NUTRIENT MANAGEMENT

FOR POTATOES

USED FOR POTATO CHIPS

FINAL REPORT
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A grower initiated demonstration

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ABSTRACT

Seven Central Maine potato growers initiated a program to better manage nitrogen in order to improve quantity and quality of the growing crop. The field work and computerization of data was performed by four area high school students under the supervision of an area crop specialist and the high school chemistry teacher. This demonstration project has been extremely successful and growers have committed to a long term sampling program. That program will continue to develop a data base to assist growers in making management decisions which will improve net income while protecting the environment.

INTRODUCTION

The purpose of this 1993 Nitrogen Demonstration Project funded with SARE funds was multi-fold. The larger goal was to manage nitrate levels in potato fields (i.e. soil, plant, and the potato tuber) while minimizing ground water contamination by leaching nitrogen.

During the growing season leaf petiole samples were taken and dry weight nitrate levels were measured at 50, 60, 70 and 90 days from planting. Soil samples were taken and soil nitrate levels measured at 50 days of growth and at harvest. At 50 days of growth full leaf samples were taken for micro-nutrient analysis. Rainfall and growing degree days were calculated from weather data. Irrigation amounts were recorded. Yields were measured after top kill in early September. At the 70 and 90 day sampling periods, paired samples were taken. One sample was sent to the UNiversity of Maine Analytical Lab for petiole nitrate analysis while the other was retained and tested using a portable Cardy Unit. This was done in an attempt to standardize the Cardy on-site nitrate test.

The report that follows will help define certain fertility, cultural, and related parameters that are especially important in raising potatoes for making potato chips. The consuming public demands potato chips having certain specific physical, chemical and visual characteristics. Prudent use of nitrogen not only protects ground water supplies but is essential for high quality potatoes that fry white as consumers demand. It is necessary that potato farmers grow tubers that will allow chip makers to produce what the public wants to buy. Therefore, it is vital that the several influencing parameters be quantified so that they may serve as management tools for the potato farmers who occupy this specific niche in the production of potato chips.

The expected result of this work will be better knowledge of how to consistently grow quality chipping potatoes so that crops will:

- Produce potato chips that will be more desirable, and thus more saleable, leading to greater demand for the potato chips and ultimately, leading to increases in acreage grown;

- Lead to better yields of higher quality tubers (fewer rejects) making for better profitability, and thus business viability for the farmer, for the agri-businesses supporting the farmer, and for the chip producers;

- Be more environmentally benevolent; that is, crop fertilization will be managed in such a way that ground and surface waters will be better protected from being charged with excess fertilizing nutrients. This factor is especially important, because most of the potatoes grown in this area are in the watersheds of the Sebasticook River and the Kenduskeag Stream, both of which are valued waterways that are required to be protected from the effects of undue erosion and pollution.

NITROGEN MANAGEMENT

Nitrogen management is a major concern in crop production. Growers must balance economics, environmental risks, yields, and quality. Both excessive and restricted nitrogen levels can lead to poor yields and low quality. In addition to environmental risks, excess nitrogen can retard tuber set, delay maturity, and result in a crop with higher storage losses. Restricted nitrogen can result in stressed plants with low disease and pest resistance, poor top growth, and a parallel reduction in yield.

A soils nitrate test can be a measurement of potentially available nitrogen, but tissue nitrate tests can be used as an indicator of the actual nitrogen available to the plant under particular weather conditions, soil conditions, seasons and crop growth stages.

