

2015 ONION VARIETY TRIALS

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Introduction

Direct-seeded yellow, white, and red onion varieties were evaluated in the field for plant disease, thrips, maturity, bolting, bulb single centers. Out of storage the varieties were evaluated for yield, grade, and bulb decomposition. Five early-season yellow varieties and one early-season red variety were planted in March and were harvested and graded in early August. Forty full-season varieties (29 yellow, 5 red, and 6 white) were planted in March, harvested in September, and graded out of storage in December 2015. Each year, growers and seed industry representatives have the opportunity to examine the varieties at our annual Onion Variety Field Day in late August and during bulb evaluations in early January. Onion varieties are evaluated objectively for bolting, occurrence of onion thrips, yield, grade, single centers, and storability. Varieties are evaluated subjectively for maturity, iris yellow spot virus, bulb shape, bulb shape uniformity, flesh brightness, and skin color and retention.

Materials and Methods

Onions were grown in 2015 on a Greenleaf silt loam previously planted to wheat. A soil analysis taken in the fall of 2014 showed that the top foot of soil had a pH of 7.4, 1.92% organic matter, 15 ppm nitrate, 5 ppm ammonium, 44 ppm phosphorus (P), 270 ppm potassium (K), 23 ppm sulfur (S), 3880 ppm calcium, 203 ppm magnesium (Mg), 128 ppm sodium, 3.0 ppm zinc, 5 ppm manganese (Mn), 1.5 ppm copper, 11 ppm iron, and 0.6 ppm boron (B). In the fall of 2014, the wheat stubble was shredded and the field was irrigated. The field was then disked, moldboard plowed, and groundhogged. Based on a soil analysis, 75 lb of P/acre, 200 lb of K/acre, 230 lbs of S/acre, 20 lb Mg/acre, 7 lb of Mn/acre, and 1 lb of 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 designs for the full-season trial and the early-maturing trial were randomized complete blocks with five replicates. A sixth nonrandomized replicate was planted for demonstrating onion variety performance to growers and seed company representatives at the Onion Variety Day. Both trials were planted on March 19 in plots 4 double rows wide and 27 ft long. The early-maturing trial had 6 varieties from 3 seed companies and the full-season trial had 40 varieties from 8 seed companies.

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 6. On May 12, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. On May 14-15, 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 (T-Tape, Rivulis USA, San Diego, 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 applied: prior to emergence on March 30, Roundup PowerMax[®] at 24 oz/acre was broadcast; on May 1, GoalTender[®] at 0.09 lb ai/acre (4 oz/acre), Buctril[®] at 0.25 lb ai/acre (16 oz/acre), and Poast[®] at 0.25 lb ai/acre (16 oz/acre) were broadcast; on May 4, Prowl[®] H₂O at 0.83 lb ai/acre (2 pt/acre) was broadcast; on June 2, GoalTender at 0.09 lb ai/acre (6 oz/acre), and Buctril at 0.25 lb ai/acre (16 oz/acre) and Poast at 0.25 lb ai/acre (16 oz/acre) were broadcast; on June 25, Poast at 0.25 lb ai/acre (16 oz/acre) was broadcast.

For thrips control, the following insecticides were applied: Movento[®] at 5 oz/acre on May 24 by ground application; Movento at 5 oz/acre and Aza-Direct[®] at 2 pt/acre on June 4 by ground application; Agri-Mek[®] SC at 3.5 oz/acre on June 11 and June 18 by ground application; Radiant[®] at 10 oz/acre on June 25 by ground application and on July 4 by aerial application; Lannate[®] at 0.9 lb ai/acre on July 15 and July 25 by aerial application; and Radiant at 10 oz/acre on August 8 by aerial application.

Urea ammonium nitrate solution (URAN) at 20 lb nitrogen (N)/acre was applied through the drip tape weekly starting May 28 and ending June 24, totaling 100 lb N/acre. Starting on June 8, 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).

Nitrogen was applied at the fixed amount previously mentioned. The other nutrients were applied through the drip tape only if both the root tissue and soil solution analyses concurrently indicated a deficiency (Table 3).

Table 1. Onion root tissue nutrient content in the onion variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Nutrient	Sufficiency range	8-Jun	12-Jun	19-Jun	26-Jun	6-Jul	10-Jul	20-Jul	24-Jul	31-Jul
NO ₃ -N (ppm)	Sufficiency range	7500	6500	5500	4500	4000	3000	2500	1250	500
NO ₃ -N (ppm)		5177	5004	3042	2726	2938	2359	1933	2342	2834
P (%)	0.32 - 0.7	0.7	0.7	0.6	0.5	0.4	0.4	0.4	0.3	0.2
K (%)	2.7 - 6.0	4.9	3.0	3.5	3.1	3.4	3.1	2.5	1.9	1.8
S (%)	0.24 - 0.85	0.4	0.3	0.5	0.6	0.6	0.6	0.7	0.8	0.9
Ca (%)	0.4 - 1.2	1.0	0.7	0.8	0.5	0.6	0.6	0.8	0.9	1.0
Mg (%)	0.3 - 0.6	0.4	0.4	0.3	0.3	0.3	0.3	0.2	0.3	0.2
Zn (ppm)	25 - 50	45	32	51	37	28	36	49	49	31
Mn (ppm)	35 - 100	21	95	195	170	136	157	155	121	118
Cu (ppm)	6 - 20	7	5	23	19	16	13	16	17	11
B (ppm)	19 - 60	43	28	52	40	38	32	30	39	21

Table 2. Weekly soil solution analyses in the onion variety trial. 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, 2015.

