

2019 ONION VARIETY TRIALS

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Introduction

Direct-seeded yellow, white, and red onion varieties were evaluated in the field in 2019 for plant disease, thrips damage, maturity, bolting, and bulb single centers. Out of storage, the varieties were evaluated for yield, grade, and bulb decomposition. Three early-season yellow varieties and one early-season red variety were planted in March and harvested and graded in mid-August. Fifty-four full-season varieties (35 yellow, 11 red, and 8 white) were planted in March, harvested in September, and graded out of storage in January 2020. Each year, growers and seed industry representatives have the opportunity to examine the varieties at our annual Onion Variety Day in late August and during bulb evaluations in January. Onion varieties were evaluated objectively for bolting, yield, grade, single centers, and storability. Varieties were evaluated subjectively for maturity, thrips leaf damage, Iris Yellow Spot Virus (IYSV), bulb shape, bulb shape uniformity, flesh brightness, and skin color and retention.

Materials and Methods

Onions were grown in 2019 on an Owyhee silt loam previously planted to wheat. After the wheat was harvested in 2018, the stubble was shredded and the field was irrigated to sprout unharvested wheat kernels and then the field was disked. A soil analysis taken in the fall of 2018 showed a pH of 7.7, 2.5% organic matter, 6 ppm nitrogen (N) as nitrate, 2 ppm N as ammonium, 41 ppm phosphorus (P), 323 ppm potassium (K), 9 ppm sulfur (S), 2751 ppm calcium, 500 ppm magnesium, 186 ppm sodium, 2.9 ppm zinc (Zn), 2 ppm manganese (Mn), 1.7 ppm copper (Cu), 11 ppm iron, and 1.1 ppm boron (B). Based on the soil analysis, 50 lb N/acre, 22 lb P/acre, 42 lb K/acre, 80 lb S/acre, 12 lb Mn/acre, and 1 lb B/acre were broadcast before plowing. In addition to the chemical fertilizer, 10 ton/acre of composted cattle feedlot manure was broadcast before plowing. Based on an analysis of the manure, 186 lb N/acre, 107 lb P/acre, and 375 lb K/acre were added from the manure. After plowing and groundhogging, the field was fumigated with Vapam[®] at 15 gal/acre and bedded at 22 inches.

The varieties were planted in three adjacent trials based on bulb color (yellow, white, red). The experimental designs for each 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. All trials were planted on March 21 in plots 4 double rows wide and 27 ft long. The early-maturing trial had 4 varieties from 2 seed companies, the full-season yellow trial had 35 varieties from 9 seed companies, the full-season white trial had 8 varieties from 6 seed companies, and the full-season red trial had 11 varieties from 7 seed companies. An additional trial with onion transplants is not reported here.

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/1000 ft (0.82 lb ai/acre) over the seed rows and the soil surface was cultipacked. Onion emergence started on April 9. On May 13, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. The seedlings were hand thinned on May 15 and 16, and then, due to rainfall, thinning was finished on May 23 and 24. The seedlings were hand thinned to a target 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: oxyfluorfen at 0.13 lb ai/acre (GoalTender[®] at 4 oz/acre), bromoxynil at 0.25 lb ai/acre (Brox[®] 2EC at 16 oz/acre), pendimethalin at 0.95 lb ai/acre (Prowl[®] H₂O at 2 pt/acre), and clethodim at 0.12 lb ai/acre (Shadow[®] 3EC at 5.3 oz/acre) on May 7 and pendimethalin at 0.48 lb ai/acre on May 30.

For thrips control, the following insecticides were applied by ground: azadirachtin at 0.0093 lb ai/acre (Aza-Direct[®] at 12 oz/acre) and potassium salts of fatty acids at 2% v/v (M-Pede[®]) on May 30; spirotetramat at 0.078 lb ai/acre (Movento[®] at 5 oz/acre) and azadirachtin at 0.0093 lb ai/acre on June 5; spirotetramat at 0.078 lb ai/acre and spinetoram at 0.078 lb ai/acre (Radiant[®] at 10 oz/acre) on June 12; abamectin at 0.019 lb ai/acre (Agri-Mek[®] SC at 3.5 oz/acre) on June 21; cyantraniliprole at 0.13 lb ai/acre (Exirel[®] at 20.5 oz/acre) on July 12 and 22; spinetoram at 0.078 lb ai/acre on July 30. The following insecticides were applied by air: abamectin at 0.019 lb ai/acre and spinetoram at 0.078 lb ai/acre on July 3.

Starting on June 11, root tissue and soil 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 based on the root tissue and soil solution recommendations from Western Labs (Table 3). In 2019, both the soil solution N and the root nitrate levels went above the critical level only in late July. Urea ammonium nitrate solution (URAN) was applied through the drip tape seven times from May 30 to July 18, supplying a total of 152 lb N/acre. A total of 127 lb K/acre as potassium chloride was also injected through the drip tape based on the root tissue analyses during the season.

Table 1. Onion root tissue nutrient content in the onion variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Nutrient		11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug
NO ₃ -N (ppm)	Sufficiency range	8500	7667	6833	6000	5168	4338	3508	2678	1834	1000
NO ₃ -N (ppm)		4155	3724	4158	4211	3864	4279	4349	3361	2523	4387
P (%)	0.32 - 0.7	0.58	0.49	0.65	0.48	0.51	0.45	0.38	0.36	0.32	0.37
K (%)	2.7 - 6.0	2.47	2.42	2.90	2.53	2.79	2.13	1.76	2.15	1.86	1.46
S (%)	0.24 - 0.85	0.69	0.82	0.80	0.96	0.97	0.49	0.64	0.40	0.50	0.55
Ca (%)	0.4 - 1.2	0.52	0.62	0.53	0.38	0.45	0.37	0.34	0.43	0.52	0.64
Mg (%)	0.3 - 0.6	0.28	0.32	0.33	0.25	0.30	0.25	0.26	0.22	0.27	0.29
Zn (ppm)	25 - 50	48	57	52	40	34	36	37	35	45	39
Mn (ppm)	35 - 100	120	101	73	94	82	95	72	55	52	61
Cu (ppm)	6 - 20	20	18	15	13	10	9	8	7	7	8
B (ppm)	19 - 60	35	34	28	20	26	30	23	29	26	29

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. Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Nutrient	Critical level lb/ac or g/ac	11-Jun	18-Jun	25-Jun	2-Jul	9-Jul	16-Jul	23-Jul	30-Jul	6-Aug	13-Aug
N	Critical levels	8.6	7	6.2	5	4	4	3.8	2.8	2	1.5
N		1.7	1.7	1.7	2.0	2.3	2.6	2.9	3.1	3.4	6.6
P	0.7 lb/acre	2.0	2.5	3.0	2.3	3.2	2.8	3.5	3.8	3.2	2.9
K	5 lb/acre	6.0	5.3	5.6	4.7	4.3	4.0	4.4	3.4	4.2	4.5
S	1 lb/acre	1.6	1.8	2.0	2.6	2.3	3.1	2.0	1.8	2.2	2.1
Ca	3 lb/acre	5.4	5.9	5.0	4.9	4.4	5.2	4.8	5.4	5.4	4.9
Mg	2 lb/acre	0.7	0.8	0.9	1.1	0.9	0.8	0.9	1.1	1.2	1.0
Zn	28 g/acre	90	84	63	63	72	60	57	48	57	60
Mn	28 g/acre	30	24	18	21	27	27	33	36	39	33
Cu	12 g/acre	75	78	84	78	57	57	63	72	66	54
B	21 g/acre	36	26	20	21	24	20	23	29	23	27

Table 3. Nutrients applied through the drip irrigation system in the onion variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Date	N	K	Mg	Ca
	----- lb/acre -----			
30-May	20			
3-Jun	25			
12-Jun	20			
14-Jun		10		
19-Jun	20			
21-Jun		10		
28-Jun	23			
3-Jul	24		2	
5-Jul		9		
8-Jul		9		
17-Jul		10	2	
18-Jul	20			
19-Jul		10		
24-Jul		10	2	4
2-Aug		15	2	
5-Aug		15		
8-Aug		10	2	
15-Aug		19	2	
Total	152	127	12	4

Table 4. Soil-available N (as NO₃ + NH₄) in lb/acre in the top foot of soil in the onion variety trial from 2014 through 2019, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

2014		2015		2016		2017		2018		2019	
		29-May	42			26-May	38				
		8-Jun	48			12-Jun	32	8-Jun	14	11-Jun	12
		12-Jun	51	14-Jun	207	19-Jun	28	15-Jun	16	18-Jun	12
17-Jun	48	19-Jun	123	23-Jun	147	27-Jun	46	22-Jun	68	25-Jun	12
24-Jun	102	26-Jun	87	29-Jun	168	4-Jul	76	29-Jun	60	2-Jul	14
1-Jul	90	6-Jul	165	6-Jul	150	11-Jul	90	9-Jul	68	9-Jul	16
8-Jul	33	10-Jul	81	13-Jul	144	17-Jul	92	23-Jul	60	16-Jul	18
15-Jul	219	20-Jul	99	20-Jul	129	24-Jul	112	27-Jul	70	23-Jul	20
22-Jul	141	24-Jul	99	27-Jul	120	31-Jul	112	3-Aug	88	30-Jul	22
29-Jul	255	31-Jul	90	3-Aug	99	7-Aug	102	10-Aug	70	6-Aug	24
5-Aug	174	7-Aug	87							13-Aug	46
14-Aug	225	17-Aug	147								

Onions were irrigated automatically to maintain the soil water tension (SWT) at 8-inch depth 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 sensor model 200SS, Irrrometer Co. Inc., Riverside, CA) installed at 8-inch depth in the center of the double row of onions. Sensors had been calibrated to SWT (Shock et al. 1998). The GMS were connected to the datalogger via multiplexers (AM16/32, 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 at 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 April 22 and irrigations ended on September 3.

