Impurities in Sugarbeet Crown and Root[1]

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The ease and efficiency of sucrose recovery from sugarbeet depends on the relative amounts and types of impurities in factory juices (8, 16, 18)[3]. The steady decline in sugar recovery since the late 1940's may be attributed, in part, to excessive use of nitrogen (N) fertilizers (1, 7, 15, 20) and to processing greater portions of crown material (4, 5, 8, 19). Other possible reasons for loss in sugar recovery have been previously outlined (8).

Investigations by several workers (3, 5, 6, 11, 22, 23) showed that 10 to 22 percent of the weight of the whole beet was crown tissue. Percent sucrose in crown of fresh beet ranged from 0.5 to 2.0 percentage points less than in root (5, 6, 11, 22, 23). Juice purity values for crown averaged about 4.0 percentage points less than for root (6, 23). Despite the lower sucrose content and juice purity inherent in crown material, Zielke (23) found that significant quantities of sucrose could be recovered from crown material, that harvesting crown along with root had only a small influence in lowering beet quality and sucrose recovery, and that the additional yield gained from harvesting the crown could substantially increase overall sugar production. Dexter *et al.* (5) found that beets stored better with crowns intact, and that more sucrose was conserved during long storage periods than if crowns were removed.

In one study (6), raffinose in the crown was lower than in the root. Reducing sugars ranged from 20% (6) to 750% (3) greater in the crown. Hirst and Greaves (9) found "noxious" N in the crown to be double that in the root, and Carruthers *et al.* (3) determined the same relationship for amino-N.

Methods and Materials

1967 field experiment

A factorial split-split-plot design with six replications was arranged, with two N levels serving as the main-unit treatment. Cultivars and harvest dates were the successive subunit levels. The 24-lb/A rate

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[3]Numbers in parentheses refer to literature cited.

of N was applied as row fertilizer at planting time. The 150-lb rate consisted of the basic rate plus 126 lb/A of N applied at thinning time and cultivated into the soil. P and K were uniformly applied before planting, according to soil-test recommendations. Beet stands were thinned to a uniform 120 plants per 100 feet of row.

Three cultivars of sugarbeet (*Beta vulgaris* L.) were planted on May 2 near Sebewaing, Michigan. The cultivars were 'SP63194-0' (No. 1 in the tables), an open-pollinated monogerm; '02 clone' (No. 2), an open-pollinated multigerm; and 'US H20' (No. 3), a commercial monogerm hybrid. Each plot was four rows wide (28-inch rows) and 76 feet long. One interior-positioned row was randomly divided into four sections for harvest. A 13-foot sample was harvested on Sept. 14, Oct. 5, Oct. 24, and Nov. 7 for laboratory analyses.

1968 field experiment

We used a block design with six replications, involving two N levels in a split-plot. Factorial combinations within each split-plot consisted of two in-row spacings of beets, two cultivars, and two harvest dates. Each plot was 18 feet long and six rows wide (28-inch rows).

Row fertilizer supplied the 30-lb rate of N. An additional 120 lb of N was applied as in 1967 to provide the 150-lb/A rate. No supplemental fertilizer was used, because soil-test readings showed that P and K were adequate. Row fertilizer was placed 2 to 3 inches below the seed both years.

At harvest, the two in-row spacings of beets averaged 9.8 and 15.4 inches (122 and 78 plants per 100 feet of row).

Two cultivars were planted on April 30 near Saginaw, Michigan, both of which had as the female parent the F_1 monogerm 'SL(129× 133)cms.' 'SP6322-0' was the pollinator parent of cultivar No. 3 (US H20), and 02 clone of cultivar No. 4.

On Sept. 23 and on Oct. 21, 14 to 16 beets from each plot were harvested for laboratory analyses.

Laboratory analyses and techniques

Freshly harvested beets without petioles were delivered to the laboratory within four hours. Crowns on the beets were prepared by removing the petiole stubs and leaf buds with a knife, exposing the white crown tissue (Jorritsma and Oldfield, 10). The beets were then washed free of soil, and crowns were separated from roots with a straight cut at the lowest original leaf scar. Brei was collected by sawing each root in half through the long axis, and crowns were quartered to obtain sufficient brei. Juice samples were extracted from the brei and quickly frozen in a dry ice-alcohol bath. Various analyses were made on these samples by the methods listed in Table 1.