Nutrient	Critical level,	8-Jun	12-Jun	26-Jun	6-Jul	10-Jul	20-Jul	24-Jul	31-Jul
	lb or oz								
N	Critical level, lb	7.5	6	5	4.5	4	3	2	1
N		6.0	7.7	8.6	23.1	12.4	15.4	15.9	20.6
P	0.7 lb	1.4	0.8	0.6	1.4	1.1	1.2	1.0	1.1
K	8 lb	15.0	8.0	7.2	9.6	6.6	8.3	6.7	9.7
S	3 lb	3.7	2.7	1.8	5.0	5.6	3.8	4.5	5.9
Ca	3 lb	5.2	4.7	3.7	4.7	3.9	3.3	3.6	4.0
Mg	2 lb	15.2	10.1	8.6	12.9	10.2	10.3	9.1	12.0
Zn	1 oz	5.0	1.5	1.1	2.6	2.7	2.8	2.4	2.9
Mn	1 oz	0.5	0.2	0.5	0.4	0.5	0.9	0.7	0.5
Cu	0.4 oz	3.0	0.5	0.4	0.7	0.4	0.6	0.6	0.6

Table 3. Nutrients applied through the drip irrigation system in the onion variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Date	N	K	Mn	S	Cu
----- lbs/acre -----					
28-May	20				
2-Jun	20				
8-Jun	20				
17-Jun	20		0.5	2	0.3
24-Jun	20				
29-Jul		5.5			
3-Aug		5.5			
Total	100	11.0	0.5	2	0.3

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, Irrrometer Co., 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 multiplexer, Campbell Scientific, Logan, UT). The datalogger (CR1000, 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 controller, Campbell Scientific, Logan, UT) 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 19. Irrigations were terminated on August 22.

Onions in the early-maturing trial were evaluated for maturity, severity of symptoms of iris yellow spot virus (IYSV), and bolting on July 31. Onions in the full-season trial were evaluated for maturity on July 31 and August 14. On August 7, onions in the full-season trial were evaluated for IYSV and thrips damage severity. Onions in each plot were evaluated subjectively for maturity by visually rating the percentage of onions with the tops down and the percent dry leaves. For IYSV, onions in each plot were given a subjective rating on a scale of 0 to 5 of increasing severity of IYSV symptoms. The rating was 0 if there were no symptoms, 1 if 1-25% of foliage was diseased, 2 if 26-50% of foliage was diseased, 3 if 51-75% of foliage was diseased, 4 if 76-99% of foliage was diseased, and 5 if 100% of foliage was diseased. For thrips leaf damage, each plot was given a subjective rating on a scale of 0 to 10 of increasing severity of leaf damage from thrips feeding. The number of bolted onion plants was counted in each plot.

At harvest, bulbs from one of the border rows in each plot of both trials were rated for single centers. Twenty-five consecutive onions ranging in diameter from 3½ to 4¼ inches were rated. The onions were cut equatorially through the bulb middle and separated into single-centered (bullet) and multiple-centered bulbs. The multiple-centered bulbs had the long axis of the inside diameter of the first single ring measured. These multiple-centered onions were ranked according to the inside diameter of the first entire single ring: small had diameters less than 1½ inches, medium had diameters from 1½ to 2¼ inches, and large had diameters greater than 2¼ inches. Onions were considered "functionally single centered" for processing if they were single centered or had a small multiple center.

Onions from the middle two double rows in each plot in the early-maturity trial were topped by hand and bagged on August 6. Onions from the early-maturity trial were graded on August 7. After grading, onions were stored in a shed at ambient air temperature for 2 weeks. After 2 weeks, the onions were evaluated for decomposition and sprouting.

The onions in the full-season trial were lifted on August 31 to field cure. Onions from the middle two rows in each plot of the full-season trial were topped by hand and bagged on September 7. The bags were put in storage on September 11. The storage shed was ventilated and the temperature was slowly decreased to maintain air temperature as close to 34°F as possible. Onions from the full-season trial were graded out of storage December 2-4, 2015.

During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), bulbs infected with the fungus *Botrytis allii* in the neck or side, bulbs infected with the fungus *Fusarium oxysporum* (plate rot), bulbs infected with the fungus *Aspergillus niger* (black mold), and bulbs infected with unidentified bacteria in the external scales. The No. 1 bulbs were graded according to diameter: small (<2¼ inches), medium (2¼-3 inches), jumbo (3-4 inches), colossal (4-4¼ inches), and supercolossal (>4¼ inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading. Marketable yield consisted of No.1 bulbs larger than 2¼ inches.

During grading, one bag from each plot was saved for additional evaluations of internal bulb quality. Fifty bulbs from each plot were cut longitudinally and evaluated for the presence of incomplete scales, internal bacterial rot, and internal rot 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.

After grading, two replicates of each yellow and red variety were evaluated for bulb shape, bulb shape uniformity, firmness, skin color, skin retention, and flesh brightness on January 12, 2016. The quality characteristics were evaluated by a consensus of 10-15 people without knowing the variety identities. Evaluators included OSU personnel, seed company employees, and others.

The varieties from each of the early-maturity and full-season trials were compared for yield, grade, internal quality, and disease expression. Varietal differences were determined using 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 varieties for significant differences in their performance characteristics. Differences between varieties equal to or greater than the LSD value for a characteristic should exist before any variety is considered different from any other variety in that characteristic. Variety performance varies by year. Growers are encouraged to review performance over a number of years before choosing a variety to plant.

Results

The rate of accumulation and total number of growing degree-days (50-86°F) in 2015 were the highest since measurements began in 1993 (Fig. 1).

Through tissue and soil solution analyses conducted during the season and using the nutrient sufficiency ranges (Tables 1 and 2), the onions required nutrient amendments during the growing season (Table 3). Root nitrates remained below the sufficient range for most of the season. However, soil solution N remained above the sufficiency range after June 12, precluding the need for additional N applications beyond the total of 100 lb N/acre that was applied.