Onions in the early-maturing trial were evaluated for maturity, severity of symptoms of IYSV, and bolting on August 1. Onions in the full-season trial were evaluated for maturity on August 1, August 13, and August 29. On August 29, onions in the full-season trial were also evaluated for IYSV, thrips damage severity, and bolting. Onions in each plot were evaluated subjectively for maturity by visually rating the percentage of onions with the tops down and percent dry leaves. For the IYSV evaluations, onions in each plot were given a subjective rating on a scale of 0 to 5 for severity of IYSV symptoms. The rating was 0 if there were no symptoms, 1 if 1 to 25% of foliage was diseased, 2 if 26 to 50% of foliage was diseased, 3 if 51 to 75% of foliage was diseased, 4 if 76 to 99% of foliage was diseased, and 5 if 100% of foliage was diseased. For thrips leaf-feeding damage, each plot was given a subjective severity rating on a scale of 0 to 10. The number of bolted onion plants was counted in each plot and compared to the plant population.

Onions from the middle two double rows in each plot in the early-maturity trial were topped by hand, bagged, and graded on August 14. After grading, onions were stored in a shed at ambient air temperature for 2 weeks, after which the onions were evaluated for decomposition and sprouting.

In the full-season trial, the red onion varieties matured before the yellow and white varieties. About half of the red varieties were harvested on August 21 and the other half on August 27. At harvest, onions from the middle two rows in each plot of the red onion varieties were topped and bagged to cure in the field for a week, when they were put in storage. The remaining yellow and white onions were lifted on September 10 to field cure. Onions from the middle two rows in each plot of the yellow and white varieties were topped by hand and bagged on September 16. The bags of white varieties were moved into storage on September 16. The bags of yellow varieties were moved into storage on September 23. 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 in early January 2020.

After 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 (bullet) or had a small multiple center.

During grading, bulbs were separated according to external 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 super colossal (>4¼ inches). Bulb counts per 50 lb of super colossal onions were determined for each plot of every variety by weighing and counting all super colossal bulbs during grading. Marketable yield consisted of No.1 bulbs larger than 2¼ inches.

After grading, 50 No. 1 bulbs from each plot were cut longitudinally and evaluated for the presence of incomplete scales, dry scales, internal bacterial rot, and internal rot caused by *Fusarium proliferatum* or other fungi. 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 that had either more than 0.25 inch from the center of the neck dry or any part dry lower down on the scale.

On January 14, 2020, two replicates of each variety were evaluated for bulb shape, bulb shape uniformity, firmness, skin color, skin retention, and flesh brightness (Tables 5 and 6, Figure 1). The quality characteristics were evaluated by a group of 10 people who did not know 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. Because variety performance varies by year, growers are encouraged to review variety performance data over a number of years before choosing a variety to plant.

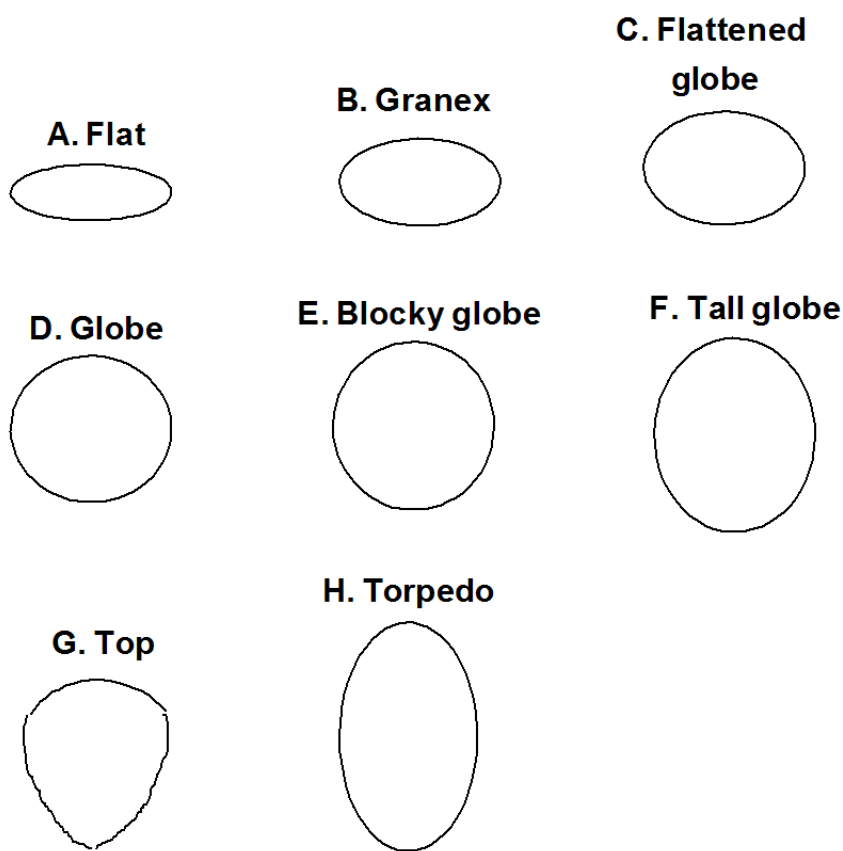


Figure 1. Onion bulb shape rating system. Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 5. Bulb shapes. For a description of bulb shapes, see Fig. 1.

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

Table 6. Onion variety subjective quality evaluation rating system.

Characteristic	Scale	Description
Bulb shape	A-H	see Fig. 1
Skin color	1-5	1 = light, 5 = dark, white varieties: 1=dark, 5=white
Bulb shape uniformity	1-5	1 = nonuniform 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 = pale red, 5 = dark red white varieties: 1 = less white, 5 = very white

Results

The rate of accumulation and total number of growing degree-days (50–86°F) in 2019 were close to the 26-year average (Figures 2, 3). Precipitation for the months of February, April, May, and September was substantially higher than average. Precipitation in February, April, May, and September was 3.4, 1.5, 2.3, and 1.4 inches in 2019 compared to the 75-year average of 0.9, 0.8, 1.1, and 0.5 inches, respectively. The high spring precipitation could have been the cause of the unusually low amounts of soil N during the season in 2019 compared to previous years (Table 4). The onions were subject to higher than average precipitation in September after irrigations were terminated and during curing. The red varieties were placed into storage in early September, before precipitation events occurred. The yellow and white varieties were subject to 4 days of precipitation totaling 0.39 inches in early September after irrigations were terminated and before lifting. The yellow varieties were later subject to another 3 days of precipitation totaling 0.86 inches in mid-September during curing. With regards to irrigation management, the SWT at 8-inch depth frequently exceeded the target of 20 cb by 5 to 10 cb during the season (Figure 4).

Early-maturing Trial

On August 13, all varieties had at least 85% tops down (Table 7). After 2 weeks of storage, bulb sprouting or decomposition was low, averaging 1.2%. The percentage of onions that were functionally single centered averaged 28% and ranged from 19% for ‘Yosemite’ to 39% for ‘Ovation’ (Table 8). Total yield averaged 1031 cwt/acre, ranging from 730 cwt/acre for ‘Redstone’ to 1192 cwt/acre for ‘Spanish Medallion’ (Table 9).

Full-season Trials

Yellow varieties. On August 1, the percentage of tops down averaged 8% and ranged from 0% for ‘Joaquin’ to 81% for ‘Elsye’ (Table 10). By August 13, the percentage of tops down averaged 45% and ranged from 11% for ‘Caliber’ to 94% for Elsy. The severity of thrips leaf damage, on a scale from 0 to 10, averaged 2.7 and ranged from 2 for ‘Oracle’, Joaquin, ‘SV6672’, ‘Aruba’, and ‘Dulce Reina’ to 3.8 for ‘Traverse’. Bolting averaged 0.1% and ranged from 0% for many varieties to 0.3% for Dulce Reina. Iris Yellow Spot Virus Severity was low in this trial, with all varieties showing low intensity of symptoms with a rating of 1 (0–25% of foliage diseased), except for Caliber, which had a rating of 2 (25–50% of foliage diseased).

The percentage of functionally single-centered bulbs averaged 71% and ranged from 23% for ‘Ridge Line’ to 98% for ‘Oloroso’ (Table 11).

