TIMING 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. The internal decomposition is often associated with one or more scales that do not finish forming completely into the neck, resulting in small gaps close to the neck. Alternatively the gaps may be caused by dehydration of the scales. To determine the causes of internal quality problems, it would be valuable to know when these problems start. This trial sought to determine when internal quality problems start occurring.

Materials and Methods

Onions were grown in 2016 on an Owyhee silt loam previously planted to wheat. A soil analysis taken in the fall of 2015 showed that the top foot of soil had a pH of 7.5, 3.4% organic matter, 6 ppm nitrate, 1 ppm ammonium, 30 ppm phosphorus (P), 629 ppm potassium (K), 43 ppm sulfur (S), 4,808 ppm calcium, 822 ppm magnesium (Mg), 413 ppm sodium, 4.3 ppm zinc, 10 ppm manganese (Mn), 2.8 ppm copper, 51 ppm iron, and 0.6 ppm boron (B). In the fall of 2015, the wheat stubble was shredded and the field was irrigated. The field was then disked, moldboard plowed, and groundhogged. Based on a soil analysis, 66 lb P/acre, 400 lb S/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) were planted on March 23 in plots 4 double rows wide and 50 ft long. Seed was planted 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/1,000 ft of row (0.82 lb ai/acre) over the seed rows and the soil surface was rolled. Onion emergence started on April 7. On May 9, alleys 4 ft wide were cut between split plots, leaving split plots 23 ft long. On May 16-20, 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 on May 2: GoalTender® at 0.09 lb ai/acre (4 oz/acre), Buctril® at 12 oz/acre, Poast® at 0.25 lb ai/acre (16 oz/acre), and Prowl® H_2O at 0.83 lb ai/acre (2 pt/acre).

For thrips control, the following insecticides were applied: Movento® at 5 oz/acre and Aza-Direct® at 12 oz/acre on May 26 and June 2 by ground application; Agri-Mek® SC at 3.5 oz/acre on June 10 and 17 by ground application; Radiant® at 10 oz/acre on June 25, July 2 and 23 by aerial application; Lannate® at 3 pt/acre on July 10, 17, and 30 by aerial application.

Urea ammonium nitrate solution (URAN) at 20 lb nitrogen (N)/acre was applied through the drip tape on May 27, June 10 and 24, totaling 60 lb N/acre. Starting on June 14, root tissue and soil solution samples were taken every week from field borders (variety Vaquero) 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 60 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 80 lb K/acre was applied in 20-lb increments during the season based on the soil and tissue analyses.

Table 1. Onion root tissue nutrient content, Malheur Experiment Station, Oregon State University, Ontario, OR, 2016.

Nutrient		14-Jun	23-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug
NO_3-N (ppm)	Sufficiency range	8501	7667	6833	6000	5168	4338	3508	2678
NO_3-N (ppm)		3050	2521	3097	2575	2550	3172	3916	3137
P (%)	0.32 - 0.7	0.38	0.47	0.53	0.62	0.51	0.51	0.32	0.41
K (%)	2.7 - 6.0	3.33	4.42	2.24	1.92	2.28	2.50	3.20	2.30
S (%)	0.24 - 0.85	0.50	0.70	0.82	0.93	0.71	0.61	0.47	0.70
Ca (%)	0.4 - 1.2	0.30	0.45	0.46	0.47	0.63	0.90	0.66	0.57
Mg (%)	0.3 - 0.6	0.33	0.33	0.27	0.20	0.20	0.30	0.21	0.20
Zn (ppm)	25 - 50	46	53	65	55	38	52	29	30
Mn (ppm)	35 - 100	107	160	98	115	95	63	35	50
Cu (ppm)	6 - 20	9	11	12	18	10	13	18	10
B (ppm)	19 - 60	36	42	30	21	29	39	32	35

Table 2. Weekly soil solution 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, 2016.

Nutrient	Critical level, lb or oz	14-Jun	23-Jun	29-Jun	6-Jul	13-Jul	20-Jul	27-Jul	3-Aug
N	Critical level, lb	8.6	7.8	7	6.2	5.4	4.6	3.8	2.8
N		9.4	8.1	9.9	12.0	14.6	15.0	15.4	18.4
P	0.7 lb	1.0	0.9	1.2	1.0	1.2	1.5	1.3	1.8
K	5 lb	4.9	4.2	6.1	4.3	3.7	4.3	5.2	6.2
S	1 lb	4.2	4.5	6.5	7.1	7.6	9.5	9.9	8.6
Ca	3 lb	4.0	4.1	4.9	5.8	4.4	5.2	6.7	4.1
Mg	2 lb	5.1	5.5	7.9	9.0	6.2	8.6	9.5	5.3
Zn	1 oz	4.2	5.9	5.5	5.7	6.1	4.4	2.6	3.6
Mn	1 oz	0.9	0.7	0.4	0.3	0.2	0.3	0.4	0.5
Cu	0.4 oz	0.6	0.5	0.7	1.0	0.7	0.9	1.1	0.9

Table 3. Nutrients applied through the drip irrigation system, Malheur Experiment Station, Oregon State University, Ontario, OR, 2016.

