Response of potato cultivars (Burbank, Norland, Snowden and Superior) to supplemental calcium nitrate applications during 1997 and 1998 seasons: Tuber yield, internal quality and tuber calcium concentration

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In the 1998 season we evaluated the response of three potato cultivars (cvs. Dark Red Norland, Snowden and Superior) and in 1997 three cultivars (cvs. Burbank, Dark Red Norland, Snowden) to supplemental calcium applications. Treatments applied were non split ammonium nitrate, split ammonium nitrate and split calcium nitrate (Table 1). For the 1997 field season we determined yield, internal defects and tuber calcium levels. For the 1998 season we have collected and analyzed yield and internal quality data but tuber calcium content data are not yet available from this season. The 1997 results showed a dramatic shift in the frequency distribution of tubers toward higher calcium following treatment with calcium nitrate. The 1997 and 1998 results show that there was no significant improvement in yield with calcium treatment for all cultivars. In general, quality of potato tubers were very good during the 1997 and 1998 seasons. Analysis from the 1997 season show that the cultivar Burbank responded to calcium nitrate application with decreased incidence of hollow heart and brown center. Other cultivars from 1997 and 1998 demonstrated no significant differences for the incidence of defect with the exception of Superior in which the incidence of hollow heart and brown center increased with calcium nitrate treatment. In general, the incidence of physiological defects was very low during the 1997 and 1998 seasons.

The results of this study demonstrate that by supplemental calcium nitrate application we can dramatically improve the calcium level of the tubers. However, the impact of this calcium improvement on yield and tuber quality is influenced by cultivar as

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well as by seasonal variations. In general, when climatic conditions (season) is ideal for potato growth and development one would expect only limited influence on quality and yield.

Experimental Plan

Individual plots consisted of two 30 foot rows in 1998 and two 15 foot rows in 1997 separated by a guard row. All seed pieces were hand planted with one seed piece per foot. Starter fertilizer (6-20-19) pretreated with admire was applied at a rate of (500 lbs/acre). At emergence 224 lbs/acre of ammonium nitrate (33.5-0-0) was given. Total nitrogen was 228 lbs/Acre to all treatments. The balance of 123 lbs of nitrogen was split equally into three applications starting at hilling, using combinations of ammonium nitrate and calcium nitrate in 1997 and 1998 seasons. Table 1 shows all treatments which were replicated five times.

Table 1: Nutrient application schedule 1997 and 1998

Application of Nutrients: 1997 and 1998

Treatment	Source	Amount (lbs/acre)		Application	
		Nitrogen	Calcium	Number	Timing[1]
Amm Nit (split)	NH_4NO_3	123	0	1	H
Amm Nit (nonsplit)	NH_4NO_3	41	0	3	H,H+3,H+6
Cal Nit (split)	$Ca(NO_3)_2$	41	50	3	H,H+3,H+6

Note: All treatments received equal amount of total nitrogen which was 228 lbs/acre.

[1] H = hilling; H + 3-6 = number of weeks after hilling

Tubers were harvested in both years at maturity and held at about 40 °F until they were analyzed and sampled for calcium six to eight weeks later. For defect analysis tubers were cut in half along longitudinal axis and visually inspected for defects. Table 2 (next page) defines the defects encountered and analyzed. For calcium analyses in 1997 a

longitudinal slice of about 0.25 inch was taken from tubers for calcium analysis. A total of 75 tubers per treatment (15 per replication) were processed for calcium analyses individually.

Table 2: Definition of specific defects and terms used in analysis presentation. Please note that some tubers rated with physiological evidence of defects will not be deemed defective by industry standards.

Defect category	Definition for Defective Tuber
Hollow Heart	**Cavity of any perceptible size** in center of medullary tissue with or without discoloration.
Brown Center	**Any light brown discoloration** in the **center** of the potato. Very faint, or small, but discernible browning was rated as a defect.
Internal Brown Spot	**Any spot** contained inside of the vascular ring in the medullary tissue but **not in the center.**
Multiple	Any tuber containing **two or more** of the above defects.
Total	**Sum** of all incidences of defect.

