Reduction of Sugar Loss in Sugarbeet Piles with Straw and Plastic Covering

W. R. Akeson and S. D. Fox[1]

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A number of attempts to reduce sugar loss in stored sugarbeets by protection with pile covering material have been made by U.S. sugar companies but little has been published on the results of those attempts (1, 4)[2]. Loss of sugar and recoverable sugar in the rim or outer two feet of the pile is two to four times as great as the loss in the interior of the pile where beets are not subjected to dehydration and alternate freezing and thawing (1, 5). Akeson, et al (1) reported that covering a pile with a layer of straw, a woven plastic material or a combination of the two substantially reduced the sugar loss in the outer portion of the pile. Measurement of the relative sugar losses in the rim with different systems of pile protection will show whether a type of covering has potential for reducing losses. However, the pile covering may cause undesirable conditions in the interior of the pile such as heating or interior freezing which will increase losses in the interior and offset a saving of sugar on the rim. Therefore, final evaluation of a pile protection material must be made on the entire pile. Since weather conditions vary from year to year, three or more years' data are required to prove that a material is effective in reducing storage loss. In this paper, data are presented for four years of comparisons between non-covered and straw covered piles and two years of comparisons between non-covered piles and piles which are covered with woven polypropylene plastic sheeting.

Methods and Materials

Two types of tests were carried out to determine the effect of various pile covering materials on storage loss. Detailed tests were carried out on commercial size piles in which weight shrink, sugar loss, and recoverable (extractable) sugar losses were measured in covered and corresponding non-covered piles. These tests were carried out by the agricultural personnel in the factory districts where the tests were located. Locations and type of tests are given in Table 1. The weight into and out of the pile was determined from the truck weights of beets minus the dirt tare. Percent sugar into the pile was obtained from the grower's tare sample, which is taken from alternate loads. A representative beet sample for determination of percent sugar out of the

[1]Sr. Plant Physiologist and Agricultural Development Engineer, respectively, The Great Western Sugar Company, Agricultural Research Center, Longmont, Colorado 80501.

[2]Numbers in parentheses refer to literature cited.

Table 1.—Description of pile protection tests.

Location		Cover		Beets Piled		
District	Receiving Station	Sides	Top	Tons	Sugar %	C.J. Purity %
1969-70						
Fremont	Factory	None	None	3747	14.61	92.57
Ohio	Factory	Straw — 6"	Straw — 2"	3592	15.29	92.60
	Factory	Straw — 6"	Straw — 2"	4040	14.86	92.03
Lovell	Factory	None	None	3693	16.15	93.62
Wyo.	Factory	Straw — 6"	Straw — 2"	3703	16.24	93.84
1970-71						
Greeley	Farmers Spur	None	None	5993	15.06	91.11
Colo.	Bracewell	Straw — 6"	Straw — 2"	12561	15.03	90.90
Goodland	Factory	None	None	22331	15.20	90.10
Kan.	Factory	Straw — 12"	Straw — 2"	21101	15.25	90.10
Billings	Huntley	None	None	12730	15.70	91.56
Mont.	Huntley	Straw -- 18"	Straw — 6"	14565	15.63	91.34
1971-72						
Gering	Costin	None	None	20469	14.82	89.30
Neb.	Haig	Straw — 6"	Straw — 1"	15399	15.11	89.72
Billings	Huntley	None	None	9511	16.21	93.32
Mont.	Huntley	Straw — 18"	Straw — 1"	9903	15.84	93.38
Ft. Morgan	Narrows	None	None	13749	16.22	90.80
Colo.	Maudru	Woven Plastic	None	12674	15.59	90.34
Goodland	Factory	None	None	14667	15.88	--
Kan.	Factory	Straw — 6" + Woven Plastic	Straw — 1"	16108	15.77	--
Greeley	Gilchrest	None	None	10332	14.34	89.54
Colo.	Humbert	Straw — 6" + Woven Plastic	Straw — 1"	11035	14.15	89.06
1972-73						
Gering	Costin	None	None	18741	16.43	92.15
Neb.	Haig	Straw — 6"	Straw — 1"	25097	16.64	92.18
	Mathers	Woven Plastic	None	15596	16.29	91.56
Ft. Morgan	Narrows	None	None	14622	16.52	91.04
Colo.	Maudru	Straw — 6"	Straw — 1"	10387	16.34	91.29
	Hurley	Woven Plastic	None	18364	16.51	90.10
Goodland	Factory	None	None	5797	15.11	90.05
Kan.	Factory	Straw — 6"	Straw — 1"	5677	15.41	90.22
Greeley	Gilchrest	None	None	15248	16.37	88.73
Colo.	Vasquez	Straw — 6"	Straw — 1"	14812	16.83	89.86
Billings	Mann	None	None	11601	16.39	89.48
Mont.	Knox	Straw — 6"	Straw — 1"	18489	16.17	89.20
	Huntley	Straw — 18"	Straw — 1"	16072	16.30	89.68