Results for each impurity were expressed as mg impurity/100 g RDS (refractometric dry substance). The concentration of total impurities in the juice (mg/100 g RDS) was calculated from the equation 100 − % CJP × 1,000; where % CJP is calculated from the ratio of sucrose to RDS in the clarified juice. Sucrose values (in the % CJP calculation) were corrected for polarimetric rotational effects of raffinose and reducing sugars (5). Alpha-amino N values were multiplied by 9.5 to express total amino acids. Chloride and betaine analyses were made only in 1968 on juices from cultivar 3. Crown/root ratios, calculated from raw data, were used to indicate relative concentrations of impurities in root and crown.

Table 1.—Methods of analyses of the brei collected from sugarbeets in the 1967 and 1968 experiments.

Analysis	Method	Literature citation
Juice clarification	DFS	Dexter *et al.* (4)
Alpha-amino N	Ninhydrin	Moore and Stein (14)
Reducing sugars	DNSA	Miller (13)
Raffinose	Coupled-enzyme	McCready and Goodwin (12)
Na and K	Flame photometer	
Chloride	Mercuric nitrate	Schales and Schales (17)
Betaine	Reineckate	Carruthers and Oldfield (2)

Results

Total impurities

Crown/root (C/R) ratios were significantly different for all treatments in two years' of tests (Table 2). Values ranged from a low of 1.54 in the 1968 spacing treatment to 2.00 for cultivar 3 in 1967. The average C/R values for each year differed by 0.21 (1.84 vs. 1.63), which may indicate that an unstable relationship exists between root and crown for total impurity accumulations under various environmental conditions.

The roots had greater total impurities (20% in 1967 and 25% in 1968) at high N than at low N level, and crowns at high N contained about 17% more impurities than those at low N. C/R ratios were not greatly altered by N levels, although the differences were significant.

Spacing of beets in the row did not affect total impurities in the crown, but the root had 11% less impurities at the 9.8-inch spacing than at 15.4 inches.

Impurities in root and crown decreased considerably after the first harvest in both years. A rainy period early in October 1967 may have caused the impurity level in the crown tissue to fluctuate more than in the root, so that C/R ratios did not establish a clear pattern of development.

Table 2.—Effect of nitrogen, plant spacing, cultivar, and harvest date on total impurities in sugarbeet root and crown.

1967 treatment	Total impurities: Root	Crown	Wtd avg	Crown/root ratio	1968 treatment	Total impurities: Root	Crown	Wtd avg	Crown/root ratio
	-----mg/100 g RDS-----					-----mg/100 g RDS-----			
N applied					N applied				
24 lb/A	5,177	9,424	6,002	1.86	30 lb/A	5,523	9,116	6,081	1.67
150 lb/A	6,201	11,005	7,399	1.82	150 lb/A	6,898	10,780	7,668	1.59
	**	**	**	*		**	**	**	**
					Spacing				
					9.8 in.	5,850	9,894	6,549	1.72
					15.4 in.	6,571	10,002	7,200	1.54
						**	ns	**	**
Cultivar					Cultivar				
1	5,993	9,763	6,861	1.66	3	6,219	10,370	6,983	1.68
2	5,852	10,600	6,791	1.85	4	6,201	9,526	6,765	1.57
3	5,222	10,281	6,450	2.00		ns	**	ns	*
	**	**	*	**					
Harvest					Harvest				
Sept. 14	7,095	11,103	7,971	1.58	Sept. 23	6,412	10,686	7,180	1.69
Oct. 5	5,232	9,519	6,208	1.84	Oct. 21	6,009	9,210	6,569	1.57
Oct. 24	5,259	10,290	6,366	1.98		**	**	**	*
Nov. 7	5,170	9,947	6,258	1.94					
	**	**	**	**					
Test avg	5,689	10,215	6,701	1.84	Test avg	6,210	9,948	6,874	1.63

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

A nitrogen × cultivar interaction in 1967 indicated that impurities in the root for cultivar 2 were 1,400 mg greater at high than at low N, but cultivar 1 was only 700, and cultivar 3 was 1,100 mg greater.

Amino acids

On the average, amino acids (Table 3) accounted for 22 to 24% of the total impurities (Table 2) in the root and about 30% of the total impurities in the crown.

