

Four Years' Results of Pre-Harvest Sampling in Estimating Yield and Sugar Percentage

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In preparation for a processing campaign, a fairly precise estimate of the tonnage of beets to be harvested and the sugar to be processed is highly important to the management of a sugar beet company.

Previous to 1941, harvest estimates for the Great Western Sugar Company were based on samples chosen by the fieldmen in each factory district from a few farms without any prescribed plan being used. For the 1941 season a plan based on random sampling technique was designed and initiated, with results indicating considerable improvement in precision over previous methods. (1)²

The general method as based on random sampling technique has been continued to date with a few changes as to details. Complete results for the years 1941 to 1944 are included in this study.

Methods Used

Contracts smaller than 5 acres were not eligible for sampling because the contracts of such size were few in number and their total constituted a very small part of the gross acreage. The total acreage included in the contracts from 0-5 acres amounted to 1.3 percent of the total as an average of four factory districts taken more or less at random. All contracts of 5 acres or over were numbered and those to be sampled chosen by lottery. In 1941 all contracts with previous yield records of 3 consecutive years were stratified into five yield classes, a similar number of contracts being chosen from each class. Because a possible bias was recognized in the 1941 method due to the exclusion of certain contracts not having previous consecutive yield records of 3 years, a geographic method of stratification and sampling by fieldman districts was used in 1942 and 1943 and by dump districts in 1944.

In 1941 two samples were taken from the same field for each 100 acres, the basis being changed to one sample per each 90 acres since 1941.

The number of contracts sampled for each factory for each year is shown in table 1.

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²Italic numbers in parentheses refer to literature cited.

Table 1.—Number of contracts sampled.

Factory	1941	1942	1943	1944
Colorado				
Katon	120	170	111	120
Greeley	100	128	83	90
Windsor	80	117	83	87
Fort Collins	90	137	90	87
Loveland	75	114	84	71
Longmont	90	169	137	112
Brighton	61	110	87	61
Fort Lupton	65	138	101	90
Ovid	115	201	146	117
Sterling	100	158	103	88
Brush	62	91	68	71
Fort Morgan	90	183	105	104
Colorado total	1,057	1,723	1,198	1,088
Nebraska				
Scottsbluff	....	135	70	77
Gering	....	117	72	72
Bayard	85	139	86	81
Minatare	....	73	57	53
Mitchell	45	88	51	69
Lyman	50	78	55	67
Nebraska total	180	680	391	419
Montana				
Billings	....	205	302	227
Wyoming				
Lovell	80	112	63	62
Grand total	1,317	2,760	1,843	1,796

The sampling unit which consisted of exactly 10 feet of row remained the same throughout the 4 years, the location being chosen on an arbitrary pre-arranged basis so that the fieldman had no choice in taking the sample. In case the contract selected for sampling included more than one field, the larger field was sampled, in 1911 two samples of 10 feet of row were taken for each field chosen for each of two dates of sampling, from which the error per sample was determined. After 1941 only one sample was taken from each field. To determine the location of the sample, the fieldman was directed to enter the field at the "nearest corner" and count over a specified number of paces to the beginning of the sample. If the beginning or the end of any sample centered on a beet, the decision as to whether or not it would be included in the sample was made by flipping a coin. All beets over 1 inch in diameter were topped according to tare standards, placed immediately in water-proofed bags, and later washed, counted, weighed, and tested for sugar.

For the second date of sampling, which was 2 weeks after the first, the sample location was 10 feet beyond the first in the same row.

Harvest stand figures were obtained from tare samples taken at frequent intervals for each contract, the average weight per beet for these samples and the total tonnage for the contract being used for this calculation.