pile was taken for every 20-25 tons of beets reloaded. This sample was washed and analyzed in the same manner as harvest samples except that the beets were not crown tared. One brei sample was composited from every 25 tare samples (both into and out of the pile) and quick frozen in a freezing bath of acetone and dry ice. Brie samples were later analyzed at the Agricultural Research Center in Longmont for clarified juice purity (2), raffinose (6), and invert sugars (3). The apparent sucrose and apparent purities were corrected for raffinose and invert sugars (5). Extraction was estimated from the true sucrose and clear juice purity percentages with the Great Western formula (8) and recoverable sugar was based on this extraction factor.

Data from ordinary commercial piles were also used in evaluating pile cover protection. Truck weight into and out of the pile along with the tare lab sugar in and factory cossette sugar (corrected for steam) out of the pile were used to calculate weight and sugar shrink. Sugar percentages were not corrected for raffinose and invert sugar contents.

Piles used in a comparison were usually on adjacent pile grounds, had the same orientation and were of a similar size. Occasionally, test pile comparisons were from the same pile ground.

Straw was blown onto the piles with a commercial straw blower. Baled wheat straw was normally used but barley straw was satisfactory. A six inch layer of straw was blown onto the sides of the pile no sooner than four days after piling or after pile temperatures had dropped below 55 degrees F. If additional layers of straw were applied to the side or if straw was applied to the top, application was made after the pile had cooled to less than 45 degrees F. Straw is quite resistant to wind erosion; however, in most tests a 16 foot wide net was put over the upper half of the side or sides facing the prevailing wind to prevent wind erosion. The net was a black wide weave (4 × 5 strands per inch) polypropylene fabric woven from oriented 750 denier ribbon yarns.

Woven polypropylene was applied along when the pile temperature was below 55 degrees F but no sooner than seven days after piling or on top of a six inch layer of straw when the pile temperature had dropped below 40 degrees F. The beige colored fabric was woven (12 × 10 strands per inch) from oriented 750 denier polypropylene ribbon yarns. The woven polypropylene (which comes in rolls 17 feet wide) was precut to the vertical length of the sides, attached on both ends to 2″ × 4″ × 4′ boards and rolled into bundles which were lifted to the top of the pile with a crane. The panels were attached to the top edge of the pile with three foot stakes (made from ⅜″ reinforcing bars), rolled down the side of the pile and then attached about three feet from the bottom of the pile with similar stakes. The vertical sides of the panels, which overlapped about 1.5 feet, were wrapped around 1″ × 4″ boards and staked to the pile. When properly attached the woven polypropylene cover was quite resistant to wind damage.

Results and Discussion

A description of each of the detailed tests is given in Table 1. Included in the description is the year, location, size of pile, and quality of beets put into the pile. The effects of straw cover on weight, sugar, and recoverable sugar losses for four years of tests are summarized in Table 2. Effect of the protection on changes in purity and purity components is also shown. Straw cover reduced weight shrink by an average of 20.5 percent. Weight shrink was higher on covered piles in only one of twelve comparisons (Billings, 1972-73). Sugar shrink averaged 19.6 percent lower in straw covered piles than in non-covered piles. Only one of the twelve comparisons had a higher shrink in the covered than in the non-covered pile. Drop in clear juice purity was one percent less in the covered than in the non-covered piles. This difference in purity change during storage is reflected in recoverable sugar loss which averages 23.8 percent less in the covered than in the non-covered piles. Loss in recoverable sugar was less in the straw covered than in the non-covered piles in all 12 tests. Only one test (Goodland, 1970-71) showed a greater purity drop in the covered than in the non-covered pile. Straw covering had no overall effect upon raffinose but did have a significant effect upon invert sugar accumulation which was less in straw covered piles.

An 18 inch layer of straw appeared to give no more benefit than a six inch layer as was previously reported (1). No more than one to two inches of straw should be put on the top. Additional straw on the top slows down the rate at which the pile cools and thus will cause higher losses in the interior of the pile. A six inch layer of straw on the side and one to two inch layer on the top had no adverse effect on pile temperatures.

