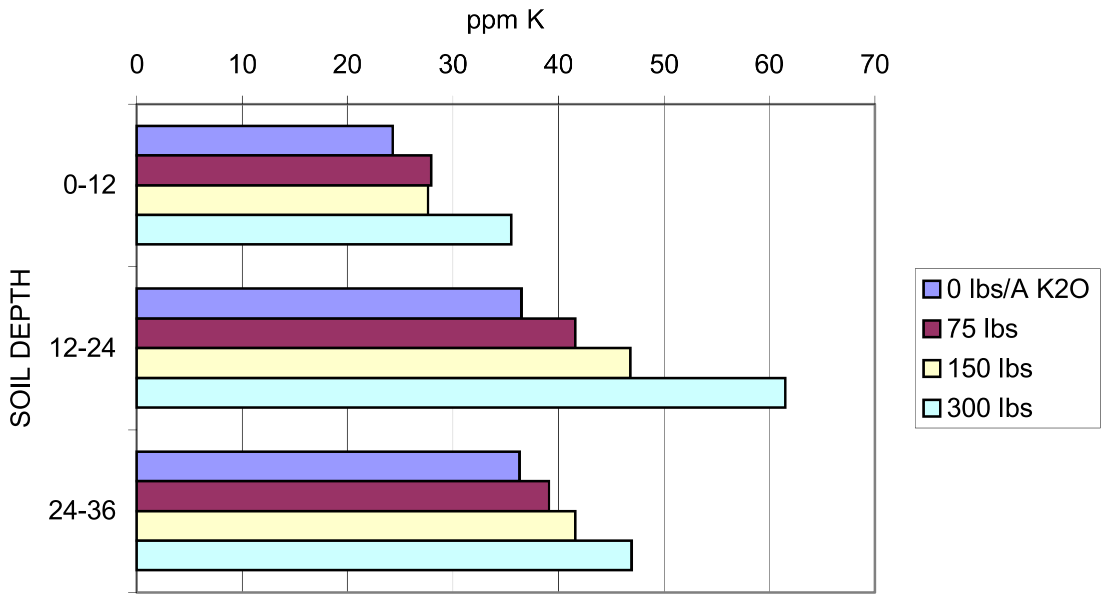

Figure 5. Average soil potassium (as ppm K) from 0 to 3 feet as affected by potash fertilizer rate. LSD (0.90) for 12, 24, and 36" depths are 4.16, 7.05, and 4.33 ppm respectively.

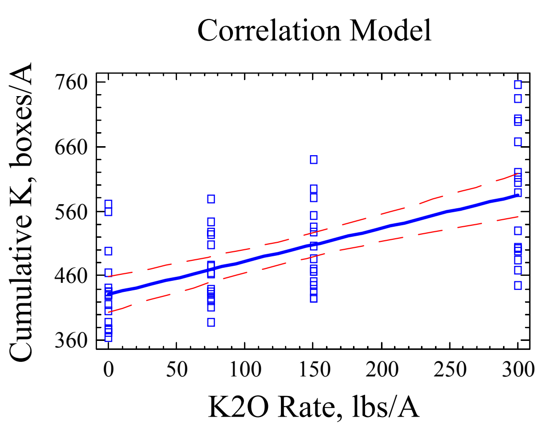

Figure 6. Correlation between applied potash and total K in the 3 ft profile. Best fit line is linear, with the equation K_{soil} = 432 + 0.51(K_2O rate).

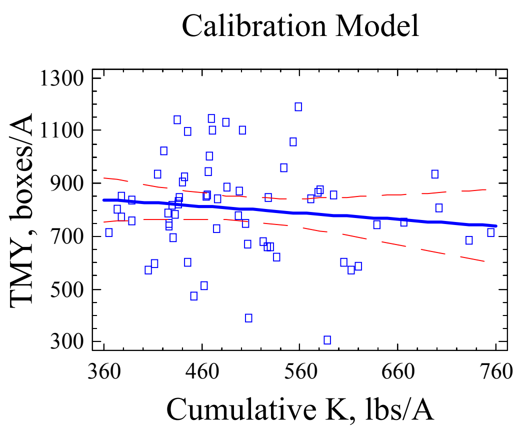

Figure 7. Regression model showing the lack of any significant correlation between cumulative soil K (to 3 ft) and total marketable yield.

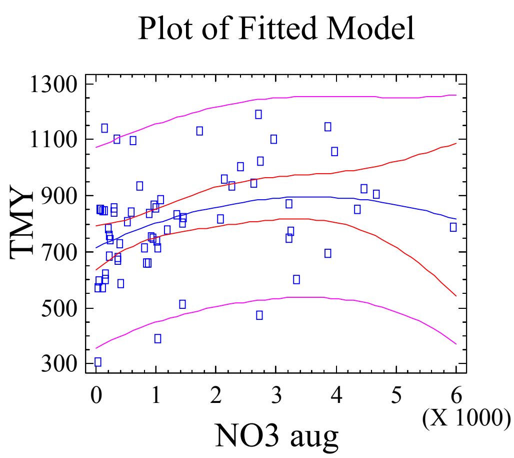

Figure 8. Relationship between leaf and petiole tissue sampled in August and total marketable yield (TMY). Best fit equation: $TMY = 715 + 0.1x – 0.000014x^2$, where x = NO_3-N in ppm.