Results

From the 1941 data (1) for 16 factory districts an increase in precision of 14 percent in tonnage of roots was obtained with 2 samples per field as compared with 1 sample. On the basis of one sample per field the number of acres per sample to secure various levels of accuracy per factory district was as follows:

Levels of accuracy tons roots per acre	Acres per sample
±0.5	9
±1.0	36
±1.5	80
±2.0	144
±2.5	225

A ±1.5 tons level of accuracy per factory, requiring 80 acres per sample, would have resulted in an approximate accuracy for an average of 20 operating Great Western factories of $1.5 \div 20$ or about ±0.34 tons of roots per acre.

The relative precision of stratification for 1941, 1942, and 1944, representing respectively the three methods used, viz., by previous 3-year yield records, fieldman districts and dump districts, is summarized for yield of beets with corresponding number of strata for the various factory districts in table 2.

The precision for 1948 was not determined, since it represents the same form of stratification used in 1942. For complete data and the statistical method used to test precision, see reference 1. The variance for percentage of sugar was not calculated, since this character is considerably less variable than yield of roots.

The precision due to stratification (table 2) was calculated in percentage of complete randomization considered as 100. There is a certain amount of bias in these precision figures since the samples as taken, with the limitations imposed due to stratification, were used to calculate the error without stratification. The same total error of sampling has been assumed for both cases. The bias in making this assumption is probably too small to be of any practical significance.

There is also an additional bias for the method as used in 1941, since not all farms were eligible to be included in the lottery, which excluded all contracts (all new beet growing farms and those which

Table 2—Relative precision of stratification in percentage of complete randomization and number of strata.

Factory	1941 ¹		1942 ²		1944 ³	
	Strata No.	Precision Percent	Strata No.	Precision Percent	Strata No.	Precision Percent
Colorado						
Eaton	6	116.68	5	106.56	11	101.99
Greeley	5	104.09	4	100.49	9	97.07
Windsor	5	118.07	3	98.48	9	102.98
Fort Collins	5	109.09	4	105.82	15	100.37
Loveland	5	118.18	3	109.41	14	92.69
Longmont	5	112.08	6	105.06	27	96.78
Brighton	5	107.50	3	99.99	13	90.79
Fort Lupton	5	127.01	3	99.76	13	110.25
Ovid	5	104.09	6	114.86	18	108.14
Sterling	5	105.97	4	104.89	15	109.60
Brush	5	98.75	2	98.89	13	100.21
Fort Morgan	5	118.46	5	109.74	14	101.71
Colorado average	...	111.58	...	104.66	...	100.87
Nebraska						
Scottsbluff	...	...	6	108.80	9	118.46
Gerling	...	...	4	119.93	10	120.66
Bayard	6	108.16	4	98.71	17	119.53
Minatare	...	...	3	98.48	5	211.37
Mitchell	5	108.07	2	100.19	7	104.81
Lyman	5	122.18	2	99.55	7	116.00
Nebraska average ⁴	...	112.80	...	99.45	...	113.11
Nebraska average ⁵	...	...	...	103.43	...	114.37
Montana						
Billings	...	...	8	102.89	30	113.95
Wyoming						
Lovell	5	118.56	4	108.15	11	106.07
Colorado-Nebraska average ⁴	...	111.83	...	102.02	...	103.39
G. W. S. Co. average ⁴	...	112.28	...	103.20	...	104.17

¹Stratified according to previous yield records²Stratified according to fieldman districts³Stratified according to dump districts⁴Averages for only those factories represented 3 years⁵1942-1944 average

may have been temporarily out of beet production), without a consecutive 3-year previous record. The precision based on stratification by the previous 3-year yield record amounted to 112.23 percent as an average for 10 factories in 1941, while the precisions using the geographic methods of stratification for 1942 and 1944 were 103.20 percent and 104.17 percent, respectively, as averages for the same 16 factories. The increase in precision due to stratification for the 1941 results is somewhat higher than for either 1942 or 1943. The geographic distribution of the samples, however, was not as complete

in 1941 as for either of the other 2 years and, for this reason, it is entirely possible that the pre-harvest estimates for the later years constitute more accurate indices of the true yield situation.

