FARMING 4R ISLAND

4R Advocates — Demonstration Farm Report

nutrient stewardship

Introduction

Genesis Crop Systems Inc (GCS) was contracted by the Canadian Fertilizer Institute (CFI) to coordinate activities in PEI in 2013 to establish and manage five field scale demonstration trials intended to compare various 4R Nutrient Stewardship best management practices with practices currently popular among members of the PEI potato industry.

Current fertilizer programs for potatoes in PEI are based on several factors and vary somewhat from farm to farm. The majority of farms have active soil testing programs in place and rely at least partially on the results and recommendations put forward by the participating soil test facility. Many growers, however, question part or all of the recommendations and tend to utilize programs that may deviate somewhat for several of the plant nutrients involved. Many farms also utilize some form of nutrient management planning strategy to help account for use of organic amendments, green manure crop incorporation, etc.

Access to current local independent potato crop fertility research conducted on a field scale basis is quite limited. A number of farms have conducted various types of crop nutrition field scale comparisons in the past, but plots sometimes never receive the attention deserved at harvest time, therefore may not get harvested. As well, the results can sometimes be confusing and difficult to interpret. Proper coordination and management of these various types of comparisons is necessary in order to provide relevant information that might allow for adjustments, and subsequently, potential improvements to occur.

CFI introduced the 4R Nutrient Stewardship (Right Source, @ Right Rate, Right Time, Right Place®) initiative to the Island industry during the winter of 2012-13. The desired objectives of the program can be summarized as follows:

- Growers identify and use 4R best management practices in the selection, application, timing and placing of all of their crop nutrition inputs through various techniques and strategies.
- Utilize current (and local when available) research to assist in identifying what levels of nutrition the crop actually requires.
- Utilize modern soil testing technology to ensure a good level of understanding of the soils' current nutritional status.
- Account for additional nutritional credits provided by application of organic amendments, incorporation of green manure cover crops, etc.
- Identify the best source of the appropriate nutrient and apply it at the right rate, at the right time and in the right place during crop development. It is important to realize that for the most part, the majority of potatoes in PEI are grown under non-irrigated conditions and therefore it becomes somewhat more difficult to predict exact the timing of nutrient availability and uptake by the crop in any given season.
- It is not the objective of the 4R demonstration farms to prove that farmers are doing anything wrong, or using too much of any given crop nutrient input. Rather, the main purpose is to incorporate aspects from various types of research information into a fertilizer strategy that will provide improvements in crop performance and profitability while at the same time producing a situation whereby the environmental aspects associated with crop production are reduced.

Methodology:

GCS engaged five commercial PEI potato farms to participate in the 4R program. Listed below are the cooperators, addresses and varieties under evaluation (Figure 1);

- Site A — MacLennan Properties, West Cape–Shepody
- Site B — Brian and Scott Annear, Lower Montague –Shepody
- Site C — Hunter Farms, Indian River–Ranger Russet
- Site D — Birch Farms, North Bedeque–Russet Burbank
- Site E — Willard Waugh & Sons, North Bedeque–Russet Burbank

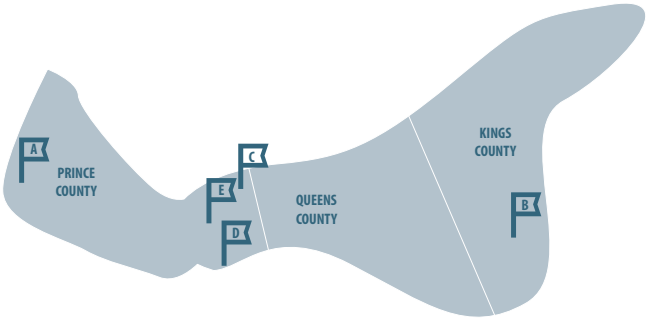


Figure 1. Location of 2013 PEI CFI 4R trial sites.

Selection of demonstration fields evaluated several factors including suitable shape, size, past performance and access to a current soil test report. Growers were required to provide a field large enough whereby at least a ten acre strip could be evaluated using a 4R modified (Mod) program while leaving enough area to serve as a grower standard practice (GSP) treated area.

Following a soil test report review and identification of the particular variety crop nutrition requirements, a 4R modified crop nutrition strategy was developed and presented to each grower for consideration. In all cases the modified programs had one or more alterations to the source, rate, time, and/or placement location of the fertilizer program to be evaluated.

Main features of the 4R modified programs are as follows;

- Split application of Nitrogen using various sources. In some cases total N application was reduced. In all cases N application was divided into at least two (and three for Russet Burbank) application timings featuring use of several sources including Urea, Ammonium Nitrate and Calcium Ammonium Nitrate.
- Lower overall Phosphorous application. All fields had current soil test reports indicating that soil [P] levels were in the high to very high range.
- Split Potassium applications featuring removal of Chlorine from the planter blend (Figure 2). Chlorine has been associated with lower dry matter values in potato tubers. This was achieved by substituting Muriate of Potash with Sulfate of Potash in the planter blend. KCl was the source of K used for all pre–plant broadcast applications.
- Addition of incremental Calcium and Magnesium to the planter mix. Very few PEI soils show higher than a low to medium rating for these elements.
- Addition of Zinc and/or Boron to fields indicating low levels for these elements.

Figure 2. Pre-plant broadcast application of nitrogen and potassium.

Two GPS identified reference points were established within close proximity of each other in each of the five fields. The grower ensured that the GSP program was initiated over one of these points, the 4R Mod program over the other.

These points served as reference for soil sample collection at 6", 12" and 18" depths at the pre-plant, mid-season and post-harvest growth stages. In addition, plant petiole and whole plant tissue samples were collected and analyzed for various nutrient levels once at the time of row closure. All soil, whole plant and petiole samples were delivered to the PEI Soils Lab for subsequent laboratory analysis.

Prior to commercial harvest (Figure 3), six X 15 foot strips were hand harvested from each of the GSP and 4R treatments at each of the five sites.

Care was taken to ensure that the same number of plants were harvested from each treatment within each field.

Figure 3. 2013 fall Russet Burbank harvest.

Two 6–8 oz tubers were collected from each plot and incorporated into a 12 tuber composite sample that represented each treatment and were delivered to the PEI Soils Lab for NO_3 and mineral analysis. Results from this and other lab tests were used to calculate nutrient removal, system loss and overall efficiency values for each of the treatments at each of the sites.

All remaining tubers were delivered to Cavendish Farms central grading facility for simulated industry inspection procedures to provide assessment values for total/payable yields, evaluation of French fry processing quality and calculation of net crop sales returns.