During "normal" years, most rainfall, runoff, and nutrient leaching takes place during the early crop season. Excess, early single applications of nitrogen run a greater risk of leaching. However, nitrogen demand and uptake are high during early top growth and must be made available when needed. During vegetative growth, nitrogen is stored in the vegetative part of the plant and is transferred during later growth stages for tuber development and bulking. Nutrients are at maximum concentrations in the plant at the beginning of tuber set and decrease until maturity. Therefore, if optimum nitrate concentrations have been available for vegetative growth, amounts are adequate for growth during the tuber bulking stage. Petiole nitrate levels are recommended to be between 1.5% and 2.5% (dry weight basis) at the end of the vegetative growth stage and the beginning of the tuber bulking stage. At early tuber bulking, plants with petiole nitrate levels below 1.5% can recover but may have quality losses. Those plants with nitrate levels of 1.0% or less are reported to have increased leaf death leading to early maturity and the end of growth. General recommendations are for petiole nitrate levels to be:

2.2% (or greater) at the 6 to 8 leaf stage of growth
1.5% (or greater) at tuber set and bulking stages
1.0% (or greater) at end of season

Difficulties in the use of tissue analysis in nitrogen management include: plant maturity stage, cultivar variations, and the leaf sampled. Maturity stage can be estimated by using days from planting. However, accumulated growing degree days may give a better estimate of plant maturity stage. Many authors recommend sampling the 4th petiole of the main stem as a standard because younger or older leaves give very different results. Optimum petiole nitrate levels vary among varieties and must be established for each cultivar by variety testing at agricultural research facilities.

METHODS

The methods used in this study are a composite of methods documented from various journals and researchers. Our intent in methods was to parallel that of other researchers so that valid comparisons of results could be made.

Standard soil nitrate tests were done at 50 days of growth and at harvest. Full-leaf micronutrient analysis was done at the 50 day sampling period. Petiole nitrate levels were measured four times during the growing season. Each petiole nitrate sample consisted of thirty stripped petioles taken from the field in a zigzag pattern. Edges, shaded areas, bare spots, foreign growth areas, excessive insect damage and all atypical areas were avoided. Sampling was done during the mornings (6:30 am - 12 noon). At the fifty day sampling period paired samples were taken from adjacent plants. One of the samples was taken to the Maine lab for full leaf micro-nutrient analysis, and the other was stripped of its leaflets and submitted to the lab for petiole nitrate analysis.

Wescott et al (1993) recommended sampling the third or fourth leaf from the growing tip. Bourgoin (of Maine) and Westerman (of Idaho, both University Cooperative Extension agents) both recommended sampling the fourth leaf from the growing tip. We took the fourth leaf from the growing tip on the main stem of the plant. On some varieties at later stages of growth, it was very difficult to distinguish which was the main stem of the plant and which was the branch. Samples to be taken to the lab were placed in labeled paper bags and placed on ice for same day delivery to the lab.

At the 70 and 90 day sampling periods paired petiole samples were again taken. One sample was taken to the lab for dry weight nitrate analysis and the other was analyzed with a hand held Cardy unit. Those samples to be measured with the Cardy unit were kept in plastic bags to prevent the loss of plant moisture. The samples were iced and taken into a local high school lab for analysis. To extract a sample of petiole sap, the petioles were first cut in half (Approximately three inch pieces). The pieces were then mashed between two 1x4x6 inch hardwood boards with a hammer. After mashing, the boards (with the petioles) were squeezed with a C-clamp and the juice was extracted by pressure into a petri dish. The large C-clamp was hand tightened as tight as possible each time giving approximately the same pressure on each sample. The juice was immediately placed in the Cardy and the value recorded. The unit was standardized each day according to the manufacturer's directions using the manufacturer's standard solutions.

At harvest, after top kill, yields were estimated by digging and weighing two 50 ft sections of row. When possible, the two samples were taken from opposite ends of the fields but were taken very near the field edges to minimize damage to the rest of the crop. In 1994, truckload quantities will be weighed and the total length of row needed to fill the truck can be measured from instruments on the harvester.

The sugar levels were measured with a YSI 2700 sucrose testing unit using manufacturer's recommendations and directions. Quality was determined by using Frito Lay Quality Standards Equations. Overall quality rating for 1993 was "63", up from "54" in 1992.