It will be observed from the number of strata used in 1944 that many units ("dumps") were involved in the stratification, in which case some strata were represented by only one or two samples, particularly for several factories in Colorado. Precision was lost for several such factories by this geographic restriction as compared with complete random sampling, the method being somewhat less efficient for those factories than either of the other stratification methods. For the factories in Nebraska, however, geographic stratification by dump districts in 1944 appeared to be somewhat more efficient than by fieldman districts as in 1942, being equal to the method used in 1941.

The results for percentage of stand, yield of beets, and percentage of sugar are presented for the 4 years 1941-44 in tables 3, 4, and 5, and also are summarized for Colorado, Nebraska, and Great Western averages in table 6. The results for yield of roots and percentage of sugar are graphically presented in figures 1 and 2, respectively.

In stand (table 3) a slight loss is indicated in most cases for the 2-weeks period between samplings. This condition seems to be too consistent to be due to random error, but there seems to be no reason-

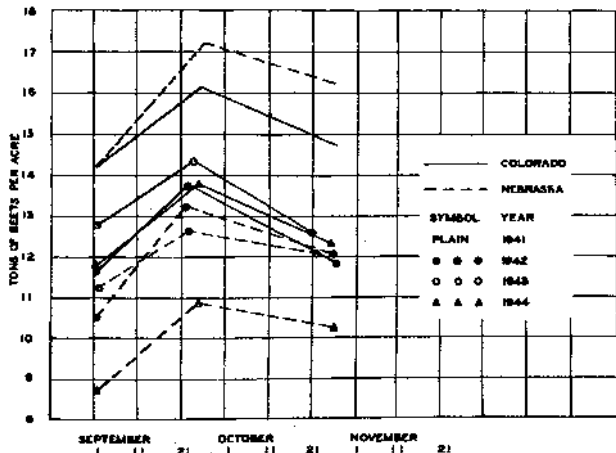


Figure 1.—Sample estimates and final results for tons beets per acre for farms sampled.

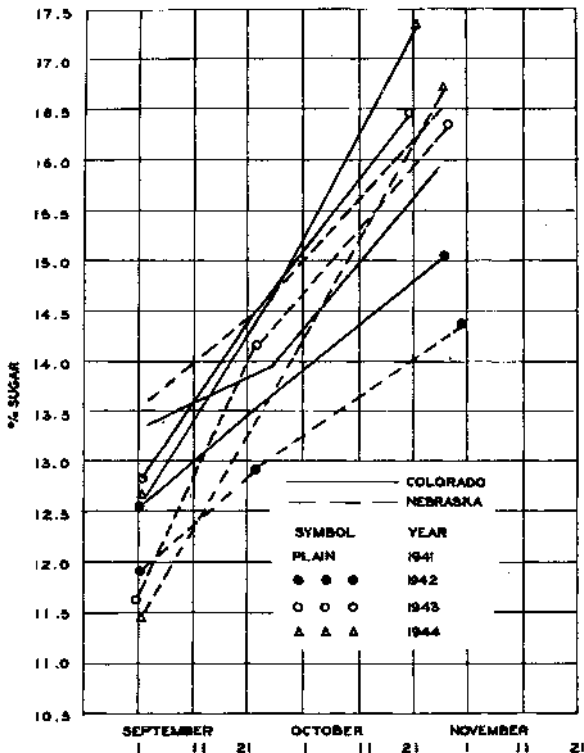


Figure 2.—Sample estimates of final results for percentage sugar for farms sampled.

able explanation for a loss of even this magnitude. The loss between pre-harvest samples and harvested stand for the contract is considerable and may be at least largely accounted for by (1) beets left in the field or dropped from trucks in delivery, (2) small beets returned at the piler in the tare, (3) some loss from root rots, (4) weak stands at the ends of the rows which were not included in the sampling, and (5) some breakage at the piler with the net result that broken pieces in the tare sample may not have been counted.

Table 3.—Percentage of stand as obtained from pre-harvest samples (1st and 2nd) and tare samples for contracts sampled in comparison with factory harvest averages.