Results:

Foliage canopy development, color and date of crop senescence appeared similar in the Shepody and Ranger Russet fields (Figure 4). In both Russet Burbank fields, however, the 4R modified sections of the field were slower in reaching row closure, maintained slightly paler foliage color throughout most of the growing season and senesced earlier than the GSP sections in the field. It was also observed more so in one Burbank field that the foliage growth was

noticeably reduced in the modified section, making harvest more efficient due to much less vine growth for the harvesting equipment to deal with.

Figure 4. Mid-season view of 4R modified program (left hand side) and grower standard practice fertility program (right hand side) at site B.

All soil and plant tissue analytical summaries are presented in Appendix 1. No major differences were observed between treatments with regards to the mid-season leaf petiole and whole plant nutrient contents of plants from either nutrition program at any particular site.

Crop grade, yield and economic return results combined for all sites are presented in Table 1. Crop yield data for individual sites is presented in Appendix 2. An issue arose at Site A whereby streaking occurred (Figure 5) in the crop during the latter part of the growing season. One can only speculate that the streaking is due to improper application of the pre-plant fertilizer materials (note that approx. 40% of the N and 50% of the K was broadcast ahead of the planter at this site).

Table 1. 2013 PEI CFI 4R Potato Fertility Trials: Yield and Crop Return Summary

Grower	Variety	Fertility Program	Total Yield	Smalls	> 10 oz	URK[1]	Total Defects	Pay Weight	Specific Gravity	Gross Return[2]	Incremental Cost	Net Change Crop Value
			(cwt /acre)	%				(cwt/ acre)		($/acre)		
A[3]	Shep	GSP	310	14.7	29	0.9	9.1	295	1.085	2764	-	-
A	Shep	Mod	274	14.3	28	0.7	9.2	263	1.089	2439	64	-389
B	Shep	GSP	276	19.1	20	0.5	4.2	273	1.088	2441	-	-
B	Shep	Mod	300	14.5	32	0.8	6.3	293	1.089	2797	54	302
C	RR	GSP	279	17	36	0.3	5.2	276	1.083	2485	-	-
C	RR	Mod	314*	19.5	29	0	4	309	1.087	2829	-28	372
D	RB	GSP	312	27.3	25	5.4	7.5	300	1.079	2290	-	-
D	RB	Mod	334*	31.5	15	1.3	3	331	1.083	2549	50[4]	209
E	RB	GSP	271	20.2	30	6.1	12.4	257	1.076	2161	-	-
E	RB	Mod	320*	19	31	4.3	9.3	303	1.081	2592	45	386

[1] Unusable roughs and knobs
[2] Gross return value is based on period 11D delivery price.
[3] Grower A data is for crop production information only. Fertilizer application variability on part of the 4R modified section of the field does not allow for a balanced comparison of fertilizer program treatments
[4] Approximate incremental fertilizer cost
* Denotes a mean total yield significantly greater between treatments, at a 90% significance level (p-value =0.1).

Figure 5. Remnants of alternating actively growing and prematurely senesced vines at Site A.

The 4R modified fertilizer treated areas at sites B–E did not experience losses in total or marketable yields, or crop value as compared to the GSP treated areas, even with substantial reductions in several major plant nutrients. Marketable and total yields trended upwards at each of sites B–E. In fact, crop value was improved at each of these four sites due to a combination of several factors including improved pay weight yields, improved specific gravity values and decreases in overall dockage values observed at the grading facility.

Specific gravity (4R matter) values for tubers produced from the 4R Mod program increased significantly at three of the five sites and showed a trend line improvement at the other two sites. There were no detrimental effects to french fry color from the 4R Mod plots where the Chlorine was eliminated from the planter blend.

Table 2 provides a summary of major nutrient removal from the system via harvested tubers. It does not account for nutrients tied up in remaining crop debris or in the soil in organic/inorganic forms. Generally, across the different varieties, tubers removed 96–116 lbs N, 30–48 lbs P_2O_5 and 139–174 lbs K_2O per acre from the system. Potato plants are quite inefficient at utilizing P_2O_5 as approximately 15–25% of the P_2O_5 applied was removed from the field via crop harvest. Potatoes are somewhat more efficient with Nitrogen removal (50-60%) and greater yet with K_2O (60–80%).

Table 2. 2013 PEI CFI 4R Potato Fertility Trials: Crop nutrient removal rates.

Grower	Variety	Fertility Program	Total Yield	Dry Matter	Dry Matter Per Acre	N		P		P_2O_5	K		K_2O
			(lbs/acre)	(%)	(lbs/acre)	(%)	(lbs)	(%)	(lbs)	(lbs)	(%)	(lbs)	(lbs)
A[1] # 1	Shep	GSP	31000	23.9	7409	1.51	112	0.24	18	33	1.87	139	167
A # 2	Shep	Mod	27400	23.5	6439	1.61	104	0.21	14	32	1.99	128	154
B # 9	Shep	GSP	27600	22.4	6182	1.87	116	0.29	18	33	1.88	116	139
B # 10	Shep	Mod	30000	23.5	7050	1.63	115	0.3	21	48	2.03	143	172
C # 7	RR	GSP	27900	21.9	6110	1.57	96	0.21	13	30	2.12	130	156
C # 8	RR	Mod	31400	22.7	7128	1.5	107	0.2	14	32	1.96	140	168
D # 5	RB	GSP	31200	20.3	6334	1.72	109	0.21	13	30	1.95	123	148
D # 6	RB	Mod	33400	20.6	6880	1.55	107	0.19	13	30	1.87	129	155
E # 3	RB	GSP	27100	21.6	5854	1.7	100	0.21	13	30	1.99	118	142
E # 4	RB	Mod	32000	22.2	7104	1.5	107	0.19	13	30	2.04	145	174

[1] Grower A data is for crop production information only. Fertilizer application variability on part of the modified section of the field does not allow for a balanced comparison of fertilizer program treatments

Table 3. 2013 PEI CFI 4R Potato Fertility Trials: Nutrient balance sheet.

