Sucrose Production as Affected by Root Yield and Sucrose Concentration of Sugarbeets*

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INTRODUCTION

Refined sugar production of sugarbeets (*Beta vulgaris* L.) is based on the product of root yield and extractable sucrose concentration. Conditions that affect either of these components may either increase or decrease refined sugar yield. Therefore, it is of prime importance to use practices and conditions that provide adequate top and root growth while maintaining sufficiently high sucrose concentration and purity for profitable sucrose extraction and yield.

An inherent inverse relationship exists between sugarbeet root yield and wet root sucrose concentration (9,10,15). Increasing root yields by plant breeding, genetic selection, nitrogen (N) fertilization, agronomic practices, and environmental conditions will generally decrease sucrose concentration (5,14). Milford (13) and Doney (7,8) have both reported an inverse relationship between root cell size and sucrose concentration, and have suggested that the negative correlation results from the opposite effects of cell size on root yield and sucrose concentration. Large cells produce large roots with high root yields and low sucrose concentration; whereas small cells produce small roots with low root yields and high sucrose concentration.

Recently reported experimental results showed that N uptake and the proportion and amounts of potassium (K) and sodium (Na) have a major influence on sucrose concentration and root quality (2,3). Increased N uptake reduces

sucrose concentration by making the tops the dominant pho-
tosynthate   sink   at   the expense of the   roots,   and   by
changing   the concentration and proportion of root   K   and
Na.   Increasing   the   Na concentration or decreasing   the
K:Na ratio by increased N uptake, increases the root water
concentration   with a reduction in sucrose   concentration.
Variations in Na concentrations and K:Na ratios for sugar-
beets grown at different locations the same year,   between
years, and   between different genotypes   also   results   in
water and sucrose concentration changes.   These variations
in   water   concentration between treatments and   genotypes
indicate   that root Na concentrations and/or   K:Na   ratios
may   be involved in the inverse relationship between   root
yield and sucrose concentration.   Therefore, the objective
of   this investigation was to evaluate sucrose   production
as affected by root yield,   wet and dry sucrose concentra-
tions,   and   dry matter and water concentrations of widely
different *Beta vulgaris* genotypes   grown at   different   N
uptake levels,   field locations,   climatic conditions, and
years.

MATERIALS AND METHODS

Eleven   experiments on sugarbeets have been   conducted
since 1967 by scientists located at Kimberly, with experi-
mental plots at 36 locations in southern Idaho.   Referen-
ces   to and specific procedures used in these   experiments
have been published (2,3).   These experiments were conduc-
ted on Portneuf silt loam soil (Durixerollic Calciorthids;
coarse-silty,   mixed, mesic) with the exception of some of
the plot areas in the 1971 and 1972 studies.   The majority
of   soils in southern Idaho have a weakly cemented hardpan
at the 0.5- to 0.6-m depth that has little effect on water
movement but may restrict some root penetration.

Soil samples were taken from each experiment in   early
spring   before fertilizer application by 0.15-m depth   in-
crements to the   0.6-m depth or to the hardpan.   The soil
samples were air dried, ground, and stored until analyzed.
The   potentially   available soil N was determined   on   all
samples (5).

Most of the agronomic practices such as planting date, cultivation, and harvest date were rather uniform among years. However, variations in these practices that cause changes in the sugarbeet growth and yield components are given in this section, tables, figures, or in the discussion of this information.

The sugarbeets [Amalgamated AH-10 (1967 to 1980), WS-76 (1982), WS-76 and WS-88 (1983), and *Beta vulgaris* genotypes (4) with the common name of GWD2, AH-10 (commercial hybrids); LHY-1, LHS-1 (Experimental hybrids); Monorosa, Monoblanc (Fodder beet hybrids); Pajbjerg Korsroe, and Rota (Fodder beets) (1980)] were planted in early to mid-April in either 0.56 or 0.61 m rows and thinned to a 0.23 to 0.30 m within row spacing in early June.[1]

Nitrogen, as ammonium nitrate, was applied preplant and in mid-June by broadcast or sidedress applications. Later N applications were broadcast as urea and moved into the soil with sprinkler irrigation. All experimental plot areas were adequately supplied with phosphorus (16).