Woven polypropylene applied directly to the beets or on top of a six inch layer of straw appeared to reduce weight sugar and recoverable sugar losses under some conditions. The reduction in loss under woven polypropylene is not statistically significant. In some tests (Ft. Morgan 1971-72 and 1972-73), woven polypropylene gave nearly as good protection as did straw. In these tests, piles were not subjected to thawing late in the storage period by warm chinook winds. At Gering in 1972-73, the plastic-covered pile was subjected to warm winds after a cold period had extensively frozen the center of the pile. The frozen areas were thawed and weight, sugar and recoverable sugar losses were greater than in comparison to straw covered and non-covered piles. Woven polypropylene cover gives slightly better protection of the rims than straw (1) but can set up undesirable freeze and thaw conditions in the center of the pile. Plastic cover had no significant effect upon purity decline or on accumulaton of raffinose and invert sugars.

In addition to the detailed tests described above, additional weight and sugar shrink data were obtained from commercial piles without any special testing (Table 4). These data, which came from all Great Western

Table 2.—Effect of straw cover on storage losses in test piles.

Factory District	Storage Period — Days		Change During Storage: Invert Sugars Increase — g/100 RDS		Change During Storage: Raffinose Increase — g/100 RDS		Change During Storage: C.J. Purity Decrease — %		Loss During Storage — Lb/T/D: Weight		Loss During Storage — Lb/T/D: Sugar		Loss During Storage — Lb/T/D: Rec. Sugar	
	Non Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered
1969-70														
Lovell	144	145	3.540	1.840	0.450	0.435	7.72	3.10	2.13	1.57	0.500	0.300	0.710	0.380
Fremont	102	99	1.510	1.554	0.352	0.290	2.95	2.39	0.06	†0.23	0.250	0.200	0.360	0.310
		95		1.475		0.312		2.16		†0.34		0.150		0.250
1970-71														
Greeley	75	75	0.617	0.534	0.582	0.662	1.73	1.28	2.44	1.76	0.344	0.275	0.409	0.320
Goodland	102	110	1.300	1.840	0.740	0.900	3.14	4.10	2.58	1.54	0.423	0.268	0.507	0.432
Billings	106	114	1.030	1.080	0.280	0.190	2.75	2.26	1.73	1.23	0.349	0.317	0.436	0.374
1971-72														
Gering	103	98	2.28	0.320	0.460	0.630	2.45	0.97	1.87	1.52	0.319	0.290	0.380	0.286
Billings	123	128	1.65	1.440	0.650	0.530	4.28	3.71	0.77	0.67	0.299	0.261	0.458	0.389
1972-73														
Gering	100	108	0.511	0.538	0.685	0.614	3.75	2.45	1.00	0.69	0.284	0.246	0.467	0.347
Ft. Morgan	102	118	0.605	0.544	0.916	0.623	2.00	1.19	0.78	0.72	0.280	0.194	0.348	0.222
Goodland	113	112	1.645	1.069	0.813	1.122	3.69	2.80	1.19	0.86	0.352	0.302	0.468	0.387
Greeley	99	108	0.994	1.066	0.688	0.620	1.94	1.44	0.57	0.19	0.201	0.164	0.283	0.223
Billings	116	103	2.432	1.377	0.504	0.354	3.38	1.42	0.73	1.65	0.375	0.405	0.474	0.400
		111		1.851		0.397		2.00		1.50		0.387		0.413
Avg. — All Locations*			1.510	1.116	0.593	0.584	3.32	2.27	1.32	1.05	0.331	0.266	0.442	0.337
Reduction Loss — % of Non Covered										20.5		19.6		23.8
T-Test p† =				0.05		N.S.		0.01		0.05		0.005		0.0005

*Two values for Fremont-Covered (1969-70) and Billings Covered (1972-73) were averaged for determination of overall averages and paired t test.
†P values equal to or less than 0.05 are regarded as significant and those equal to or smaller than 0.01 are highly significant.

Table 3.—Effect of woven polypropylene plastic cover* on storage loss in test piles.

Factory District	Storage Period — Days		Change During Storage: Invert Sugars Increase — g/100 RDS		Change During Storage: Raffinose Increase — g/100 RDS		Change During Storage: C.J. Purity Decrease — %		Loss During Storage — Lb/T/D: Weight		Loss During Storage — Lb/T/D: Sugar		Loss During Storage — Lb/T/D: Rec. Sugar	
	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered	Non-Cov'd	Covered
1971-72														
Ft. Morgan	97	100	0.88	1.28	0.57	0.76	2.45	2.66	1.67	1.52	0.328	0.237	0.420	0.350
Goodland			--	--	--	--	--	--	1.67	1.34	0.310	0.247	--	--
Greeley	77	84	0.51	0.92	0.67	0.57	2.10	2.35	1.88	1.43	0.278	0.218	0.367	0.324
1972-73														
Gering	100	114	0.51	0.56	0.69	0.510	3.75	4.01	1.00	1.20	0.284	0.334	0.467	0.484
Ft. Morgan	102	111	0.61	0.62	0.92	0.463	2.00	1.07	0.78	0.91	0.280	0.226	0.348	0.224
Avg. All Locations			0.63	0.84	0.71	0.58	2.58	2.52	1.40	1.28	0.296	0.252	0.400	0.346
Reduction in loss % of Non-covered			--		--		--		8.6		14.9		13.5	
t Test† p =			0.10		N.S.		N.S.		N.S.		0.10		0.10	