Grower	Variety	Fertility Program	Total Yield (lbs/acre)	Nutrients applied (lbs)			Nutrients removed (lbs)			Nutrient Balance (lbs)		
				N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
A[1] # 1	Shep	GSP	31000	156	168	204	112	33	167	44	135	37
A # 2	Shep	Mod	27400	160	120	300	104	32	154	56	88	146
B # 9	Shep	GSP	27600	182	161	206	116	33	139	66	128	67
B # 10	Shep	Mod	30000	180	120	222	115	48	172	65	72	50
C # 7	RR	GSP	27900	183	209	302	96	30	156	87	179	146
C # 8	RR	Mod	31400	164	144	224	107	32	168	57	112	56
D # 5	RB	GSP	31200	200	196	315	109	30	148	91	166	167
D # 6	RB	Mod	33400	180	150	250	107	30	155	73	120	95
E # 3	RB	GSP	27100	203	151	242	100	30	142	103	121	100
E # 4	RB	Mod	32000	180	120	200	107	30	174	73	90	26

[1] Grower A data is for crop production information only. Fertilizer application variability on part of the modified section of the field does not allow for a balanced comparison of fertilizer program treatments

A crop nutrient balance sheet was created (Table 3) indicating the amount of the three major plant nutrients applied, amount removed and amount remaining in the system. In all cases, the amount of N, P_2O_5 and K_2O remaining in the system was less in the 4R Mod programs than in the GSP program. It is quite probable that the extra K_20 will benefit subsequent crops, but it is difficult to assign incremental value to the remaining Nitrogen (unless a fall cover crop is being planted) and P_2O_5 as all fields had pre-plant soil tests in the high range.

Conclusions:

Data presented from this series of field scale trials indicated that modifications can be made to current PEI potato crop nutrition strategies that entertain slight–moderate reductions in the application of several major nutrients without having any negative impact on crop yields or grower economic returns. In fact, data collected from this series of trials indicated pay weight yields and crop values were improved at each of the four qualifying sites.

Subtle changes were made to the GSP strategy and did not always result in a decrease in fertilizer cost due to several factors including changes in choice of product source, addition of, in some cases, relatively uncommon nutrients (eg Magnesium) or addition of other intermediate/micro elements such as Sulphur or Boron.

Data presented in Table 2 indicated that the potato plant is generally inefficient at conversion/utilization of several plant nutrients, especially Phosphorous and to a lesser extent Nitrogen. This situation, combined with the fact that both of these elements have been associated with incremental environmental risk demonstrates the need to continue to seek more efficient and cost effective alternative methods for fertilizing the potato crop.

Site A provided a preview of potential risk associated with altering a grower's fertility program. It is imperative that any equipment used for broadcast application of crop nutrition products be maintained and operated to provide uniform application of the appropriate products. Beyond proper machine maintenance, factors such as spreading

width, ground speed and wind speed must also be considered.

Readers are cautioned that the data presented in this report represent only one years of evaluation of a crop fertilizer strategy that is relatively new to many growers and relies on product sources and application times that are not currently common in PEI. Similar to any type of on farm scale research, repeatable results from multiyear evaluations will provide growers with the confidence necessary to implement change and improvement.

Acknowledgements:

The author would like to acknowledge the staff from the PEI Department of Agriculture & Forestry and Cavendish Farms Research Division and Central Grading Facility for their assistance in the execution of this project.

Appendix 1A. Grower A Soil and Tissue Test Results (MacLennan Properties)

Code	ID	O.M.	NA	P	K	B	CU	ZN	S	MG	FE	CA	MN	BUFFER PH	WATER PH	NIT-N	CEC	% K	%MG	%CA	%H	%NA	TOT. %	AL
MPGSPPre6	**CFI 1**	2.24	9	407	113	0.3	0.3	1.1	21	73	117	538	24	6.7	6.0	12.8	7	3.4	8.5	37.5	50.1	0.5	49.4	1799
MPGSPM6	CFI 2	2.08	15	492	200	0.3	0.4	1.3	82	108	140	620	36	6.5	5.4	33.5	10	4.1	8.6	29.5	57.2	0.6	42.2	1941
MPGGSPPo6	CFI 3	2.03	8	399	116	0.4	0.3	0.7	47	53	133	504	31	6.7	5.8	7.9	7	3.6	6.5	36.8	52.6	0.5	46.9	1963
MPModPre6	**CFI 10**	2.31	11	333	87	0.3	0.5	0.9	23	74	114	684	21	6.7	6.1	10.6	8	2.4	7.8	43.5	45.7	0.6	53.7	1777
MPModM6	CFI 11	2.24	14	333	199	0.3	0.6	0.8	70	86	116	749	29	7.3	5.9	36.0	5	8.6	14.5	75.7	0.0	1.2	98.8	1898
MPModPo6	CFI 12	1.95	14	351	129	0.3	1	1.7	47	55	105	576	19	6.8	6	6.6	6	4.5	7.5	47.4	39.5	1	59.4	1887
MPGSPPre12	CFI4	2.21	9	364	129	0.3	0.3	1.0	30	77	112	564	26	6.7	6.0	13.9	7	3.7	8.7	38.2	48.8	0.5	50.6	1834
MPGSPM12	CFI 5	2.35	12	384	163	0.3	0.4	1.2	59	83	128	682	36	6.6	5.4	32.4	9	3.7	7.4	36.7	51.6	0.6	47.8	1948
MPGSPPo12	CFI 6	**2.1**	**15.0**	**463.0**	**91.0**	**0.4**	**0.4**	**1**	82	115	142	762	34	6.8	6.1	8.4	7	2.6	12.9	51.3	32.3	0.9	66.8	1924
MPModPre12	CFI 13	2.35	8	337	100	0.3	0.5	0.8	27	90	121	701	21	6.8	6.2	11.0	7	3.1	10.9	50.8	34.8	0.5	64.8	1777
MPModM12	CFI14	2.37	12	381	158	0.3	0.6	0.8	49	94	120	874	29	6.8	5.8	32.3	8	4.3	9.9	55.0	30.2	0.7	69.2	1886
MPModPo12	CFI 15	1.5	15	347	78	0.3	0.6	0.4	74	79	113	658	22	6.8	5.9	8.1	7	2.5	10	50	36.5	1	62.5	1973
MPGSPPre18	CFI 7	1.04	10	268	74	0.2	0.2	0.7	31	44	67	326	35	6.9	6.0	4.8	3	4.7	10.8	48.0	35.3	1.3	63.5	1955
MPGSPM18	CFI 8	2.06	9	372	151	0.2	0.3	0.9	43	82	118	584	33	6.8	5.6	18.3	6	5.1	10.7	45.9	37.7	0.6	61.7	1949
MPGSPPo18	CFI 9	1.33	12	325	79	0.3	0.3	0.3	70	76	119	398	22	6.9	5.8	6.9	4	4.2	15.7	49.2	29.7	1.3	69.1	2051
MPModPre18	CFI 16	1.02	14	152	61	0.2	0.1	0.2	26	35	63	323	13	7.3	6.7	2.0	3	5.1	11.4	63.1	18.0	2.4	79.6	1947
MPModM18	CFI 17	2.15	9	316	164	0.3	0.6	0.6	51	95	109	810	27	6.8	6.0	24.6	8	4.6	10.4	53.1	31.4	0.5	68.1	1909
MPModPo18	CFI 18	**2**	**11.0**	**253.0**	**65.0**	**0.3**	**0.3**	**4.5**	**70**	64	107	491	19	6.9	5.9	7.6	4	3.2	12.2	56.1	27.4	1.1	71.5	1967

