TIMING OF THE OCCURRENCE OF INTERNAL QUALITY PROBLEMS IN ONION BULBS

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Introduction

In the past few years in the Pacific Northwest, there has been an increase in internal onion bulb decomposition of one or more scales. Unlike neck rot or plate rot, this internal decomposition is difficult to detect externally, resulting in quality control issues in marketing. We have suggested that the internal decomposition is often associated with one or more scales that do not finish forming completely the neck or become dehydrated, resulting in small gaps close to the neck, which we have called "incomplete scale". Another suggestion is that internal decomposition is favored by the occurrence of dry scales in the neck or in the neck extending down into the bulb, providing a path for pathogen entry. To learn more about bulb internal quality problems, this trial sought to determine when incomplete scale, dry scale, and internal decomposition can be observed and how quickly they increase.

Materials and Methods

Onions were grown in 2017 on an Owyhee silt loam previously planted to wheat. A soil analysis taken in the fall of 2016 showed that the top foot of soil had a pH of 8.1, 3.0% organic matter, 9 ppm nitrate, 3 ppm ammonium, 50 ppm phosphorus (P), 341 ppm potassium (K), 16 ppm sulfur (S), 2927 ppm calcium (Ca), 502 ppm magnesium (Mg), 269 ppm sodium, 2.2 ppm zinc (Zn), 5 ppm manganese (Mn), 0.6 ppm copper (Cu), 4 ppm iron, and 0.5 ppm boron (B). In the fall of 2016, the wheat stubble was shredded and the field was irrigated. The field was then disked, moldboard plowed, and groundhogged. Based on a soil analysis, 22 lb P/acre, 42 lb K/acre, 200 lb S/acre, 2 lb Zn/acre, 2 lb Mn/acre, and 1 lb B/acre were broadcast before plowing. After plowing, the field was fumigated with K-Pam® at 15 gal/acre and bedded at 22 inches.

The experimental design was a randomized complete block with five replicates. Seed of two varieties ('Joaquin' and 'Granero', Nunhems, Parma, ID) was planted on April 5 in double rows spaced 3 inches apart at 9 seeds/ft of single row. Each double row was planted on beds spaced 22 inches apart. Planting was done with customized John Deere Flexi Planter units equipped with disc openers. Immediately after planting, the field received a narrow band of Lorsban 15G® at 3.7 oz/1000 ft of row (0.82 lb ai/acre) over the seed rows and the soil surface was rolled. Onion emergence started on April 20. On May 9, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. On May 25, the seedlings were hand thinned to a spacing of 4.75 inches between individual onion plants in each single row, or 120,000 plants/acre.

The field had drip tape laid at 4-inch depth between pairs of beds during planting. The drip tape had emitters spaced 12 inches apart and an emitter flow rate of 0.22 gal/min/100 ft (Toro Aqua-Traxx, Toro Co., El Cajon, CA). The distance between the tape and the center of each double row of onions was 11 inches.

The onions were managed to minimize yield reductions from weeds, pests, diseases, water stress, and nutrient deficiencies. For weed control, the following herbicides were broadcast: Prowl® H_2O at 0.83 lb ai/acre (2 pt/acre) and Poast® at 0.25 lb ai/acre (16 oz/acre) on May 4; GoalTender® at 0.09 lb ai/acre (4 oz/acre) and Buctril® at 16 oz/acre on May 15; and Prowl H_2O at 0.31 lb ai/acre (0.75 pt/acre) and Poast at 0.5 lb ai/acre (32 oz/acre) on June 4.

For thrips control, the following insecticides were applied by ground: Movento® at 5 oz/acre on May 26; Movento at 5 oz/acre and Aza-Direct® at 12 oz/acre on June 2; Agri-Mek® SC at 3.5 oz/acre on June 15 and 23. The following insecticides were applied by air: Radiant® at 10 oz/acre on July 1, 8, and 30; Lannate® at 3 pt/acre on July 17 and 23.