Early-maturing Trial

On July 31, all varieties had at least 50% or higher tops down. The percentage of onions that were functionally single centered averaged 68.5% and ranged from 51.2% for 'Salute' to 80.6% for 'Scout' (Table 4). Total yield averaged 833 cwt/acre, ranging from 484 cwt/acre for SV4643 to 982 cwt/acre for 'Avalon' (Table 5). After 2 weeks of storage, bulb sprouting was low, averaging 0.2 % of total bulbs (Table 6). Bulb decomposition after 2 weeks of storage averaged 3% and ranged from 1.5% for Avalon to 5.1% for Salute.

Full-season Trial

On July 31, all varieties had at least 10% tops down with an average of 29% tops down (Table 7). By August 14, all varieties had 30% or higher tops down with an average of 59% tops down. The severity of thrips leaf damage ranged from 1.4 for 'Oracle' to 6.6 for 'Purple Haze'. Oracle, 16000, 'Joaquin', 'Dulce Reina', Avalon, 'Morpheus', and 'Pandero' were among the varieties with the lowest thrips leaf damage. The severity of IYSV ranged from 1.0 for Oracle and Joaquin to 3.0 for 'Red Beret', Purple Haze, 'Red Devil', and 'Marenge'.

The percentage of functionally single-centered bulbs averaged 81.3% and ranged from 41.6% for DPS2053 to 98.4% for 'Oloroso' (Table 8).

Marketable yield averaged 681 cwt/acre and ranged from 11 cwt/acre for DPS2053 to 986 cwt/acre for Morpheus (Table 9). Morpheus, Joaquin, Scout, Dulce Reina, Avalon, Oracle, Vaquero, and Arcero were among the varieties with the highest marketable yield. Storage decomposition averaged 12.7% and ranged from 2.4% for 'Sedona' to 76.5% for DPS2053.

A high percentage of bulbs had incomplete scales (Table 10). The percentage of bulbs with internal decomposition was much lower and most of those with internal decomposition also had incomplete scales. The evaluation of internal quality showed that most of the internal decomposition could not be detected from the outer appearance or feel of the bulbs. There were significant differences between varieties for incomplete scales and internal decomposition. The percentage of bulbs with incomplete scales averaged 34.9% and ranged from 11.5% for Avalon to 62.8% for 'Cruiser' (Table 10). Total internal decomposition (bacterial and fungal) averaged 7% and ranged from 2% for Joaquin to 22% for SV4058.

Subjective Quality Evaluation

Subjective bulb quality ratings can be found in Table 13 and explanation of the rating system can be found in Figure 2 and Tables 11 and 12. Significant variations were found between varieties in all the subjective characteristics except bulb shape.

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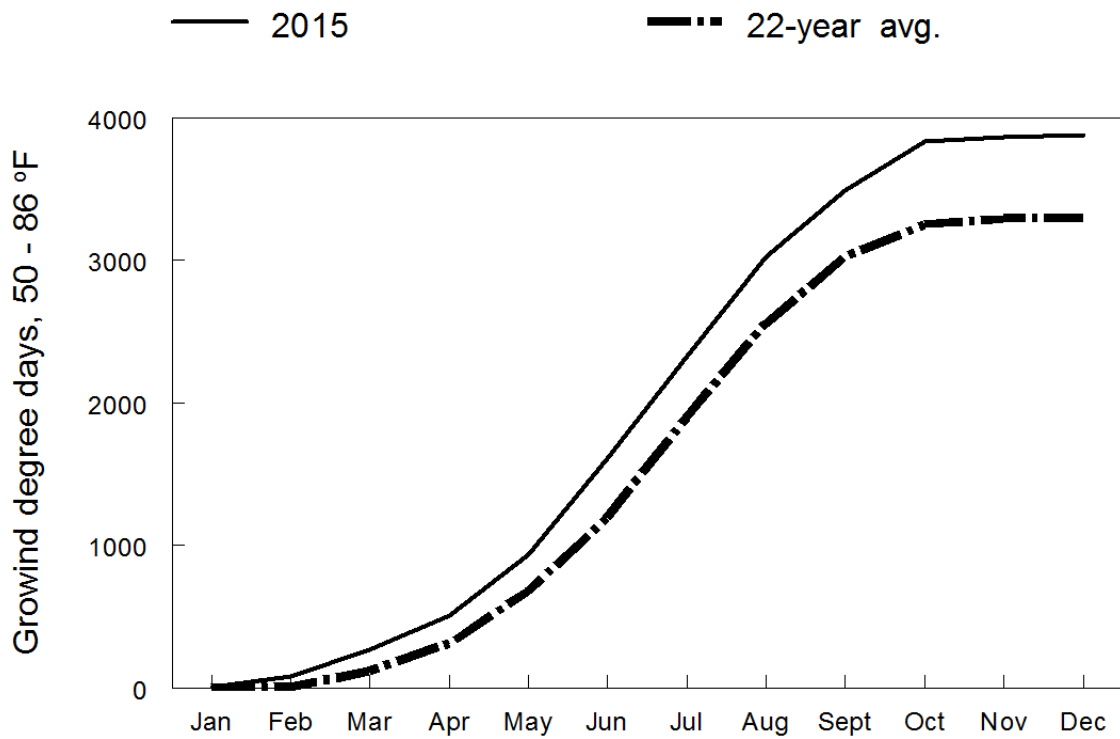


Figure 1. Cumulative growing degree-days (50-86°F) over time for 2015 and the 22-year average (1993-2014), Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 4. Maturity, single- and multiple-center bulb ratings, and iris yellow spot virus (IYSV) severity ratings for early-maturing varieties lifted and harvested August 6, 2015, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb color	Maturity July 31			Multiple center			Single center	
			Tops down	Leaf dryness	IYSV	Large	Medium	small	Functional*	Bullet
			----- % -----	----- % -----	0 - 5	----- % -----				
Crookham	Avalon	Y	58	28	1.1	0.8	19.2	30.4	80.0	49.6
	Salute	Y	60	36	1.3	16.0	32.8	31.2	51.2	20.0
	Scout	Y	58	33	1.3	1.2	18.1	38.6	80.6	42.0
Sakata	Ovation	Y	62	34	1.5	6.4	33.6	35.2	60.0	24.8
	Spanish Medallion	Y	70	36	1.4	5.6	27.2	33.6	67.2	33.6
Seminis	SV4643	R	72	52	2.0	7.2	20.9	34.7	71.9	37.1
Average			63	37	1.4	6.2	25.3	34.0	68.5	34.5
LSD (0.05)			10	8	0.3	8.0	NS	NS	14.4	8.3

*Functional single center bulbs are the bullet single + small double.