Factory	1941				1942				1943				1944			
	Farms sampled			Fac- tory ave.	Farms sampled			Fac- tory ave.	Farms sampled			Fac- tory ave.	Farms sampled			Fac- tory ave.
	1st	2nd	Harv.		1st	2nd	Harv.		1st	2nd	Harv.		1st	2nd	Harv.	
Colorado	Percent				Percent				Percent				Percent			
Eaton	94	92	77	79	85	82	66	68	82	79	72	71	76	74	61	61
Greeley	91	87	78	80	75	77	65	68	86	87	67	70	70	80	58	60
Windsor	82	86	76	75	84	87	68	66	87	87	72	73	78	77	61	59
Fort Collins	88	87	79	80	83	79	66	69	81	77	66	70	71	63	58	58
Loveland	92	90	81	82	85	86	74	76	86	88	76	78	75	73	56	59
Longmont	97	93	85	84	88	87	74	78	87	83	72	71	74	71	61	64
Brighton	87	91	83	79	85	88	75	71	86	82	66	68	70	70	59	61
Fort Lupton	88	90	81	82	86	86	70	78	85	82	69	73	72	72	61	59
Ovid	90	88	73	75	84	87	63	68	84	83	66	74	71	69	56	55
Sterling	87	88	81	82	81	82	66	67	85	82	70	71	65	68	56	61
Brush	86	84	70	73	71	73	63	64	87	88	68	68	72	68	57	57
Fort Morgan	88	86	77	78	79	75	61	65	83	80	65	68	71	69	59	55
Colorado ave. ¹	90.1	88.6	78.3	78.9	82.9	82.5	67.9	66.5	84.8	83.1	68.9	70.4	72.2	71.4	58.4	59.2
Nebraska																
Scottsbluff	...	...	...	...	82	81	85	67	92	88	66	69	77	73	61	64
Gering	...	...	...	...	17	78	65	62	85	84	67	64	63	64	51	53
Bayard	82	82	76	72	77	78	62	55	73	71	57	59	64	61	51	53
Minatare	...	...	...	...	91	89	62	62	80	83	53	62	68	61	51	51
Mitchell	83	79	70	71	71	73	68	65	73	72	63	66	62	66	53	56
Lyman	62	80	74	74	76	77	56	60	93	90	67	65	74	74	59	61
Nebraska ave. ¹	85.0	86.2	71.1	72.3	79.1	79.3	62.9	63.1	83.4	80.0	63.5	63.2	67.4	66.6	54.4	56.5
Montana																
Billings	...	...	...	...	97	94	74	77	90	89	68	70	79	76	59	62
Wyoming																
Lovell	100	97	74	71	93	95	88	69	84	87	62	62	87	89	69	66
Colorado- Nebraska ave. ¹	89.4	87.8	77.3	77.9	81.9	81.6	66.9	67.0	84.1	82.6	67.1	68.6	70.6	69.8	57.1	58.3
G. W. S. Co. ave. ¹	91.5	88.3	77.0	77.5	83.9	83.5	66.9	68.2	84.7	82.4	66.9	68.6	71.8	71.1	57.5	58.9

¹Averages weighted according to number of farms sampled in each factory.

Table 4.—Yield of beets in tons per acre as obtained from pre-harvest samples (1st and 2nd) and contract deliveries in comparison with factory harvest averages.