Results

1997 Tuber Calcium Concentrations (Refer to Figures 1,2 and 3)

The 1997 results showed for all three cultivars a dramatic shift in the frequency distribution of tubers toward higher calcium following treatment with calcium nitrate.
The details follow:

I. **For Norland** (Figure 1), nonsplit ammonium nitrate treatments yielded approximately 5 % of tubers with calcium concentration greater than 150 µg/g concentration while in calcium nitrate treatment, 96% of tubers exceeded this calcium concentration. Furthermore, following treatment with nonsplit ammonium nitrate 95% of tubers ranged in calcium concentration from 50 to 100 µg/g while for calcium nitrate treatment 4% of tubers had less than 100 µg/g calcium. Thus calcium nitrate application dramatically increased the proportion of tubers with high calcium level. Interestingly, split application of ammonium nitrate also raised some calcium level in the tubers as compared to nonsplit application.

II. **For Burbank** (Figure 2), nonsplit ammonium nitrate treatments yielded approximately 32 % of tubers with calcium concentration greater than 150 µg/g concentration while in calcium nitrate treatment, 87% of tubers exceeded this calcium concentration. Furthermore, following treatment with nonsplit ammonium nitrate 68% of tubers ranged in calcium concentration from 50 to 100 µg/g while for calcium nitrate treatment 14% tubers had less than 100 µg/g calcium. Thus calcium nitrate application dramatically increased the proportion of tubers with high calcium level. Interestingly, split application of ammonium nitrate also raised some calcium level in the tubers as compared to nonsplit application.

III. **For Snowden** (Figure 3), nonsplit ammonium nitrate treatments yielded approximately 9 % of tubers with calcium concentration greater than 150 µg/g concentration while in calcium nitrate treatment, 62% of tubers exceeded this calcium concentration. Furthermore, following treatment with nonsplit ammonium nitrate 92% of tubers ranged in calcium concentration from 50 to 100 µg/g while for calcium nitrate treatment 37% tubers had less than 100 µg/g calcium. Thus calcium nitrate application dramatically increased the proportion of tubers with high calcium level. Interestingly, split application of ammonium nitrate also raised some calcium level in the tubers as compared to nonsplit application.

Total tuber yield and yield of US #1 tubers (Refer to Tables 3 and 4):

Both 1997 and 1998 were good years for tuber production in central Wisconsin. In general our yields were good and there was no significant differences among treatments.

This is expected since calcium influences yields primarily during season when some environmental stress (heat) is present.

Tuber Quality (Hollow Heart, Brown Center and Internal Brown Spot)
(Refer to Tables 5 and 6)