TISSUE_ID	Ca	P	Mg	K	Cu	NIT_N_R	Zn	B	S
MP GSP Pet	1.01	0.26	0.58	9.24	2.10	6.25	44.7	27.6	0.25
MP Mod Pe	1.08	0.19	0.46	9.20	2.86	6.05	28.0	29.7	0.23
MP GSP WP	1.33	0.27	0.57	4.98	3.75	1.22	52.7	22.6	0.39
MP Mod WP	1.27	0.23	0.52	5.47	3.89	1.44	41.1	21.8	0.36

	TISSUE_ID	CA	P	MG	K	CU	FE	MOIST.	N	Zn	B	S
GSP	CFITBR-1	0.02	0.24	0.08	1.87	2.9	35	23.9	1.51	18.9	3.9	0.17
Mod	CFITBR-2	0.02	0.21	0.09	1.99	3.69	30	23.5	1.61	19.3	4.3	0.17

Appendix 1A. Grower A Soil and Tissue Test Results (MacLennan Properties)

Code	ID	O.M.	NA	P	K	B	CU	ZN	S	MG	FE	CA	MN	BUFFER PH	WATER PH	NIT-N	CEC	% K	%MG	%CA	%H	%NA	TOT. %	AL
BAGSPPre6	5/1/2013	CFI 73	2.09	16	968	99	0.5	2.9	3.4	9	78	177	1394	50	7.1	6.8	11.9	9	2.2	6.9	73.5	16.7	0.7	82.6
BASGSPM6	8/1/2013	CFI 74	1.98	18	1223	167	0.4	3.1	4.2	131	109	240	1480	62	6.9	5.8	37.1	10	3.6	9.1	74.4	12.1	0.8	87.1
BASGSPPo6	10/20/2013	CFI 75	1.92	11	1132	133	0.7	3.3	3.3	47	84	317	1244	66	7.0	6.1	11.7	7	3.9	9.7	85.8		0.7	99.4
BAModPre6	5/1/2013	CFI 82	2.25	13	1058	119	0.5	3.5	3.5	10	67	213	1391	51	7.0	6.5	10.6	10	2.5	5.6	69.4	21.9	0.6	77.5
BAModM6	8/1/2013	CFI 83	2.19	18	1123	185	2.1	3.9	3.1	156	127	230	1362	65	6.8	5.7	46.7	11	3.7	9.9	63.4	22.3	0.7	77.0
BAModPo6	10/20/2013	CFI 84	2.03	12	874	139	1.1	3.7	2.1	38	67	271	1190	61	6.9	6.3	10.8	8	3.7	6.9	73.8	14.9	0.6	84.4
BAGSPPre12	5/1/2013	CFI 76	1.90	19	719	91	0.5	2.6	2.6	9	67	140	1414	39	7.1	7.0	9.3	9	2.1	6.1	77.8	13.1	0.9	86.0
BAGSPM12	8/1/2013	CFI 77	1.97	15	1152	144	0.4	3.1	3.8	109	90	232	1441	60	6.8	5.8	27.1	11	2.9	7.0	67.2	22.4	0.6	77.1
BAGSPPo12	10/20/2013	CFI 78	1.82	16	859	95	0.6	3.0	2.1	82	76	273	1207	56	7.0	6.2	10.6	7	2.9	9.1	86.9	0.0	1.0	98.9
BAModPre12	5/1/2013	CFI 85	1.79	13	811	128	0.5	3.4	2.4	9	57	203	1452	42	7.1	6.9	15.8	9	2.9	5.0	76.9	14.6	0.6	84.8
BAModM12	8/1/2013	CFI 86	2.33	16	1257	177	1.8	4.0	3.6	104	117	249	1338	66	6.8	5.7	34.6	11	3.6	9.3	63.6	22.8	0.7	76.5
BAModPo12	10/20/2013	CFI 87	2.05	14	859	102	1.0	3.7	2.0	79	68	272	1258	61	7.0	6.3	11.9	7	3.1	7.9	88.2	0.0	0.9	99.2
BAGSPPre18	5/1/2013	CFI 79	1.25	12	498	90	0.4	1.7	1.4	7	47	118	1088	32	7.2	7.1	7.9	7	2.9	5.9	81.4	9.0	0.8	90.2
BAGSPM18	8/1/2013	CFI 80	1.80	11	710	124	0.3	2.4	1.8	40	74	172	1299	36	7.0	6.4	16.2	7	3.6	8.3	87.5	0.0	0.6	99.4
BAGSPPo18	10/20/2013	CFI 81	1.35	12	502	87	0.4	1.9	0.7	60	58	190	1007	35	7.1	6.5	7.9	7	2.5	6.6	68.3	21.9	0.7	77.4
BAModPre18	5/1/2013	CFI 88	1.35	13	399	111	0.4	1.8	1.0	9	37	165	1181	24	7.2	7.1	12.7	7	3.3	4.3	82.5	9.1	0.8	90.1
BAModM18	8/1/2013	CFI 89	1.87	12	746	128	0.6	3.6	1.6	45	74	182	1421	44	7.0	6.4	23.8	8	3.4	7.7	88.3	0.0	0.6	99.4
BAModPo18	10/20/2013	CFI 90	1.63	13	501	100	0.8	2.8	0.8	57	56	215	1206	43	7.1	6.6	9.7	8	2.5	5.5	71.3	20.0	0.7	79.3

TISSUE_ID	Ca	P	Mg	K	Cu	NIT_N_R	Zn	B	S
BAGSP Pe	1.68	0.39	0.54	8.86	5.82	2.54	42.2	30.3	0.22
BAMod Pe	1.74	0.31	0.46	8.16	6.18	2.85	60.9	30.2	0.20
BAGSP WP	1.78	0.37	0.53	4.56	8.04	1.21	70.5	32.0	0.27
BAMod WP	1.63	0.34	0.43	4.52	8.69	1.11	69.5	46.9	0.30

	TISSUE_ID	CA	P	MG	K	CU	FE	MOIST.	N	Zn	B	S
GSP	CFITBR-9	0.02	0.29	0.09	1.88	6.48	35	22.4	1.87	19.3	4.2	0.19
Mod	CFITBR-10	0.02	0.3	0.09	2.03	5.9	33	23.5	1.63	16.3	4.2	0.17