Factory	1941				1942				1943				1944			
	For Farms Sampled			Factory ave.	For Farms Sampled			Factory ave.	For Farms Sampled			Factory ave.	For Farms Sampled			Factory ave.
	1st	2nd	Harv.		1st	2nd	Harv.		1st	2nd	Harv.		1st	2nd	Harv.	
	Tons per Acre				Tons per Acre				Tons per Acre				Tons per Acre			
Colorado																
Gaton	16.13	17.28	16.02	16.43	12.70	14.55	13.20	12.96	14.73	16.49	14.97	14.91	13.61	16.33	14.86	14.55
Greeley	14.90	15.50	14.58	14.38	11.64	13.56	11.44	11.95	13.10	14.62	12.27	12.78	11.41	13.56	12.58	12.54
Windsor	13.13	17.94	15.63	16.03	13.95	16.57	13.82	13.62	16.04	17.78	14.98	14.61	14.29	15.36	14.22	14.53
Fort Collins	12.58	14.43	13.49	13.23	10.66	12.35	10.33	10.77	12.51	13.33	11.67	12.46	11.40	13.05	11.77	11.70
Loveland	13.16	14.53	13.66	13.78	12.02	15.14	12.94	13.48	13.26	14.70	13.50	13.20	11.22	13.30	13.13	13.84
Longmont	14.71	16.25	14.87	14.00	12.41	14.49	12.83	13.30	13.77	15.56	13.24	13.35	11.63	13.38	12.17	12.83
Brighton	13.70	15.82	15.90	14.67	12.55	13.61	11.32	11.37	11.63	13.06	11.36	11.76	10.05	12.11	11.38	11.65
Fort Lupton	14.42	16.77	15.35	15.42	11.25	12.85	11.45	11.68	12.65	14.43	13.20	13.52	11.77	12.10	12.16	11.74
Ovid	13.03	15.00	13.33	13.25	9.56	13.28	10.43	10.92	9.47	11.92	10.26	10.67	10.17	13.14	10.71	10.95
Sterling	12.56	14.92	13.92	14.13	11.00	12.86	11.01	11.06	11.19	13.18	11.28	11.33	8.73	11.61	10.06	11.00
Brush	13.58	17.42	14.54	15.56	9.55	11.32	9.45	9.96	13.18	14.50	12.89	13.27	14.05	15.82	13.47	13.12
Fort Morgan	13.45	17.29	16.73	15.90	12.04	13.71	12.12	12.42	13.08	14.32	12.30	12.91	12.97	15.26	12.76	13.08
Colorado ave. ¹	14.29	16.11	14.78	14.79	11.65	13.71	11.75	11.90	12.73	14.42	12.54	12.61	11.82	13.88	12.46	12.63
Nebraska																
Scottsbluff	....	....	....	....	10.98	13.33	12.43	12.83	13.00	14.42	13.72	13.87	12.32	14.44	12.68	12.90
Gering	....	....	....	....	12.24	13.34	14.07	14.12	9.89	12.08	12.22	12.35	7.14	9.87	9.20	9.41
Bayard	12.00	16.10	14.83	14.70	9.46	11.72	11.24	11.71	8.00	9.03	9.25	10.09	7.81	9.32	9.62	10.04
Minatare	....	....	....	....	13.23	16.71	12.92	12.50	13.40	15.03	13.02	12.33	8.14	10.93	9.95	9.71
Mitchell	15.30	17.74	17.36	17.39	10.20	13.13	11.76	12.25	12.29	13.68	12.03	13.56	7.87	10.21	9.64	10.35
Lyman	13.35	18.52	17.69	17.95	7.23	10.05	9.29	9.68	12.63	13.33	12.96	13.14	8.71	11.57	11.17	11.93
Nebraska ave. ¹	14.23	17.18	16.25	16.28	10.57	13.31	12.05	12.31	11.25	12.64	12.11	12.39	8.73	10.90	10.37	10.77
Montana																
Billings	....	....	....	....	12.43	14.90	12.56	13.47	11.10	12.56	10.81	10.91	9.54	12.13	10.20	10.47
Wyoming																
Lovell	15.24	16.45	13.11	13.73	10.70	12.76	10.80	11.23	11.42	14.00	11.22	11.20	11.76	15.10	12.88	12.20
Colorado- Nebraska ave. ¹	14.28	16.27	15.00	15.01	11.36	13.80	11.83	12.08	12.97	13.98	12.43	12.71	10.80	12.92	11.78	12.01
G. W. S. Co. ave.	14.34	16.28	14.88	14.89	11.45	13.71	11.00	12.19	12.20	13.83	12.22	12.47	10.78	13.04	11.72	11.94

¹ Averages weighted according to number of farms sampled in each factory district.