Alternate furrow (every other furrow and alternating furrows at each irrigation) or sprinkler irrigations were used. Experimental areas were adequately irrigated based on previous irrigation experiments except where deficit irrigation was intentionally imposed.

The sugarbeets were harvested in October by taking top and root samples from three to six 3-m row lengths or by mechanically harvesting the roots from a larger area of each plot at final harvest in October. All beet roots were horizontally sectioned at the lowest leaf scar into harvested root and crown tissue before taking duplicate or triplicate root (16 to 18 roots per sample) and crown samples. The sucrose concentration in the beet roots and crowns was determined by the Amalgamated Sugar Company using the Sachs-le Docte cold digestion procedure as outlined by McGinnis (12).

[1]Mention of trade names or companies is for the benefit of the reader and does not imply endorsement by the U.S. Department of Agriculture.

Moisture content and dry weights were determined in
beet top, root, and crown samples dried at 65°C. The
dried samples were ground and total N was determined by
the macro, or semimicro, Kjeldahl procedure modified to
include nitrate (1). The N uptake was estimated by
assuming that the element concentration was the same in
both the fibrous and storage roots (root + crown) and the
weight of the unharvested fibrous roots was equal to 25%
of the total harvested storage root weight (11).

Dry matter and water yields were calculated by multi-
plying their concentrations in the roots by the root
yield. The root yield gains attributed to changes in dry
matter and water concentrations were calculated by sub-
tracting the dry matter or water yields of the check or
reference treatment from the dry matter or water yields of
the adjusted or higher yielding treatment.

The decrease in sucrose concentration of the wet root
attributed to increases in the water concentration was
calculated by using either of the following equations:

$$S_L = S_c - [SY_c/(DMY_c/(100-W_T))]$$

or

$$S_L = S_c - [(DM_T \times S_c)/(100 - W_c)]$$

where S_L is the percent unit sucrose decrease resulting
from root water gain, S_c is the percent wet root sucrose
of the check or reference treatment, SY_c is the sucrose
yield of the check or reference treatment, DMY_c is the dry
matter yield of the check or reference treatment, W_T is
the percent root water of the adjusted treatment, DM_T is
the percent root dry matter of the adjusted treatment, and
W_c is the percent root water of the check or reference
treatment.

The decrease in sucrose concentration resulting from
decreases in the percent sucrose of the dry matter was
calculated by differences between that attributed to water
gain and the total percent sucrose decrease of the wet
roots.

The change in sucrose yield between treatments, years,
or genotypes attributed to percent sucrose of the dry

matter (PSDM) and dry matter changes was calculated using
the following equations:

$$S_{PSDM} = SWt_2 - SWt_{1\&2}$$

and

$$S_{DM} = SWt_{1\&2} - SWt_1$$

where S_{PSDM} is the sucrose yield change attributed to
PSDM, S_{DM} is the sucrose yield change attributed to dry
matter, $SWt_1 = (PSDM_1/100) \times DM\ yd_1$, $SWt_2 = (PSDM_2/100) \times DM\ yd_2$, $SWt_{1\&2} = (PSDM_1/100) \times DM\ yd_2$, DM yd is the dry
matter yield, subscript 1 is the lower sucrose yield
treatment, and subscript 2 is the higher sucrose yield
treatment.

RESULTS AND DISCUSSION

The *Beta vulgaris* genotypes varied widely in their
root yield, sucrose and water concentrations (Table 1).
When the genotype with the lowest root yield and highest
sucrose concentration (LHS-1) was compared with the other
genotypes, the proportion of the root yield increase at-
tributed to water and dry matter varied with genotype.
The proportion of the root yield increase attributed to
water varied from 86 to 102% and averaged 95% of the total
increase. The remaining increase in root yield of -2 to
14% was attributed to dry matter increase. The sucrose
concentration (% wet root) decrease resulting from water
increase varied among the genotypes from 68 to 95% and
averaged 89% of the total decrease. Whereas, sucrose con-
centration decrease resulting from a decrease in the per-
cent sucrose of the dry matter (PSDM) varied from 5 to
32% and averaged 11% of the total. Total sucrose yield is
the product of PSDM and dry matter production. Genotypes,
treatments, or conditions that affect either or both of
these yield factors usually change sucrose yield. The
sucrose yield changes among genotypes resulted from both a
change in PSDM and dry matter production (Table 1). How-
ever, the major cause of sucrose yield change was, in most
cases, attributed to dry matter production. Sucrose pro-
duction generally followed the proportion of dry matter to
water that increased root yield. Higher sucrose produc-

Table 1. Changes in root and sucrose yields, and sucrose concentration between *Beta vulgaris* genotypes attributed (attr.) to percent sucrose of the dry matter (PDSM), dry matter (DM), and water in the roots during 1980.