Urea ammonium nitrate solution (URAN) was applied through the drip tape five times from May 26 to June 28, totaling 105 lb N/acre. Starting on June 19, root tissue and soil solution samples were taken every week from field borders and analyzed for nutrients by Western Laboratories, Inc., Parma Idaho (Tables 1 and 2). Nutrients were applied through the drip tape only if both the root tissue and soil solution analyses concurrently indicated a deficiency (Table 3). Nitrogen was applied at the fixed amount previously mentioned, but was limited to 105 lb/acre, because the soil solution test indicated the soil was supplying the crop with ample amounts of N. Ample supplies of soil N are also indicated by the amounts of total available soil N during the season (Table 4). Potassium was deficient in both the soil and the roots on several sampling dates. A total of 197 lb K/acre was applied in 25-lb increments during the season based on the soil and tissue analyses.

Onions were irrigated automatically to maintain the soil water tension (SWT) in the onion root zone below 20 cb (Shock et al. 2000). Soil water tension in each treatment plot was measured with two granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Inc., Riverside, CA) installed at 8-inch depth in the center of the double row. Sensors had been calibrated to SWT (Shock et al. 1998). The GMS were connected to the datalogger via multiplexers (AM 16/32, Campbell Scientific, Logan, UT). The datalogger (CR10X, Campbell Scientific) read the sensors and recorded the SWT every hour. The datalogger automatically made irrigation decisions every 12 hours. The field was irrigated if the average of the 24 sensors in the check and kaolinite treatments was a SWT of 20 cb or higher. The irrigations were controlled by the datalogger using a controller (SDM CD16AC, Campbell Scientific) connected to a solenoid valve. Irrigation durations were 8 hours, 19 min to apply 0.48 inch of water. The water was supplied from a well and pump that maintained a continuous and constant water pressure of 35 psi. The pressure in the drip lines was maintained at 10 psi by a pressure regulating valve. The automated irrigation system was started on June 5 and irrigations ended September 5.

Onions in each plot were evaluated weekly in the field starting July 7 and ending September 15. After harvest, the onions from each plot were evaluated out of storage monthly starting in mid-November. Five consecutive bulbs from each single row in the four-double-row plot were cut longitudinally and rated for the presence of incomplete scales, dry scales, and internal decay caused by, bacteria, neck rot, black mold, or *Fusarium proliferatum*. Incomplete scales were defined as scales that had more than 0.25 inch from the center of the neck missing or any part missing lower down on the scale. Dry scales were defined as scales with a small dry section inside the bulb either near the top of the neck or lower down on the scale. Bulbs from the first two single rows in each plot had the number of leaves counted and the diameter measured.

Table 1. Onion root tissue sufficiency levels and nutrient content, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

Nutrient		19-Jun	4-Jul	11-Jul	17-Jul	24-Jul	31-Jul	7-Aug
NO_3-N (ppm)	Sufficiency range	7667	7200	6833	5000	3500	1834	1000
NO_3-N (ppm)		7325	6868	5773	4847	4903	6090	5218
P (%)	0.32 - 0.7	0.45	0.52	0.44	0.52	0.34	0.27	0.33
K (%)	2.7 - 6.0	2.20	2.58	2.40	1.97	1.48	1.88	0.96
S (%)	0.24 - 0.85	0.84	0.96	1.09	0.98	0.76	0.90	0.99
Ca (%)	0.4 - 1.2	0.61	0.67	0.74	0.85	1.10	0.94	1.18
Mg (%)	0.3 - 0.6	0.39	0.38	0.37	0.36	0.41	0.40	0.41
Zn (ppm)	25 - 50	55	52	48	39	32	32	31
Mn (ppm)	35 - 100	193	183	160	144	139	118	83
Cu (ppm)	6 - 20	24	18	14	12	10	10	12
B (ppm)	19 - 60	30	29	33	41	32	23	25

Table 2. Soil solution critical levels and weekly analyses. Data represent the amount of each plant nutrient per day that the soil can potentially supply to the crop. Numbers following each nutrient are the critical levels. Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

Nutrient	Critical level, lb/ac or g/ac	19-Jun	4-Jul	11-Jul	17-Jul	24-Jul	31-Jul	7-Aug
N	Critical level	7.8	5.5	4.6	4	3	2	1.5
N		7.7	10.9	14.3	17.1	16.6	18.6	23.7
P	0.7 lb/acre	0.3	0.5	0.6	0.7	1.0	1.4	0.9
K	5 lb/acre	1.5	1.8	2.1	2.6	3.0	3.7	4.5
S	1 lb/acre	1.6	2.1	2.6	3.2	3.8	3.9	2.5
Ca	3 lb/acre	10.0	8.8	8.6	6.9	5.6	5.8	4.7
Mg	2 lb/acre	6.4	7.3	6.6	7.7	8.3	9.2	7.2
Zn	28 g/acre	6	15	18	24	30	39	39
Mn	28 g/acre	9	27	21	27	30	36	42
Cu	12 g/acre	3	9	15	18	21	24	24