Marketable yield out of storage in January 2020, averaged 1052 cwt/acre and ranged from 841 cwt/acre for ‘Saffron’ to 1348 cwt/acre for ‘Ranchero’ (Table 12). Ranchero, Joaquin, and ‘Vaquero’ were among the varieties with the highest marketable yield. Storage decomposition averaged 5% and ranged from 0.5% for ‘Sedona’ to 48% for Elsy. Elsy had the highest storage decomposition followed by ‘Avalon’, ‘Scout’, and Oracle.

In January 2020, the percentage of bulbs with incomplete scales, regardless of dry scale or disease, averaged 39% and ranged from 11% for ‘Grand Perfection’ to 84% for Traverse (Table 13). The percentage of bulbs with internal decomposition, regardless of incomplete or dry scales, averaged 0.4% and ranged from 0% for many varieties to 2% for ‘Tucannon’. In 2019, the percentage of bulbs with internal decomposition was low and was almost exclusively caused by neck rot (Table 14). Internal decomposition caused by bacterial rot was observed only in

'Mondella' at 4%. Internal decomposition caused by *Fusarium proliferatum* and black mold was not observed in 2019.

Subjective bulb quality ratings can be found in Table 15. Significant variations were found among varieties in all the subjective characteristics except flesh brightness.

White varieties. On August 1, the percentage of tops down averaged 4% and ranged from 1% for 'Bridewhite' to 5% for several varieties (Table 16). On August 13, the percentage of tops down averaged 24% and ranged from 14% for '37-127' to 36% for 'Rhea'. The severity of thrips leaf damage, on a scale from 0 to 10, averaged 2.3 and ranged from 2 for Rhea to 2.6% for 'SV4058' and 'Diamond Swan'. Bolting averaged 0.03% and was less than 0.1% for all varieties. Iris Yellow Spot Virus Severity was low in this trial, with all varieties showing low intensity of symptoms, with a rating of 1 (0–25% of foliage diseased).

The percentage of functionally single-centered bulbs averaged 80% and ranged from 42% for Bridewhite to 98% for 'White Cap' (Table 17).

Marketable yield in January 2020 averaged 970 cwt/acre and ranged from 813 cwt/acre for Diamond Swan to 1114 cwt/acre for 37-127 (Table 18). Varieties 37-127, 'Cometa', and Rhea were among those with the highest marketable yield. Storage decomposition averaged 14% and ranged from 9% for Rhea to 21% for 'DPS-2056'.

In January 2020, the percentage of bulbs with incomplete scales, regardless of dry scale or disease, averaged 27% and ranged from 10% for Cometa to 42% for Diamond Swan (Table 19). The percentage of bulbs with internal decomposition, regardless of incomplete or dry scales, averaged 5% and ranged from 2% for White Cap to 12% for SV4058. In 2019, the internal decomposition was caused by neck rot (Table 20). Internal decomposition caused by bacteria, *Fusarium proliferatum*, and black mold were not observed in white onion varieties in the 2019 trial.

Subjective bulb quality ratings can be found in Table 21. There were no statistically significant variations among varieties in any of the subjective characteristics.

Red varieties. On August 1, the percentage of tops down averaged 17% and ranged from 3% for 'RW011' to 86% for 'Monastrell' (Table 22). On August 13, the percentage of tops down averaged 51% and ranged from 19% for 'Purple Haze' and RW011 to 95% for Monastrell. Bolting averaged 0.03% and was less than 0.1% for all varieties.

The percentage of functionally single-centered bulbs averaged 45% and ranged from 16% for 'TAS040' to 82% for Purple Haze (Table 23).

Marketable yield in January 2020 averaged 530 cwt/acre and ranged from 396 cwt/acre for TAS040 to 590 cwt/acre for 'SV4643NT' (Table 24). SV4643NT, Purple Haze, and 'Marengo' were among the varieties with the highest marketable yield. Storage decomposition averaged 9% and ranged from 1% for RW011 to 19% for Monastrell.

In January 2020, the percentage of bulbs with incomplete scales, regardless of dry scale or disease, averaged 69% and ranged from 57% for TAS040 to 84% for 'TAS042' (Table 25). The percentage of bulbs with internal decomposition, regardless of incomplete or dry scales, averaged 1.6% and ranged from 0% for Monastrell to 5% for Marengo. In 2019, the percentage of bulbs with internal decomposition was low and was caused by neck rot (Table 26). Internal

decomposition caused by bacteria, *Fusarium proliferatum*, and black mold was not observed in red onion varieties in the 2019 trial.

Subjective bulb quality ratings can be found in Table 27. Significant variations were found among varieties in all the subjective characteristics except bulb shape, bulb shape uniformity, and flesh brightness.

Acknowledgements

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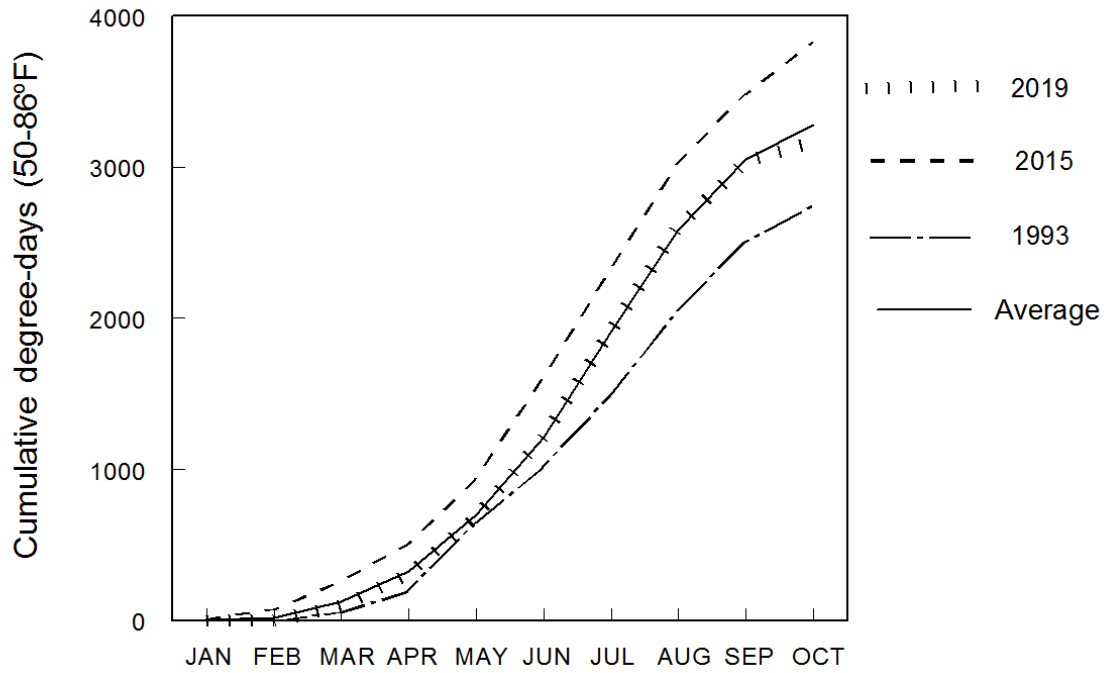


Figure 2. Cumulative growing degree-days (50–86°F) for selected years and 26-year average, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019. Lines for 2019 and the average overlap.

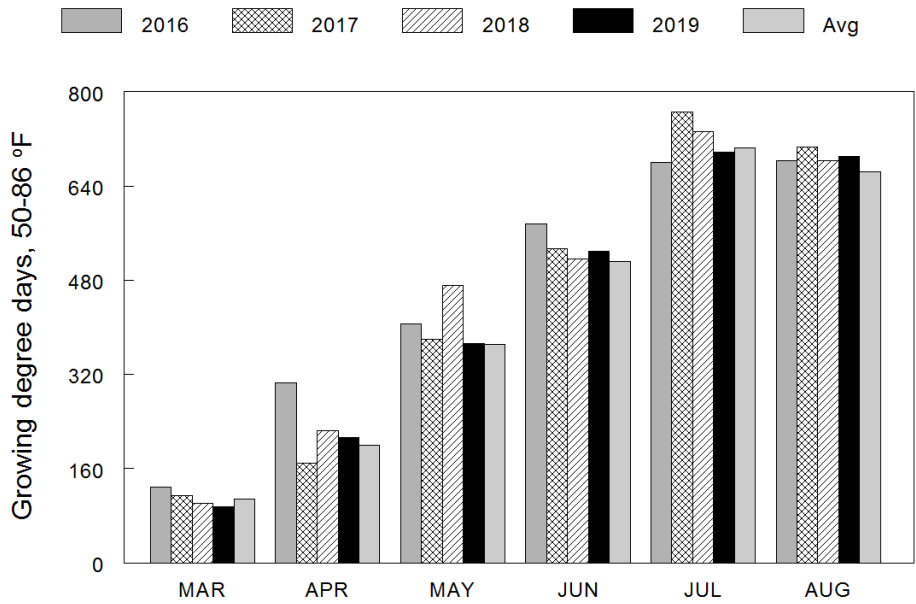


Figure 3. Monthly growing degree-days (50–86°F) for 2016–2019 and 26-year average, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