C/R ratios ranged from a low of 2.15 in 1967 to a high of 2.70 in 1968 (Table 3), although the test averages differed by only 0.16. Nitrogen treatments affected C/R ratios most. This was caused by relatively larger increases (66% in 1967 and 80% in 1968) in amino acids in the root at the high than at the low N levels, compared to increases observed in the crown (about 45% both years).

The 9.8-inch plant spacing did not significantly lower amino acid levels in either the root or crown, as compared with the 15.4-inch spacing.

Among cultivars, amino acid concentrations varied considerably more in the crown than in the root. In 1968, cultivar 4 contained less amino acids in the crown than cultivar 3, which had a different male parent, but content in the root did not differ.

Amino acids decreased in both root and crown during the early harvests in 1967, but they did not change between the two harvests in 1968.

Potassium

Potassium (Table 4) accounted for about 15% of total impurities in roots and 13% in crowns.

C/R values differed for varieties, harvest dates (1967), and spacing treatments (1968), but in general, they did not vary as much among treatments in the same year as between years (Table 4).

The high N rate significantly increased K in the crown for both tests as compared to low N, but levels of K in the root differed only in 1967. Also, the wider spacing of beets (1968) increased K in both root and crown compared to the closer spacing. For cultivars, K in crown was more variable than in the root. The C/R ratios for cultivar 3 differed by 0.46 between the two tests, which indicates considerable environmental effect on accumulation of K in root and crown.

Much lower levels of K were found in root and crown in October harvests each year than in September harvests. Most of the reduction in 1967 occurred before October 5.

Table 3.—Effect of nitrogen, plant spacing, cultivar, and harvest date on amino acids in sugarbeet root and crown.

1967 treatment	Amino acids: Root	Amino acids: Crown	Amino acids: Wtd avg	Crown/root ratio
	----- mg/100 g RDS -----			
N applied				
24 lb/A	1,041	2,486	1,322	2.42
150 lb/A	1,731	3,604	2,199	2.15
	**	**	**	*
Cultivar				
1	1,256	2,677	1,585	2.21
2	1,439	3,132	1,778	2.28
3	1,463	3,326	1,919	2.37
	*	**	**	**
Harvest				
Sept. 14	1,627	3,471	2,033	2.21
Oct. 5	1,380	2,935	1,741	2.20
Oct. 24	1,261	2,891	1,624	2.36
Nov. 7	1,276	2,883	1,645	2.37
	**	**	**	ns
Test avg	1,386	3,045	1,761	2.29

1968 treatment	Amino acids: Root	Amino acids: Crown	Amino acids: Wtd avg	Crown/root ratio
	----- mg/100 g RDS -----			
N applied				
30 lb/A	977	2,522	1,220	2.70
150 lb/A	1,762	3,691	2,144	2.21
	**	**	**	**
Spacing				
9.8 in.	1,304	3,081	1,616	2.59
15.4 in.	1,436	3,132	1,748	2.32
	ns	ns	ns	*
Cultivar				
3	1,366	3,362	1,738	2.63
4	1,374	2,850	1,626	2.28
	ns	**	ns	**
Harvest				
Sept. 23	1,368	3,199	1,698	2.47
Oct. 21	1,372	3,014	1,666	2.43
	ns	ns	ns	ns
Test avg	1,370	3,106	1,682	2.45

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

Table 4.—Effect of nitrogen, plant spacing, cultivar, and harvest date on potassium in sugarbeet root and crown.

1967 treatment	Potassium Root	Potassium Crown	Potassium Wtd avg	Crown/root ratio	1968 treatment	Potassium Root	Potassium Crown	Potassium Wtd avg	Crown/root ratio
	------ mg/100 g RDS ------					------ mg/100 g RDS ------			
N applied					N applied				
24 lb/A	771	1,222	859	1.61	30 lb/A	916	1,148	952	1.28
150 lb/A	877	1,345	995	1.57	150 lb/A	982	1,225	1,030	1.26
	**	**	**	ns		ns	**	*	ns
					Spacing				
					9.8 in.	889	1,163	937	1.33
					15.4 in.	1,009	1,211	1,045	1.22
						**	*	**	**
Cultivar					Cultivar				
1	888	1,274	977	1.45	3	971	1,232	1,019	1.29
2	794	1,207	875	1.56	4	927	1,141	963	1.25
3	790	1,369	930	1.75		ns	**	**	ns
	**	**	**	**					
Harvest					Harvest				
Sept. 14	1,005	1,490	1,111	1.50	Sept. 23	1,024	1,264	1,066	1.25
Oct. 5	798	1,249	901	1.59	Oct. 21	874	1,110	916	1.29
Oct. 24	764	1,225	867	1.64		**	**	**	ns
Nov. 7	728	1,169	830	1.61					
	**	**	**	*					
Test avg	824	1,283	927	1.59	Test avg	949	1,187	991	1.27