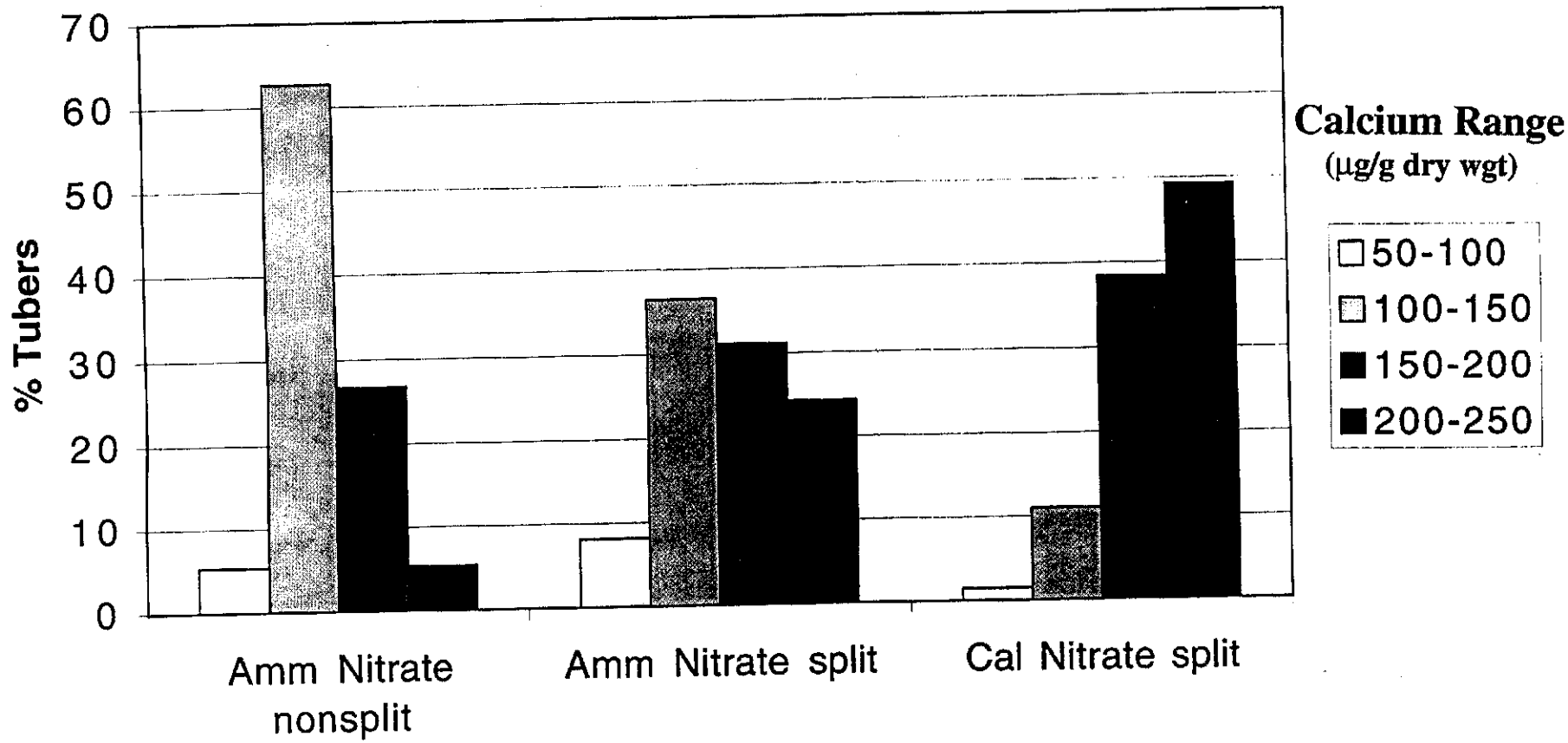
Tubers were cut and rated for internal defects between five to eight weeks following harvest. For each treatment in 1998, 1000 tubers were analyzed (100 from each row / two rows per plot / five replications per treatment). Three samples of ten tubers (30 tubers total) were collected, a 0.25 inch slice taken, halved and slices diced, combined and oven dried for calcium analysis, however this data is not yet completed for 1998. In 1997 a total of 400 tubers from each treatment (two 15 foot rows combined) were evaluated (80 tubers per replication, 5 replications per treatment).

Analysis from the 1997 season show that only Burbank responded with decreased incidence of hollow heart and brown center with calcium nitrate and split nitrogen applications. Other cultivars from 1997 and 1998 demonstrated no statistically differences for the incidence of defects with the exception of Superior in which the incidence of hollow heart and brown center increased with calcium nitrate treatment. However, it is important to note that, in general, incidence of hollow heart and brown center was very low in the 1998 season. This may be the reason for the lack of significant differences among treatments for these defects.

Figure 1:

Burbank: Frequency distribution of tuber calcium concentration

Presented are the proportion (percentage) of tubers within various ranges of tuber calcium concentration. For each treatment, each of 75 individual tubers were analyzed for tuber calcium concentration. The comparison of means between treatments having the same letter are not significantly different (based on SAS General Linear Model Procedure).

