

ARTHUR A. SHILLANDER



125
582
THS

THESIS
THE SHRINKAGE OF
POTATOES IN STORAGE

ARTHUR ALEXIS SHILLANDER

1915

Review

Thesis

THE SHRINKAGE OF POTATOES IN STORAGE.

Submitted by

Arthur Alexis Shillander.

To the Horticultural Department,

Michigan Agricultural College,

June, 1915.

THESIS

Table of Contents.

Introduction	1
Resume of Literature	1
Description of Experiment	8
Results	9
Conclusions	12

THE SHRINKAGE OF POTATOES IN STORAGE.

Introduction.

It is a well known fact that potatoes lose weight when kept in storage. As several investigators have discovered, this loss is due to evaporation of water and to changes caused by the process of respiration in the organic matter. Considerable amounts of potatoes are kept over winter by the potato growers for the purpose of selling them in the spring when the price is usually higher. Therefore, if cheap and convenient methods of storing the tubers can be discovered, that will lessen the amount of shrinkage, these will be the means of saving money to the grower. Even determining how much the loss in weight will be, will undoubtedly be of value to the grower in helping him to decide whether it will pay to keep the potatoes over winter or not. Briefly stated, the primary purpose of this experiment is to solve such problems as the ones mentioned.

A few experiments on this subject have been carried on by men in different parts of this country and in other countries. A brief survey of what these investigators have found would not be out of place at this time.

Resume of Literature.

One of the first investigators was Nobbe. He studied the changes in weight and in chemical composition as influenced by temperature, moisture, light, etc. His con-

* Landw. Vers. Stat., 7(1865) 452 -461., obs. in E.S.R.V.

as follows for each month: Oct. 202%, Nov. 1, 18%, Dec. 50%, Jan. 50%, Feb. 81%, Mar. 41%, April 50%. Wollny stated that $0^{\circ} - 10^{\circ}\text{C}$. ($32^{\circ} - 50^{\circ}\text{F}$) is the most rational temperature for keeping potatoes since within these limits the respiration is low. Losses of organic matter increase in proportion to the growth of sprouts. When they start, the loss in weight is rapid.

C. O. Appleman* after carrying on experiments at the Maryland Experiment Station, states that potatoes lose weight due to evaporated water and respired carbon dioxide. Dry conditions favor evaporation. The loss of CO_2 is higher at high temperatures. The greatest loss in weight occurs just after digging and decreases during the winter months. At the beginning of the period of warm weather sprouting commences and the loss in weight rapidly increases. A storage temperature of slightly above freezing is best for seed potatoes but for culinary purposes a moderately dry well ventilated cellar, temperature 38° to 42° F. is preferable.

L. R. Taft and U. P. Hedrick,* in 1893 stored 180 pounds of potatoes in a barrel in a potato basement and found that the tubers lost five per cent of their weight between Sept. 30, 1893 and Mar. 28, 1894. On May first they weighed them again and found an additional loss of

* Appleman, C.O.O. Changes in Irish Potatoes During Storage. Maryland Agr. Exp. Sta. Bul. 167. pp. 327-34.

** Taft, L. R. and U. P. Hedrick. Does it Pay to Keep Potatoes Over Winter. Mich. Agr. Exp. Sta. Bul. No. 119. p. 9.

6½ per cent making a total of 11½ per cent loss between September 30th and May 1st. At the latter weighing the tubers were beginning to get soft and flabby. They state also that the basement was perhaps a little warmer than it should have been. They recommend a well ventilated root-house, kept at about 45°F. or a little lower as a very good place for keeping potatoes.

In 1897, R. H. Price* of the Texas Agricultural Experiment Station, tried several methods of storing potatoes. The author states that the tubers rotted rapidly there because of moisture and warm weather. Tubers were stored in sand in a barrel but they rotted soon. Also, some were placed in the ground, one foot under the surface; tiling was run thru the center to give ventilation but under these conditions the tubers were rotted in six weeks. Another plan was to spread the tubers on the ground under partial shade and cover them with hay about two inches deep. They were kept moist by sprinkling with water from a hose. About fifty per cent of them kept till the first of October. Several rows of potatoes were left in the ground and a plow was used to throw dirt upon each row. They were left in this condition until the 15th of August and 75 per cent had kept well; by the first of September fifty per cent had decayed. A few sound ones were found on the 15th of February.