Appendix 1C. Grower C Soil and Tissue Test Results (Hunter Farms)

Code	ID	O.M.	NA	P	K	B	CU	ZN	S	MG	FE	CA	MN	BUFFER PH	WATER PH	NIT-N	CEC	% K	%MG	%CA	%H	%NA	TOT. %	AL
HFGSPPre6	5/1/2013	CFI 55	2.47	17	684	235	0.4	3.5	4.0	13	96	178	822	43	6.5	5.6	18.8	11	4.4	7.0	35.8	52.2	0.6	47.2
HFSGSPM6	8/1/2013	CFI 56	2.58	20	943	328	0.4	3.8	6.5	126	99	213	987	62	6.4	4.8	92.2	14	5.1	6.0	35.9	52.4	0.6	47.0
HFSGSPPo6	10/20/2013	CFI 57	2.56	16	754	321	1.1	4.5	6.3	93	80	253	890	80	6.5	5.3	30.9	12	5.8	5.6	37.5	50.5	0.6	48.9
HFModPre6	5/1/2013	CFI 64	2.38	20	721	216	0.3	3.7	4.1	14	75	156	636	40	6.5	5.4	19.5	10	4.5	6.0	30.7	58.0	0.8	41.2
HFModM6	8/1/2013	CFI 65	2.45	20	893	334	0.4	4.9	8.0	129	86	189	877	57	6.5	4.9	75.4	12	6.0	6.0	36.8	50.4	0.7	48.8
HFModPo6	10/20/2013	CFI 66	2.49	16	738	290	1	5.1	5.2	154	77	210	1128	62	6.5	5.4	37.1	13	4.8	4.9	43.5	46.3	0.5	53.2
HFGSPPre12	5/1/2013	CFI 58	2.42	16	591	211	0.4	3.1	3.0	14	95	168	794	38	6.6	5.6	28.4	10	4.5	7.9	39.4	47.6	0.7	51.8
HFGSPM12	8/1/2013	CFI 59	2.61	21	931	285	0.4	3.8	5.4	105	110	205	1060	60	6.5	5.0	94.9	13	4.7	7.1	41.0	46.5	0.7	52.8
HFGSPPo12	10/20/2013	CFI 60	2.6	20	697	227	0.9	4.4	4.8	75	104	240	975	79	6.6	5.5	45.8	11	4.4	7.8	43.9	43.2	0.8	56.1
HFModPre12	5/1/2013	CFI 67	1.92	16	624	217	0.3	2.5	3.0	11	79	129	602	36	6.6	5.4	21.4	9	5.2	7.3	33.4	53.3	0.8	45.9
HFModM12	8/1/2013	CFI 68	2.55	24	900	377	0.5	4.9	6.3	117	114	190	1042	65	6.5	5.0	112.0	13	6.2	7.3	39.9	45.9	0.8	53.4
HFModPo12	10/20/2013	CFI 69	2.42	18	723	218	0.7	4.6	4.1	75	83	214	816	59	6.6	5.5	24.2	10	4.6	6.8	40.3	47.5	0.8	51.7
HFGSPPre18	5/1/2013	CFI 61	1.28	19	406	177	0.3	1.2	1.1	11	116	145	726	29	6.8	5.9	9.8	7	5.1	13.0	48.7	32.2	1.1	66.8
HFGSPM18	8/1/2013	CFI 62	2.54	25	906	264	0.4	3.7	6.1	82	114	208	1031	57	6.5	5.0	75.1	13	4.4	7.4	40.3	47.0	0.9	52.1
HFGSPPo18	10/20/2013	CFI 63	2.14	18	479	176	0.7	3.1	2.7	38	97	217	843	61	6.6	5.5	34.9	10	3.7	7.9	41	46.7	0.8	52.6
HFModPre18	5/1/2013	CFI 70	0.81	16	454	208	0.2	0.8	0.7	7	91	94	532	20	6.7	5.6	8.2	8	5.9	10.1	35.3	47.8	0.9	51.3
HFModM18	8/1/2013	CFI 71	2.47	22	817	359	0.4	4.4	5.4	89	110	179	976	63	6.6	5.1	89.8	11	6.7	8.0	42.6	41.9	0.8	57.3
HFModPo18	10/20/2013	CFI 72	1.57	19	524	205	0.4	2.7	1.7	40	87	152	697	41	6.7	5.6	15.9	8	5.3	8.7	41.8	43.2	1	55.8

TISSUE_ID	Ca	P	Mg	K	Cu	NIT_N_R	Zn	B	S
HFGSP Pe	0.81	0.45	0.23	10.80	8.27	3.02	49.1	20.4	0.18
HFMod Pe	0.90	0.48	0.25	11.44	9.31	3.19	55.6	21.6	0.20
HFGSP WP	1.32	0.35	0.37	5.87	15.86	1.53	73.3	27.9	0.29
HFMod WP	1.28	0.38	0.38	6.31	12.87	1.60	65.1	28.5	0.31

	TISSUE_ID	CA	P	MG	K	CU	FE	MOIST.	N	Zn	B	S
GSP	CFITBR-7	0.06	0.21	0.1	2.12	4.58	37	21.9	1.57	19.6	6.1	0.13
Mod	CFITBR-8	0.04	0.2	0.1	1.96	6.07	39	22.7	1.5	20.9	5.8	0.13

Appendix 1D. Grower D Soil and Tissue Test Results (Birch Farms)