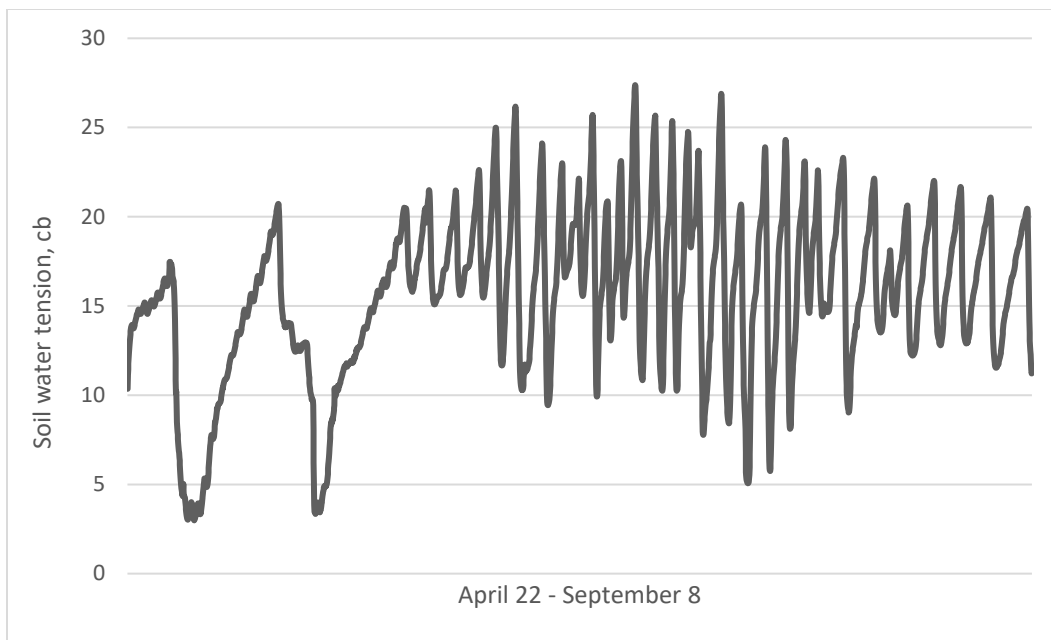


Figure 4. Soil water tension at 8-inch depth below the onion row, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Table 7. Maturity ratings and bulb quality for early-maturing onion varieties lifted and harvested August 14, 2019, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb color	Maturity Aug. 1		Maturity Aug. 13		Bulb quality 2 weeks after harvest			
			Tops down	Leaf dryness	Tops down	Leaf dryness	Sprouted	Decomposed	Sprouted and decomposed	Sprouted or decomposed
			----- % -----							
Hazera	Redstone	R	50	6	100	10	0.0	0.8	0.0	0.8
Sakata	Ovation	Y	22	2	85	5	1.6	0.0	0.0	1.6
	Spanish Medallion	Y	22	1	87	5	0.8	0.8	0.0	1.6
	Yosemite	Y	48	3	92	5	0.0	0.8	0.0	0.8
Average			35.5	3.0	91.0	6.3	0.6	0.6	0.0	1.2
LSD (0.05)			19.0	3.3	5.7	NS	NS	NS	NS	NS

Table 8. Single- and multiple-center bulb ratings for early-maturing onion varieties lifted and harvested August 14, 2019, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Multiple center			Single center	
		large	medium	small	functional ^a	bullet
		----- % -----				
Hazera	Redstone	37.6	43.2	16.0	19.2	3.2
Sakata	Ovation	26.6	34.7	22.6	38.7	16.1
	Spanish Medallion	23.2	40.0	8.8	36.8	28.0
	Yosemite	50.9	30.6	4.9	18.5	13.7
Average		34.6	37.1	13.1	28.3	15.3
LSD (0.05)		16.0	NS	11.7	16.6	NS

^aFunctional single-centered bulbs are the small multiple-centered plus the bullet-centered onions.

Table 9. Yield and grade performance of early-maturing onion varieties lifted and harvested August 14, 2019, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Total yield	Marketable yield by grade							Split root	Total rot	Black mold	Slime rot	Bulb counts >4¼ in
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small	No. 2s					
		----- cwt/acre -----							----- % -----		----- #/50 lb -----			
Hazera	Redstone	729.7	659.5	10.6	70.3	500.9	77.7	14.6	27.1	0.2	2.4	2.4	0.0	34.2
Sakata	Ovation	1174.0	1107.1	213.0	482.6	397.7	13.8	8.3	23.0	0.6	2.4	1.9	0.5	30.6
	Spanish Medallion	1192.2	1116.0	179.7	465.0	451.1	20.2	6.6	31.0	0.3	3.0	2.6	0.4	30.7
	Yosemite	1026.8	877.6	81.9	327.1	434.4	34.3	11.0	62.1	1.2	5.6	5.6	0.0	31.5
Average		1030.7	940.1	121.3	336.3	446.0	36.5	10.1	35.8	0.6	3.3	3.1	0.2	31.8
LSD (0.05)		288.0	211.3	59.1	199.8	NS	33.1	NS	NS	NS	NS	NS	NS	1.0

Table 10. Maturity, bolting, thrips leaf damage, and Iris Yellow Spot Virus symptoms ratings of full-season yellow onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Seed company	Variety	1-Aug		13-Aug		29-Aug		29-Aug		IYSV ^b
		Tops down	Leaf dryness	Tops down	Leaf dryness	Tops down	Leaf dryness	Bolting	Thrips leaf damage ^a	
		----- % -----						0-10	0-5	
A. Takii	Grand Perfection	4	0	31	5	87	20	0.00	2.2	1.0
	Ridge Line	16	3	86	15	100	42	0.00	3.6	1.0
	Traverse	10	2	84	16	100	40	0.00	3.8	1.0
Bejo	Mondella	5	0	25	8	82	25	0.04	3.4	1.0
	Hamilton	6	0	15	5	52	16	0.09	2.8	1.0
	Legend	7	0	42	6	96	19	0.00	2.4	1.0
	Sedona	5	0	18	7	78	24	0.17	3.2	1.0
	Gunnison	7	1	76	10	96	35	0.00	3.4	1.0
	Crockett	5	0	14	5	50	18	0.00	2.8	1.0
Crookham	Avalon	7	0	72	8	94	25	0.09	2.2	1.0
	Scorpion	11	0	64	13	94	32	0.00	3.6	1.0
	Scout	8	0	64	9	88	24	0.04	2.6	1.0
	Oracle	1	0	18	5	68	19	0.09	2.0	1.0
	Trident	7	0	48	8	86	30	0.00	3.2	1.0
	OLYX08-640	11	0	82	9	94	30	0.00	3.2	1.0
	Caliber	1	0	11	5	52	28	0.00	3.0	2.0
Enza Zaden	Elsye	81	3	94	13	100	29	0.00	2.6	1.0
Hazera	Rhino	6	0	70	8	90	23	0.00	2.6	1.0
	37-120	8	0	82	7	93	26	0.22	2.8	1.0
Nunhems	Arcero	5	0	20	10	74	28	0.04	2.8	1.0
	Granero	5	0	32	5	90	24	0.04	2.6	1.0
	Ranchero	5	0	46	5	90	22	0.00	2.6	1.0
	Joaquin	0	0	12	5	62	16	0.13	2.0	1.0
	Montero	9	0	70	12	98	35	0.04	3.4	1.0
	Oloroso	4	0	18	5	72	22	0.00	3.0	1.0
	Pandero	3	0	19	5	70	18	0.09	2.2	1.0
	Vaquero	4	0	31	6	86	22	0.00	2.8	1.0
Sakata	Aruba	9	0	72	6	94	26	0.17	2.0	1.0
	Dulce Reina	1	0	34	5	84	21	0.30	2.0	1.0
	Yukon	7	0	50	7	90	26	0.00	2.2	1.0
Seminis	Tucannon	4	0	44	6	90	26	0.00	2.6	1.0
	16000	5	0	70	5	96	22	0.04	2.2	1.0
	SV6646	3	0	20	5	82	21	0.00	2.2	1.0
	SV6672	4	0	26	5	82	23	0.04	2.0	1.0
D. Palmer	Saffron	6	0	23	6	78	25	0.00	2.6	1.0
Average		8	0	45	7	84	25	0.05	2.7	1.0
LSD (0.05)		4	1	11	3	8	5	0.13	0.6	NS

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

^bIYSV: 0 = no symptoms, 5 = 100% foliage diseased.