Beta vulgaris genotypes	Total N uptake	Root yield				ROOT + CROWN†							
			Change. attr. to:				Sucrose Concentration				Sucrose Yield		
		Total	DM	Water	% §	Wet wt.	Change. attr. to:		% §	Dry wt.	Total	Change. attr. to:	
							PSDM	Water				PSDM	DM
	kg ha⁻¹	----- Mg ha⁻¹ -----			% §	%	-% units ¶		% §	%	----- Mg ha⁻¹ -----		
LHS-1‡	322	73.0				19.7				75.4	14.32		
AH-10	332	79.8	+0.2	+6.6	+97	17.5	-0.7	-1.5	-68	72.5	13.91	-0.56	+0.15
GWD2	339	86.0	+1.4	+11.6	+89	17.7	-0.1	-1.9	-94	74.8	15.24	-0.12	+1.04
LHY-1	324	87.0	+1.9	+12.1	+86	18.0	-0.2	-1.5	-90	74.7	15.62	-0.15	+1.45
Monorosa	360	98.5	+0.4	+25.1	+98	14.5	-0.4	-4.8	-93	73.5	14.26	-0.37	+0.31
Monoblanc	343	112.0	+1.5	+37.5	+96	13.5	-0.3	-5.9	-95	73.8	15.11	-0.33	+1.12
Rota	318	130.2	-1.2	+58.4	>+100	9.5	-0.8	-9.4	-92	69.6	12.37	-1.10	-0.85
Pajbjerg K.	357	131.8	+1.9	+56.9	+97	11.2	-0.8	-7.7	-90	70.3	14.68	-1.08	+1.44

† Avg. of 196 and 392 kg N ha⁻¹ applied N treatments.
‡ Lowest root yield and highest wet root sucrose concentration.
§ Percent of total gain or decrease.
¶ Actual % sucrose units, wet weight.

tion was obtained when the increase in dry matter in rela-
tion to water was highest while maintaining a reasonably
high PSDM and vice versa.

High negative linear correlations existed between the
root water and sucrose concentrations of the different
genotypes at each of the two N levels (Figure 1A). There
also was a high negative linear correlation between root
or water yields and sucrose concentration at the two N
levels (Figure 1B). The slopes of the regression lines
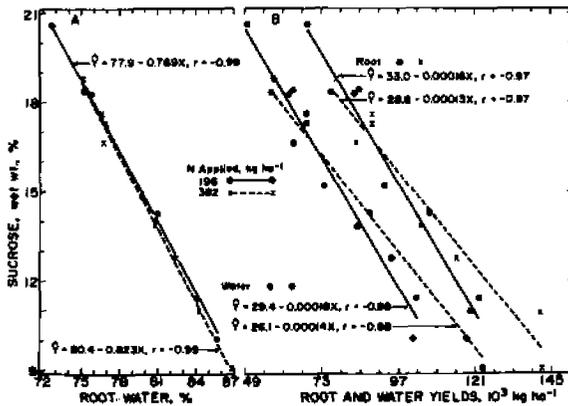
Figure 1. Effect of root: (A) water concentration on suc-
          rose concentration, and (B) water and root yields
          on sucrose concentration of different *Beta vul-*
          garis genotypes during 1980. All correlation co-
          efficients highly significant at the 1% level.

were also essentially the same for root and water yields
when compared with sucrose concentration at the two N
levels. These relationships indicate that the inverse
relationship between root yield and sucrose concentration
of different genotypes resulted mainly from the increased
proportion of water to dry matter in the roots with higher
root yields. However, PSDM level does contribute to this
inverse relationship that varies among genotypes and may
contribute up to 32% of the change in sucrose concentra-
tion. This increase in root water among genotypes was as-
sociated with an increase in the Na concentration and/or a
decrease in the K:Na ratio of the root (3).