Code	ID	O.M.	NA	P	K	B	CU	ZN	S	MG	FE	CA	MN	BUFFER PH	WATER PH	NIT-N	CEC	% K	%MG	%CA	%H	%NA	TOT. %	AL
BFGSPPre6	5/1/2013	CFI 37	2.53	20	538	81	0.4	2.9	1.1	16	78	152	867	39	6.6	5.7	15.6	10	1.7	6.5	43.2	47.8	0.9	51.4
BFSGSPM6	8/1/2013	CFI 38	2.64	24	560	134	0.6	3.5	0.9	52	99	163	1150	45	6.7	5.3	106.4	11	2.7	7.8	54.4	34.1	1.0	64.9
BFSGSPPo6	10/20/2013	CFI 39	2.42	24	585	113	0.8	3.4	1	90	94	227	914	59	6.5	5.4	36.7	12	2.1	6.7	39.1	51.3	0.9	47.9
BFModPre6	5/1/2013	CFI 46	2.41	17	438	81	0.3	2.4	0.7	18	71	115	832	29	6.7	5.8	19.3	9	2.0	6.9	48.4	41.9	0.9	57.3
BFModM6	8/1/2013	CFI 47	2.63	32	525	189	0.8	3.1	1.0	51	91	139	974	40	6.6	5.2	94.2	11	3.7	6.9	44.4	43.8	1.3	55.0
BFModPo6	10/20/2013	CFI 48	2.55	29	540	152	1.6	3.4	2.1	108	110	178	1315	52	6.6	5.4	46.9	13	2.5	7.2	51.6	37.7	1	61.3
BFGSPPre12	5/1/2013	CFI 40	2.33	18	488	94	0.3	2.5	0.9	17	72	132	822	35	6.5	5.7	22.8	11	1.8	5.5	37.4	54.6	0.7	44.7
BFGSPM12	8/1/2013	CFI 41	2.67	22	617	148	0.9	3.6	1.2	69	102	180	1027	57	6.5	5.2	111.0	12	2.6	6.9	41.4	48.4	0.8	50.9
BFGSPPo12	10/20/2013	CFI 42	2.72	28	533	94	0.6	3.4	2.1	72	95	216	937	63	6.6	5.4	57.6	11	1.9	7.5	44.2	45.3	1.1	53.6
BFModPre12	5/1/2013	CFI 49	1.94	17	346	114	0.3	1.5	1.6	20	68	104	679	23	6.6	5.6	23.3	9	2.7	6.2	37.4	52.9	0.8	46.3
BFModM12	8/1/2013	CFI 50	2.58	23	513	150	0.9	3.0	1.0	41	82	140	901	41	6.6	5.2	83.6	10	3.1	6.6	43.3	46.1	1.0	53.0
BFModPo12	10/20/2013	CFI 51	2.72	32	510	93	1.2	3.5	1.6	87	97	191	899	51	6.6	5.4	48.6	10	1.9	7.7	43.1	46	1.3	52.7
BFGSPPre18	5/1/2013	CFI 43	0.86	21	289	82	0.2	0.6	0.2	14	68	83	690	24	6.8	5.9	5.2	7	2.6	8.5	51.6	35.9	1.4	62.7
BFGSPM18	8/1/2013	CFI 44	2.69	19	618	142	0.8	3.5	1.5	41	97	180	1032	56	6.6	5.4	71.4	11	2.7	7.2	46.3	43.0	0.7	56.2
BFGSPPo18	10/20/2013	CFI 45	1.83	24	416	98	0.4	2.4	1.4	38	81	161	822	47	6.7	5.5	46.4	9	2.4	7.8	47.2	41.4	1.2	57.4
BFModPre18	5/1/2013	CFI 52	0.83	14	252	88	0.2	0.4	0.2	20	50	66	501	17	6.8	5.6	7.0	6	3.4	7.5	45.0	43.1	1.1	55.9
BFModM18	8/1/2013	CFI 53	2.63	22	510	145	0.7	3.0	2.2	30	83	139	908	41	6.6	5.4	61.4	10	3.0	6.6	43.5	46.0	0.9	53.1
BFModPo18	10/20/2013	CFI 54	1.99	22	333	75	0.7	2.1	0.2	39	71	134	963	37	6.7	5.5	46.4	9	1.7	6.4	52	38.9	1	60.1

TISSUE_ID	Ca	P	Mg	K	Cu	NIT_N_R	Zn	B	S
BFGSP Pe	1.15	0.29	0.54	8.96	6.53	3.17	40.9	23.1	0.20
BFMod PE	1.33	0.22	0.51	9.20	6.23	3.27	41.7	25.8	0.17
BFGSP WP	1.17	0.24	0.53	5.15	12.96	1.32	39.3	20.9	0.29
BFMod WP	1.34	0.25	0.56	5.26	10.43	1.45	53.8	38.5	0.21

	TISSUE_ID	CA	P	MG	K	CU	FE	MOIST.	N	Zn	B	S
GSP	CFITBR-5	0.06	0.21	0.08	1.95	5.47	41	20.3	1.72	21.1	4.3	0.14
Mod	CFITBR-6	0.04	0.19	0.08	1.87	6.17	48	20.6	1.55	21.4	5.6	0.13

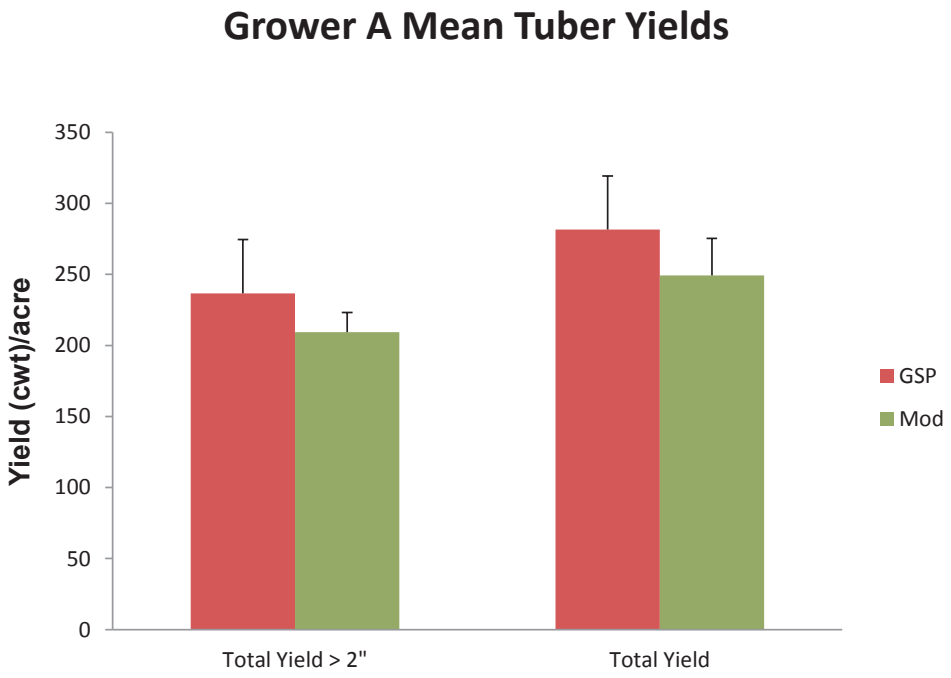
Appendix 1E. Grower E Soil and Tissue Test Results (Willard Waugh and Sons)

