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Table Grape Cultivar Performance in Oregon's Willamette Valley

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Abstract

Many cultivars of table grapes (*Vitis* sp.) are grown in Oregon's Willamette Valley, but with the availability of several new cultivars, it is important to compare their performance to well-established standards in this region. Commonly grown cultivars ("established": Canadice, Interlaken, Jupiter, Lakemont, Neptune, Reliance, and Remaily Seedless) along with new cultivars from the University of Arkansas breeding program ("new"; 'Passion', 'Faith', 'Gratitude', 'Hope', 'Joy', and 'Sweet Magic') were planted in Corvallis and Aurora, OR in 2001 ("established") and 2006 ("new") and data collected from 2014 to 2016. Despite differences in growing degree day accumulation and precipitation during the bloom and harvest period, cultivar had a stronger impact than year on traits such as cluster fullness and plant vigor. 'Neptune', 'Canadice', and 'Hope' had the best cluster fill while 'Jupiter' and 'Sweet Magic' had looser clusters. Yield for most cultivars was highest in 2016 and lowest in 2014, and some cultivars performed better at one location than another. 'Faith' and 'Neptune' had consistently high yield at both locations while 'Canadice' had outstanding yield at one location only. 'Interlaken', 'Lakemont', 'Remaily Seedless', and 'Passion' tended to have the lowest yields. Average berry weight ranged from 1.8 to 5.1 g. Large berries contributed to higher yield, except for 'Jupiter' where very poor fruit set resulted in large but very few berries, and in 'Canadice' where berry weight was low, but excellent fruit set coupled with many berries per cluster led to high yield. Total soluble solids (TSS) were often higher in early season than in late-season cultivars, which were sometimes picked before full ripeness to avoid the onset of autumn rain and disease development. Disease pressure ranged from very low in 'Canadice' and 'Neptune' to very high in 'Sweet Magic', 'Reliance', and 'Remaily Seedless', negatively impacting quality at harvest and during storage. Wide ranges in flavor and texture were observed and rated. "Established" cultivars frequently rated higher for flavor intensity than "new" cultivars that were bred to have a mild flavor, considered palatable to a broader range of consumers. Overall, three of the new cultivars (Passion, Faith, and Joy) show promise for production in this region, along with the best performing established cultivars Canadice, Neptune, and Interlaken.

Oregon's Willamette Valley has a good climate for grape (*Vitis* sp.) growing but is primarily known for its wine grape (V. *vinifera* L.) production, with over 11,300 ha planted in Oregon in 2015 and about 70% of this area in the Willamette Valley (SOURCE, 2015). Table grapes, however, remain a minor crop, mostly grown on a small scale within diversified farming operations. In California, the top table grape producing state in the United States, the area increased by 2.5 percent from 2013 to 2015 (CDFA, 2016), suggesting that consumer demand is rising. With increasing interest in purchasing local foods, it is reasonable to suggest that consumers in Oregon would support a larger table grape industry.

The cultivars currently being grown in Oregon are largely from the East Coast and Midwestern United States as there are no active grape breeding programs in the Pacific Northwest. There are several private breeding companies in California, but their table grape cultivars are typically bred for a warmer, drier climate than is found in Or-

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egon and may be restricted in plant availability to growers. While there are many table grape cultivars grown in Oregon (Strik, 2011), there are several new cultivars available (Clark and Moore, 2013).