Table 5. Yield and grade performance of early-maturing varieties lifted and harvested August 6, 2015, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb color	Total yield	Marketable yield by grade							Plate rot	Bulb counts >4¼ in
				Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small	No. 2s		
			----- cwt/acre -----							% by number	#/50 lb	
Crookham	Avalon	Y	982.0	968.2	26.5	328.6	592.0	21.1	6.0	0.0	2.3	32.7
	Salute	Y	842.8	829.5	3.0	120.3	680.7	25.4	9.3	0.0	0.7	34.7
	Scout	Y	923.5	906.2	17.6	267.2	601.5	19.9	3.0	0.0	4.6	33.1
Sakata	Ovation	Y	875.5	868.8	10.1	230.7	611.9	16.2	5.7	0.0	1.2	31.2
	Spanish Medallion	Y	887.7	873.4	25.4	332.6	493.3	22.1	7.3	0.0	2.6	32.7
Seminis	SV4643	R	483.7	460.3	0.0	4.9	394.0	61.4	12.4	0.0	5.7	
Average			832.5	817.7	13.7	214.1	562.2	27.7	7.3	0.0	2.8	32.9
LSD (0.05)			80.6	82.0	15.9	73.2	111.7	12.2	5.8	NS	1.5	NS

Table 6. Bulb quality 2 weeks after harvest for early-maturing varieties lifted and harvested August 6, 2015, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb quality 2 weeks after harvest			
		Sprouted	Decomposed	Sprouted and decomposed	Total sprouted or decomposed
		----- % -----			
Crookham	Avalon	0.0	1.5	0.0	1.5
	Salute	0.4	5.1	0.0	5.5
	Scout	0.2	3.1	0.4	3.7
Sakata	Ovation	0.0	1.9	0.0	1.9
	Spanish Medallion	0.4	3.2	0.0	3.6
Seminis	SV4643	0.3	3.3	0.0	3.6
	Average	0.2	3.0	0.1	3.3
LSD (0.05)		NS	2.2	NS	NS

Table 7. Maturity, thrips leaf damage, and iris yellow spot virus (IYSV) severity ratings of full-season varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Seed company	Variety	Bulb color	31-Jul		14-Aug		7-Aug	
			Tops down	Leaf dryness	Tops down	Leaf dryness	Thrips leaf damage	IYSV
			----- % -----				0 – 10 ^a	0 – 5 ^b
A. Takii	Grand Perfection	Y	24	40	50	68	3.6	1.6
Bejo	Calibra	Y	38	52	76	80	5.8	2.8
	Crockett	Y	28	30	58	72	5.8	1.8
	Delgado	Y	32	36	62	64	5.0	1.9
	Hamilton	Y	22	26	52	72	4.2	1.4
	Legend	Y	30	36	56	70	3.6	1.9
	Sedona	Y	28	34	54	82	5.0	1.7
Crookham	Avalon	Y	20	62	42	88	2.2	1.2
	Morpheus	Y	20	46	42	76	2.2	1.3
	Oracle	Y	14	22	32	60	1.4	1.0
	Scout	Y	24	62	50	88	3.2	1.3
	OLYX08-640	Y	40	68	82	90	6.4	2.8
	Purple Haze	R	42	42	80	84	6.6	3.0
	Red Beret	R	48	44	80	78	6.2	3.0
	Red Devil	R	40	46	82	86	6.2	3.0
	Brundage	W	22	30	44	68	3.6	1.5
Hazera	Cruiser	Y	40	54	72	78	6.4	2.5
Nunhems	Anillo	Y	32	42	62	80	5.2	2.0
	Arcero	Y	30	24	64	56	5.2	2.1
	Granero	Y	26	38	50	84	4.6	1.6
	Joaquin	Y	12	24	34	56	2.0	1.0
	Montero	Y	46	58	86	92	6.2	2.6
	Pandero	Y	20	30	50	62	2.6	1.4
	Vaquero	Y	32	54	58	82	5.6	1.7
	Oloroso	Y	24	32	56	56	5.4	1.9
	Cometa	W	24	32	50	60	3.6	1.7
	Marengo	R	52	72	96	98	6.0	3.0
Sakata	Dulce Reina	Y	14	36	40	66	2.2	1.1
	Lasso	Y	22	58	52	82	2.8	1.2
Seminis	Barbaro	Y	22	24	50	60	3.6	1.8
	Swale	Y	18	44	48	80	3.6	1.6
	16000	Y	16	44	42	82	2.0	1.2
	SV6646	Y	24	32	48	74	3.6	1.5
	SV6672	Y	28	44	56	88	4.6	1.5
	SV4058	W	30	26	58	46	3.6	1.8
D. Palmer	Saffron	Y	30	44	64	62	5.0	2.2
	Diamond Swan	W	22	24	56	56	3.4	1.6
	Cherry Mountain	R	40	36	70	72	5.4	2.6
	DPS-2001	W	38	88	60	100	4.3	2.0
	DPS-2053	W	48	92	100	100		
	average		29	43	59	75	4	2
LSD (0.05)			5.7	9.3	7.6	9.0	1.3	0.4

^aThrips leaf damage: 0 = no damage, 10 = severest damage.