*Includes piles covered with woven polypropylene over straw.
†Paired t test.

growing areas, are not as accurate in an individual test comparison as the detailed tests because a sugar analysis was made for every 300 to 600 tons compared to every 20-25 tons for the detailed tests. Furthermore, no correction of the pol reading was made for raffinose and invert sugars on the commercial tests. Despite limitations, commercial pile tests gave results comparable to detailed tests. Average reduction of sugar loss with straw cover was 23.8 percent in commercial tests compared with 19.6 in detailed tests. Plastic cover reduced losses by 11.9 and 14.9 in the two sets of tests respectively. Thus, commercial pile data provides an inexpensive supplement to test pile data in donfirming the value of pile covering in reducing storage losses.

The tests described in this paper conclusively show that straw cover reduces loss of sugar and extractable sugar during storage. These tests, as well as the rim tests (1), show that a six inch straw layer on the sides is as effective as an 18 inch layer in reducing storage loss. The thin one to two inch layer of straw which drifts on top of the pile when covering the sides gives sufficient protection to the top. A thicker top layer will retard pile cooling and thus increase losses in the interior. The primary obstacle to the use of straw for pile protection is the problems which straw causes in some factories. Techniques are being developed to improve the separation of straw from beets at the pile and in the flume. Many factories can handle straw when the straw and beets are uniformly mixed during reloading. Improved trash removal systems and regulation of beet and water flow in the flume would help most factories which have trouble with straw.

Woven polypropylene was tested as an alternative material for pile protection. Under some conditions the plastic cover gave nearly as good protection as the straw; however, the plastic causes more extensive freezing in the center of the pile which is subject to thawing and subsequent deterioration. Woven polypropylene may be used as a cover for the end or side which is to be opened first on a straw covered pile. In this way a large initial shipment of straw to the factory could be avoided. Tough plastic neeting can also be used under the straw layer to strip the straw from pile sides before reloading.

The pile covering described in this paper does not prevent freezing of beets on the sides of the pile but retards the rate at which they thaw. Frozen beets under straw will eventually thaw if subjected to warm winds and will undergo extensive deterioration. Thus, a straw cover gives protection through January in our climate but does not give complete protection for safe, long term storage of beets.

Table 4.—Summary of weight and sugar shrink in commercial piles.

Year	Treatment	No. Piles	Average Storage Days	Weight Shrink		Sugar Shrink	
				Lb/T/D	Loss Reduction	Lb/T/D	Loss Reduction
				Mean ± S.E	% of Check	Mean ± S.E	% of Check
1970-71	No Cover	8	77.9	1.93 ± 0.27	--	0.379 ± 0.021	--
	Straw Cover	9	88.7	1.10 ± 0.17	43.0	0.279 ± 0.014	26.4
1971-72	No Cover	10	76.8	1.92 ± 0.16	--	0.388 ± 0.034	--
	Straw Cover	13	83.9	1.36 ± 0.20	29.2	0.291 ± 0.033	25.0
	Woven Plastic Cover	8	96.1	1.63 ± 0.20	15.1	0.336 ± 0.042	13.4
1972-73	No Cover	6	78.2	0.71 ± 0.39	--	0.401 ± 0.026	--
	Straw Cover	7	91.7	0.63 ± 0.17	11.3	0.322 ± 0.024	19.7
	Woven Plastic Cover	1	114	1.15	+62.0	0.377	6.0
Avg All Piles	No Cover	24	77.5	1.62 ± 0.18	--	0.387 ± 0.017	--
	Straw Cover	29	87.3	1.10 ± 0.12	32.1	0.295 ± 0.016	23.8
	Woven Plastic Cover	9	98.1	1.57 ± 0.19	3.1	0.341 ± 0.037	11.9

Summary

Straw covering of beet piles reduced weight loss, sugar loss and recoverable sugar loss by 20.5, 19.6 and 23.8 percent respectively when compared with non-covered piles in tests conducted over a four year period. The purity decrease and invert sugar formation during storage was significantly reduced with straw cover. The most satisfactory covering was a six inch layer of straw on the side and a one to two inch layer on the top.

Woven polypropylene covering reduced storage losses under some conditions but promoted freezing and thawing in the interior of the pile.

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