RESULTS & SUMMARY

Charts of the raw field data and selected graphs can be found in the appendix. The selected graphs are:

1. Nitrate levels for each of the four sampling periods
2. Yields vs. nitrate levels
3. Yields vs. variety
4. Yields vs. planting date

The results are:

1. The 1993 season was unusually dry.

2. Petiole nitrate levels at the start of the season were at or above general recommendations.

3. At 90 days of growth, some of the fields had nitrate levels below end of season recommendations.

4. Yields were down from the 1992 season.

5. Quality was up from the 1992 season.

Most values for the 50 day sampling period were high in the recommended range or above the general recommended range of 1.5 to 2.5% petiole nitrate level during vegetative growth stage. At the 60 day sampling period a few of the values were approaching the lower recommended limit of 1.5% petiole nitrate. By the 90 day sampling period, some of the nitrate values were below the recommended end of season value of 1.0% nitrate. However, when graphed, there seems to be little correlation between the nitrate levels for the four sampling periods and the final yields. Because the 1993 season was unusually dry, the first possible explanation would be that water, rather than available nitrogen, had been the limiting factor for the crop. It might be that low field moisture levels restricted plant nutrient uptake. The soil nitrate levels remaining after harvest seemed to indicate enough residual nitrogen available if the plants could have absorbed it. A larger data base will be needed to determine if current fertilization practices are optimum.

The 1993 growing season was a very dry season having a major impact on yields and quality of the crop. Yields were adversely affected and quality was favorable affected because of improved maturity. In June, moisture became a problem and remained a problem until September after tuber bulking had taken place. From June 1 through August 30 the Corinna, Maine area received only 6.62 inches of rain. June 2 received 1.35 inches. The remainder of the rain came in small showers ranging from a trace to 0.5 inches. Primarily wetting the soil surface and re-evaporating, these small showers provided little or no growth benefits to the tubers.

Compounding low rainfall with high growing degree days, 1993 was a very different growing season from 1992. While 1992 had a lower total rainfall, it was distributed better through the growing season. Growing degree days were lower because of a cooler season. Higher rainfall and lower growing degree days contributed to higher yields in 1992 but with lower quality due to delayed maturity. The data collected during the last two years suggests that precipitation and growing degree days have a major impact on yields and quality. Growers are beginning to tie results of fertilization practices to: leave less nitrate in the soil at the end of the crop year, to time applications for higher quality, better yields, and lower costs.

In the 1994 sampling year, it is hoped that improved yield measurements can be made by weighing truckload samples from larger measured areas. Improved methods for harvest sampling and for tracking those samples through storage should result in more reliable comparisons of crop growth conditions, sucrose levels, and final quality of shipped product. This has been the second year of a field study with "normal" fluctuations of conditions rather than a controlled test. As such, several years data will have to be compiled to establish a large enough data base for optimum management decisions.

AKNOWLEDGEMENTS

The Sebasticook Growers of Central Maine is appreciative of the SARE funding for the first year of an intensive sampling program. This program was undertaken in an attempt to promote a system of sustainable agricultural and deal with local public concerns about agricultural nutrient runoff before they are raised. It has set up a reliable system for ongoing data gathering and crop monitoring on a long term basis.

The program also provided employment, career exploration and a unique educational opportunity for the participating high school students. Seldom does the adult community in our culture provide an opportunity for our young people to participate as functioning members of our economic and social systems. This project allowed them to assume a defined role in a relatively large cooperative effort among several public and private agencies. In the field, they worked alongside 30 year PhD researchers. The students developed a working relationship with personnel at the Analytical Lab and had a chance to meet and share information with researchers at the University level. They talked with local agricultural producers and were treated as respected, knowledgeable persons providing information about growing the crop. The producers, in turn, got to see some of the positive results from their local education tax monies. SARE can take immense pride and credit in their contribution and commitment to the educational process.