^bIYSV rating: 0 = no symptoms; 1 = 1-25% of foliage was diseased; 2 = 26-50% of foliage was diseased; 3 = 51-75% of foliage was diseased; 4 = 76-99% of foliage was diseased; 5 = 100% of foliage was diseased.

Table 8. Single- and multiple-center ratings for full-season onion varieties. Malheur Experiment Station, Oregon State University, Ontario, OR, 2015.

Seed company	Variety	Bulb color	Multiple center			Single center	
			Large	Medium	Small	Functional ^a	Single
			----- % -----				
A. Takii	Grand Perfection	Y	5.6	18.4	20.8	76.0	55.2
Bejo	Calibra	Y	17.6	29.6	40.8	52.8	12.0
	Crockett	Y	11.2	15.2	42.4	73.6	31.2
	Delgado	Y	23.2	31.2	28.8	45.6	16.8
	Hamilton	Y	12.8	24.8	22.4	62.4	40.0
	Legend	Y	23.2	20.8	36.8	56.0	19.2
	Sedona	Y	10.4	16.8	32.8	72.8	40.0
	Crookham	Avalon	Y	7.2	23.2	31.2	69.6
Morpheus		Y	2.3	1.6	4.8	96.1	91.3
Oracle		Y	2.4	12.0	15.2	85.6	70.4
Scout		Y	8.0	20.0	28.0	72.0	44.0
OLYX08-640		Y	0.8	4.0	4.0	95.2	91.2
Purple Haze		R	0.0	4.8	16.8	95.2	78.4
Red Beret		R	2.4	0.8	20.0	96.8	76.8
Red Devil		R	1.6	5.6	11.2	92.8	81.6
Brundage		W	1.6	4.0	4.8	94.4	89.6
Hazera	Cruiser	Y	3.2	12.8	29.7	84.0	54.3
Nunhems	Anillo	Y	1.6	5.6	17.6	92.8	75.2
	Arcero	Y	1.6	0.8	4.0	97.6	93.6
	Granero	Y	0.8	8.8	16.8	90.4	73.6
	Joaquin	Y	0.8	2.4	14.4	96.8	82.4
	Montero	Y	0.8	2.4	11.2	96.8	85.6
	Pandero	Y	4.8	6.4	16.0	88.8	72.8
	Vaquero	Y	3.2	1.6	9.6	95.2	85.6
	Oloroso	Y	0.0	1.6	4.8	98.4	93.6
	Cometa	W	4.0	6.4	14.4	89.6	75.2
	Marengo	R	1.6	8.7	31.7	89.7	58.0
	Sakata	Dulce Reina	Y	13.6	16.8	15.2	69.6
Lasso		Y	8.0	14.4	18.4	77.6	59.2
Seminis	Barbaro	Y	3.2	5.6	15.2	91.2	76.0
	Swale	Y	4.0	5.6	29.6	90.4	60.8
	16000	Y	3.9	4.8	9.6	91.3	81.8
	SV6646	Y	3.2	4.8	12.0	92.0	80.0
	SV6672	Y	9.6	12.8	22.4	77.6	55.2
	SV4058	W	1.5	7.6	15.1	90.9	75.9
D. Palmer	Saffron	Y	16.8	15.2	36.8	68.0	31.2
	Diamond Swan	W	17.6	16.8	30.4	65.6	35.2
	Cherry Mountain	R	9.6	16.8	24.0	73.6	49.6
	DPS-2001	W	6.4	29.6	52.8	64.0	11.2
	DPS-2053	W	10.4	48.0	36.0	41.6	5.6
average			6.5	12.2	21.2	81.3	60.1
LSD (0.05)			7.0	10.1	12.6	11.4	12.8

^aFunctional single centered bulbs are the small multiple center plus the bullet centered onion.

Table 9. Yield and grade of full-season experimental and commercial onion varieties graded out of storage in December 2015. Malheur Experiment Station, Oregon State University, Ontario, OR. Continued on next page.

Seed company	Variety	Bulb color	Total yield	Marketable yield by grade						No. 2s	Bulb counts >4¼ in	Total rot	Neck rot	Plate rot	Black mold	Slippery skin
				Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small							
				----- cwt/acre -----						#/50 lb		----- % of total yield -----				
A. Takii	Grand Perfection	Y	921.5	870.8	21.4	324.4	507.2	17.9	5.2	0.8	31.1	5.2	0.2	2.6	1.4	1.0
Bejo	Calibra	Y	620.3	535.8	0.0	26.6	466.9	42.3	8.2	6.4		11.3	3.3	6.2	0.9	0.8
	Crockett	Y	707.2	669.2	0.0	39.3	580.0	50.0	9.7	2.1		3.7	1.2	2.2	0.0	0.3
	Delgado	Y	792.3	720.7	3.7	113.7	581.5	21.8	4.2	7.6	27.8	7.6	0.4	6.1	0.9	0.2
	Hamilton	Y	809.4	771.1	0.0	38.3	689.7	43.0	12.8	3.0		2.8	0.2	1.9	0.2	0.5
	Legend	Y	770.8	708.4	0.0	48.5	621.5	38.3	6.7	7.0		6.2	2.4	3.8	0.0	0.0
	Sedona	Y	859.5	830.6	7.7	137.7	658.9	26.4	8.1	0.0	34.1	2.4	0.4	1.8	0.0	0.2
Crookham	Avalon	Y	1157.8	973.1	96.2	437.0	429.2	10.7	4.7	1.6	31.3	15.4	0.4	2.2	10.3	2.4
	Morpheus	Y	1022.2	986.4	28.4	291.0	644.9	22.0	8.3	2.2	29.0	2.5	0.6	1.7	0.2	0.0
	Oracle	Y	948.9	910.6	76.2	329.7	489.7	15.0	4.5	0.0	32.5	3.7	0.3	1.4	1.9	0.1
	Scout	Y	1071.0	974.5	64.1	425.9	472.4	12.1	4.8	0.7	27.0	8.7	0.7	1.9	4.9	1.2
	OLYX08-640	Y	624.2	569.1	0.0	17.8	487.7	63.6	12.6	0.0		6.9	1.1	3.2	1.8	0.8
	Purple Haze	R	470.2	397.7	0.0	0.0	298.8	98.9	18.8	0.0		11.5	7.4	2.2	0.0	1.9
	Red Beret	R	457.5	385.3	0.0	0.5	245.6	139.2	26.2	0.0		9.8	5.5	1.8	1.7	0.8
	Red Devil	R	442.2	381.2	0.0	1.1	253.2	127.0	30.4	0.0		7.0	4.5	2.1	0.0	0.4
Brundage	W	819.8	628.4	10.1	164.4	432.8	21.0	8.5	0.0	30.7	22.3	9.7	2.6	5.0	5.0	
Hazera	Cruiser	Y	632.7	587.1	0.0	19.0	512.8	55.4	8.8	0.0		5.9	0.6	4.8	0.1	0.4