Date	N	K
	----- lb/acre -----	
27-May	20	
10-Jun	20	
20-Jun		20
24-Jun	20	
8-Jul		20
15-Jul		20
22-Jul		20
Total	60	80

Table 4. Soil available N (NO_3 + NH_4) in the top foot of soil, Malheur Experiment Station, Oregon State University, Ontario, OR, 2016.

Date	Available soil N, lb/acre
14-Jun	66
23-Jun	57
29-Jun	69
6-Jul	84
13-Jul	102
20-Jul	105
27-Jul	108
3-Aug	129

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 was measured with eight 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 eight sensors 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 May 18 and irrigations ended on September 2.

Onions in each plot were evaluated weekly in the field starting July 7 and ending September 9. After harvest, the onions from each plot were evaluated out of storage monthly starting in early 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, internal bacterial decay, and internal decay caused by *Fusarium proliferatum*. Incomplete scales were defined as scales that had either more than 0.25 inch from the center of the neck missing or any part missing 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.

The onions were lifted on September 12 to field cure. Onions from the middle two rows in each split plot were topped by hand and bagged on September 17. The bags were put in storage on September 30. The storage shed was ventilated and the temperature was slowly decreased to maintain air temperature as close to 34°F as possible.

Treatment differences 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 2016 were higher than average, but below the record year of 2015 (Fig. 1).

On July 7, 2016 the bulbs had an average of 13 leaves, were 1.7 inches in diameter, and had no symptoms of incomplete scale or decomposition (Table 5). The average number of leaves peaked at 15 and the average diameter peaked at close to 4 inches.

Both dry scales and incomplete scales were detected only starting on September 9, just before the onions were lifted on September 12. Substantially more bulbs had incomplete scales than dry scales. The percentage of bulbs with incomplete scales increased over time. Averaged over the two varieties, 58% of the bulbs had symptoms of dry scales, incomplete scales, or both on February 15.

There was very little internal decay in this trial (Table 6). For Joaquin, no F. *proliferatum* decay was found and bacterial decay was first found on the February 15 evaluation. For Granero, F. *proliferatum* decay was first found on November 3 and bacterial decay was first found on December 16. Averaged over the two varieties, 1.3% of the bulbs had internal decay from either bacteria or *Fusarium proliferatum* on February 15. None of the bulbs that retained complete scales developed internal decomposition.

Rather than the scales growing into an "incomplete" state, the pattern in the data suggested the loss of wet tissue at the upper edges of the scales. The scale defects were not evident in the bulbs in this trial on September 1, but occurred during maturation and continued developing during storage. The data suggest that the onions may have become over-mature, and possibly continued to lose water during storage from the edges of the outer scales.

Acknowledgements

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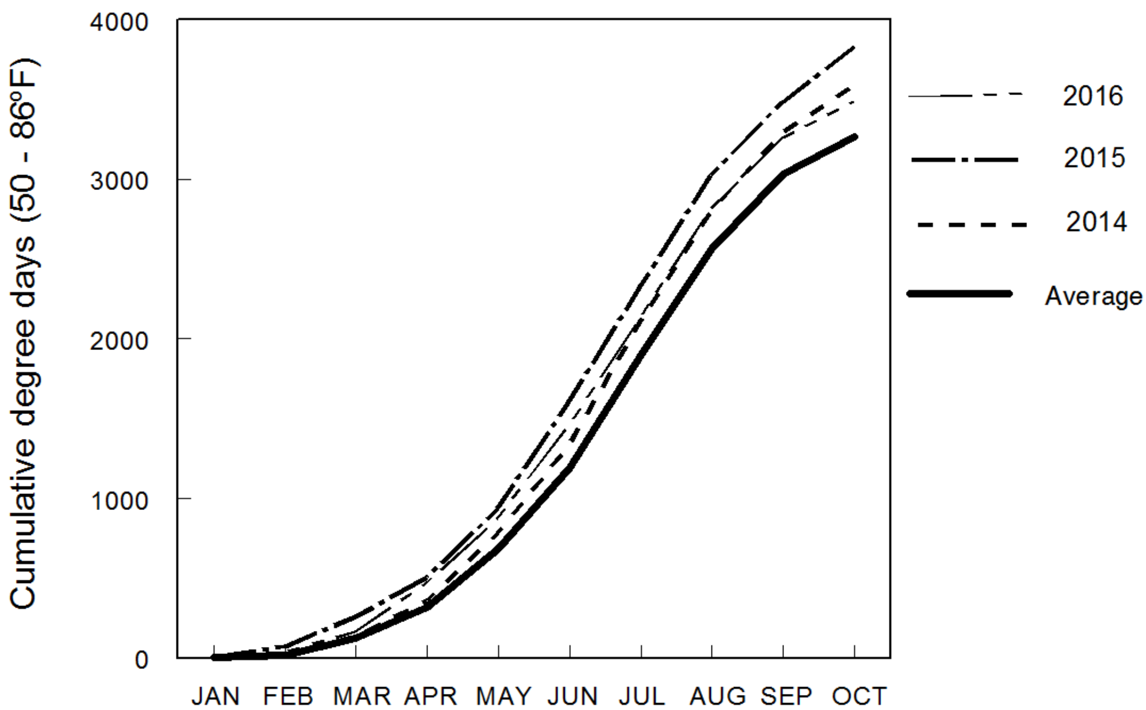

Figure 1. Growing degree-days (50-86°F) for 2014-2016 and 21-year average, Malheur Experiment Station, Oregon State University, Ontario, OR, 2016.