Regional differences in growing conditions, including soil types and climate, can impact the growth and yield of table grape cultivars (Strik, 2011). In addition, several common issues can impact the productivity and economic sustainability of a table grape vineyard. Poor fruit set due to cool, wet weather during bloom can reduce yield and lead to excessively loose clusters (Vasconcelos et al., 2009). Grape powdery mildew [*Erysiphe necator* Schw. (syns. *Uncinula necator* (Schw.) Burr., E. tuckeri Berk., *U. americana* Howe, and *U. spiralis* Berk. & Curt; anamorph *Oidium tuckeri* Berk.)], which is most problematic in cultivars with more *V. vinifera* in their parentage, damages all parts of the plant, including the fruit, and causes "off" flavors (Cain, 2010; Pscheidt and Ocamb, 2016). The presence of seed traces in seedless cultivars, typically an undesirable trait for consumers (Cain, 2010), can vary among berries within a cultivar depending on weather during the growing season (Reisch, 1993). While summer rains do not ordinarily occur in the Willamette Valley, it is not uncommon to have rain in Sept. before many cultivars are harvested. This can lead to berry splitting and decreased fruit quality and storage (Strik, 2011). Our objective was to evaluate existing and promising new table grape cultivars to determine which are most suited to growing conditions in the Willamette Valley.

Materials and Methods

Two Oregon State University research farm locations were included in this study: North Willamette Research and Extension Center (NWREC; Aurora, OR, lat. 45°28′ N, long. 122°76′ W) and Lewis Brown Farm (LB; Corvallis, OR, lat. 44°55'N, long. 123°22'W). The cultivars included those well-known and commonly grown in many production regions ("established"; 'Canadice', 'Interlaken', 'Jupiter', 'Lakemont', 'Neptune', 'Reliance', and 'Remaily Seedless', all planted in 2001) and newly released cultivars from the University of Arkansas breeding program ("new"; 'Passion', 'Faith', 'Gratitude', 'Hope', 'Joy', and 'Sweet Magic', all planted in 2006). 'Sweet Magic' was primarily intended for California table grape growers based on its fruit characteristics, but it was tested in Oregon for climate adaptability as well. All cultivars were planted at both locations except 'Lakemont' and 'Hope' which were only at NWREC.

At NWREC, the field was maintained without fertilization or irrigation for the duration of the study, with the exception of one application of foliar boron (B; Solubor) in Spring 2016 due to low soil B levels and leaf tissue concentration; other nutrients were sufficient (data not shown). The in-row area was kept weed-free using herbicides and a perennial grass was grown and maintained by mowing between the rows. Vines were spaced at 1.8 m with either 3.0 m ("new") or 4.9 m ("established") between rows and were trained bilaterally to a single wire at 1.5 m high with shoots growing downward. All cultivars were spur pruned except 'Interlaken', 'Jupiter', 'Neptune', and 'Remaily Seedless' which were cane pruned due to observed differences in basal bud fruitfulness. Plants were pruned each dormant season and were shoot thinned each spring at 10–15 cm shoot length to remove growth from secondary, tertiary, and latent buds. Fungicides were applied once or twice per year for control of powdery mildew and botrytis [*Botrytis cinerea* (Pers.)].

At LB, 14.5 $kg \cdot ha^{-1}$ N (16N–16P–16K) was applied in April of each year and plants were irrigated using sprinklers three to four times between July and Aug. (approx. 25 mm applied each time). Fungicides were applied approximately biweekly from May through early Aug. to control powdery mildew. In-row and between-row weed management was similar to that at NWREC. Vines were

spaced at 1.8 m in-row by 4.3 m between rows and trained to a Geneva Double Curtain system. Vines were pruned using the methods described for NWREC, however, no shoot thinning was performed.

At both locations, "established" cultivars had single plots of two plants each whereas "new" cultivars were arranged in a completely randomized design with four two-plant plots (NWREC) or a randomized block design with four one-plant plots (LB).

Timing of fruit harvest varied by cultivar and was based on reaching a balance of sugars and acids (determined subjectively by tasting fruit) but before potential deterioration of berries due to rain or disease occurred. All clusters of each cultivar were harvested on the same day, though harvest date varied by cultivar, location and year (Table 1). Cluster fullness and plant vigor were visually rated at the time of harvest on a 1 to 3 and 1 to 5 scale, respectively, with 1 being low and 3 or 5 being high. The clusters were weighed to obtain total plant yield and five clusters were subsampled to determine average cluster weight and assess berry characteristics. The diameter and length of two typical berries per cluster were measured using calipers (Mitutoyo, Aurora, IL) and an average calculated.