Table 9. Continued. Yield and grade of full-season experimental and commercial onion varieties graded out of storage in December 2015. Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb color	Total yield	Marketable yield by grade						No. 2s	Bulb counts >4¼ in	Total rot	Neck rot	Plate rot	Black mold	Slippery skin
				Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small							
				----- cwt/acre -----						#/50 lb		----- % of total yield -----				
Nunhems	Anillo	Y	798.4	724.5	10.8	151.9	536.7	25.1	4.9	0.8	33.3	8.7	0.6	6.4	0.6	1.1
	Arcero	Y	940.5	887.3	11.8	197.9	660.6	17.0	7.2	0.0	30.5	5.1	0.6	3.7	0.7	0.0
	Granero	Y	918.9	880.9	12.9	254.2	591.6	22.2	5.5	0.0	32.7	3.7	0.1	3.0	0.3	0.1
	Joaquin	Y	1028.2	981.8	41.1	371.9	555.3	13.5	6.0	0.0	33.4	3.9	0.4	2.3	0.4	0.7
	Montero	Y	721.1	635.5	2.2	50.5	538.3	44.5	7.9	2.2	23.1	10.7	1.5	3.7	2.1	3.4
	Pandero	Y	919.8	869.6	27.2	238.4	584.6	19.5	9.5	0.8	31.0	4.4	0.4	3.5	0.2	0.3
	Vaquero	Y	926.2	894.0	19.6	256.9	592.3	25.1	7.4	0.0	31.5	2.6	0.5	1.1	0.9	0.2
	Oloroso	Y	764.0	728.6	1.4	39.2	657.5	30.4	8.0	0.9	35.7	3.4	0.8	1.3	1.3	0.0
	Cometa	W	833.3	702.8	3.0	177.5	505.0	17.2	5.1	0.0	34.0	15.2	6.2	1.3	4.8	2.8
	Marengo	R	461.8	364.6	0.0	0.0	269.6	95.0	17.2	0.0		17.7	11.8	2.4	0.1	3.4
Sakata	Dulce Reina	Y	1000.4	937.3	87.9	360.5	468.6	20.3	8.0	5.3	32.0	5.0	0.6	1.2	2.1	1.2
	Lasso	Y	887.4	837.3	15.7	197.8	596.5	27.3	9.0	1.6	29.7	4.5	1.7	0.9	1.4	0.6
Seminis	Barbaro	Y	906.8	849.9	34.8	327.0	461.8	26.3	8.0	1.9	30.2	5.3	0.3	4.7	0.2	0.2
	Swale	Y	838.1	790.3	12.5	150.9	614.3	12.6	5.1	1.4	29.4	5.0	0.3	3.0	0.6	1.1
	16000	Y	935.2	858.9	97.9	402.4	347.7	10.9	3.4	2.4	29.3	7.7	0.1	7.2	0.2	0.2
	SV6646	Y	878.1	816.4	21.5	258.7	519.7	16.6	3.0	0.0	30.3	6.8	0.0	5.3	1.1	0.4
	SV6672	Y	961.0	875.0	54.0	363.4	447.4	10.1	5.2	0.0	29.8	8.6	0.4	7.3	0.4	0.4
	SV4058	W	732.5	263.0	2.0	48.0	199.3	13.6	8.3	0.0	25.3	62.8	47.8	2.6	0.8	11.6
D. Palmer	Saffron	Y	561.7	494.5	0.0	11.2	424.9	58.5	13.4	24.4		5.3	0.4	4.1	0.0	0.8
	Diamond Swan	W	823.8	488.8	5.4	80.3	381.6	21.5	5.8	3.2	29.1	39.3	22.1	2.7	5.6	8.9
	Cherry Mountain	R	425.5	361.9	0.0	2.6	239.2	120.1	34.1	11.1		4.4	2.4	1.8	0.1	0.1
	DPS-2001	W	355.9	100.8	0.0	10.2	69.2	21.4	5.2	4.4		70.1	0.2	0.1	49.1	20.7
	DPS-2053	W	182.7	11.0	0.0	0.0	0.4	10.6	33.1	0.0		76.5	0.0	2.1	70.5	3.9
	average		773.2	681.4	19.2	159.2	465.9	37.1	10.1	2.3	30.5	12.7	3.5	3.0	4.3	2.0
LSD (0.05)			102.2	105.4	17.8	55.8	87.9	17.1	7.6	6.0	3.5	6.1	4.4	2.6	4.8	5.6

Table 10. Internal bulb decomposition of full-season experimental and commercial onion varieties cut after grading, December 2015. Malheur Experiment Station, Oregon State Univ., Ontario, OR. Continued on next page.