Table 3. Nutrients applied through the drip irrigation system to the onion variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

Date	N	K
	------ lb/acre -------	
26-May	30	
5-Jun	15	
15-Jun	15	
20-Jun	30	31
28-Jun	15	
6-Jul		31
11-Jul		26
18-Jul		31
26-Jul		26
1-Aug		26
9-Aug		26
total	105	197

Table 4. Soil available N (NO_3 + NH_4) in the top foot of soil, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

Date	Available soil N, lb/acre
19-Jun	54
4-Jul	76
11-Jul	100
17-Jul	120
24-Jul	116
31-Jul	130
7-Aug	166

The onions were lifted on September 25 to cure in the field. Onions from each plot were topped by hand and bagged on October 2. The bags were moved into storage on October 11. The storage shed was ventilated and the temperature was slowly decreased to maintain air temperature as close to 34°F as possible.

The effects of variety and evaluation date were determined using repeated measures analysis of variance. Means separation was determined using a protected Fisher's least significant difference test at the 5% probability level, LSD (0.05). The least significant difference LSD (0.05) values in each table should be considered when comparisons are made between treatments. A statistically significant difference in a characteristic between two treatments exists if the difference between the two treatments for that characteristic is equal to or greater than the LSD value for that characteristic.

Results and Discussion

The rate of accumulation and total number of growing degree-days (50-86°F) in 2017 were close to the 24-year average, until July (Fig. 1), which had higher than average growing degree-days (Fig. 2).

On July 7, 2017 the bulbs had an average of 12 leaves, were 1.8 inches in diameter (Table 5), and had no symptoms of incomplete scale or decomposition (Table 6). The average number of leaves peaked at 17 and the average diameter peaked at close to 4 inches.

Both dry scales and incomplete scales were detected starting in late July (Table 6). The percentage of bulbs with incomplete scales or dry scales increased over time until the November evaluation for both varieties. Between the November and the January evaluations, the percentage of bulbs with incomplete scales and dry scales did not increase. Bulbs with internal decomposition were first found on August 25. Averaged over the two varieties, the percentage of bulbs with internal decomposition increased over time until September 15, reaching 9.5%. Evaluated out of storage in November and January, bulbs with internal decomposition decreased to 3.3 and 3.8%, respectively. Most of the internal decomposition was found in bulbs with incomplete scales. Of the bulbs with internal decomposition, 94.7% had incomplete or dry scales and only 5.3% had neither. Averaged over dates, Granero had a higher percentage of bulbs with incomplete scales and internal decomposition.

Most of the internal decomposition in this trial in 2017 was caused by black mold (Table 7). There was very little internal decomposition caused by bacteria, *Fusarium proliferatum*, or botrytis neck rot. For both varieties, black mold was first detected in late August and increased until September 15, just before harvest. At the November and January evaluations, the internal decomposition caused by black mold decreased. The internal decomposition caused by black mold decreased from 7% in September to 1% in January for Joaquin and from 10% in September to 5.5% in January for Granero.

In 2016, incomplete scales were first detected in early September and internal decomposition was first detected in December, later than in 2017 (Table 8). In 2016, most of the internal decomposition was due to bacterial rot and neck rot, with very little *Fusarium proliferatum* (Table 9). No internal decomposition due to black mold was detected in 2016.