Table 11. Single- and multiple-center ratings for full-season yellow onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Seed company	Variety	Multiple center			Single center	
		large	medium	small	functional ^a	bullet
		----- % -----				
A. Takii	Grand Perfection	20.8	24.0	23.2	55.2	32.0
	Ridge Line	36.1	41.2	16.2	22.7	6.5
	Traverse	20.0	47.2	24.0	32.8	8.8
Bejo	Mondella	10.4	10.4	29.6	79.2	49.6
	Hamilton	27.2	7.2	19.2	65.6	46.4
	Legend	41.6	26.4	26.4	32.0	5.6
	Sedona	29.4	15.1	23.0	55.5	32.5
	Gunnison	11.2	27.0	25.2	61.8	36.6
	Crockett	24.0	24.0	26.4	52.0	25.6
Crookham	Avalon	23.3	16.8	22.7	59.9	37.2
	Scorpion	2.4	2.4	17.6	95.2	77.6
	Scout	19.2	27.2	16.0	53.6	37.6
	Oracle	2.4	7.3	18.0	90.3	72.3
	Trident	3.2	3.2	7.2	93.6	86.4
	OLYX08-640	1.6	7.2	9.6	91.2	81.6
	Caliber	1.6	4.0	8.8	94.4	85.6
Enza Zaden	Elsye	42.4	34.4	17.6	23.2	5.6
Hazera	Rhino	8.7	17.4	11.1	73.9	62.8
	37-120	20.8	7.2	26.4	72.0	45.6
Nunhems	Arcero	2.4	3.2	8.7	94.5	85.8
	Granero	7.2	11.2	13.6	81.6	68.0
	Ranchero	9.1	8.8	20.3	82.1	61.8
	Joaquin	2.4	4.0	11.2	93.6	82.4
	Montero	4.0	6.3	21.9	89.7	67.8
	Oloroso	1.6	0.0	1.6	98.4	96.8
	Pandero	7.2	10.4	28.8	82.4	53.6
	Vaquero	4.0	5.6	15.2	90.4	75.2
Sakata	Aruba	12.0	10.4	8.8	77.6	68.8
	Dulce Reina	8.7	15.8	15.0	75.5	60.5
	Yukon	30.4	17.6	17.6	52.0	34.4
Seminis	Tucannon	6.3	1.6	10.9	92.1	81.1
	16000	16.0	11.2	11.2	72.8	61.6
	SV6646	8.8	3.2	15.2	88.0	72.8
	SV6672	25.8	12.9	13.8	61.3	47.5
D. Palmer	Saffron	32.5	25.4	28.3	42.1	13.7
Average		15.0	14.2	17.4	70.8	53.4
LSD (0.05)		10.3	9.1	11.7	11.9	12.3

^aFunctional single-centered bulbs are the small multiple-centered plus the bullet-centered onions.

Table 12. Yield and grade of full-season experimental and commercial yellow onion varieties graded out of storage in January 2020, Malheur Experiment Station, Oregon State University, Ontario, OR. (Continued on next page)

Seed company	Variety	Total yield	Marketable yield by grade						No. 2s	Bulb counts >4¼ in	Total rot	Neck rot	Plate rot	Black mold	Split basal plate
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small							
		----- cwt/acre -----						#/50 lb		--- % of total yield ---					
A. Takii	Grand Perfection	1254.8	1111.2	276.4	451.6	363.5	19.6	5.5	33.1	31.0	8.0	6.1	0.7	1.2	0.1
	Ridge Line	943.9	901.5	19.5	254.9	597.3	29.8	8.8	17.3	32.1	1.4	0.4	0.9	0.0	0.4
	Traverse	889.9	852.5	22.5	217.3	588.3	24.4	5.2	6.7	32.1	2.8	0.3	1.2	1.3	0.0
Bejo	Mondella	962.4	909.9	51.4	327.9	514.9	15.7	5.9	21.4	32.3	2.4	0.6	1.8	0.0	0.2
	Hamilton	1094.7	998.7	89.3	388.3	494.6	26.5	7.6	60.1	32.9	2.6	1.1	0.5	1.0	0.0
	Legend	1115.7	1021.1	84.5	420.0	496.2	20.3	5.8	57.5	31.8	2.7	1.1	1.2	0.4	0.2
	Sedona	1159.8	1054.7	112.3	398.0	522.1	22.4	8.1	91.5	32.0	0.5	0.1	0.4	0.0	0.0
	Gunnison	901.0	844.3	1.3	143.4	670.1	29.5	6.2	18.7	41.0	3.5	1.2	1.4	0.8	0.0
	Crockett	1034.7	916.4	59.3	315.3	512.0	29.8	9.3	100.2	34.6	0.8	0.2	0.6	0.0	0.1
Crookham	Avalon	1404.4	1150.4	300.6	483.4	348.3	18.3	5.8	5.7	28.4	17.2	14.3	0.1	2.9	0.0
	Scorpion	872.4	848.5	22.5	137.8	654.4	33.9	9.4	0.0	31.7	1.6	0.8	0.7	0.2	0.0
	Scout	1400.9	1197.9	363.3	490.4	331.9	12.4	3.7	23.3	28.3	12.6	4.3	0.4	8.0	0.1
	Oracle	1306.1	1159.6	317.0	465.1	365.0	12.4	5.2	2.1	31.2	10.1	8.4	0.7	1.0	0.1
	Trident	974.2	943.9	46.0	277.1	589.2	31.7	9.4	2.4	33.7	1.9	0.2	0.8	0.9	0.0
	OLYX08-640	936.3	900.9	30.2	224.9	623.1	22.8	8.8	4.8	32.3	2.3	1.3	0.4	0.6	0.0
	Caliber	1214.8	1164.4	336.3	476.4	334.6	17.1	4.5	5.1	31.3	3.4	1.9	0.6	0.9	0.0
Enza Zaden	Elsye	1298.0	670.4	132.5	243.5	278.8	15.6	4.7	0.0	27.5	47.8	43.0	0.0	4.8	0.0

Table 12. (continued) Yield and grade of full-season experimental and commercial yellow onion varieties graded out of storage in January 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Total yield	Marketable yield by grade						No. 2s	Bulb counts >4¼ in	Total rot	Neck rot	Plate rot	Black mold	Split basal plate	
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small								
		----- cwt/acre -----									#/50 lb		----- % of total yield -----			
Hazera	Rhino	1074.4	1025.5	160.9	407.5	442.0	15.2	5.7	15.3	30.8	2.7	1.8	0.8	0.1	0.0	
	37-120	927.7	883.6	49.9	262.7	535.0	36.0	6.5	23.6	32.0	1.5	0.7	0.8	0.0	0.0	
Nunhems	Arcero	1174.6	1130.5	129.3	493.4	493.5	14.2	6.4	5.1	32.4	2.8	1.6	1.2	0.0	0.0	
	Granero	1225.8	1149.6	218.4	478.2	443.6	9.4	3.8	8.5	30.3	5.3	2.9	0.8	1.7	0.0	
	Ranchero	1392.6	1347.7	461.1	536.7	338.4	11.4	4.7	17.0	29.7	1.6	1.0	0.6	0.0	0.0	
	Joaquin	1324.7	1283.0	359.9	544.7	367.7	10.8	5.3	5.3	30.9	2.3	1.8	0.6	0.0	0.0	
	Montero	1165.0	1115.4	126.1	495.4	473.3	20.6	5.8	3.0	31.7	3.4	2.8	0.6	0.0	0.0	
	Oloroso	1044.9	1021.5	93.0	390.5	522.8	15.1	6.6	1.4	33.4	1.4	0.8	0.5	0.1	0.1	
	Pandero	1224.7	1180.3	261.6	503.0	403.1	12.6	4.0	19.6	30.9	1.3	0.8	0.5	0.0	0.4	
	Vaquero	1305.0	1235.9	347.9	515.2	361.0	11.9	2.9	10.2	28.5	4.3	3.7	0.5	0.0	0.0	
Sakata	Aruba	1178.4	1127.2	242.7	445.7	421.2	17.6	4.6	21.7	29.7	2.2	1.5	0.3	0.4	0.0	
	Dulce Reina	1260.2	1140.8	359.2	399.8	367.3	14.6	5.9	24.6	30.6	6.9	5.3	0.2	1.4	0.0	
	Yukon	1230.9	1116.2	294.8	409.7	395.0	16.7	10.4	55.8	29.5	3.9	2.8	0.7	0.4	0.1	
Seminis	Tucannon	1125.0	1039.5	222.1	432.8	373.2	11.4	3.1	6.5	30.8	6.7	5.8	0.3	0.6	0.3	
	16000	1281.6	1200.0	376.8	466.8	342.6	13.7	4.6	34.8	29.2	3.4	2.1	0.9	0.4	0.0	
	SV6646	1258.9	1154.1	440.2	436.5	268.0	9.5	4.9	23.0	29.1	5.8	4.9	0.7	0.2	0.3	
	SV6672	1269.0	1192.0	400.4	494.2	285.1	12.4	5.1	33.9	28.9	3.0	1.8	0.9	0.3	0.1	
D. Palmer	Saffron	973.6	841.1	61.1	257.2	485.3	37.5	9.2	102.1	33.1	2.2	1.3	0.8	0.0	0.0	
Average		1148.6	1052.3	196.3	391.0	445.8	19.2	6.1	24.6	31.3	5.2	3.7	0.7	0.8	0.1	
LSD (0.05)		101.2	117.4	83.5	89.3	79.6	11.2	4.3	19.9	2.3	5.2	4.6	0.8	NS	NS	

Table 13. Internal defects of full-season experimental and commercial yellow onion varieties evaluated out of storage in December 2019, Malheur Experiment Station, Oregon State University, Ontario, OR. (Continued on next page)