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

Reducing sugars

Reducing sugars in root and crown (Table 5) comprised about 6 to 9% of the total impurities analyzed.

Except for harvest dates, C/R values did not differ for treatments in the same year, but values were quite different between years (average difference of 0.32).

Reducing sugars were significantly, but not substantially, greater at the 150-lb rate than at the lower N rate. Increases in reducing sugars from low to high N were 5% for roots and 9% for crowns in 1967, and 11% for roots and for crowns in 1968.

Cultivar 2 contained less reducing sugars than the other cultivars in 1967, but cultivars did not differ appreciably in 1968. The C/R value for cultivar 3 was 0.37 lower in 1968 than in 1967. The difference may be attributable to environmental effects that caused differential accumulations of reducing sugars in root and crown.

Reducing sugar concentrations declined at variable rates in both root and crown after the first harvests, as indicated by the changing C/R ratios. Most of the decline occurred before the second harvest in 1967.

Raffinose

Raffinose in root and crown in 1967 was about triple that in 1968 (Table 6). The higher values also affected the percent composition of raffinose to total impurities analyzed. Raffinose comprised 15% of total impurities found in root and 12% in crown in 1967, whereas it accounted for about 5% of all impurities in either roots or crowns in 1968.

N rates, plant spacings, and various cultivars had little effect on the levels of raffinose found in root and crown. Substantial increases in raffinose occurred as harvests progressed, however. Between the September and late October harvests, raffinose increased 58% in the root and 39% in the crown in 1967 and 115% and 80% in root and crown, respectively, in 1968.

Sodium

In these tests, sodium comprised less than 1.0% of the total impurities found in root and about 2.0% of the total found in the crown. C/R ratios for sodium were quite different for the two years, however, averaging 2.39 in 1967 and 1.45 in 1968 (Table 7). Only the ratios for cultivars in 1967 were significantly different, however.

Nitrogen had a marked effect on sodium in both tests. Sodium was 41% greater in the root, and 28% greater in the crown at the high compared to low N level in 1967, and 79% and 72% greater at high N in 1968.

Table 5.—Effect of nitrogen, plant spacing, cultivar, and harvest date on reducing sugars in sugarbeet root and crown.

1967 treatment	Reducing sugars Root	Reducing sugars Crown	Reducing sugars Wtd avg	Crown/root ratio
	----- mg/100 g RDS -----			
N applied				
24 lb/A	392	585	430	1.53
150 lb/A	410	639	468	1.57
	*	**	**	ns
Cultivar				
1	429	647	480	1.52
2	356	524	389	1.51
3	418	664	478	1.61
	**	**	**	ns
Harvest				
Sept. 14	460	706	515	1.54
Oct. 5	403	556	439	1.39
Oct. 24	371	618	426	1.70
Nov. 7	370	567	415	1.56
	**	**	**	**
Test avg	401	612	449	1.55

1968 treatment	Reducing sugars Root	Reducing sugars Crown	Reducing sugars Wtd avg	Crown/root ratio
	----- mg/100 g RDS -----			
N applied				
30 lb/A	515	628	533	1.23
150 lb/A	574	698	599	1.23
	*	*	*	ns
Spacing				
9.8 in.	543	682	568	1.27
15.4 in.	546	645	563	1.19
	ns	*	ns	ns
Cultivar				
3	554	680	577	1.24
4	536	646	555	1.22
	ns	*	*	ns
Harvest				
Sept. 23	567	712	592	1.27
Oct. 21	522	615	539	1.19
	**	**	**	*
Test avg	545	663	566	1.23

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

Table 6.—Effect of nitrogen, plant spacing, cultivar, and harvest date on raffinose in sugarbeet root and crown.