APPENDIX

GROWER FIELD CODES

GROWER	FIELD NAME	CODE	VARIETY	PLANT DATE MAY
CAMPBELL	HOME-5	HM5	1625	8
CAMPBELL	HOME CONTOUR	HMC	945	12
CAMPBELL	GRINNEL	GRN	1533	15
CAMPBELL	HATCH-NEAL	HNL	SNOWDEN	18
CRANE	WORTHEN 7B	WRN	1625	3
CRANE	NEILS 10D,10G	NLS	SNOWDEN	4
CRANE	COWAN	CWN	945	6
CRANE	UPPER ELLIS	UPE	945	7
CRANE	MARSH	MRH	1533	9
C.D. SMITH	NUTTER #1 AMM	NT1	SNOWDEN	6
C.D. SMITH	NUTTER #2 BLND	NT2	SNOWDEN	6
C.D. SMITH	BROOKS	BRK	1533	12
C.R. SMITH	MILLETT #1	MLT	1625	7
C.R. SMITH	SLINK 2B AMM	S2B	945	11
C.R. SMITH	SLINK 2A BLND	S2A	945	11
DOUBLE D	SMITH	SMT	1533	11
DOUBLE D	BUBAR	BBR	945	14
DOUBLE D	COUNTRY SIDE	CSD	ME CHIP	26
DOUBLE D	BEAN	BEN	945	26
DOUBLE D	MARSH FARM	MFM	SNOWDEN	27
DOWNING	HOME DAY RD	HDY	SNOWDEN	7
DOWNING	HOME FIELD RD	HFD	1533	9
DOWNING	POND	POD	1625	12
DOWNING	STROUT	STR	945	18
GLP	CRANE	CRN	SNOWDEN	6
GLP	DIVERSION	DVS	945	8
GLP	LINKS	LKS	1533	11
GLP	WITHEE	WTH	1625	20
S. SMITH	HURD	HRD	1625	16
S. SMITH	CORLISS LONG	CSL	SNOWDEN	22
S. SMITH	CORLISS SHORT	CSS	1533	23
S. SMITH	POVERAMO	PVM	945	28