Acknowledgements

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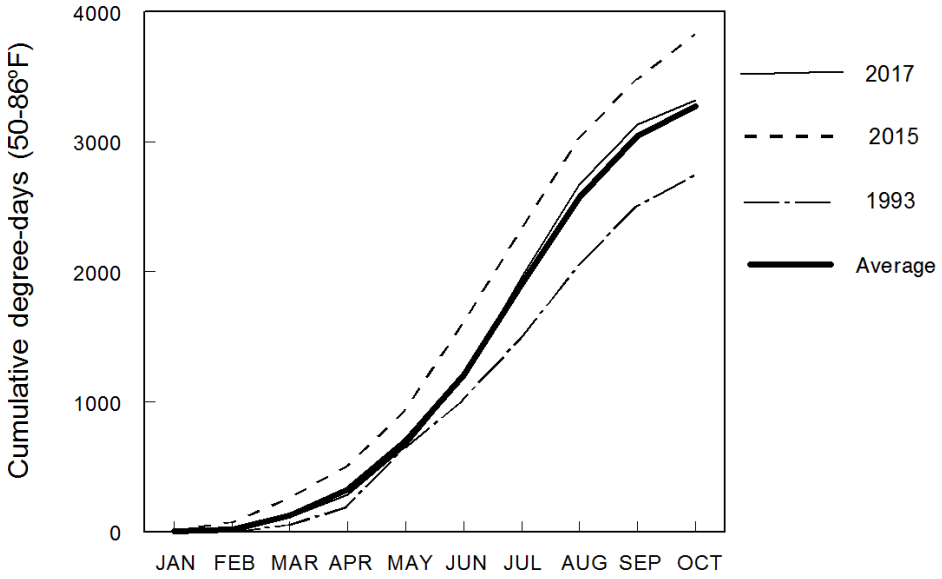

Figure 1. Cumulative growing degree-days (50-86°F) for 2015-2017 and 24-year average, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

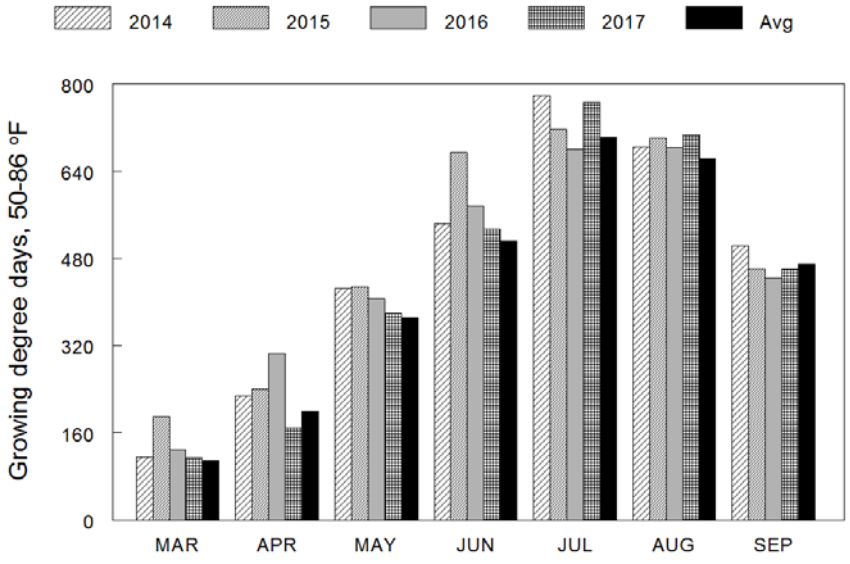

Figure 2. Monthly growing degree-days (50-86°F) for 2014-2017 and 24-year average, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

Table 5. Number of leaves and bulb diameter over time for onion bulbs evaluated for internal defects, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

Variety	Date	No. of leaves	Bulb diameter, inch
Joaquin	7-Jul	12.0	1.8
	14-Jul	13.3	2.8
	21-Jul	13.1	2.5
	28-Jul	14.2	3.0
	11-Aug	15.1	3.4
	18-Aug	14.9	3.4
	25-Aug	15.7	3.5
	1-Sep	16.0	3.5
	8-Sep	17.2	3.7
	15-Sep		3.6
Granero	7-Jul	11.9	1.8
	14-Jul	12.6	2.9
	21-Jul	13.2	2.4
	28-Jul	15.2	3.2
	11-Aug	14.7	3.3
	18-Aug	14.6	3.3
	25-Aug	15.4	3.4
	1-Sep	15.9	3.5
	8-Sep	16.5	3.4
	15-Sep		3.4
Average	7-Jul	12.0	1.8
	14-Jul	13.0	2.8
	21-Jul	13.2	2.4
	28-Jul	14.7	3.1
	11-Aug	14.9	3.3
	18-Aug	14.8	3.3
	25-Aug	15.5	3.4
	1-Sep	15.9	3.5
	8-Sep	16.8	3.6
	15-Sep		3.5
LSD (0.05)	Variety	NS	NS
	Date	0.94	0.2
	Variety X date	NS	NS

Table 6. Internal defects over time for two onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017. Continued on next page.