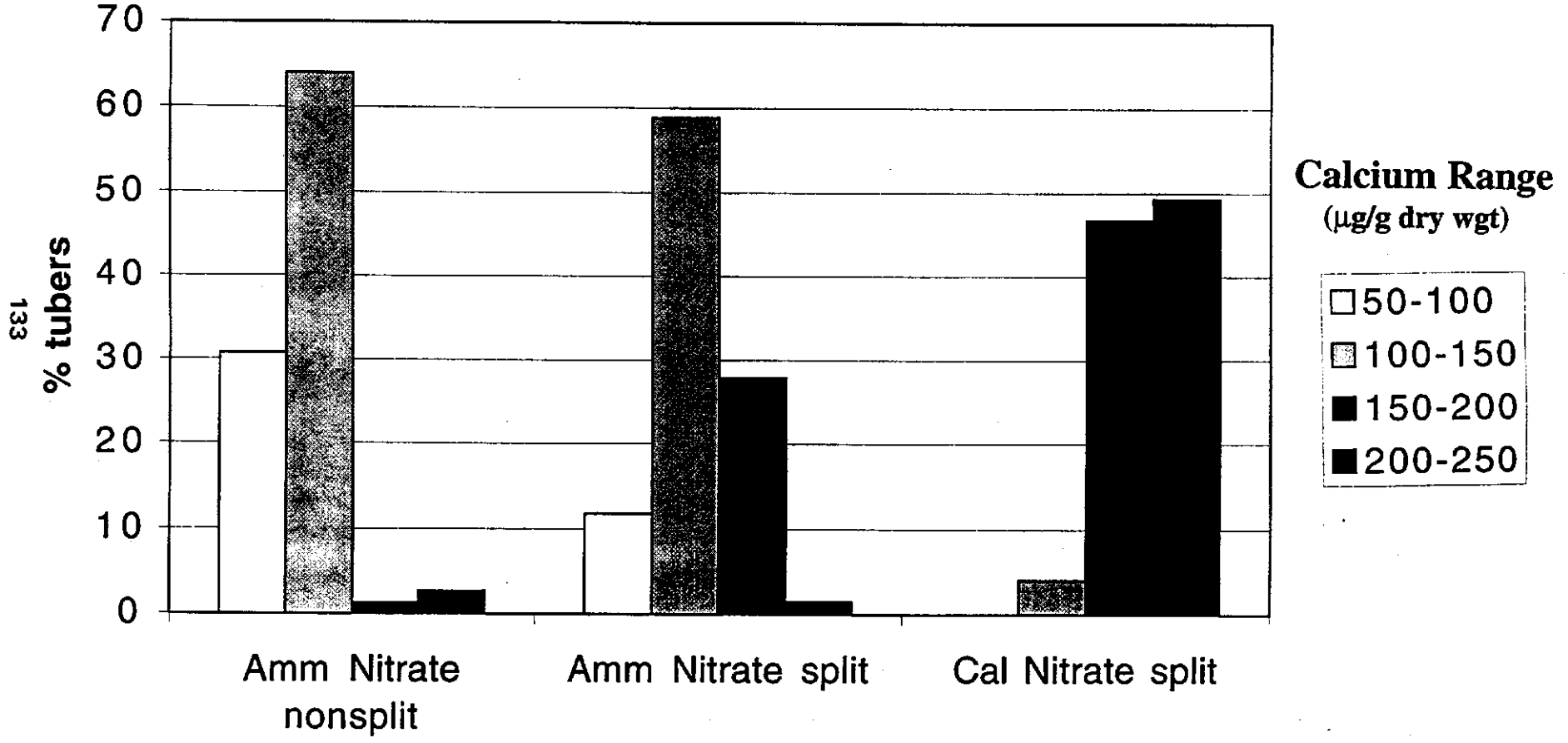


Average Calcium Concentration	**143.8 a**	**159.2 a**	**194.1 b**

Figure 2:

Norland: Frequency distribution of tuber calcium concentration

Presented are the proportion (percentage) of tubers within various ranges of tuber calcium concentration. For each treatment, each of 75 individual tubers were analyzed for tuber calcium concentration. The comparison of means between treatments having the same letter are not significantly different (based on SAS General Linear Model Procedure).