Increasing N applications and N uptake by commercial

sugarbeet varieties on low N soils, generally increase root and sucrose yields but may decrease both wet and dry sucrose concentrations during each of several years when compared with the zero N treatment (Table 2). The root yield increase consists of both dry matter and water. However, the proportion of water to dry matter increases with increasing N uptake. The decrease in sucrose concentration of the wet roots with increased N uptake was caused by both a decrease in the PSDM and a decreased dry matter or increased water concentrations. However, the greatest amount of sucrose concentration decrease was caused by the increased proportion of water to dry matter in the roots. High linear correlations generally existed between root dry matter or water (WC) and sucrose concentrations (y) during each of the years (1968: $\hat{y} = 46.9 - 0.39$ WC, $r = -0.61^*$; 1977: $\hat{y} = 113.3 - 1.26$ WC, $r = -0.99^{**}$; 1982: $\hat{y} = 89.1 - 0.92$ WC, $r = -0.97^{**}$). This indicates that the inverse relationship between root yield and sucrose concentration within genotypes with increased N uptake resulted mainly from the increased proportion of water to dry matter with a lesser but important amount that can be attributed to a decrease in the PSDM. This increase in root water with increased N uptake has also been associated with an increase in the Na concentration and/or a decrease in the K:Na ratio (3).

Sucrose yield increased above the zero N treatment with increased N uptake during each of the years with the exception of the highest N uptake in 1977 (Table 2). Sucrose yield change with increased N uptake resulted from a change in both PSDM and dry matter yield. However, the majority of the yield differences was attributed to a change in dry matter yield with a smaller change attributed to the PSDM. Maximum sucrose yield was generally obtained when the increase in root yield was highest for dry matter rather than as water while maintaining a reasonably high PSDM.

Increasing N applications and N uptake by sugarbeets grown throughout southern Idaho with varying soil and cli-

Table 2.   Changes in root and sucrose yields, and sucrose concentration between N uptake levels and year of plant growth at one location attributed (attr.) to percent sucrose of the dry matter (PSDM), dry matter (DM), and water in the roots.

Year	R + C Total N uptake	Root yield			ROOT - CROWN (R - C) Sucrose Concentration					Sucrose Yield		
		Total	Change. attr. to: DM	Water %‡	Wet wt.	PSDM	Change. attr. to: Water	%‡	Dry wt.	Total	Change. attr. to: PSDM	DM
	kg ha⁻¹	----- Mg ha⁻¹ -----			%	-% units -§			%	---- Mg ha⁻¹ ----		
1968	258†	46.1			16.6				74.5	7.65		
	380	52.5	+1.0	+5.4	+87	16.2	+0.2	-0.6	>-100	75.5	8.48	+0.11	+0.72
	416	56.9	+1.8	+9.0	+83	16.3	+0.4	-0.7	>-100	76.3	9.25	+0.22	+1.38
	459	55.4	+1.6	+7.7	+83	16.1	+0.2	-0.7	>-100	75.6	8.94	+0.13	+1.16
1977	130†	46.1			19.3				75.2	8.89		
	210	52.1	+1.3	+4.7	+79	19.0	+0.1	-0.4	>-100	75.6	9.92	+0.06	+0.97
	338	54.2	+1.4	+6.7	+83	17.8	-0.6	-0.9	-63	72.9	9.66	-0.30	+1.07
	407	51.4	+0.2	+5.1	+96	16.8	-0.9	-1.6	-66	71.5	8.62	-0.43	+0.16
1982	222†	65.1			16.8				76.7	10.95		
	321	71.8	+1.1	+5.6	+84	16.6	+0.2	-0.4	>-100	77.8	11.92	+0.16	+0.81
	376	73.8	+1.3	+7.4	+87	16.2	+0.1	-0.7	>-100	77.1	11.96	+0.06	+0.95
	436	74.2	+1.2	+7.9	+87	15.8	-0.2	-0.8	-80	75.7	11.74	-0.15	+0.94
	468	74.4	+0.9	+8.4	+92	15.5	-0.1	-1.2	-88	75.9	11.49	-0.11	+0.65

† Lowest root yield and highest wet root sucrose concentration.

‡ Percent of total gain or decrease.