		All bulbs							Diseased bulbs						
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total
Variety	Date	no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total	
		%													
Joaquin	7-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	14-Jul	99.0	0.0	99.0	0.0	1.0	1.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	98.0	0.0	98.0	2.0	0.0	2.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	97.5	2.5	100.0	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11-Aug	88.5	6.0	94.5	1.0	4.5	5.5	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	18-Aug	86.5	6.0	92.5	0.0	7.5	7.5	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25-Aug	77.5	4.0	81.5	1.0	17.5	18.5	100	0.0	0.0	0.0	0.0	2.5	2.5	2.5
	1-Sep	56.0	21.0	77.0	2.0	21.0	23.0	100	0.0	0.0	0.0	0.0	2.0	2.0	2.0
	8-Sep	61.5	22.5	84.0	0.0	16.0	16.0	100	1.0	0.5	1.5	0.0	3.0	3.0	4.5
	15-Sep	65.5	15.5	81.0	0.0	19.0	19.0	100	0.5	0.5	1.0	0.0	7.0	7.0	8.0
	21-Nov	36.8	2.0	38.8	32.0	29.2	61.2	100	0.0	0.0	0.0	0.0	1.2	1.2	1.2
	29-Jan	33.5	8.0	41.5	21.5	37.0	58.5	100	0.0	0.0	0.0	0.5	0.5	1.0	1.0
	Average	75.0	7.3	82.3	5.0	12.7	17.7	100	0.1	0.1	0.2	0.0	1.3	1.4	1.6
Granero	7-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	14-Jul	98.0	0.0	98.0	0.0	2.0	2.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	96.5	0.5	97.0	2.5	0.5	3.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	92.0	7.0	99.0	1.0	0.0	1.0	100	0.0	0.0	0.0	1.0	0.0	1.0	1.0
	11-Aug	49.0	12.5	61.5	5.0	33.5	38.5	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	18-Aug	59.0	9.5	68.5	2.0	29.5	31.5	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25-Aug	46.5	15.5	62.0	0.5	37.5	38.0	100	0.0	0.0	0.0	0.0	2.5	2.5	2.5
	1-Sep	32.0	17.0	49.0	1.5	49.5	51.0	100	0.0	0.0	0.0	0.0	4.5	4.5	4.5
	8-Sep	23.0	27.0	50.0	0.5	49.5	50.0	100	0.0	0.0	0.0	0.5	9.5	10.0	10.0
	15-Sep	29.5	9.0	38.5	1.0	60.5	61.5	100	0.0	0.0	0.0	0.0	11.0	11.0	11.0
	21-Nov	15.5	1.0	16.5	36.5	47.0	83.5	100	0.0	0.0	0.0	0.0	5.5	5.5	5.5
	29-Jan	3.0	6.0	9.0	22.5	68.5	91.0	100	0.0	0.5	0.5	0.5	5.5	6.0	6.5
	Average	53.7	8.8	62.4	6.1	31.5	37.6	100	0.0	0.0	0.0	0.2	3.2	3.4	3.4

Table 6. (Continued) Internal defects over time averaged over two onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

		All bulbs							Diseased bulbs						
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total
Variety	Date	no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total	
		%													
Average	7-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	14-Jul	98.5	0.0	98.5	0.0	1.5	1.5	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	97.3	0.3	97.5	2.3	0.3	2.5	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	94.8	4.8	99.5	0.5	0.0	0.5	100	0.0	0.0	0.0	0.5	0.0	0.5	0.5
	11-Aug	68.8	9.3	78.0	3.0	19.0	22.0	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	18-Aug	72.8	7.8	80.5	1.0	18.5	19.5	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	25-Aug	62.0	9.8	71.8	0.8	27.5	28.3	100	0.0	0.0	0.0	0.0	2.5	2.5	2.5
	1-Sep	44.0	19.0	63.0	1.8	35.3	37.0	100	0.0	0.0	0.0	0.0	3.3	3.3	3.3
	8-Sep	42.3	24.8	67.0	0.3	32.8	33.0	100	0.5	0.3	0.8	0.3	6.3	6.5	7.3
	15-Sep	47.5	12.3	59.8	0.5	39.8	40.3	100	0.3	0.3	0.5	0.0	9.0	9.0	9.5
	21-Nov	26.2	1.5	27.7	34.3	38.1	72.3	100	0.0	0.0	0.0	0.0	3.3	3.3	3.3
	29-Jan	18.3	7.0	25.3	22.0	52.8	74.8	100	0.0	0.3	0.3	0.5	3.0	3.5	3.8
LSD (0.05)															
Variety		4.7	NS	5.3	NS	3.7	5.3		NS	NS	NS	0.9	0.7	0.9	1.0
Date		6.3	5.2	6.6	3.8	6.1	6.5		NS	NS	NS	2	2.2	2.4	2.3
Var. X date		8.9	NS	9.4	NS	8.6	9.4		NS	NS	NS	NS	3.1	3.4	NS