* Price, R. H. Methods of Storage of Potatoes. Texas Agr. Exp. Sta. Bul. No. 42.

F. Parisot* states that a temperature of 8°C. is the best for storing potatoes either for food or for seed because at this temperature the respiration, combustion and formation of starch are considered as off setting the formation of sugar, and that at a higher temperature the quantity of sugar is smaller than at a lower temperature.

A storage test was made by W. Christie**, at the Hedemarken County Experiment Station by placing potatoes on the soil surface and covering them with alternating layers of straw and dirt. Two piles of tubers, of the General Cronje variety were spilled 1½ meters wide by three meters long and as high as the tubers would lie. The piles were covered with two layers of straw alternating with two layers of dirt. The larger pile was ventilated at the surface of the ground and at the top of the pile; the smaller one, only at the top. The storage period was between Nov. 1, 1908 and Apr. 20, 1909. Temperature readings at ten day intervals showed a minimum for the period of -23.9 C. When the piles were opened, a few potatoes in the top layer were frozen. Bacterial rot had spoiled considerable quantities, probably because of moist condition of the potatoes when stored. In the

* Parisot, F. E.S.R. V. 16, P. 970; Jour. Agr. Prat.,
N. ser., 8(1904) No. 50. pp 763 - 765.

**Christie, W. Ber Hedemarkens Amt. Forsookestat Verks.,
6(1910) pp. 58.

large piles 43 per cent of the tubers were sound as compared with 54 per cent in the small piles.

Denaiffe* states that the loss in weight of stored potatoes varies with the variety.

At the Agricultural Experiment Station in Arkansas** and Indiana*** tests have been carried on to determine the keeping qualities of different varieties.

* Denaiffe, Loss in Weight of Stored Potatoes, Jardin, 21 (1907), No 481, pp. 76-79.

**Arkansas State Report No. 889, p. 39.

*** Indiana Bull. 1892. p. 23.

Other investigators on the loss of weight of potatoes but whose writings are not at present available to the writer are:

R. Heinrick (Zweiter Ber. landw. Vers. Stat. Rostock 1894 p.229).

E. J. Woodhouse and H. L. Dutt (Agr. Jour. Bihar and Orissa (India), 1, 1913. No. 2, pp. 115-137.

Bengal Quarterly, published by Department of Agriculture, India, Jour 3(1909) No. 1. pp.1-12.

Description of Experiment.

The following are the questions which the writer has tried to answer in this work:

1. How does storing potatoes in crates, in bins (in cellar), in pits in the ground, wrapped in newspaper, one and two thicknesses effect the shrinkage?
2. At what time of the storage season does the greatest shrinkage take place?
3. Does the spraying of potatoes while growing affect the shrinkage in storage?

1191 tubers or about 11 bushels of the Sir Walter Raleigh variety were brushed, weighed and diameters measured separately. Each tuber was numbered with India ink and the points where the diameter was measured were marked so that it would be taken at the same points again. Most tubers have three dimensions or diameters: length, breadth, and thickness; the one giving the breadth was measured. This was done by means of a caliper. Ordinary postal scales were used for weighing. Weighing and measuring were begun one week after the potatoes were dug and was completed two weeks after, on November 28th. On account of the limited amount of time that the writer had at his disposal the work could not be completed in a shorter time as was desired.

100 tubers (that had been sprayed) were placed in each of the following conditions; in bins, in crates, in

pits in the ground and in one and two thicknesses of newspaper wrapped around each tuber. The potatoes in the pits were two feet below the surface of the ground, with enough leaves and straw over them to keep the soil from coming in direct contact with the tubers. This was put on so that they could be easily found when dug up again. The potatoes wrapped in paper were placed in boxes. This part of the experiment was repeated by putting 25 sprayed injured tubers in the same conditions. Now, the same amounts of unsprayed potatoes were placed in the same conditions. The purpose of handling injured tubers in the same way was to see if they would be effected differently.

All of the potatoes except those in the pits were kept in a moderately well ventilated potato cellar, the temperature ranging from 40° to 50°F. during the whole storage period. The atmosphere contained slightly more moisture than that outside. The weighing and measuring was done on the 28th of each month, April 28th being the last.