MICRO-NUTRIENT ANALYSIS

GROWER	VARIETY	PLANT DATE MAY	* * *	50 DAY SOIL NO3 mg/kg	HAR-VEST SOIL NO3 mg/kg	N %	Ca %	K %	Mg %	P %	Al ppm	B ppm	Cu ppm	Fe ppm	Mn ppm	Zn ppm
						FULL MICRO-NUTRIENT ANALYSIS										
CAMPBELL	1625	8	*	22.1	47.9	6.01	1.17	3.90	0.49	0.44	118	44.8	17.3	204	611	31.5
CAMPBELL	945	12	*	42.7	87.7	6.16	1.29	4.33	0.36	0.42	437	68.9	17.9	469	484	46.2
CAMPBELL	1533	15	*	36.1	55.9	6.04	1.56	4.42	0.57	0.44	415	73.2	22.3	442	764	41.0
CAMPBELL	SNOWDEN	18	*	16.8	119	5.58	1.06	5.24	0.45	0.33	204	109.0	18.1	261	516	42.2
CRANE	1625	3	*	21.3	16.8	5.40	1.21	5.51	0.55	0.45	158	29.5	13.0	225	1030	44.5
CRANE	SNOWDEN	4	*	20.3	68.2	5.00	2.37	10.80	0.83	0.78	651	349.0	34.3	734	1450	114.0
CRANE	945	6	*	13.9	36.2	5.55	1.14	5.50	0.47	0.41	273	21.0	19.6	337	476	44.7
CRANE	945	7	*	26.6	57.3	5.55	1.36	4.93	0.46	0.38	563	20.8	13.1	649	619	38.0
CRANE	1533	9	*	37.7	39.6	5.60	1.06	4.78	0.51	0.36	361	58.2	9.1	389	550	39.4
C.D. SMITH	SNOWDEN	6	*	25.3	48.5	5.65	1.41	6.87	0.65	0.42	259	24.0	20.9	302	759	47.9
C.D. SMITH	SNOWDEN	6	*	21.5	72.4	5.20	1.43	6.60	0.57	0.39	538	24.9	20.7	589	895	47.3
C.D. SMITH	1533	12	*	36.9	33.1	5.72	1.75	5.56	0.62	0.40	205	20.9	12.8	282	895	48.2
C.R. SMITH	1625	7	*	93.1	80.3	5.15	1.39	5.80	0.39	0.52	263	18.6	14.7	334	250	33.1
C.R. SMITH	945	11	*	36.7	29.1	6.01	0.99	4.68	0.40	0.48	354	27.8	18.4	434	891	77.7
C.R. SMITH	945	11	*	14.0	37.7	5.75	1.17	5.33	0.48	0.39	277	23.8	20.5	353	1020	75.8
DOUBLE D	1533	11	*	15.9	62.3	6.05	0.99	4.36	0.35	0.46	364	22.1	19.3	459	551	29.6
DOUBLE D	945	14	*	26.4	75.4	6.06	1.06	5.39	0.39	0.49	931	23.1	30.9	1050	990	85.4
DOUBLE D	ME CHIP	26	*	21.2	35	5.17	1.18	4.24	0.38	0.36	159	24.6	8.2	269	199	18.9
DOUBLE D	945	26	*	34.8	70	5.79	1.09	4.15	0.35	0.45	167	24.4	22.9	314	710	24.4
DOUBLE D	SNOWDEN	27	*	16.1	52.6	4.97	1.37	4.24	0.58	0.30	531	26.7	9.9	557	1170	33.7
DOWNING	SNOWDEN	7	*	15.5	26.6	5.15	1.30	5.50	0.51	0.39	474	19.9	15.4	516	384	26.3
DOWNING	1533	9	*	20.7	38.8	6.03	1.20	3.90	0.55	0.36	297	18.1	12.7	366	412	31.7
DOWNING	1625	12	*	28.6	29.2	5.87	1.19	4.05	0.50	0.32	442	16.9	9.1	389	550	39.4
DOWNING	945	18	*	17.4	32.6	6.10	1.30	4.84	0.70	0.36	108	23.2	14.3	184	303	35.2
GLP	SNOWDEN	6	*	21.2	122	5.55	1.26	6.19	0.67	0.38	323	23.6	19.8	345	381	36.7
GLP	945	8	*	14.3	87.5	6.11	1.25	4.66	0.57	0.41	602	28.5	20.8	622	541	51.1
GLP	1533	11	*	13.4	64.7	5.90	1.05	4.21	0.61	0.42	557	19.1	16.6	595	369	38.3
GLP	1625	20	*	47.8	151	6.12	1.15	4.97	0.42	0.37	228	40.7	18.7	286	140	30.3
S. SMITH	1625	16	*	14.4	54.2	5.43	1.17	4.37	0.67	0.36	259	21.2	13.5	365	242	27.2
S. SMITH	SNOWDEN	22	*	22.8	48.6	5.40	1.72	3.60	0.40	0.32	488	28.4	22.2	530	531	46.8
S. SMITH	1533	23	*	64.8	26.1	5.95	1.37	3.95	0.35	0.40	271	24.1	23.9	328	257	25.0
S. SMITH	945	28	*	24.4	138	5.26	1.45	4.28	0.66	0.33	232	22.1	16.2	341	378	33.1