Table 7. Internal decomposition over time by disease for two onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2017.

Variety	Date	Bacterial rot	*Fusarium proliferatum*	Neck rot	Black mold
			---------- % ----------		
Joaquin	7-Jul	0.0	0.0	0.0	0.0
	14-Jul	0.0	0.0	0.0	0.0
	21-Jul	0.0	0.0	0.0	0.0
	28-Jul	0.0	0.0	0.0	0.0
	11-Aug	0.0	0.0	0.0	0.0
	18-Aug	0.0	0.0	0.0	0.0
	25-Aug	0.0	0.0	0.0	2.5
	1-Sep	0.0	0.0	0.0	2.0
	8-Sep	0.5	0.0	0.5	3.5
	15-Sep	0.5	0.5	0.0	7.0
	21-Nov	0.0	0.0	0.0	1.2
	29-Jan	0.0	0.0	0.0	1.0
	Average	0.1	0.0	0.0	1.4
Granero	7-Jul	0.0	0.0	0.0	0.0
	14-Jul	0.0	0.0	0.0	0.0
	21-Jul	0.0	0.0	0.0	0.0
	28-Jul	1.0	0.0	0.0	0.0
	11-Aug	0.0	0.0	0.0	0.0
	18-Aug	0.0	0.0	0.0	0.0
	25-Aug	0.0	0.0	0.0	2.5
	1-Sep	0.0	0.0	0.0	4.5
	8-Sep	0.0	1.0	0.0	9.0
	15-Sep	0.0	1.0	0.0	10.0
	21-Nov	0.0	0.0	0.0	5.5
	29-Jan	1.0	0.0	0.0	5.5
	Average	0.2	0.2	0.0	3.1
Average	7-Jul	0.0	0.0	0.0	0.0
	14-Jul	0.0	0.0	0.0	0.0
	21-Jul	0.0	0.0	0.0	0.0
	28-Jul	0.5	0.0	0.0	0.0
	11-Aug	0.0	0.0	0.0	0.0
	18-Aug	0.0	0.0	0.0	0.0
	25-Aug	0.0	0.0	0.0	2.5
	1-Sep	0.0	0.0	0.0	3.3
	8-Sep	0.3	0.5	0.3	6.3
	15-Sep	0.3	0.8	0.0	8.5
	21-Nov	0.0	0.0	0.0	3.3
	29-Jan	0.5	0.0	0.0	3.3
LSD (0.05)					
Variety		NS	NS	NS	0.9
Date		NS	NS	NS	2.1
Var. X date		NS	NS	NS	3.0

Table 8. Internal defects over time for two onion varieties in 2016, Malheur Experiment Station, Oregon State University, Ontario, OR, 2016. Continued on next page.

		All bulbs							Diseased bulbs						
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total
Variety	Date	no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total	
		%													
Joaquin	7-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	13-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	17-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	26-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-Sep	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9-Sep	94.0	0.0	94.0	6.0	0.0	6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Nov	32.5	5.0	37.5	29.5	33.0	62.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	16-Dec	38.0	0.0	38.0	38.0	24.0	62.0	100.0	0.0	0.0	0.0	0.5	0.0	0.5	0.5
	15-Feb	47.0	0.0	47.0	46.5	6.5	53.0	100.0	0.0	0.0	0.0	2.5	0.0	2.5	2.5
	Average	85.5	0.4	85.9	9.2	4.9	14.1	100.0	0.0	0.0	0.0	0.2	0.0	0.2	0.2
Granero	7-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	13-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11-Aug	99.5	0.0	99.5	0.5	0.0	0.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	17-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	26-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-Sep	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9-Sep	70.0	0.0	70.0	30.0	0.0	30.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Nov	27.0	7.0	34.0	26.0	40.0	66.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	16-Dec	31.0	0.0	31.0	32.5	36.0	68.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	15-Feb	32.5	0.5	33.0	52.0	14.0	66.0	100.0	0.0	0.0	0.0	1.5	0.0	1.5	1.5
	Average	81.5	0.6	82.1	10.8	6.9	17.8	100.0	0.0	0.0	0.0	0.1	0.0	0.1	0.1