§ Actual % sucrose units, wet weight.

matic conditions showed essentially the same trends (data
not shown). Root yields may or may not increase depending
upon the N status of the soil. On sites where there was a
root yield increase, both dry matter and water changes
contributed to these yield differences. The root yield
changes resulting from changes in water content generally
increased with increasing N uptake. However, with in-
creased N uptake and water concentration, there was a re-
duction in both wet and dry sucrose concentrations. Suc-
rose concentration of the wet root generally followed the
dry matter concentration as previously shown which indi-
cates root water change was the major contributing factor
in the decline of sucrose concentration with increased N
uptake at each of the different locations. Maximum suc-
rose production again occurred when the proportion of dry
matter to water that increased root yield was highest with
a maximum increase or a minimum decrease in PSDM.

Commercial varieties grown during different years
varied widely, at maximum sucrose yield, in their root
yield, sucrose concentration, and sucrose yield (Table 3).
When the year with the lowest root yield and highest suc-
rose concentration (1977) was compared with the other
years, the proportion of the root yield increase at-
tributed to water and dry matter varied with the year.
The majority of the root yield increase between years re-
sulted from increased water with smaller, but important
increases during certain years, attributed to dry matter.
The sucrose concentration decrease resulted from a change
in the PSDM and the increased proportion of water to dry
matter in the roots. However, most of the decrease in
sucrose concentration between years resulted from an in-
creased root water concentration. High linear correla-
tions existed between root water (WC) or dry matter and
sucrose concentrations (y) indicating again that the in-
verse relationship between root yield and sucrose concen-
tration resulted mainly from the increased proportion of
water to dry matter in the roots ($\hat{y}$ = 68.7 − 0.66 WC, r =
−0.89**). Sucrose production again followed the propor-

Table 3. Changes in root and sucrose yields, and sucrose concentration between years of plant growth at maximum sucrose yield and one location attributed (attr.) to percent sucrose of the dry matter (PSDM), dry matter (DM), and water in the roots.

Year	R & C Total N uptake	Root yield				ROOT - CROWN (R - C)† Sucrose Concentration					Sucrose Yield		
		Total	Change. attr. to:			Wet wt.	Change. attr. to:			Dry wt.	Total	Change. attr. to:	
			DM	Water	%§		PSDM	Water	%§			PSDM	DM
	kg ha^{-1}	----- Mg ha^{-1} -----			%	%	-% units -¶		%	%	----- Mg ha^{-1} -----		
1977‡	210	52.1				19.0				75.6	9.92		
1976	205	53.4	-1.1	+2.4	>+100	17.1	+0.2	-2.1	>-100	76.6	9.15	+0.13	-0.90
1967	389	56.7	-1.2	+5.8	>+100	14.7	-1.1	-3.2	-74	70.4	8.35	-0.69	-0.88
1968	416	56.9	-1.0	+5.8	>+100	16.3	+0.2	-2.9	>-100	76.3	9.25	+0.09	-0.76
1971	243	61.0	+0.2	+8.7	+97	17.8	+1.3	-2.5	>-100	81.4	10.88	+0.77	+0.19
1969	263	61.3	0	+9.2	+100	16.5	+0.3	-2.8	>-100	77.3	10.14	+0.21	+0.01
1972	371	63.9	-0.9	+12.7	>+100	15.3	+0.9	-4.6	>-100	80.1	9.79	+0.58	-0.71
1978	323	70.9	+4.1	+14.7	+78	18.8	+0.5	-0.7	>-100	77.6	13.34	+0.33	+3.09
1982	321	71.8	+2.3	+17.4	+89	16.8	+0.6	-2.8	>-100	77.8	11.92	+0.32	+1.68
1983	312	75.5	+4.3	+19.1	+81	17.6	+0.1	-1.5	>-100	76.1	13.34	+0.09	+3.33
1980	257	76.0	+5.8	+18.1	+76	18.3	-0.5	-0.2	-30	73.6	13.90	-0.39	+4.37

†At maximum sucrose yield.
‡Lowest root yield and highest wet root sucrose concentration.
§Percent of total gain or decrease.
¶Actual % sucrose units, wet weight.

tion of dry matter to water that increased root yield.
Highest sucrose production was obtained when the propor-
tion of dry matter to water for the root yield increase
was highest while maintaining a reasonably high PSDM.