1967 treatment	Raffinose Root	Crown	Wtd avg	Crown/root ratio
	----- mg/100 g RDS -----			
N applied				
24 lb/A	860	1,270	939	1.49
150 lb/A	809	1,195	904	1.61
	*	*	*	ns
Cultivar				
1	842	1,258	937	1.55
2	822	1,277	911	1.69
3	839	1,163	917	1.41
	ns	**	ns	**
Harvest				
Sept. 14	592	1,061	694	1.99
Oct. 5	627	807	666	1.29
Oct. 24	937	1,471	1,052	1.57
Nov. 7	1,181	1,590	1,273	1.35
	**	**	**	**
Test avg	834	1,232	921	1.55

1968 treatment	Raffinose Root	Crown	Wtd avg	Crown/root ratio
	----- mg/100 g RDS -----			
N applied				
30 lb/A	288	448	312	1.84
150 lb/A	312	458	341	1.61
	ns	ns	ns	ns
Spacing				
9.8 in.	308	469	336	1.81
15.4 in.	291	436	317	1.64
	ns	**	ns	ns
Cultivar				
3	310	476	340	1.83
4	389	430	313	1.62
	ns	**	*	ns
Harvest				
Sept. 23	190	323	214	1.79
Oct. 21	409	583	439	1.67
	**	**	**	ns
Test avg	300	453	326	1.73

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

Table 7.—Effect of nitrogen, plant spacing, cultivar, and harvest date on sodium in sugarbeet root and crown.

1967 treatment	Sodium Root	Sodium Crown	Sodium Wtd avg	Crown/root ratio	1968 treatment	Sodium Root	Sodium Crown	Sodium Wtd avg	Crown/root ratio
	----- mg/100 g RDS -----					----- mg/100 g RDS -----			
N applied					N applied				
24 lb/A	39	92	49	2.48	30 lb/A	92	127	98	1.49
150 lb/A	55	118	71	2.30	150 lb/A	165	218	176	1.42
	*	**	**	ns		**	**	**	ns
					Spacing				
					9.8 in.	121	166	129	1.47
					15.4 in.	137	179	144	1.44
						ns	*	*	ns
Cultivar					Cultivar				
1	48	105	61	2.33	3	136	187	145	1.50
2	48	100	59	2.17	4	122	158	128	1.40
3	44	110	60	2.68		ns	**	*	ns
	ns	*	ns	**					
Harvest					Harvest				
Sept. 14	72	156	91	2.31	Sept. 23	154	200	162	1.40
Oct. 5	39	94	52	2.58	Oct. 21	104	145	111	1.50
Oct. 24	39	82	49	2.27		**	**	**	ns
Nov. 7	37	86	49	2.40					
	**	**	**	ns					
Test avg	47	105	60	2.39	Test avg	129	173	137	1.45

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

Data for cultivar 3 pointedly illustrate the independence of sodium accumulation in root and crown. Content in the crown was 2.7 times greater than that of the root in 1967 but only 1.5 times that of the root in 1968.

Sodium in root and crown decreased between the first and second harvest in 1967, but remained relatively stable thereafter.

Betaine

Betaine accounted for 15% of the total impurities found in both root and crown of cultivar 3. The average C/R ratio did not vary as a result of nitrogen, spacing, or harvest date (Table 8).

Betaine in the root was about 11% greater at high than at low N, but did not differ in the crown at these N levels. Root and crown had 10% greater betaine at the wide as compared to close plant spacing. Although betaine in root and crown was lower for the second harvest than for the first, differences were not significant, except between weighted averages.

Table 8.—Effect of nitrogen, plant spacing, and harvest date on betaine in sugarbeet root and crown (1968).

Treatment	Betaine Root	Betaine Crown	Betaine Wtd avg	Crown/root ratio
	--------mg/100 g RDS--------			
N applied				
30 lb/A	885	1,518	986	1.72
150 lb/A	979	1,575	1,100	1.62
	*	ns	**	ns
Spacing				
9.8 in.	889	1,474	992	1.67
15.4 in.	975	1,620	1,094	1.68
	**	**	**	ns
Harvest				
Sept. 23	946	1,587	1,064	1.69
Oct. 21	918	1,506	1,022	1.66
	ns	ns	*	ns
Test avg	932	1,547	1,043	1.67

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

Chloride

Chlorides comprised 2% of total impurities in root and 3% in crown of cultivar 3. The average C/R ratio was 2.17 (Table 9), but C/R ratios varied significantly within nitrogen and spacing treatments.