Code	ID	O.M.	NA	P	K	B	CU	ZN	S	MG	FE	CA	MN	BUFFER PH	WATER PH	NIT-N	CEC	% K	%MG	%CA	%H	%NA	TOT. %	AL
WWSGSPPre6	5/1/2013	CFI 19	2.37	18	757	186	0.4	2.2	1.4	15	105	174	839	35	6.6	5.8	15.2	10	3.8	8.5	40.5	46.4	0.8	52.8
WWSGSPM6	8/1/2013	CFI 20	2.41	22	724	176	0.4	3.0	1.5	17	107	186	904	51	6.6	5.3	73.2	11	3.5	8.3	42.3	44.9	0.9	54.1
WWSGGSPPo6	10/20/2013	CFI 21	3.1	18	734	136	0.6	2.9	1.3	22	64	214	638	58	6.5	5.4	13.5	10	2.9	5.3	31.6	59.5	0.8	39.8
WWSModPre6	5/1/2013	CFI 28	2.41	22	724	176	0.4	3.0	1.5	17	107	186	904	51	6.6	5.3	73.2	11	3.5	8.3	42.3	44.9	0.9	54.1
WWSModM6	8/1/2013	CFI 29	2.48	19	821	205	0.7	3.2	1.4	26	99	204	827	49	6.6	5.4	35.9	10	4.3	8.0	40.2	46.7	0.8	52.5
WWSModPo6	10/20/2013	CFI 30	2.45	20	823	138	1	3.4	1.2	39	91	224	758	57	6.6	5.5	9.1	10	3	7.8	39	49.3	0.9	49.8
WWSGSPPre12	5/1/2013	CFI 22	0.97	22	364	116	0.2	0.7	0.4	12	101	94	642	20	6.8	5.9	6.1	7	3.6	12.4	47.2	35.3	1.4	63.2
WWSGSPM12	8/1/2013	CFI 23	0.97	22	364	116	0.2	0.7	0.4	12	101	94	642	20	6.8	5.9	6.1	7	3.6	12.4	47.2	35.3	1.4	63.2
WWSGSPPo12	10/20/2013	CFI 24	1.86	21	692	114	0.4	3	1.4	18	80	205	730	60	6.6	5.4	35.9	9	2.6	7.1	38.6	50.8	1	48.3
WWSModPre12	5/1/2013	CFI 31	2.23	24	693	159	0.3	2.4	1.5	13	95	157	814	41	6.7	5.8	19.3	9	3.8	8.9	45.7	40.4	1.2	58.4
WWSModM12	8/1/2013	CFI 32	2.52	20	872	195	0.8	3.2	1.5	26	102	211	806	53	6.6	5.4	24.0	10	4.1	8.3	39.6	47.1	0.9	52.0
WWSModPo12	10/20/2013	CFI 33	2.35	22	782	136	0.9	3.3	1.2	44	97	221	781	55	6.6	5.7	10	10	2.9	8.2	39.4	48.5	1	50.5
WWSGSPPre18	5/1/2013	CFI 25	2.52	20	872	195	0.8	3.2	1.5	26	102	211	806	53	6.6	5.4	24.0	10	4.1	8.3	39.6	47.1	0.9	52.0
WWSGSPM18	8/1/2013	CFI 26	2.52	20	872	195	0.8	3.2	1.5	26	102	211	806	53	6.6	5.4	24.0	10	4.1	8.3	39.6	47.1	0.9	52.0
WWSGSPPo18	10/20/2013	CFI 27	1.6	18	409	99	0.3	1.7	0.3	15	73	129	603	35	6.8	5.7	20.4	6	3.4	9.6	47.8	38	1.2	60.8
WWSModPre18	5/1/2013	CFI 34	0.77	22	343	125	0.1	0.6	0.3	9	97	67	631	22	6.9	6.1	9.1	6	4.8	14.6	57.1	21.7	1.7	76.5
WWSModM18	8/1/2013	CFI 35	2.51	17	846	210	0.5	3.2	1.5	20	98	215	785	58	6.7	5.5	18.8	9	5.1	9.2	44.3	40.6	0.8	58.6
WWSModPo18	10/20/2013	CFI 36	1.94	23	524	120	0.7	2.5	0.6	36	92	207	702	44	6.6	5.7	10.4	9	2.7	8.1	37.2	50.9	1.1	48

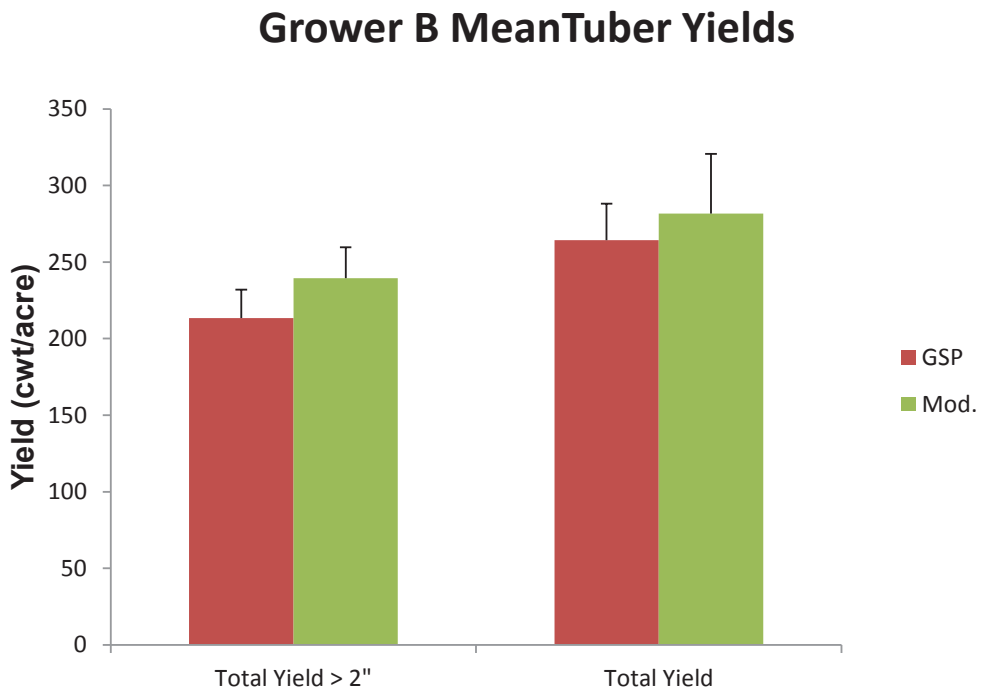
TISSUE_ID	Ca	P	Mg	K	Cu	NIT_N_R	Zn	B	S
WWSGSP Pe	1.06	0.23	0.36	9.03	3.94	2.81	47.4	24.0	0.10
WWSMod Pe	1.05	0.20	0.42	9.86	3.38	2.44	41.0	27.8	0.13
WWSGSP WP	1.11	0.39	0.47	5.74	13.42	1.27	64.0	31.5	0.28
WWSMod WP	1.19	0.32	0.56	5.94	9.08	1.12	52.3	38.6	0.26