Seed company	Variety	All bulbs							Diseased bulbs							
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total	
		no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total		
----- % -----																
A. Takii	Grand Perfection	89.6	0.0	89.6	9.7	0.8	10.5	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Ridge Line	32.4	0.0	32.4	60.0	7.6	67.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Traverse	16.0	0.0	16.0	70.4	13.6	84.0	100.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.4
Bejo	Mondella	43.2	0.0	43.2	48.8	8.0	56.8	100.0	0.0	0.0	0.0	0.4	0.4	0.8	0.8	0.8
	Hamilton	69.4	0.0	69.4	25.0	5.6	30.6	100.0	0.4	0.0	0.4	0.0	0.0	0.0	0.0	0.4
	Legend	74.8	0.8	75.6	23.2	1.2	24.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Sedona	61.0	0.0	61.0	33.8	5.2	39.0	100.0	1.5	0.0	1.5	0.4	0.0	0.4	0.4	1.9
	Gunnison	30.0	0.0	30.0	63.2	6.8	70.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Crockett	42.4	0.4	42.8	46.0	11.2	57.2	100.0	0.0	0.0	0.0	0.8	0.4	1.2	1.2	1.2
Crookham	Avalon	67.8	0.4	68.2	31.0	0.8	31.8	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Scorpion	39.2	8.8	48.0	43.2	8.8	52.0	100.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4
	Scout	52.0	0.4	52.4	41.6	6.0	47.6	100.0	0.0	0.0	0.0	0.4	0.0	0.4	0.4	0.4
	Oracle	78.4	0.0	78.4	20.0	1.6	21.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Trident	47.6	0.0	47.6	41.6	10.8	52.4	100.0	0.0	0.0	0.0	0.4	0.0	0.4	0.4	0.4
	OLYX08-640	65.6	0.0	65.6	23.6	10.8	34.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Caliber	78.9	0.0	78.9	17.4	3.7	21.1	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Enza Zaden	Elsye	59.6	0.0	59.6	38.0	2.4	40.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Table 13. (Continued) Internal defects of full-season experimental and commercial yellow onion varieties evaluated out of storage in December 2019, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	All bulbs							Diseased bulbs						
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total
		no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total	
----- % -----															
Hazera	Rhino	50.8	0.0	50.8	41.2	8.0	49.2	100.0	0.0	0.0	0.0	0.0	0.8	0.8	0.8
	37-120	44.4	0.0	44.4	50.8	4.8	55.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Nunhems	Arcero	73.2	0.0	73.2	20.8	6.0	26.8	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Granero	58.0	0.0	58.0	37.2	4.8	42.0	100.0	0.4	0.0	0.4	0.4	0.4	0.8	1.2
	Ranchero	78.4	0.0	78.4	17.2	4.4	21.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Joaquin	76.9	0.4	77.3	20.3	2.4	22.7	100.0	0.0	0.0	0.0	0.4	0.0	0.4	0.4
	Montero	42.7	0.0	42.7	35.1	22.3	57.3	100.0	0.0	0.0	0.0	0.4	0.0	0.4	0.4
	Oloroso	59.0	0.0	59.0	32.1	8.8	41.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pandero	65.9	0.8	66.7	24.9	8.4	33.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Vaquero	72.0	0.0	72.0	22.0	6.0	28.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sakata	Aruba	71.6	0.0	71.6	22.0	6.4	28.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Dulce Reina	80.7	0.0	80.7	15.8	3.5	19.3	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Yukon	70.4	0.0	70.4	25.9	3.7	29.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Seminis	Tucannon	87.2	0.4	87.6	9.2	3.2	12.4	100.0	1.6	0.0	1.6	0.4	0.0	0.4	2.0
	16000	63.4	0.0	63.4	35.3	1.2	36.6	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	SV6646	71.9	0.4	72.3	24.4	3.2	27.7	100.0	0.4	0.0	0.4	0.4	0.0	0.4	0.8
	SV6672	64.1	0.0	64.1	32.8	3.0	35.9	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
D. Palmer	Saffron	54.1	0.0	54.1	36.5	9.5	45.9	100.0	0.4	0.0	0.4	0.9	0.0	0.9	1.3
Average		60.5	0.4	60.9	33.5	5.5	39.1	100.0	0.2	0.0	0.2	0.1	0.1	0.2	0.4
LSD (0.05)		14.6	NS	15.4	14.7	7.0	15.4		NS	NS	NS	NS	NS	NS	NS

Table 14. Internal decomposition by disease type of full-season experimental and commercial yellow onion varieties evaluated out of storage in December 2019, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bacterial rot	<i>Fusarium proliferatum</i>	Neck rot	Black mold
		----- % -----			
A. Takii	Grand				
	Perfection	0.0	0.0	0.0	0.0
	Ridge Line	0.0	0.0	0.0	0.0
-----				0.4	0.0
Bejo	Mondella	0.4	0.0	0.4	0.0
	Hamilton	0.0	0.0	0.4	0.0
	Legend	0.0	0.0	0.0	0.0
	Sedona	0.0	0.0	1.9	0.0
	Gunnison	0.0	0.0	0.0	0.0
	Crockett	0.0	0.0	1.2	0.0
	-----				0.0
Crookham	Avalon	0.0	0.0	0.0	0.0
	Scorpion	0.0	0.0	0.4	0.0
	Scout	0.0	0.0	0.4	0.0
	Oracle	0.0	0.0	0.0	0.0
	Trident	0.0	0.0	0.4	0.0
	OLYX08-640	0.0	0.0	0.0	0.0
	Caliber	0.0	0.0	0.0	0.0
-----				0.0	0.0
Enza Zaden	Elsye	0.0	0.0	0.0	0.0
Hazera	Rhino	0.0	0.0	0.8	0.0
	37-120	0.0	0.0	0.0	0.0
-----				0.0	0.0
Nunhems	Arcero	0.0	0.0	0.0	0.0
	Granero	0.0	0.0	1.2	0.0
	Ranchero	0.0	0.0	0.0	0.0
	Joaquin	0.0	0.0	0.4	0.0
	Montero	0.0	0.0	0.4	0.0
	Oloroso	0.0	0.0	0.0	0.0
	Pandero	0.0	0.0	0.0	0.0
	Vaquero	0.0	0.0	0.0	0.0
-----				0.0	0.0
Sakata	Aruba	0.0	0.0	0.0	0.0
	Dulce Reina	0.0	0.0	0.0	0.0
	Yukon	0.0	0.0	0.0	0.0
-----				2.0	0.0
Seminis	Tucannon	0.0	0.0	0.0	0.0
	16000	0.0	0.0	0.0	0.0
	SV6646	0.0	0.0	0.8	0.0
	SV6672	0.0	0.0	0.0	0.0
-----				1.3	0.0
D. Palmer	Saffron	0.0	0.0	0.4	0.0
Average		0.0	0.0	0.4	0.0
LSD (0.05)		NS	NS	NS	NS

Table 15. Subjective evaluations of yellow onion appearance and firmness by variety on January 14, 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Variety	Bulb shape ^a	Bulb shape uniformity ^b	Firmness ^b	Scale retention ^b	Skin color ^b	Flesh brightness ^b
			----- 1-5 -----				
A. Takii	Grand Perfection	f	2.5	3.0	4.0	3.3	3.3
	Ridge Line	d	2.5	3.1	3.0	3.0	3.3
	Traverse	d	3.5	3.3	2.5	3.3	3.6
Bejo	Mondella	d	3.8	3.9	4.1	3.5	3.8
	Hamilton	f	3.0	4.5	4.3	4.4	3.5
	Legend	e	3.0	4.0	4.8	3.5	3.8
	Sedona	f	2.4	3.5	3.5	3.3	3.3
	Gunnison	f	2.8	4.3	3.8	3.6	3.3
	Crockett	f	3.8	4.3	4.0	4.0	3.5
Crookham	Avalon	d	2.0	2.0	2.0	3.0	3.8
	Scorpion	e	3.5	3.3	3.5	3.5	3.0
	Scout	d	2.5	2.8	2.5	2.5	3.3
	Oracle	e	3.0	3.0	3.8	3.8	4.3
	Trident	c	2.8	3.0	3.3	3.3	3.3
	OLYX08-640	e	2.5	4.3	4.0	4.0	3.0
	Caliber	d	3.3	3.6	4.0	3.5	4.0
Enza Zaden	Elsye	d	2.8	2.0	1.8	2.5	3.5
Hazera	Rhino	f	2.5	3.1	4.0	3.8	3.3
	37-120	c	3.5	3.8	3.5	3.8	3.3
Nunhems	Arcero	f	3.0	3.5	4.3	4.0	3.8
	Granero	d	3.5	4.0	4.3	4.3	3.8
	Ranchero	d	4.0	3.0	3.5	3.3	3.5
	Joaquin	f	3.3	3.8	4.3	3.8	3.8
	Montero	d	2.5	2.8	3.5	3.4	3.8
	Oloroso	d	4.0	4.0	4.5	4.0	3.3
	Pandero	e	4.0	4.3	4.3	4.0	3.3
	Vaquero	d	3.0	3.5	4.0	3.4	3.8
Sakata	Aruba	d	2.5	3.0	2.8	2.5	4.3
	Dulce Reina	f	3.5	2.8	3.0	3.0	4.0
	Yukon	d	3.3	3.0	2.5	3.0	3.5
Seminis	Tucannon	e	3.5	3.6	4.3	4.3	3.5
	16000	d	3.5	3.3	3.3	3.3	3.8
	SV6646	d	3.5	3.8	3.8	3.5	4.0
	SV6672	d	3.5	2.9	4.0	3.5	3.8
D. Palmer	Saffron	d	4.0	4.3	4.3	4.0	3.3
Average		e	3.1	3.4	3.6	3.5	3.6
LSD (0.05)		1.0	0.7	0.5	0.5	0.4	NS

^aBulb shape: see Fig. 1. ^bSubjective ratings are described in Table 6.