SOIL & PETIOLE NITRATE AND YIELDS

GROWER	VARIETY	PLANT DATE MAY	50 DAY SOIL NO3 mg/kg	HAR-VEST SOIL NO3 mg/kg	CARDY 70 DAY	CARDY 90 DAY	PETIOLE NITRATE ANALYSIS (% NO3-N DRY WEIGHT BASIS) 50 DAY	60 DAY	70 DAY	90 DAY	YIELDS POUNDS /100 ROWFEET	YIELDS POUNDS /ACRE	ROW WIDTH INCHES
CAMPBELL	1625	8	22.1	47.9	900	2100	3.27	2.58	2.60	1.51	188	27298	36
CAMPBELL	945	12	42.7	87.7	1000	2300	3.34	2.44	1.93	1.23	168	24394	36
CAMPBELL	1533	15	36.1	55.9		3400	3.51	2.70	2.14	1.28	166	24103	36
CAMPBELL	SNOWDEN	18	16.8	119		2800	2.57	2.64	1.78	1.48	89	12923	36
CRANE	1625	3	21.3	16.8	1100	3900	2.94	2.56	2.79	1.71	206	31671	34
CRANE	SNOWDEN	4	20.3	68.2	1400	4700	2.92	2.70	2.57	2.02	229	35207	34
CRANE	945	6	13.9	36.2	1400	1700	3.06	2.73	2.48	1.28	142	21831	34
CRANE	945	7	26.6	57.3		4300	3.25	2.76	3.02	1.66	171	26290	34
CRANE	1533	9	37.7	39.6	1000	1900	3.09	2.83	2.80	1.72	172	26443	34
C.D. SMITH	SNOWDEN	6	25.3	48.5	1100	2600	3.31	3.31	3.19	2.21	184	26717	36
C.D. SMITH	SNOWDEN	6	21.5	72.4	1000	2800	3.17	2.98	2.89	2.65	140	20328	36
C.D. SMITH	1533	12	36.9	33.1		3000	2.89	2.76	1.86	2.18	162	23522	36
C.R. SMITH	1625	7	93.1	80.3	1100	4700	2.66	2.72	2.90	2.20		0	36
C.R. SMITH	945	11	36.7	29.1		2300	2.97	2.99	2.46	2.26	132	19166	36
C.R. SMITH	945	11	14.0	37.7		2500	3.66	3.19	2.57	2.20	148	21490	36
DOUBLE D	1533	11	15.9	62.3		1600	2.86	2.37	1.80	0.64	187	27152	36
DOUBLE D	945	14	26.4	75.4		1400	2.39	2.11	2.13	0.95	159	23087	36
DOUBLE D	ME CHIP	26	21.2	35		3000	2.06	2.31	2.13	1.38	198	28750	36
DOUBLE D	945	26	34.8	70		5200	2.62	2.94	2.52	2.20	103	14956	36
DOUBLE D	SNOWDEN	27	16.1	52.6		4500	2.18	1.86	2.04	1.56	100	14520	36
DOWNING	SNOWDEN	7	15.5	26.6	1100	2000	3.15	2.87	2.51	1.34	155	22506	36
DOWNING	1533	9	20.7	38.8	1000	2000	3.28	2.54	2.39	1.30	208	30202	36
DOWNING	1625	12	28.6	29.2		2800	3.08	2.62	2.15	1.86	112	16262	36
DOWNING	945	18	17.4	32.6		5200	3.20	2.67	2.63	1.67	106	15391	36
GLP	SNOWDEN	6	21.2	122	1400	2800	3.12	2.56	2.28	2.07	112	16262	36
GLP	945	8	14.3	87.5	1100	3000	3.09	3.28	2.59	2.40	116	16843	36
GLP	1533	11	13.4	64.7		870	3.01	2.01	1.71	1.02	172	24974	36
GLP	1625	20	47.8	151		4500	2.63	2.06	2.01	2.20		0	36
S. SMITH	1625	16	14.4	54.2		3300	2.52	1.65	1.65	0.80	203	31209	34
S. SMITH	SNOWDEN	22	22.8	48.6		4200	2.78	2.03	2.38	1.68	143	21985	34
S. SMITH	1533	23	64.8	26.1		5000	2.56	2.33	1.74	1.40	200	30748	34
S. SMITH	945	28	24.4	138		3200	2.49	1.58	2.10	1.22	178	27366	34

SUMMARY OF GDD & PRECIPITATION (as of 8/31/93)