Most of the agronomic and fertilization practices
among years were similar with two major exceptions.
Starting in 1978, aldicarb at a rate of 2.24 kg of active
ingredients per hectare, was applied preplant to all
sugarbeets grown in succeeding years. Starting in 1982,
Amalgamated WS-76 and WS-88 varieties were used replacing
the previous variety, AH-10. From 1978, an increasing
proportion of the root yield increase, when compared with
the year 1977, was as dry matter, rather than as water
(Table 3). This increase in dry matter, while maintaining
a reasonably high PSDM, increased sucrose production sub-
stantially above that previously received. This would in-
dicate that root, dry matter, and sucrose yields during
1967 to 1977 were being reduced by undetected insect
damage which was controlled by aldicarb application from
1978 to 1983. However, the newer high yielding varieties
used during the 1982-83 season undoubtedly contributed to
these yield changes.

Nitrogen fertilizer applied preplant and during the
growing season to N deficient soil generally increased
root yields and reduced both wet and dry sucrose concen-
trations (Table 4A). Delaying N application beyond pre-
plant delayed N uptake and plant growth that further re-
duced sucrose concentration with a resulting sucrose yield
reduction below those received from zero N or that applied
preplant. When the treatment with the lowest root yield
and highest sucrose concentration (zero N) was compared
with the other treatments, the proportion of the root
yield increase attributed to water and dry matter varied
with the treatment. The root yield change resulting from
water increased with each delay in N application. The de-
crease in wet root sucrose concentration caused by delayed
N application resulted from both a decrease in the PSDM
and a decreased dry matter or increased water concentra-

Table 4. Changes in root and sucrose yields, and sucrose concentration between: (A) time of N applications, and (B) irrigation treatments at one location attributed (attr.) to percent sucrose of the dry matter (PSDM), dry matter (DM), and water in roots.

A-Time N applied B-Irrig. treatment	R + C Total N uptake	Root yield Total	Change. attr. to: DM	Water	%†	ROOT - CROWN (R - C) Sucrose Concentration Wet wt. %	Change. attr. to: PSDM	Water	%†	Dry wt. %	Sucrose Yield Total	Change. attr. to: PSDM	DM
A†	kg ha⁻¹	----- Mg ha⁻¹ -----			%†	%	-% units -#		%†	%	----- Mg ha⁻¹ -----		
Check#	130	46.1				19.3				75.2	8.89		
Preplant	318	52.6	+1.0	+5.5	+85	17.9	-0.4	-1.0	-70	73.3	9.40	-0.23	+0.74
Mid-June	335	50.0	+0.3	+3.6	+93	17.7	-0.5	-1.1	-69	73.0	8.86	-0.25	+0.22
Mid-July	337	47.6	-0.3	+1.8	>+100	17.5	-0.6	-1.2	-65	72.5	8.34	-0.31	-0.24
Mid-August	317	49.5	-0.3	+3.7	>+100	17.0	-0.5	-1.8	-80	73.1	8.45	-0.23	-0.21
B†													
M_1 ˢ	338	54.2				17.8				72.9	9.66		
M_3	278	50.2	+0.1	-4.1	>-100	18.9	-0.4	+1.5	>+100	71.3	9.49	-0.21	+0.04
M_4	237	44.5	-1.2	-8.5	-88	19.7	0	+1.9	>+100	72.8	8.77	0	-0.89

† Avg. of 112, 252, and 392 kg N ha⁻¹ applied N treatments.
‡ Adequately irrigated (M_1), no irrigation after 1 August (M_3), and no irrigation after 15 July 1977 (M_4), respectively (6).
ˢ Check or reference treatment
¶ Percent of total gain or decrease.
# Actual % sucrose units, wet weight.

tion (WC). However, the largest amount of sucrose concen-
tration (y) decrease was caused by the increased propor-
tion of water to dry matter in the roots with each delay
in N application ($\hat{y}$ = 91.7 - 0.98 WC, r = -0.99**). The
sucrose yield change resulted from a change in both PSDM
and dry matter production. The sucrose yield change with
delayed N application beyond mid-June was attributed about
equally to a reduction in PSDM and dry matter production.
Maximum sucrose yield was obtained with N applied preplant
when the increase in root yield was highest for dry matter
rather than as water while maintaining a reasonably high
PSDM.