Results.

The unsprayed potatoes, wrapped in two thicknesses of newspaper did not keep well. They were attacked by a fusarium rot so that in February 6 of the 100 were starting to rot and they were thrown out of the experiment. On March 11th more had to be thrown out, making a total of 17 rotten ones in 125. The rotting, undoubtedly was

S

	28.	April 28	Nov. 28 to Apr. 28.		
Sprayed or:	% Gain	Gain	% Gain	Gain	% Gain
Unsprayed	of	or loss	or	or loss	or
	Loss	ounces	loss	Ounces	Loss
Unsprayed	2.64	-10.0	-1.25	-10.4	-1.3
"	.36	-5.2	-2.38	1.8	.81
Sprayed	-1.77	4.5	.66	-54.3	-7.28
"	.41	3.5	2.04	3.6	2.1
Unsprayed	-.39	32.7	4.74	-3.5	-.48
"	-5.34	7.3	4.43	16.9	-3.86
Sprayed	.61	13.5	1.93	-5.5	-7.18
"	s t	l o s t			
Unsprayed	1.04	43.5	6.25	-11.4	-1.52
"	1.19	3.49	2.75	-7.8	-3.73
Sprayed	-1.35	29.5	3.9	-50.4	-6.03
"	-3.69	3.9	2.26	-6.7	-3.66
Unsprayed	.07	22.4	4.54	-12.5	-2.36
"	none	2.7	1.03	-7.5	-4.28
Sprayed	-.55	21.0	2.7	-29.0	-3.6
Sprayed	.58	4.1	2.57	-1.1	-.61
Unsprayed				9.5	1.32
"				-4.1	-1.04
Sprayed				22.5	3.02
"				-3.1	-1.04

GIV

	March 28		April 28		Nov. 28 to Apr. 28.	
Sprayed	in		Gain		Gain	
or	loss:	%	or loss:	%	or loss:	%
Unsprayed	C.M.		c.m.		C.M.	
Unsprayed	3.0	-.43	-3.7	-.54	-32.3	-4.46
"	.6	.34	-.9	-.51	-4.5	-2.51
Sprayed	2.3	-.32	-3.1	-.45	-27.2	-3.88
"	2.1	-1.25	2.2	1.33	-2.5	-1.46
Unsprayed	53	-.78	-2.0	-.30	-17.2	-2.5
"	1.1	-.64	-.6	-.35	-8.7	-4.98
Sprayed	-.6	-.08	-9.1	-1.33	-34.	-4.8
"	10.6	-1.62	none	none	-29.2	-4.28
Unsprayed	-2.4	-1.4	-1.3	-.77	-7.	-4.02
"	1.4	-.21	-4.7	-.71	-23.1	-3.42
Sprayed	-.5	-.29	-.9	-.52	-6.7	-3.78
"	8.3	-1.52	-9.6	-1.79	-29.9	-5.38
Unsprayed	-.7	-.48	-.8	-.49	-5.2	-3.13
"	none	none	-1.5	-.21	-33.4	-4.74
Sprayed	none	none	-1.4	-.79	-7.6	-4.10
"					-.7	-.01
					-.7	-.30
Unsprayed						
"					-5.3	-.78
Sprayed					-1.4	-.62
"						

Table III.

Giving the average gains and losses in weight in per cent
of sprayed and unsprayed potatoes.

Method of Storage	Dec.	Jan.	Feb.	Mar.	Apr.	Nov. 28 to Apr. 28.
In Bins	-6.76 $\frac{3}{4}$ %	.06%	-2.31%	-1.87 $\frac{1}{2}$ %	2.91%	-2.73%
In Grates	-2.58%	-3.24%	.63%	.02 $\frac{1}{4}$ %	2.70%	-2.71%
1 Thickness						
Paper	-2.57%	-1.37%	1.40%	.41%	-2.35%	-1.42%
2 Thickness						
Paper	-4.42%	-2.98%	1.79%	-.70%	2.70%	-3.84%
In Pits						.57%
Average	4.08%	-1.91%	.37 $\frac{1}{2}$ %	-1%	1.70%	-2.02

Table IV.

Giving the average gains and losses in diameter in per
cent of sprayed and unsprayed potatoes.