Table 5.—Percentage of sugar as obtained from pre-harvest samples (1st and 2nd) and tare samples for contracts sampled in comparison with factory harvest averages.

Factory	1941				1942				1943				1944			
	Farms Sampled			Factory ave.	Farms Sampled			Factory ave.	Farms Sampled			Factory ave.	Farms Sampled			Factory ave.
	1st	2nd	Harv.		1st	2nd	Harv.		1st	2nd	Harv.		1st	2nd	Harv.	
Colorado	Percent				Percent				Percent				Percent			
Eaton	18.2	18.9	16.0	16.0	12.5	13.3	13.9	14.0	12.4	14.7	16.8	16.8	12.3	14.0	18.2	18.2
Greeley	18.7	14.4	16.1	16.2	13.4	13.5	14.7	14.8	13.1	15.3	16.0	16.7	13.3	15.9	17.8	17.9
Windsor	12.5	13.8	16.0	16.0	13.2	13.0	14.7	14.8	13.1	14.5	15.4	16.3	12.8	14.9	17.8	17.8
Fort Collins	12.5	14.2	16.1	16.0	13.1	13.5	14.6	14.8	13.1	15.1	17.3	17.0	13.1	15.4	18.1	18.0
Loveland	13.4	14.2	16.0	16.1	13.3	14.3	15.9	16.0	13.2	15.0	16.8	16.5	13.2	15.1	17.5	17.5
Longmont	14.3	14.4	16.1	16.2	13.5	14.1	16.5	16.5	13.3	14.0	16.4	16.5	13.6	15.3	17.9	18.0
Brighton	14.5	14.6	17.0	16.8	13.7	13.9	15.7	15.7	13.4	15.1	17.4	17.4	13.2	15.2	18.8	18.2
Fort Lupton	14.1	14.6	16.7	16.7	13.5	13.9	15.7	15.7	13.3	14.8	16.9	16.8	13.4	14.8	17.8	17.7
Ovid	13.0	13.7	15.1	15.1	11.2	12.3	15.2	15.1	11.8	13.8	16.1	16.1	11.2	13.1	16.5	16.5
Sterling	13.2	13.8	15.7	15.7	12.3	13.6	14.4	14.8	11.4	14.1	16.0	15.9	12.2	14.2	16.8	16.6
Brush	12.8	12.8	15.8	15.7	10.5	11.4	13.4	13.8	12.0	13.1	15.0	15.8	11.9	13.8	16.0	17.0
Fort Morgan	13.4	14.1	15.5	15.7	12.6	13.0	14.3	14.5	12.7	14.2	16.1	15.9	12.4	14.2	17.6	17.5
Colorado ave. ¹	13.4	13.9	16.0	16.0	12.6	13.5	15.0	15.1	12.8	14.5	16.5	16.5	12.7	14.7	17.6	17.8
Nebraska																
Scottsbluff	....	....	....	....	12.2	12.9	14.1	14.4	12.1	14.8	16.7	16.8	12.0	14.0	17.3	17.5
Gering	....	....	....	....	11.7	12.3	13.7	13.8	11.6	13.7	15.9	15.8	10.2	13.1	15.9	16.1
Bayard	13.3	14.1	16.1	16.0	12.1	13.2	15.1	15.0	11.5	14.1	16.4	16.5	10.9	13.3	16.8	16.9
Minotare	....	....	....	....	12.3	13.1	14.9	14.8	11.9	14.1	16.5	16.4	11.4	14.2	16.7	16.9
Mitchell	13.3	14.5	16.2	16.3	11.3	13.0	14.1	14.1	11.4	14.0	16.2	16.2	10.5	12.8	16.7	16.5
Lyman	14.4	15.4	17.5	17.3	11.3	12.9	14.0	14.1	12.0	14.6	16.4	16.5	11.7	14.1	17.0	17.0
Nebraska ave. ¹	13.6	14.5	16.5	16.4	11.9	12.9	14.3	14.4	11.7	14.2	16.3	16.3	11.1	13.7	16.7	16.8
Montana																
Billings	....	....	....	....	14.2	14.7	....²	....	13.7	16.2	....³	....	13.1	15.0	....⁴	....
Wyoming																
Lovell	14.7	15.8	....³	17.9 ³	14.3	15.0	....⁴	....	....²	....³	....⁴	....	....³	....⁴	....¹	....
Colorado- Nebraska ave. ¹	13.4	14.0	16.0	16.0	12.4	13.3	14.8	14.9	12.5	14.4	16.5	16.5	12.2	14.4	17.5	17.3
G. W. S. Co. ave. ¹	13.5	14.1	....	....	12.7	13.6	....	....	12.7	13.9	....	....	12.2	14.4	....	....