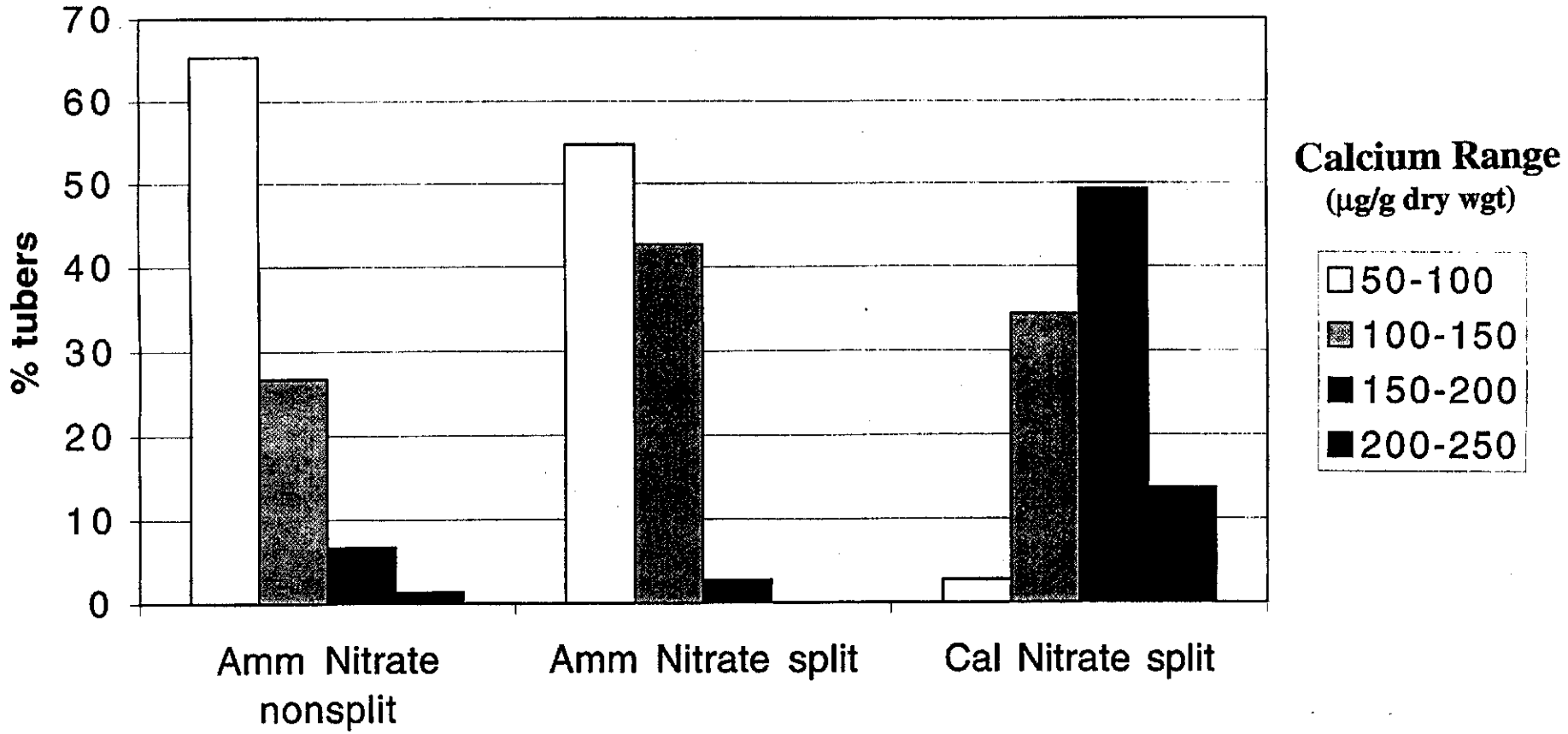


Average Calcium Concentration	**115.5 a**	**138.8 a**	**204.3 b**

Figure 3:

Snowden: Frequency distribution of tuber calcium concentration

Presented are the proportion (percentage) of tubers within various ranges of tuber calcium concentration. For each treatment, each of 75 individual tubers were analyzed for tuber calcium concentration. The comparison of means between treatments having the same letter are not significantly different (based on SAS General Linear Model Procedure).



	Amm Nitrate nonsplit	Amm Nitrate split	Cal Nitrate split
Average Calcium Concentration	93.8 a	97.2 a	164.9 b

Table 3: 1998 Yield response of cultivars to supplemental calcium applications. 1998 total yield and yield of US#1 grade (cvs. Norland, Snowden and Superior) by nutrient treatment. All yields are expressed as mean of five replications. Each replication is an average yield (lbs) of two separately harvested and rated 30 foot rows (one plot). Means within the same column having the same letter are not significantly different (based on SAS General Linear Model procedure).