Method of Storage	Dec.	Jan.	Feb.	Mar.	Apr.	Nov. 28 to Apr. 28.
In Bins	-2.45%	-.44%	-.21%	-.88%	-.50%	-3.87%
In Grates	-1.12%	.02%	-.44%	-.50%	-.82%	-4.34%
1 Thickness						
Paper	-1.80%	-.13%	-.045%	-.415%	-.04%	-3.08%
2 Thickness						
Paper	-2.17%	-.38%	-.54%	-.50%	-.66%	-4.09%
In Pits						-.43%
Average	1.88%	-.24%	-.31%	-.57%	-.53%	-3.16%

caused in part by the moisture and higher temperature kept near the tubers by two thicknesses of paper. The other potatoes kept well, even the injured ones. Those that were under ground, when dug were firm and all sound. Their increased weight was probably due to moisture absorbed from the soil.

In some instances there was a slight gain in weight over the preceding month as may be seen by referring to table I. These gains occurred mostly during the months of February and March when the losses in the others were the least. No reason for this gain can be given except that it may be due to a greater amount of moisture in the atmosphere at this time. In the case of the injured tubers, there was no appreciable difference between the percentage of shrinkage in them and the uninjured ones, for the whole length of time.

Tables III and IV contain data which answers the first question. For the month of December those tubers stored in bins lost the most by weight, 6.76 per cent while those wrapped in one thickness of paper and those in crates showed the least loss of all stored above the ground. This holds true also for the period November 28th to April 28th. In the other months there was more variation and on that data no general rule can be laid down that will hold for each month. There is a reason why the shrinkage should take place more rapidly when potatoes are in bins than in crates, wrapped in paper.

Table V.

Giving the differences in per cent between sprayed and unsprayed potatoes in changes of weight and diameter.

	In Bins	In Crates	1 Thickness Paper	2 Thick. Paper	In Ground	Av.
Unsprayed	-2.62½%	-3.32%	-.49%	-4.33%	.14%	-1.34%
Sprayed	-4.84½%	-2.10%	-5.18%	-7.18%	.99%	-3.66%
<u>Diameters</u>						
Unsprayed	-4.15%	-4.25%	-3.50%	-3.74%	-.15%	-3.09%
Sprayed	-3.60%	-4.42%	-2.67%	-4.8%	-.70%	-3.24%

When potatoes are in piles as in bins, they are kept warmer than when in small piles as in crates and when wrapped in paper. According to other investigators, Nobbe* in particular, heat increases the losses. The shrinkage in size as measured by the diameter, in the main, follows that of the loss in weight but there are some variations between December and April.

From the averages as given in table III and IV, one can easily see that the greatest shrinkage takes place in the month just following the digging, and decreases from then till March, when it begins to increase. The chief cause for this fact is the temperature; it being lower during January and February, the chemical changes are less active and there is also less evaporation of water.

As to the question whether spraying effects the shrinkage of potatoes, one may conclude from the figures given in table V that it does. An average of the percentages of losses and gains for unsprayed potatoes stored in the different places shows that they have lost only 1.34 per cent of their original weight while the sprayed potatoes placed under similar conditions have lost 3.66 per cent, a difference of 2.32 per cent in favor of the unsprayed. Shrinkage as measured by diameter follows the same rule though there is not so great a difference between the sprayed and unsprayed.

* E. S. R. V.3. p.494.

Conclusions and Summary.

1. Potatoes shrink the least when placed in pits, at least two feet deep and covered with earth so that they will not freeze. The loss in weight is greatest when potatoes are put in large piles as in bins. This is due to the fact that there is a higher temperature in the piles. Ventilating the cellar and lowering the temperature, but not to freezing point, would overcome this to a large extent.

2. As was clearly brought out by the data given, potatoes shrink in storage more in the month just after being dug than at any other time; the losses are least in February.