¹Individual tests not made

²Cossette average

³Sugar analyses not made

⁴Averages weighted according to number of farms sampled in each factory district.

Table 6.—Four years' summary for percentage of stand, yield in tons beets per acre, and percentage of sugar as obtained from pre-harvest samples and factory deliveries.

Area	Year	Fact. No.	Stand				Roots				Sugar			
			Farms Sampled			Fac- tory ave.	Farms Sampled			Fac- tory ave.	Farms Sampled			Fac- tory ave.
			1st	2nd	Harv.		1st	2nd	Harv.		1st	2nd	Harv.	
Colo.-Nehr.			Percent				Tons per Acre				Percent			
ave.	1941	15	80.4	87.8	77.3	77.9	14.28	14.27	15.00	15.01	13.4	14.0	15.0	15.0
	1942	15	81.9	81.6	83.9	87.0	11.36	13.60	11.53	12.08	12.4	13.3	14.5	14.9
	1943	18	84.1	82.6	87.1	88.6	12.37	13.98	12.43	12.71	12.5	14.4	16.5	16.5
	1944	18	70.4	69.8	57.1	68.5	10.89	12.92	11.70	12.61	12.2	14.4	17.3	17.3
G.W.S. Co.														
ave.	1941	17	91.5	88.3	77.0	77.5	14.34	14.28	14.88	14.80	...*	...*	...*	...*
	1942	20	88.9	83.5	96.0	88.2	11.45	13.71	11.90	12.19	...*	...*	...*	...*
	1943	20	84.7	85.4	86.9	88.6	12.20	13.53	12.22	12.47	...*	...*	...*	...*
	1944	20	71.8	71.1	57.8	68.9	10.78	13.04	11.72	11.64	...*	...*	...*	...*

* Grower's tare samples not analyzed for sugar content in Montana and Wyoming, and pre-harvest samples not tested for sugar content in Wyoming in 1943 and 1944.

In yield of beets (table 4) there was an increase for all factories between the two dates of sampling which, for a "company average", amounted to 1.94, 2.26, 1.63, and 2.26 tons per acre, respectively, for the 4 years 1941 to 1944. With this large increase for the 2-weeks period between samplings it is obvious that the growth curve was still on the increase to place the final potential yield at an even higher figure than that shown by the second sampling date. The final harvested yield for the contracts sampled, however, showed a consistent and material drop from the second sampling date of 10.58 percent as an average for all factories for the 4 years. Considering the growth which took place after the second sampling, it is quite probable that this loss in potential harvested tonnage would have amounted to as much as 15 percent.