Table 16. Maturity, bolting, thrips leaf damage, and iris yellow spot virus symptoms ratings of full-season white onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Seed company	Variety	1-Aug		13-Aug		29-Aug		29-Aug		
		Tops down	Leaf dryness	Tops down	Leaf dryness	Tops down	Leaf dryness	Bolting	Thrips leaf damage ^a	IYSV ^b
		----- % -----						0-10	0-5	
Bejo	Bridewhite	1.0	0.0	18.0	5.0	82.0	21.0	0.00	2.2	1
Crookham	White Cap	5.0	0.0	34.0	7.0	90.0	25.0	0.00	2.4	1
Hazera	37-127	4.0	0.0	14.0	5.0	74.0	14.0	0.00	1.8	1
Nunhems	Cometa	5.0	0.0	21.0	5.0	84.0	20.0	0.04	2.4	1
	Rhea	4.0	0.0	36.0	5.0	90.0	22.0	0.00	2.0	1
Seminis	SV4058	5.0	0.0	21.0	5.0	80.0	22.0	0.04	2.6	1
D. Palmer	Diamond Swan	5.0	0.0	21.0	5.0	76.0	23.0	0.09	2.6	1
	DPS-2056	4.0	0.0	23.0	5.0	80.0	22.0	0.09	2.4	1
Average		4.1	0.0	23.5	5.3	82.0	21.1	0.03	2.3	1
LSD (0.05)		NS	NS	8.8	1.3	7.1	5.4	NS	0.5	NS

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

^bIYSV: 0 = no symptoms, 5 = 100% foliage diseased.

Table 17. Single- and multiple-center ratings for full-season white onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Seed company	Variety	Multiple center			Single center	
		large	medium	small	functional ^a	bullet
		----- % -----				
Bejo	Bridewhite	20.8	36.8	32.8	42.4	9.6
Crookham	White Cap	0.0	1.6	7.2	98.4	91.2
Hazera	37-127	6.8	2.4	21.8	90.8	69.0
Nunhems	Cometa	0.8	4.0	6.4	95.2	88.8
	Rhea	0.8	1.6	2.4	97.6	95.2
Seminis	SV4058	3.2	4.0	13.7	92.8	79.0
D. Palmer	Diamond Swan	30.4	23.2	25.6	46.4	20.8
	DPS-2056	15.2	9.6	13.8	75.2	61.4
Average		9.7	10.4	15.5	79.8	64.4
LSD (0.05)		7.9	7.5	7.4	9.6	7.2

^aFunctional single-centered bulbs are the small multiple-centered plus the bullet-centered onions.

Table 18. Yield and grade of full-season experimental and commercial white onion varieties graded out of storage in January 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Total yield	Marketable yield by grade						No. 2s	Bulb counts >4¼ in	Total rot	Neck rot	Plate rot	Black mold	Split basal plate
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small							
			cwt/acre						#/50 lb		% of total yield				
Bejo	Bridewhite	1074.2	935.1	65.0	397.8	457.8	14.4	8.2	10.7	28.2	10.9	10.6	0.0	0.3	0.2
Crookham	White Cap	1013.6	864.8	117.0	337.8	390.2	19.7	10.9	9.6	30.5	12.8	12.3	0.4	0.1	0.1
Hazera	37-127	1327.2	1114.3	253.2	489.3	361.4	10.4	3.8	14.8	28.8	14.3	13.8	0.3	0.3	0.1
Nunhems	Cometa	1261.4	1112.2	185.1	491.6	423.1	12.4	8.5	2.8	31.7	10.6	10.1	0.0	0.5	0.3
	Rhea	1216.6	1104.7	193.9	487.9	410.7	12.3	6.7	0.0	30.9	8.6	8.4	0.2	0.1	0.0
Seminis	SV4058	1235.0	990.4	193.5	424.1	353.2	19.5	9.2	11.2	30.1	17.6	17.1	0.3	0.2	0.5
D. Palmer	Diamond Swan	1056.5	812.6	105.9	272.7	408.4	25.5	15.1	67.4	29.5	14.9	14.7	0.1	0.1	0.3
	DPS-2056	1127.4	822.4	143.7	341.7	319.8	17.2	12.3	55.8	29.4	21.0	19.8	0.2	1.0	0.0
Average		1164.0	969.6	157.2	405.4	390.6	16.4	9.3	21.5	29.9	13.9	13.3	0.2	0.3	0.2
LSD (0.05)		119.3	117.8	50.2	106.8	56.1	NS	5.6	17.6	NS	7.2	7.1	NS	0.6	NS

Table 19. Internal defects of full-season experimental and commercial white onion varieties evaluated out of storage in January 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	All bulbs							Diseased bulbs						
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total
		no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total	
----- % -----															
Bejo	Bridewhite	69.2	0.0	69.2	30.0	0.8	30.8	100.0	0.0	0.0	0.0	4.0	0.8	4.8	4.8
Crookham	White Cap	88.0	0.0	88.0	10.4	1.6	12.0	100.0	0.0	0.0	0.0	1.6	0.0	1.6	1.6
Hazera	37-127	70.8	0.0	70.8	28.4	0.8	29.2	100.0	0.0	0.0	0.0	2.9	0.0	2.9	2.9
Nunhems	Cometa	89.6	0.0	89.6	7.6	2.8	10.4	100.0	1.6	0.0	1.6	0.8	1.6	2.4	4.0
	Rhea	59.7	0.0	59.7	37.5	2.8	40.3	100.0	0.8	0.0	0.8	5.6	2.8	8.4	9.2
Seminis	SV4058	72.0	0.0	72.0	26.4	1.6	28.0	100.0	2.0	0.0	2.0	8.0	1.6	9.6	11.6
D. Palmer	Diamond Swan	58.0	0.0	58.0	38.8	3.2	42.0	100.0	0.0	0.0	0.0	2.0	2.4	4.4	4.4
	DPS-2056	78.1	0.4	78.5	20.7	0.8	21.5	100.0	0.0	0.0	0.0	2.8	0.0	2.8	2.8
Average		73.2	0.1	73.2	25.0	1.8	26.8	100.0	0.5	0.0	0.5	3.5	1.1	4.6	5.2
LSD (0.05)		14.4	NS	14.5	14.6	NS	14.5	NS	NS	NS	NS	NS	NS	4.8	4.5

Table 20. Internal decomposition by disease type of full-season experimental and commercial white onion varieties evaluated out of storage in December 2019, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bacterial rot	<i>Fusarium proliferatum</i>	Neck rot	Black mold
		----- % -----			
Bejo	Bridewhite	0.0	0.0	4.8	0.0
Crookham	White Cap	0.0	0.0	1.6	0.0
Hazera	37-127	0.0	0.0	2.9	0.0
Nunhems	Cometa	0.0	0.0	4.0	0.0
	Rhea	0.0	0.0	9.2	0.0
Seminis	SV4058	0.0	0.0	11.6	0.0
D. Palmer	Diamond Swan	0.0	0.0	4.4	0.0
	DPS-2056	0.0	0.0	2.8	0.0
Average		0.0	0.0	5.2	0.0
LSD (0.05)		NS	NS	4.5	NS

Table 21. Subjective evaluations of white onion appearance and firmness by variety on January 14, 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb shape ^a	Bulb shape uniformity ^b	Firmness ^b	Scale retention ^b	Skin color ^b	Flesh brightness ^b
		----- 1-5 -----					
Bejo	Bridewhite	c	3.5	2.8	4.0	3.0	4.0
Crookham	White Cap	e	3.3	3.5	3.8	3.0	3.5
Hazera	37-127	d	3.5	3.3	4.0	3.5	3.8
Nunhems	Cometa	f	3.9	3.8	3.5	3.0	3.8
	Rhea	d	3.5	4.0	4.0	3.0	3.8
Seminis	SV4058	d	3.3	3.0	3.5	3.5	3.5
D. Palmer	Diamond Swan	d	2.5	3.3	3.5	2.8	3.5
	DPS-2056	e	2.5	3.8	3.3	3.0	3.8
Average		d	3.2	3.4	3.7	3.1	3.7
LSD (0.05)		NS	NS	NS	NS	NS	NS

^aBulb shape: see Fig. 1. ^bSubjective ratings are described in Table 6.