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, 2016.

Variety	Date	No. of leaves	Bulb diameter, inch
Joaquin	7-Jul	13.4	1.8
	13-Jul	13.7	2.3
	21-Jul	14.4	2.7
	28-Jul	14.8	3.1
	3-Aug	14.6	3.3
	11-Aug	15.0	3.6
	17-Aug	14.4	3.8
	26-Aug	14.3	3.7
	1-Sep	14.3	4.0
	9-Sep		3.9
	3-Nov		4.0
	average	14.3	3.3
Granero	7-Jul	13.4	1.6
	13-Jul	13.5	2.2
	21-Jul	13.5	2.7
	28-Jul	15.0	3.3
	3-Aug	14.6	3.4
	11-Aug	14.3	3.7
	17-Aug	14.0	3.9
	26-Aug	14.3	3.8
	1-Sep	13.4	3.8
	9-Sep		3.8
	3-Nov		3.9
	average	14.0	3.3
Average	7-Jul	13.4	1.7
	13-Jul	13.6	2.2
	21-Jul	14.0	2.7
	28-Jul	14.9	3.2
	3-Aug	14.6	3.4
	11-Aug	14.7	3.6
	17-Aug	14.2	3.8
	26-Aug	14.3	3.8
	1-Sep	13.8	3.9
	9-Sep		3.8
	3-Nov		3.9
LSD (0.05)	Variety	NS	NS
	Date	0.9	0.3
	Variety X date	NS	NS

Table 6. Onion internal defects over time. Data are the percentage of bulbs. Malheur Experiment Station, Oregon State University, Ontario, OR, 2016. Continued on next page.

		No internal rot				Bacterial rot				*Fusarium proliferatum*				Total	
Variety	Date	No scale defect	Incompl. scale	Dry scale	Incompl. + dry scale	No scale defect	Incompl. scale	Dry scale	Incompl. + dry scale	No scale defect	Incompl. scale	Dry scale	Incompl. + dry scale	Incompl. + dry scale	Internal rot
Joaquin	7-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	13-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	17-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	26-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-Sep	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9-Sep	94.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	0.0
	3-Nov	32.5	29.5	5.0	33.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	67.5	0.0
	16-Dec	38.0	37.5	0.0	24.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	61.5	0.0
	15-Feb	47.0	44.0	0.0	6.5	0.0	1.5	0.0	0.0	0.0	0.0	0.0	0.0	50.5	1.5
	average	85.5	9.0	0.4	4.9	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	14.3	0.1
Granero	7-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	13-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11-Aug	99.5	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0
	17-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	26-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-Sep	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9-Sep	70.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	30.0	0.0
	3-Nov	27.0	26.0	7.0	39.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	72.5	0.5
	16-Dec	31.0	32.5	0.0	35.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.5	67.5	1.0
	15-Feb	32.5	50.5	0.5	14.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	65.0	1.0
	average	81.5	10.7	0.6	6.8	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	18.1	0.2

Table 6. (Continued) Onion internal defects over time. Data are the percentage of bulbs. Malheur Experiment Station, Oregon State University, Ontario, OR, 2016.

		No internal rot				Bacterial rot				*Fusarium proliferatum*				Total	
Variety	Date	No scale defect	Incompl. scale	Dry scale	Incompl. + dry scale	No scale defect	Incompl. scale	Dry scale	Incompl. + dry scale	No scale defect	Incompl. scale	Dry scale	Incompl. + dry scale	Incompl. + dry scale	Internal rot
Average	7-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	13-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	21-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	28-Jul	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	3-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	11-Aug	99.8	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.0
	17-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	26-Aug	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	1-Sep	100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	9-Sep	82.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	18.0	0.0
	3-Nov	29.8	27.8	6.0	36.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	70.0	0.3
	16-Dec	34.5	35.0	0.0	29.5	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.3	64.5	0.5
	15-Feb	39.8	47.3	0.3	10.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	0.0	57.8	1.3
LSD (0.05) Variety		NS	NS	NS	1.7	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Date		4.1	3.0	0.9	3.0	NS	0.4	NS	NS	NS	NS	NS	NS	4.1	0.5
LSD (0.05) Var. X date		5.8	4.3	NS	4.2	NS	NS	NS	NS	NS	NS	NS	NS	5.8	NS