Some of this loss in weight of roots delivered as compared with known potential tonnage in the field may be attributed to the same sources as mentioned for stand. Another source of material loss in harvested tonnage results from desiccation, a condition which did not exist in connection with the pre-harvest samples since they were placed immediately into water-proofed bags. This is not very important from the practical standpoint, however, since any such loss in weight represents merely a loss in water and is therefore compensated by a corresponding increase in percentage of sugar. One more source of loss in yield is quite important, viz., topping too deep into the root at harvest. The importance of this can be appreciated from the fact that a cross-section slice of the root 1/4 inch thick taken immediately below the lowest leaf scar amounts to about 10 percent of the total root weight. The pre-harvest samples were topped carefully and properly. Careless topping at harvest often results in considerable marketable root material being left in the fields, this source of error having entered into the harvest yields. Accurate machine harvesting may result in real savings to the grower in this respect.

For both percentage of stand and yield, the "factory average" for all contracts appears to run very slightly but rather consistently above the comparable "harvested" figures for all contracts sampled for 1942, '43, and '44. This is in contrast with the results obtained in 1941 when the harvested results for the farms sampled were nearly identical with the factory averages (table 6). In an attempt to find some explanation for this difference, a study of yields as related to size of contract was made. This study indicates that contracts of over 40 acres average slightly higher in yield than those of from 5 to 40 acres. In four factory districts contracts of over 40 acres were found to represent about 33 percent of the total acreage. These larger acreages were more likely to have been chosen in 1941, when they were classified into yield strata where each class was represented by the same num-

ber of samples before the lottery, than in the years 1942-1944 when each contract had an equal chance to be chosen regardless of size or previous production record. This source of bias in the geographic method used in 1942 and 1943, or in 1944, could probably have been entirely eliminated by allotting the larger contracts additional chances in the lottery.

It does not appear to be possible for the contracts of 5 acres or less to influence the bias materially since the analysis of the above mentioned four-factory contracts indicates only 1.3 percent of the acreage to be in this class.

For percentage of sugar (table 5) the tare-sample averages for the farms sampled duplicated the factory average in 3 years out of 4 for a mean of all factories in Colorado and Nebraska and differed by 0.1 percent for the fourth year.

Summary and Conclusions

1. This study of random sampling of sugar beet acreage to provide a basis for harvest predictions covered a period of 4 years throughout the area served by the Great Western Sugar Company. Contracts were chosen on the basis of one per 100 acres in 1941 and one per 90 acres in 1942 to 1944. Two samples per contract were taken in 1941 and one per contract in later years.

2. The contracts chosen for sampling proved to be almost perfect samples of the entire acreage for percentage of sugar. For both stand and yield, however, the contracts chosen for 1942, '43, and '44 were very slightly but consistently lower than the general acreage. The larger contracts average slightly higher in yield than the entire acreage, which would account for the bias with respect to yield.

3. The studies reveal considerable loss in both number and weight of beets between the field and the factory. The source and importance of these losses is discussed.

4. The method of sampling as developed and used in connection with these studies appears to provide a rather accurate picture of the status of the sugar beet crop at the time of the two pre-harvest samplings. The prediction of final production must remain always a matter of personal judgment, conditioned, however, by accurate pre-harvest estimates and an intimate knowledge of growing conditions throughout the area served by the Company.

5. Three pre-harvest samples spaced 2 weeks apart, with the last sample being taken as near the beginning of the commercial harvest as possible, would provide an improved picture of the growth curve for the year and, without doubt, an improved estimate of final performance.

6. It is also suggested that the larger contracts be represented by more chances in the lottery, possibly on a basis as follows :

5— 20 acres.....	1 chance
21— 50 acres.....	2 chances
51—100 acres.....	3 chances
Over—100 acres.....	4 chances

7. A geographical stratification into sampling areas based on known fertility or productive levels might constitute some improvement over the fieldman district or dump district methods. This could be done by careful and intelligent mapping of the factory district. Such sampling areas should be large enough to include not less than eight samples taken on the sampling basis used for this study.

Literature Cited

1. Brewbaker, H. E. and Bush, H. L. Pre-harvest Estimate of Yield and Sugar Percentage Based on Random Sampling Technique. Proc. Amer. Soc. Sug. Beet Tech., 184-196. 1943.