Table 22. Maturity ratings of full-season red onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Seed company	Variety	1-Aug		13-Aug		20-Aug	
		Tops down	Leaf dryness	Tops down	Leaf dryness	Tops down	Leaf dryness
----- % -----							
Bejo	Red Mountain	4	5	33	26	56	38
Crookham	Purple Haze	4	4	19	22	38	26
Enza Zaden	Monastrell	86	11	95	32	98	48
New Zealand Onion	TAS040	10	7	58	33	74	43
	TAS042	24	6	84	26	90	46
	RW011	3	6	19	20	38	32
Nunhems	Marengo	5	4	38	18	66	32
Seminis	SV4643NT	21	4	86	20	90	29
	Red Nugent	24	2	86	21	90	34
D. Palmer	Cherry Mountain	6	0	24	11	38	18
	DPR-3088	5	1	22	11	42	19
Average		17	5	51	22	65	33
LSD (0.05)		6	3	12	9	10	7

Table 23. Single- and multiple-center ratings for full-season red onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2019.

Seed company	Variety	Multiple center			Single center	
		large	medium	small	functional ^a	bullet
----- % -----						
Bejo	Red Mountain	10.5	29.6	23.4	59.9	36.5
Crookham	Purple Haze	7.1	11.1	18.2	81.7	63.5
Enza Zaden	Monastrell	29.6	38.4	18.4	32.0	13.6
New Zealand Onion	TAS040	52.8	31.2	12.8	16.0	3.2
	TAS042	52.4	29.1	9.7	18.5	8.8
	RW011	23.0	33.0	14.2	44.0	29.8
Nunhems	Marengo	21.5	26.5	15.2	52.0	36.8
Seminis	SV4643NT	41.5	19.9	9.5	38.5	29.0
	Red Nugent	43.7	17.8	8.3	38.5	30.2
D. Palmer	Cherry Mountain	34.5	17.8	29.3	47.7	18.4
	DPR-3088	30.6	8.7	17.4	60.7	43.3
Average		31.6	23.9	16.0	44.5	28.5
LSD (0.05)		16.3	11.1	NS	17.2	13.2

^aFunctional single-centered bulbs are the small multiple-centered plus the bullet-centered onions.

Table 24. Yield and grade of full-season experimental and commercial red onion varieties graded out of storage in January 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Total yield	Marketable yield by grade						No. 2s	Bulb counts >4¼ in	Total rot	Neck rot	Plate rot	Black mold	Split basal plate
			Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Small							
		----- cwt/acre -----						#/50 lb		----- % of total yield -----					
Bejo	Red Mountain	605.0	559.8	0.0	10.2	463.0	86.7	26.4	3.9		2.4	0.8	1.4	0.2	0.1
Crookham	Purple Haze	690.6	574.2	5.5	43.4	452.0	73.4	22.6	4.3	29.1	12.8	11.2	0.7	0.9	0.0
Enza Zaden	Monastrell	660.0	488.1	1.7	15.5	406.5	64.5	30.5	14.6	31.3	19.0	15.0	1.8	2.3	0.3
New Zealand Onion	TAS040	488.3	396.0	0.0	10.1	282.4	103.5	32.3	15.8		8.9	3.9	1.4	3.5	0.3
	TAS042	602.9	523.2	0.0	24.0	451.4	47.8	11.8	41.3		4.1	0.8	0.9	2.4	0.4
	RW011	588.4	557.8	0.0	8.6	482.8	66.4	16.2	6.7		1.2	0.6	0.5	0.2	0.1
Nunhems	Marengo	640.8	571.9	0.0	35.9	474.5	61.5	23.1	12.9		4.7	1.2	1.7	1.8	0.3
Seminis	SV4643NT	723.5	590.0	5.0	100.0	431.1	53.8	16.2	48.2	30.4	9.5	5.7	0.1	3.6	0.1
	Red Nugent	752.0	563.8	20.6	76.4	422.5	44.4	20.0	61.4	30.3	14.3	10.7	0.4	3.2	0.0
D. Palmer	Cherry Mountain	653.3	486.2	1.7	32.9	379.4	72.2	25.5	77.3	30.9	9.9	4.3	0.0	5.6	0.0
	DPR-3088	697.1	516.1	7.4	56.6	391.4	60.7	27.9	64.1	28.0	12.8	6.0	0.2	6.7	0.0
Average		645.6	529.8	3.8	37.6	421.5	66.8	23.0	31.9	30.0	9.1	5.5	0.8	2.8	0.2
LSD (0.05)		60.5	73.6	7.8	19.2	77.6	32.3	10.0	26.1	NS	8.3	7.9	1.2	2.4	NS

Table 25. Internal defects of full-season experimental and commercial red onion varieties evaluated out of storage in January 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	All bulbs							Diseased bulbs						
		Complete scales			Incomplete scales			Total	Complete scales			Incomplete scales			Total
		no dry scale	dry scale	total	no dry scale	dry scale	total		no dry scale	dry scale	total	no dry scale	dry scale	total	
----- % -----															
Bejo	Red Mountain	34.4	0.0	34.4	59.2	6.4	65.6	100.0	0.0	0.0	0.0	0.4	0.4	0.8	0.8
Crookham	Purple Haze	41.3	0.0	41.3	43.7	15.0	58.7	100.0	0.8	0.0	0.8	1.6	0.8	2.4	3.2
Enza Zaden	Monastrell	25.6	0.0	25.6	67.8	6.6	74.4	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Zealand Onion	TAS040	43.4	0.0	43.4	50.2	6.4	56.6	100.0	0.0	0.0	0.0	0.4	0.8	1.2	1.2
	TAS042	16.4	0.0	16.4	69.2	14.4	83.6	100.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4
	RW011	27.0	0.0	27.0	61.2	11.8	73.0	100.0	0.0	0.0	0.0	0.0	2.0	2.0	2.0
Nunhems	Marengo	33.2	0.0	33.2	59.1	7.8	66.8	100.0	0.4	0.0	0.4	1.2	2.8	4.0	4.5
Seminis	SV4643NT	21.3	0.0	21.3	70.3	8.4	78.7	100.0	0.0	0.0	0.0	0.4	0.8	1.2	1.2
	Red Nugent	18.8	0.0	18.8	72.4	8.8	81.2	100.0	0.0	0.0	0.0	0.0	1.2	1.2	1.2
D. Palmer	Cherry Mountain	38.6	0.0	38.6	50.2	11.3	61.4	100.0	0.4	0.0	0.4	1.2	0.0	1.2	1.6
	DPR-3088	40.9	0.0	40.9	51.0	8.0	59.1	100.0	0.0	0.0	0.0	0.8	0.8	1.6	1.6
Average		31.0	0.0	31.0	59.5	9.5	69.0	100.0	0.1	0.0	0.1	0.6	0.9	1.5	1.6
LSD (0.05)		13.0	NS	13.0	14.7	NS	13.0		NS	NS	NS	NS	1.6	2.1	2.1

Table 26. Internal decomposition by disease type of full-season experimental and commercial red onion varieties evaluated out of storage in January 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bacterial rot	<i>Fusarium proliferatum</i>		Neck rot	Black mold
			----- % -----			
Bejo	Red Mountain	0.0	0.0		0.8	0.0
Crookham	Purple Haze	0.0	0.0		3.2	0.0
Enza Zaden	Monastrell	0.0	0.0		0.0	0.0
New Zealand Onion	TAS040	0.0	0.0		1.2	0.0
	TAS042	0.0	0.0		0.4	0.0
	RW011	0.0	0.0		2.0	0.0
Nunhems	Marengo	0.0	0.0		4.5	0.0
Seminis	SV4643NT	0.0	0.0		1.2	0.0
	Red Nugent	0.0	0.0		1.2	0.0
D. Palmer	Cherry Mountain	0.0	0.0		1.6	0.0
	DPR-3088	0.0	0.0		1.6	0.0
Average		0.0	0.0		1.6	0.0
LSD (0.05)		NS	NS		2.1	NS

Table 27. Subjective evaluations of red onion appearance and firmness by variety on January 14, 2020, Malheur Experiment Station, Oregon State University, Ontario, OR.

Seed company	Variety	Bulb shape ^a	Bulb shape uniformity ^b	Firmness ^b	----- 1-5 -----		
					Scale retention ^b	Skin color ^b	Flesh brightness ^b
Bejo	Red Mountain	d	2.8	3.0	3.0	2.8	3.0
Crookham	Purple Haze	e	3.5	3.0	3.0	2.5	2.8
Enza Zaden	Monastrell	b	4.0	2.5	2.3	3.8	3.4
New Zealand Onion	TAS040	c	2.8	3.0	3.0	2.5	3.0
	TAS042	c	1.8	2.8	2.5	2.0	3.3
	RW011	f	3.8	3.3	4.0	3.8	3.4
Nunhems	Marengo	d	3.5	2.5	2.8	3.8	3.8
Seminis	SV4643NT	e	3.5	2.8	2.0	2.3	2.5
	Red Nugent	g	3.5	2.0	3.0	3.3	2.8
D. Palmer	Cherry Mountain	d	2.5	3.5	4.0	4.0	3.0
	DPR-3088	e	2.5	3.5	3.8	4.5	3.8
Average		d	3.1	2.9	3.0	3.2	3.1
LSD (0.05)		NS	NS	0.1	0.5	0.8	NS

^aBulb shape: see Fig. 1. ^bSubjective ratings are described in Table 6.