3. Sprayed potatoes lose more weight in storage than the unsprayed.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
95
96
97
98
99
100
101
102
103
104
105
106
107
108
109
110
111
112
113
114
115
116
117
118
119
120
121
122
123
124
125
126
127
128
129
130
131
132
133
134
135
136
137
138
139
140
141
142
143
144
145
146
147
148
149
150
151
152
153
154
155
156
157
158
159
160
161
162
163
164
165
166
167
168
169
170
171
172
173
174
175
176
177
178
179
180
181
182
183
184
185
186
187
188
189
190
191
192
193
194
195
196
197
198
199
200
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220
221
222
223
224
225
226
227
228
229
230
231
232
233
234
235
236
237
238
239
240
241
242
243
244
245
246
247
248
249
250
251
252
253
254
255
256
257
258
259
260
261
262
263
264
265
266
267
268
269
270
271
272
273
274
275
276
277
278
279
280
281
282
283
284
285
286
287
288
289
290
291
292
293
294
295
296
297
298
299
300
301
302
303
304
305
306
307
308
309
310
311
312
313
314
315
316
317
318
319
320
321
322
323
324
325
326
327
328
329
330
331
332
333
334
335
336
337
338
339
340
341
342
343
344
345
346
347
348
349
350
351
352
353
354
355
356
357
358
359
360
361
362
363
364
365
366
367
368
369
370
371
372
373
374
375
376
377
378
379
380
381
382
383
384
385
386
387
388
389
390
391
392
393
394
395
396
397
398
399
400
401
402
403
404
405
406
407
408
409
410
411
412
413
414
415
416
417
418
419
420
421
422
423
424
425
426
427
428
429
430
431
432
433
434
435
436
437
438
439
440
441
442
443
444
445
446
447
448
449
450
451
452
453
454
455
456
457
458
459
460
461
462
463
464
465
466
467
468
469
470
471
472
473
474
475
476
477
478
479
480
481
482
483
484
485
486
487
488
489
490
491
492
493
494
495
496
497
498
499
500
501
502
503
504
505
506
507
508
509
510
511
512
513
514
515
516
517
518
519
520
521
522
523
524
525
526
527
528
529
530
531
532
533
534
535
536
537
538
539
540
541
542
543
544
545
546
547
548
549
550
551
552
553
554
555
556
557
558
559
560
561
562
563
564
565
566
567
568
569
570
571
572
573
574
575
576
577
578
579
580
581
582
583
584
585
586
587
588
589
590
591
592
593
594
595
596
597
598
599
600
601
602
603
604
605
606
607
608
609
610
611
612
613
614
615
616
617
618
619
620
621
622
623
624
625
626
627
628
629
630
631
632
633
634
635
636
637
638
639
640
641
642
643
644
645
646
647
648
649
650
651
652
653
654
655
656
657
658
659
660
661
662
663
664
665
666
667
668
669
670
671
672
673
674
675
676
677
678
679
680
681
682
683
684
685
686
687
688
689
690
691
692
693
694
695
696
697
698
699
700
701
702
703
704
705
706
707
708
709
710
711
712
713
714
715
716
717
718
719
720
721
722
723
724
725
726
727
728
729
730
731
732
733
734
735
736
737
738
739
740
741
742
743
744
745
746
747
748
749
750
751
752
753
754
755
756
757
758
759
760
761
762
763
764
765
766
767
768
769
770
771
772
773
774
775
776
777
778
779
780
781
782
783
784
785
786
787
788
789
790
791
792
793
794
795
796
797
798
799
800
801
802
803
804
805
806
807
808
809
810
811
812
813
814
815
816
817
818
819
820
821
822
823
824
825
826
827
828
829
830
831
832
833
834
835
836
837
838
839
840
841
842
843
844
845
846
847
848
849
850
851
852
853
854
855
856
857
858
859
860
861
862
863
864
865
866
867
868
869
870
871
872
873
874
875
876
877
878
879
880
881
882
883
884
885
886
887
888
889
890
891
892
893
894
895
896
897
898
899
900
901
902
903
904
905
906
907
908
909
910
911
912
913
914
915
916
917
918
919
920
921
922
923
924
925
926
927
928
929
930
931
932
933
934
935
936
937
938
939
940
941
942
943
944
945
946
947
948
949
950
951
952
953
954
955
956
957
958
959
960
961
962
963
964
965
966
967
968
969
970
971
972
973
974
975
976
977
978
979
980
981
982
983
984
985
986
987
988
989
990
991
992
993
994
995
996
997
998
999
1000

MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03103 9195



MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03103 9195