Cultivar	Yield (lbs)	
Treatment	Total	US #1
Norland		
Nonsplit nitrogen	71.0a	62.2a
Split nitrogen	65.6a	57.1a
Split Cal Nit	71.7a	62.7a
LSD (α=0.05)	12.2	10.0
Snowden		
Nonsplit nitrogen	99.5a	88.9a
Split nitrogen	97.1a	84.0a
Split Cal Nit	101.9a	89.7a
LSD (α=0.05)	9.8	10.4
Superior		
Nonsplit nitrogen	87.9a	79.6a
Split nitrogen	89.9a	81.2a
Split Cal Nit	81.8a	74.0a
LSD (α=0.05)	9.9	8.7

All data reported as treatment means of five separate replications

Table 4: 1997 Yield response of cultivars to supplemental calcium applications. 1997 total yield and yield of US#1 grade tubers (cvs. Burbank, Dark Red Norland and Snowden) by nutrient treatment. All yields are expressed as two 15 foot rows combined (one plot), average lbs of five replications. Means within the same column having the same letter are not significantly different (based on SAS General Linear Model procedure).

Cultivar	Yield (lbs)	
Treatment	Total	US #1
Burbank		
Nonsplit nitrogen	59.3a	40.3a
Split nitrogen	60.0a	35.0a
Split Cal Nit	57.0a	38.0a
LSD (α=0.05)	13.7	16.6
Dark Red Norland		
Nonsplit nitrogen	45.5b	47.6a
Split nitrogen	52.2a	41.0a
Split Cal Nit	54.2a	44.4a
LSD (α=0.05)	4.1	18.4
Snowden		
Nonsplit nitrogen	62.7b	54.7a
Split nitrogen	78.3a	71.0a
Split Cal Nit	61.0b	66.3a
LSD (α=0.05)	12.1	24.6

All data reported as treatment means of five separate replications

Table 5: 1998 Incidence (%) of tuber defects in cultivars (cvs. Norland, Snowden and Superior) as influenced by nutrient applications.

1998 tuber defects reported as percent of tubers evaluated. Means within the same column having the same letter are not significantly different (based on SAS General Linear Model procedure). **1000 tubers** were evaluated for each treatment.

Cultivar Treatment	Defects (%)				
	Total	Hollow Heart	Brown Center	Internal Brown Spot	Multiple
Norland					
Nonsplit nitrogen	11.6a	0.2a	3.0a	8.4a	0.1b
Split nitrogen	11.9a	0.5a	4.0a	7.9a	0.5a
Split Cal Nit	8.7a	0a	3.0a	5.8a	0.1b
LSD (α=0.05)	6.2	0.6	2.0	5.6	0.4
Snowden					
Nonsplit nitrogen	0.7a	0.2a	0.3a	0.4a	0.2a
Split nitrogen	0.7a	0.3a	0.1a	0.4a	0.1a
Split Cal Nit	1.0a	0.1a	0.3a	0.7a	0.1a
LSD (α=0.05)	1.3	0.5	0.7	1.2	0.4
Superior					
Nonsplit nitrogen	10.2b	0b	7.3b	3.0a	0.1a
Split nitrogen	10.6b	0.1b	8.5b	2.3a	0.3a
Split Cal Nit	19.2a	0.6a	17.4a	1.8a	0.6a
LSD (α=0.05)	6.6	0.4	6.7	2.2	0.5

Table 6: 1997 Incidence (%) of hollow heart and brown center in cultivars (cvs. Burbank, Dark Red Norland and Snowden) as influenced by nutrient applications. 1997 tuber defects reported as percent of tubers evaluated. Means within the same column having the same letter are not significantly different (based on SAS General Linear Model procedure). **400 tubers** were evaluated for each treatment.

Cultivar / Treatment	Defects (%)	
	Hollow Heart	Brown Center
Burbank		
Nonsplit nitrogen	8.0a	10.0a
Split nitrogen	2.3b	2.8b
Split Cal Nit	1.8b	2.8b
LSD (α=0.05)	5.1	5.9
Dark Red Norland		
Nonsplit nitrogen	0.75a	1.3a
Split nitrogen	1.0a	1.5a
Split Cal Nit	1.3a	3.5a
LSD (α=0.05)	1.9	2.9
Snowden		
Nonsplit nitrogen	3.9a	4.4a
Split nitrogen	2.0a	2.5a
Split Cal Nit	5.5a	5.5a
LSD (α=0.05)	3.5	3.5