Precipitation

APRIL	MAY	YTD	JUNE	YTD	JULY	YTD	AUG	YTD	SEPT	TOTAL
0.02	6.62	6.64	6.04	12.68	4.54	17.22	5.72	22.94	3.73	26.67
2.42	4.49	6.91	3.16	10.07	3.75	13.82	7.41	21.23	4.70	25.93
0.90	1.63	2.53	2.97	5.50	4.85	10.35	0.42	10.77	1.20	11.97
2.74	2.50	5.24	3.59	8.83	2.13	10.96	0.90	11.86	0.00	11.86
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	3.81	5.33	3.94	9.27	3.82	13.09	3.61	16.70	2.41	19.11

GDD

APRIL	MAY	YTD	JUNE	YTD	JULY	YTD	AUG	YTD	SEPT	TOTAL
127.50	350.00	477.50	680.50	1,158.00	891.00	2,049.00	881.50	2,930.50	525.00	3,455.50
88.00	522.00	610.00	709.50	1,319.50	822.00	2,141.50	853.00	2,994.50	488.00	3,482.50
64.00	420.50	484.50	680.50	1,165.00	729.00	1,894.00	770.50	2,664.50	539.00	3,203.50
78.00	474.50	552.50	682.00	1,234.50	856.00	2,090.50	867.00	2,957.50	0.00	2,957.50
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
89.38	441.75	531.13	688.13	1,219.25	824.50	2,043.75	843.00	2,886.75	388.00	3,274.75

SUMMARY OF GDD & PRECIPITATION
(as of 9/30/93)

Precipitation

PRECIP.	APRIL	MAY	YTD	JUNE	YTD	JULY	YTD	AUG	YTD	SEPT	TOTAL
1990	0.02	6.62	6.64	6.04	12.68	4.54	17.22	5.72	22.94	3.73	26.67
1991	2.42	4.49	6.91	3.16	10.07	3.75	13.82	7.41	21.23	4.70	25.93
1992	0.90	1.63	2.53	2.97	5.50	4.85	10.35	0.42	10.77	1.20	11.97
1993	2.74	2.50	5.24	3.59	8.83	2.13	10.96	0.90	11.86	3.40	15.26
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 YR AVE		3.81	5.33	3.94	9.27	3.82	13.09	3.61	16.70	3.26	19.96

GDD

GDD	APRIL	MAY	YTD	JUNE	YTD	JULY	YTD	AUG	YTD	SEPT	TOTAL
1990	127.50	350.00	477.50	680.50	1,158.00	891.00	2,049.00	881.50	2,930.50	525.00	3,455.50
1991	88.00	522.00	610.00	709.50	1,319.50	822.00	2,141.50	853.00	2,994.50	488.00	3,482.50
1992	64.00	420.50	484.50	680.50	1,165.00	729.00	1,894.00	770.50	2,664.50	539.00	3,203.50
1993	78.00	474.50	552.50	682.00	1,234.50	856.00	2,090.50	867.00	2,957.50	490.50	3,448.00
1994	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1995	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1996	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1997	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1998	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1999	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2000	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10 YR AVE	89.38	441.75	531.13	688.13	1,219.25	824.50	2,043.75	843.00	2,886.75	510.63	3,397.38

NUTRIENT LEVELS IN POTATO TISSUE*

Element	Expressed As	Low Range	Medium Range	High Range
N	%	Below 4.13	4.13 - 5.31	Above 5.31
P	%	Below 0.3	0.3 - 0.6	Above 0.6
K	%	Below 3.51	3.51 - 6.79	Above 6.79
Ca	%	Below 0.71	0.71 - 3.3	Above 3.3
Mg	%	Below 0.22	0.22 - 0.86	Above 0.86
Mn	ppm	Below 7.0	7.0 - 200.0	473-2290 (toxic)
Fe	ppm	Below 30.0	30.0 - 200.0	Above 200.0
B	ppm	Below 14.0	14.0 - 40.0	Above 40.0
Cu	ppm	Below 7.0	7.0 - 30.0	Above 30.0
Zn	ppm	Below 17.8	17.8 - 100.0	Above 100.0

*Tissue refers to leaves and/or petioles.