No significant differences in chloride values in root or in crown were evident between N levels. However, chloride concentrations in the root were 37% greater both for the wide as compared to close

Table 9.—Effect of nitrogen, plant spacing, and harvest date on chloride in sugarbeet root and crown (1968).

Treatment	Chloride Root	Crown	Wtd avg	Crown/root ratio
	---------- mg/100 g RDS ----------			
N applied				
30 lb/A	130	281	154	2.34
150 lb/A	143	276	170	1.99
	ns	ns	ns	**
Spacing				
9.8 in.	115	262	141	2.39
15.4 in.	158	295	183	1.94
	**	**	**	**
Harvest				
Sept. 23	158	315	187	2.12
Oct. 21	115	242	138	2.22
	**	**	**	ns
Test avg	136	278	162	2.17

*,** F tests significant at the 5- and 1-percent levels of probability, respectively.
ns F test not significant.

spacing and for the September as compared to October harvest. Chloride in the crown was 13% higher at the wide than at close spacing and 30% higher for the September than for the October harvest.

Discussion

Average C/R ratios for raffinose, K, reducing sugars, and amino acids differed by no more than 0.3 between 1967 and 1968, but the ratios for Na differed by 0.9. Clearly, accumulations of Na were directly influenced by certain unknown environmental conditions. Because there was a degree of difference between the yearly C/R ratios for the other impurities, subtle environmental effects may have also altered those ratios. This is especially evident when comparisons are made for cultivar 3, which was grown both years.

Weighted averages show the integration of the proportional weight of root (about 80%) and crown (about 20%) material with their respective levels of impurities, which would represent the concentration to be found in the whole beet (root plus crown). Weighted average total impurities (Table 2) exceeded impurities of an equal weight of root by only 18% in 1967 and 11% in 1968. Thus, greater impurity concentrations in the crown are considerably ameliorated when the whole beet is considered.

These studies indicate that N fertilization of the beet crop must be judiciously regulated to avoid serious accumulations of amino acids (Table 3) and total impurities (Table 2) in both root and crown. Furthermore, we observed that total recoverable sucrose per acre at low N was equal to, or slightly greater than, that obtained at high N (23).

Thus, controlling the amount of N applied to the crop may not only reduce the quantity of impurities involved in processing, but could increase the recoverable sugar per acre.

In-row spacing of beets did not affect impurities in the crown; only potassium in the root was significantly greater at the wider spacing. Varying the row width seems to have a greater effect on impurities (21).

Total impurities in root and crown declined after the first harvest each year. Amino acids in root and crown decreased only in 1967, but potassium, sodium, and reducing sugars declined both years. According to the 1967 results, much lower impurity levels may be expected by the second week in October. These decreases, along with expected increases in yield and sucrose content (23), strongly suggest greater economic returns by delaying commercial harvest until early October.

Two important results concerning cultivars emerged from these tests. First, if cultivars were to be arranged in rank order for total impurities, the rank for roots and crowns may not be the same. Cultivar 3 (1967) had the least impurities in the root, but was intermediate for impurities in the crown. Conversely, cultivar 1 had the most impurities in the root, but least in the crown. The ideal situation for processing purposes would be the combination of impurities in root and crown giving the lowest weighted average for the whole beet. Secondly, it may be necessary in the future to characterize cultivars for individual rather than for total impurities. Cultivar 1 had the highest total impurity concentration in the root of the three cultivars tested in 1967, but the lowest for amino acids. Cultivar 3, lowest in total impurities, was highest in amino acids.

Summary

Sugarbeets were grown near Sebewaing and St. Charles, Michigan in 1967 and 1968, respectively, to measure individual and total impurities in the root and crown. Impurity accumulations were considerably influenced by date of harvest and nitrogen nutrition, whereas plant spacing in-the-row and various cultivars showed much less effect. The concentration of impurities in crowns averaged 70% more than in roots, but impurities for the whole beet (weighted average of root plus crown) were only 10 to 20% greater than those for roots.

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