Seed company	Variety	Perfect bulbs	Incomplete scale without decomposition ¹	Bulbs with decomposition					
				Incomplete scale + internal bacterial rot	Incomplete scale + internal <i>F. proliferatum</i> ² rot	Internal bacterial rot	Internal <i>F. proliferatum</i> rot	Total internal decomposition ³	
----- % -----									
A. Takii	Grand Perfection	74.8	20.4	3.2	1.2	0.4	0.0	4.8	
Bejo	Calibra	72.0	22.0	5.0	1.0	0.0	0.0	6.0	
	Crockett	50.5	44.5	1.0	4.0	0.0	0.0	5.0	
	Delgado	53.3	42.0	3.3	1.3	0.0	0.0	4.7	
	Hamilton	65.0	26.0	4.0	5.0	0.0	0.0	9.0	
	Legend	74.4	18.8	2.4	4.0	0.4	0.0	6.8	
	Sedona	63.5	32.0	3.0	1.5	0.0	0.0	4.5	
Crookham	Avalon	87.5	9.5	1.0	1.0	0.5	0.5	3.0	
	Morpheus	76.5	19.0	4.5	0.0	0.0	0.0	4.5	
	Oracle	80.0	13.6	4.0	2.4	0.0	0.0	6.4	
	Scout	73.2	19.6	4.8	2.0	0.4	0.0	7.2	
	OLYX08-640	59.5	35.0	3.0	2.0	0.5	0.0	5.5	
	Purple Haze	48.0	44.8	6.0	0.8	0.4	0.0	7.2	
	Red Beret	56.0	34.8	8.4	0.8	0.0	0.0	9.2	
	Red Devil	62.4	30.4	5.6	1.6	0.0	0.0	7.2	
Brundage	63.6	29.6	3.6	2.8	0.0	0.4	6.8		
Hazera	Cruiser	36.8	55.2	2.4	5.2	0.4	0.0	8.0	
Nunhems	Anillo	55.2	39.6	2.4	2.8	0.0	0.0	5.2	
	Arcero	57.6	36.0	2.4	3.6	0.0	0.4	6.4	
	Granero	68.0	23.5	5.0	3.5	0.0	0.0	8.5	
	Joaquin	76.8	21.6	0.4	0.8	0.4	0.0	1.6	
	Montero	59.6	30.4	6.4	3.6	0.0	0.0	10.0	
	Pandero	82.5	12.5	2.5	2.5	0.0	0.0	5.0	
	Vaquero	75.6	18.0	3.2	2.4	0.0	0.8	6.4	
	Oloroso	76.8	16.4	5.6	1.2	0.0	0.0	6.8	
	Cometa	66.4	24.8	3.2	5.6	0.0	0.0	8.8	
Marenge	71.0	20.0	7.5	1.5	0.0	0.0	9.0		

Table 10. (Continued) Internal bulb decomposition of full-season experimental and commercial onion varieties cut after grading, December 2015. Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Perfect bulbs	Incomplete scale without decomposition ¹	Bulbs with decomposition				
				Incomplete scale + internal bacterial rot	Incomplete scale + internal <i>F. proliferatum</i> ² rot	Internal bacterial rot	Internal <i>F. proliferatum</i> rot	Total internal decomposition ³
				----- % -----				
Sakata	Dulce Reina	86.4	8.0	2.0	3.6	0.0	0.0	5.6
	Lasso	78.8	14.0	2.8	4.0	0.0	0.4	7.2
Seminis	Barbaro	58.4	35.6	4.8	0.8	0.4	0.0	6.0
	Swale	65.6	27.6	4.8	2.0	0.0	0.0	6.8
	16000	72.5	21.0	6.0	0.5	0.0	0.0	6.5
	SV6646	63.2	28.8	5.6	1.6	0.8	0.0	8.0
	SV6672	65.2	27.2	2.4	4.8	0.0	0.4	7.6
	SV4058	39.6	38.8	16.8	4.8	0.0	0.0	21.6
D. Palmer	Saffron	51.2	44.4	2.4	2.0	0.0	0.0	4.4
	Diamond Swan	56.0	31.2	8.4	4.4	0.0	0.0	12.8
	Cherry Mountain	41.0	54.5	4.0	0.0	0.5	0.0	4.5
	DPS-2001	na ⁴	na	na	na	na	na	na
	DPS-2053	na	na	na	na	na	na	na
	average	64.9	28.2	4.3	2.4	0.1	0.1	7.0
LSD (0.05)		21.7	19.7	4.5	NS	NS	NS	6.3

¹dried scales extending 0.25 inch or more into bulb from neck.

²*Fusarium proliferatum*.

³internal bacterial and *F. proliferatum* rot with or without incomplete scales.

⁴na: data omitted due to excessive decomposition.