	TISSUE_ID	CA	P	MG	K	CU	FE	MOIST.	N	Zn	B	S
GSP	CFITBR-3	0.04	0.21	0.09	1.99	4.69	32	21.6	1.7	17.6	4.8	0.09
Mod	CFITBR-4	0.03	0.19	0.09	2.04	4.13	50	22.2	1.5	15.1	5.2	0.11

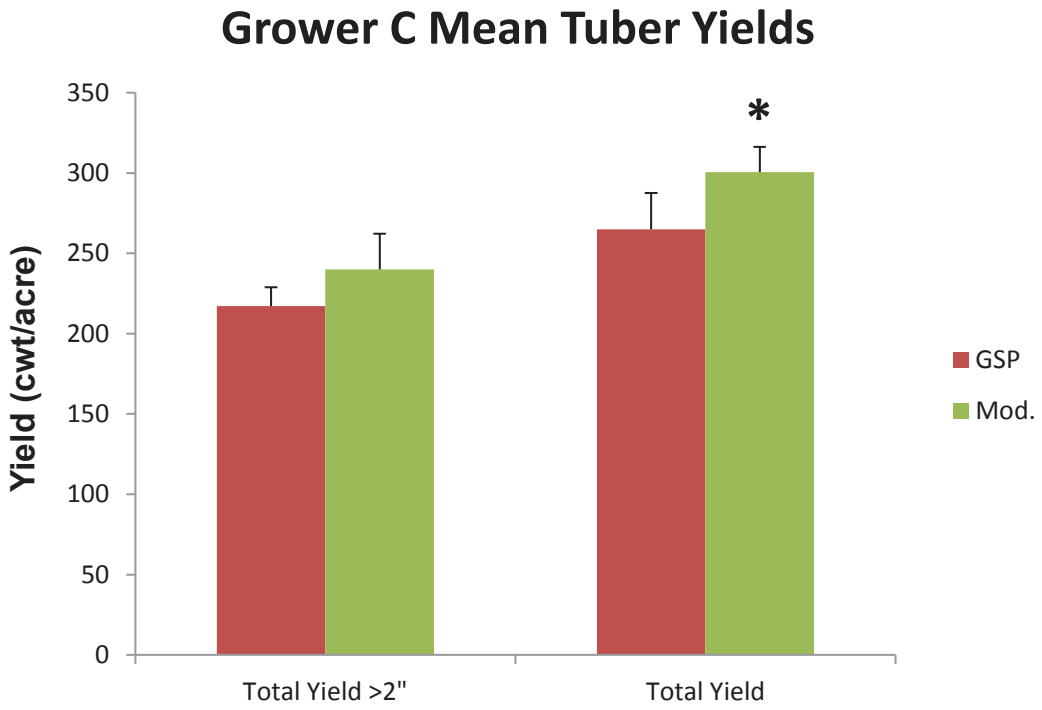
Appendix 2A. Yield data for Grower A (MacLennan Properties)



Appendix 2B. Yield data for Grower B (Brian and Scott Annear)

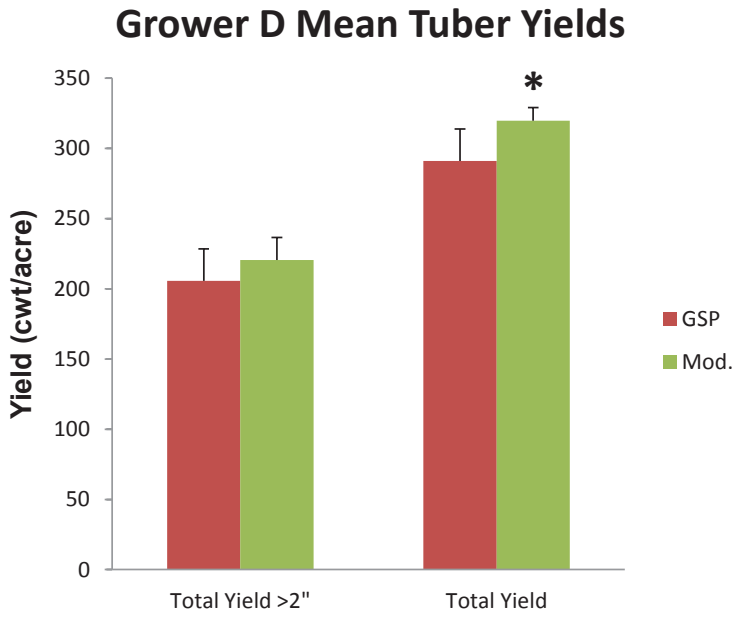


Appendix 2C. Yield data for Grower C (Hunter Farms)



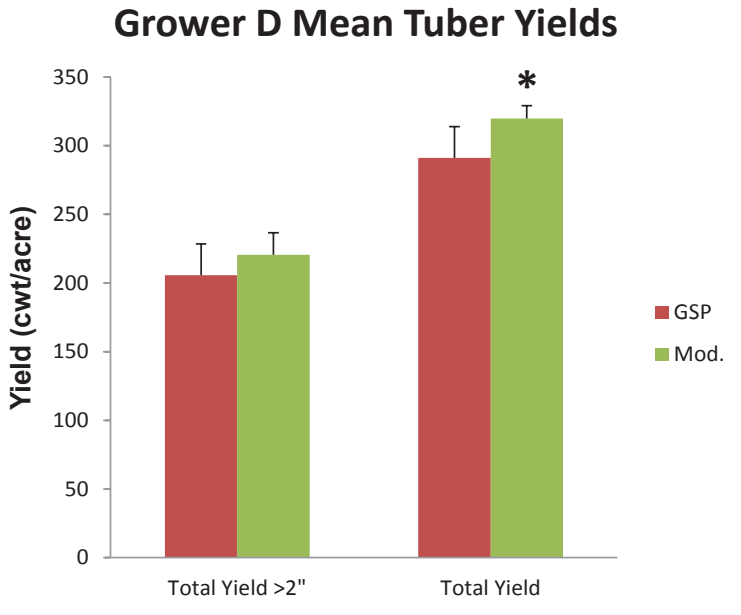
*** denotes a mean total yield significantly greater between treatments, at a 90% significance level (p-value =0.1).**

Append 2D. Yield data for Grower D (Birch Farms)



* denotes a mean total yield significantly greater between treatments, at a 90% significance level (p-value =0.1).

Appendix 2E. Yield data for Grower E (Willard Waugh and Sons)



* denotes a mean total yield significantly greater between treatments, at a 90% significance level (p-value =0.1).