Table 8. (Continued) Internal defects over time averaged over two onion varieties in 2016, Malheur Experiment Station, Oregon State University, Ontario, OR, 2016.

		All bulbs							Diseased bulbs						
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total
Variety	Date	no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total	
		%													
Average	7-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	13-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11-Aug	99.8	0.0	99.8	0.3	0.0	0.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	17-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	26-Aug	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-Sep	100.0	0.0	100.0	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9-Sep	82.0	0.0	82.0	18.0	0.0	18.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Nov	29.8	6.0	35.8	27.8	36.5	64.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	16-Dec	34.5	0.0	34.5	35.3	30.0	65.3	100.0	0.0	0.0	0.0	0.3	0.0	0.3	0.3
	15-Feb	39.8	0.3	40.0	49.3	10.3	59.5	100.0	0.0	0.0	0.0	2.0	0.0	2.0	2.0
LSD (0.05)															
Variety		NS	NS	NS	NS	1.7	NS		NS	NS	NS	NS	NS	NS	NS
Date		4.1	0.9	3.8	3.0	2.9	3.6		NS	NS	NS	0.4	NS	0.4	0.4
Var. X date		5.8	NS	5.3	4.3	4.0	5.1		NS	NS	NS	NS	NS	NS	NS

Table 9. Internal decomposition over time for two onion varieties in 2016, Malheur Experiment Station, Oregon State University, Ontario, OR, 2016.

Variety	Date	Bacterial rot	*Fusarium proliferatum*	Neck rot
			---------- % ----------	
Joaquin	7-Jul	0.0	0.0	0.0
	13-Jul	0.0	0.0	0.0
	21-Jul	0.0	0.0	0.0
	28-Jul	0.0	0.0	0.0
	3-Aug	0.0	0.0	0.0
	11-Aug	0.0	0.0	0.0
	17-Aug	0.0	0.0	0.0
	26-Aug	0.0	0.0	0.0
	1-Sep	0.0	0.0	0.0
	9-Sep	0.0	0.0	0.0
	3-Nov	0.0	0.0	0.0
	16-Dec	0.0	0.0	0.5
	15-Feb	1.5	0.0	1.0
	Average	0.1	0.0	0.1
Granero	7-Jul	0.0	0.0	0.0
	13-Jul	0.0	0.0	0.0
	21-Jul	0.0	0.0	0.0
	28-Jul	0.0	0.0	0.0
	3-Aug	0.0	0.0	0.0
	11-Aug	0.0	0.0	0.0
	17-Aug	0.0	0.0	0.0
	26-Aug	0.0	0.0	0.0
	1-Sep	0.0	0.0	0.0
	9-Sep	0.0	0.0	0.0
	3-Nov	0.0	0.5	0.0
	16-Dec	0.5	0.5	0.0
	15-Feb	1.0	0.0	0.5
	Average	0.1	0.1	0.0
Average	7-Jul	0.0	0.0	0.0
	13-Jul	0.0	0.0	0.0
	21-Jul	0.0	0.0	0.0
	28-Jul	0.0	0.0	0.0
	3-Aug	0.0	0.0	0.0
	11-Aug	0.0	0.0	0.0
	17-Aug	0.0	0.0	0.0
	26-Aug	0.0	0.0	0.0
	1-Sep	0.0	0.0	0.0
	9-Sep	0.0	0.0	0.0
	3-Nov	0.0	0.3	0.0
	16-Dec	0.3	0.3	0.3
	15-Feb	1.3	0.0	0.8
LSD (0.05)				
Variety		NS	NS	NS
Date		0.4	NS	NS
Var. X date		NS	NS	NS