The use of deficit water management during August,
September, and October curtailed leaf growth and reduced
leaf area (6), reduced N uptake from the soil, increased
sucrose concentration in the wet root, and decreased fresh
root yield when compared with the M_1 (normal irrigation)
irrigation treatment (Table 4B). These effects on root
yield and sucrose concentration were mainly caused by de-
hydration of the fresh roots. The majority of the root
yield decrease with deficit water management resulted from
decreased water with smaller, but important decreases at-
tributed to dry matter production at the M_4 (15 July water
cutoff) irrigation level. Sucrose concentration (y) in-
creases resulted mainly from the decreased water (WC) or
increased dry matter concentrations in the dehydrated
root ($\hat{y}$ = 67.4 - 0.66 WC, r = -0.96**). Sucrose yield was
scarcely affected by late season water management on the
M_3 (1 August water cutoff) irrigation treatment because
root yield decrease caused by dehydration was nearly com-
pensated for by the increased sucrose concentration.
However, sucrose yield was decreased on the M_4 irrigation
treatment which can be attributed to reduced photosynthe-
sis in the dehydrated tops causing decreased dry matter
and sucrose accumulation in the beet root. These rela-
tionships again indicate that the inverse relationship be-
tween root yield and sucrose concentration was mainly con-
trolled by the water concentration in the roots.

processing.   High sucrose concentration of the fresh root
generally   means   low impurities and   high   crystallizable
sugars and vice versa.

The   only way to change total sucrose yield is to   in-
crease   or decrease either or both of the two   yield   com-
ponents,   dry matter yield and PSDM.   Within any climatic
zone,   these   factors are normally controlled by agronomic
and fertilization practices such as,   1) weed, insect, and
disease   control,   2) transplanting or planting   date   and
leaf   area development,   3) plant nutrition, 4) irrigation
adequacy,   and   5)   genotype grown.   Within   sugarbeet
varieties   and climatic zones,   conditions that cause ade-
quate   early   top   growth   for   maximizing   photosynthesis
throughout the season should provide conditions for   maxi-
mum   sucrose production and yield.   This can normally   be
achieved   by using good agronomic practices and by   adding
adequate, but not excessive, N for maximizing partitioning
of   the photosynthate produced to the roots for storage as
dry matter and sucrose.

SUMMARY

Increasing root yield of sugarbeets (*Beta vulgaris* L.)
by plant breeding,   genetic selection, nitrogen (N) ferti-
lization,   agronomic practices,   and environmental   condi-
tions   generally decreases sucrose concentration.   There-
fore,   the objective of this investigation was to evaluate
sucrose production as affected by root yield,   wet and dry
sucrose   concentrations,   and dry matter and water concen-
trations of widely different *Beta vulgaris* genotypes grown
at different N uptake levels,   field   locations,   climatic
conditions,   and years.   Data collected at 36 field loca-
tions in southern Idaho during 11 years since 1967, mainly
on   Portneuf   silt loam soil (Durixerollic   Calciorthids,
coarse-silty,   mixed,   mesic),   were   used to identify and
evaluate factors and conditions affecting sucrose   concen-
tration,   root   and sucrose yields.   The results   clearly
show   that the inverse relationship between root yield and
sucrose   concentration within genotypes   during   different
years,   at   different N uptake or irrigation water levels,

and between genotypes, may be caused, in part, by water
concentration differences.   Root yield changes are caused
primarily by water rather than dry matter, thereby in-
creasing or decreasing wet root root sucrose concentra-
tion.   Variation in the percent sucrose of the dry matter
contributes to this inverse relationship, but generally
contributes less than does water or dry matter concentra-
tion and yield.   The change in water concentration in the
root between genotypes and within genotypes during dif-
ferent years and treatments, has been associated in pre-
vious work with a change in root Na concentration and/or
K:Na ratio.   Sucrose concentration of the fresh root is
not important for total sucrose yield if increases in root
yield with treatment compensates or more than compensates
for the reduction in sucrose concentration.   The only way
to change total sucrose yield is to increase or decrease
either or both of the two yield components, dry matter
yield and percent sucrose of the dry matter.   This can
normally be achieved by using good agronomic practices and
by adding adequate, but not excessive, N for maximizing
partitioning of the photosynthate produced to the roots
for storage as dry matter and sucrose.

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