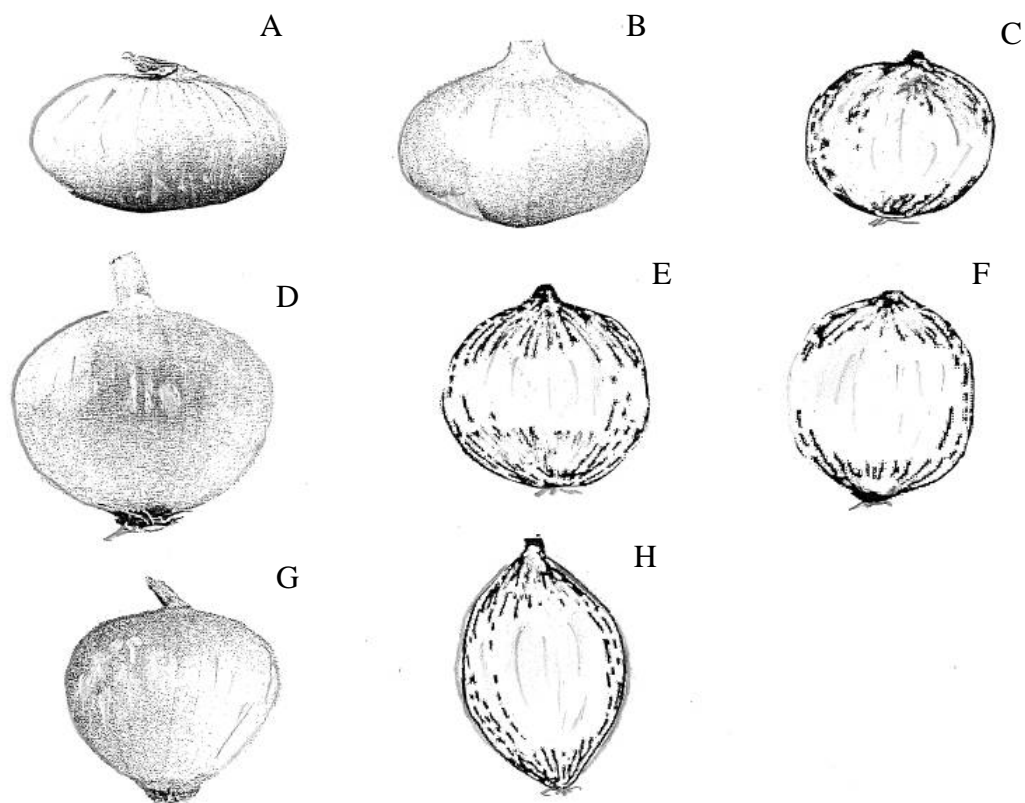


Figure 2. Onion bulb shape rating system. Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 11. Description of bulb shapes, see Fig. 2.

Bulb shape	
Scale	Shape
A	Flat
B	Granex
C	Flattened globe
D	Globe
E	Blocky globe
F	Tall globe
G	Top
H	Torpedo

Table 12. Onion variety subjective quality evaluation rating system.

Characteristic	Scale	Description
Bulb shape	A-H	see Fig. 2
Skin color	1-5	1 = light, 5 = dark
Bulb shape uniformity	1-5	1 = disuniform shape, 5 = uniform shape
Firmness	1-5	1 = soft, 5 = hard
Skin retention	1-5	1 = bald, 5 = no cracks
Flesh brightness	1-5	yellow varieties: 1 = yellow, 5 = white red varieties: 1 = dark red, 5 = pale red white varieties: 1 = less white, 5 = very white

Table 13. Subjective evaluations of onion appearance and firmness by variety on January 12, 2016, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Variety	Color	Bulb shape ^a	Skin color ^b	Bulb shape uniformity ^b	Firmness ^b	Scale retention ^b	Flesh brightness ^b
						----- 1 - 5 -----		
A. Takii	Grand Perfection	Y	E	3.0	3.0	2.3	2.5	3.5
Bejo	Calibra	Y	E	2.8	3.8	3.8	4.0	3.0
	Crockett	Y	E	3.8	4.0	4.0	4.0	2.8
	Delgado	Y	E	3.0	4.0	4.5	4.0	3.0
	Hamilton	Y	E	4.0	4.0	4.0	4.0	2.0
	Legend	Y	F	4.0	4.0	5.0	4.3	3.0
	Sedona	Y	E	3.3	3.3	3.0	3.0	3.3
Crookham	Avalon	Y	E	3.0	2.0	2.0	1.5	3.0
	Morpheus	Y	E	3.0	3.0	3.3	2.5	3.0
	Oracle	Y	F	3.5	3.3	3.0	3.3	3.5
	Scout	Y	D	2.8	2.5	1.5	2.0	3.3
	OLYX08-640	Y	E	2.5	3.8	3.0	3.3	2.3
	Purple Haze	R	E	3.0	2.8	2.5	3.0	3.0
	Red Beret	R	F	2.3	3.0	2.8	3.0	3.0
	Red Devil	R	E	2.0	3.0	2.5	3.0	3.0
	Brundage	W	F	3.3	3.5	3.3	3.0	3.5
Hazera	Cruiser	Y	F	4.0	3.3	2.8	3.3	3.0
Nunhems	Anillo	Y	E	4.0	3.5	4.0	4.0	3.0
	Arcero	Y	E	4.0	3.8	3.5	3.8	4.0
	Granero	Y	E	3.8	3.5	4.5	4.0	2.8
	Joaquin	Y	E	4.0	4.0	4.5	4.0	3.0
	Montero	Y	D	3.8	2.8	2.5	3.3	3.0
	Pandero	Y	E	4.0	3.8	3.8	4.0	3.0
	Vaquero	Y	D	3.5	3.3	2.8	3.0	4.0
	Oloroso	Y	E	3.5	3.5	3.8	4.0	3.5
	Cometa	W	F	3.5	3.0	3.3	2.8	3.5
	Marengo	R	D	3.5	3.0	2.5	3.5	2.0
Sakata	Dulce Reina	Y	F	3.8	3.0	2.5	2.3	3.3
	Lasso	Y	E	3.5	2.8	2.0	2.0	3.5
Seminis	Barbaro	Y	E	3.8	3.0	3.0	3.3	3.5
	Swale	Y	E	3.3	3.5	3.3	4.0	3.3
	16000	Y	E	4.0	3.0	3.0	3.0	3.5
	SV6646	Y	E	4.0	3.3	3.0	3.5	3.0
	SV6672	Y	E	4.0	3.3	2.3	2.8	2.5
	SV4058	W	E	3.0	3.0	3.8	2.8	3.0
D. Palmer	Saffron	Y	E	3.0	4.0	4.0	4.0	2.5
	Diamond Swan	W	E	3.0	3.0	3.3	3.0	3.5
	Cherry Mountain	R	F	2.8	3.0	3.8	4.0	2.0
	DPS-2001	W	na ^c	na	na	na	na	na
	DPS-2053	W	na	na	na	na	na	na
	average		E	3.4	3.3	3.2	3.3	3.1
LSD (0.05)			NS	0.6	1.0	0.8	0.9	0.8

^aBulb shape: see Figure 2.

^bSubjective ratings are described in Table 12.

^cNot available due to excessive storage decomposition.