Table 1. Growing degree days (GDD) and precipitation at Oregon State University's Lewis Brown (LB, Corvallis, OR) and North Willamette Research and Extension Center (NWREC, Aurora, OR), 2014-2016.

	2014	2015	2016
GDD[z] from 1 Jan to 1 Oct			
LB	2735	2833	2640
NWREC	2890	3073	2859
Precipitation (mm) in June			
LB	13.5	18.0	11.9
NWREC	35.8	10.2	32.3
Precipitation (mm) in September			
LB	33.3	51.3	16.0
NWREC	29.5	49.8	15.7

[z] Growing degree days using base 50°F (10°C) and maximum temperature of 86°F (30°C).

A subsample of 25 berries was used to determine average berry weight. These berries were then crushed and used to measure total soluble solids (TSS) using a Palette digital temperature compensating refractometer (Atago, Bellevue, WA). In addition, notes were made at harvest of fruit appearance, presence or absence of seed traces, texture, flavor, cracking, and disease susceptibility with a ranking system of 1 (low) to 5 (high) for each attribute. The primary diseases of concern on the fruit were botrytis bunch rot and powdery mildew, which will hereafter be described generally as "disease." In 2015 and 2016, five-cluster samples were placed in vented plastic bags (typically used for table grapes) and were kept in a cooler maintained between 1.1 and 2.7 °C for 3 to 4 weeks to determine fruit quality changes during storage. Plant yield and fruit quality were evaluated without the use of any growth regulator, even though gibberellic acid may be used by some commercial table grape growers to increase berry size. No vines were girdled. Data were collected for three consecutive years (2014–2016).

Data analysis. Data were analyzed using PROC MIXED (SAS version 9.3) for a randomized block design (LB) and a completely randomized design (NWREC). Locations were not compared because of differences in experimental design and training method. The effect of cultivar and year was only determined for the "new" cultivars that were in a replicated design in a 5 (cultivar) x 3 (year) factorial for LB or a 6 x 3 factorial for NWREC where an additional cultivar 'Hope' was planted. Mean comparisons were performed using Tukey's honest significant difference test. The effect of cultivar or year could not be statistically determined for "established" cultivars because there was no replication in the fields. Means are presented across years for these cultivars for comparison to the "new" cultivars.

Results and Discussion

Weather. Weather conditions varied by

Table 2. Average (2014-2016) ratings of cluster fill and plant vigor for "new" and "established" table grape cultivars at Oregon State University's Lewis Brown (LB, Corvallis, OR) and North Willamette Research and Extension Center (NWREC, Aurora, OR).

	Cluster fill[z]		Plant vigor[y]	
New	*LB*	*NWREC*	*LB*	*NWREC*
Passion	2.7 a[x]	2.8 a	2.4 a	3.1 b
Faith	2.0 c	2.5 b	3.0 a	3.0 b
Gratitude	2.6 ab	2.5 b	1.9 a	3.3 b
Hope	n/a[w]	2.9 a	n/a	2.3 c
Joy	2.2 bc	2.3 b	3.5 .	4.0 a
Sweet Magic	2.0 .[v]	2.2 .	3.4 .	2.9 .
Significance[u]	<0.0001	<0.0001	0.0245	<0.0001
Established[t]				
Canadice	2.7	3.0	4.3	3.7
Interlaken	2.5	2.3	4.0	2.3
Jupiter	1.5	1.0	4.7	3.0
Lakemont	n/a	2.3	n/a	3.0
Neptune	3.0	3.0	2.3	2.0
Reliance	2.2	2.2	3.0	3.7
Remaily Seedless	2.3	1.8	3.0	4.5

[z] Cluster fill was rated on a 1 to 3 scale with 1 being poor fruit set and 3 being excellent fruit set.
[y] Plant vigor was rated on a 1 to 5 scale with 1 being low vigor and 5 being very high vigor.
[x] Means followed by the same letter within treatment or the interaction are not significantly different (LSMeans) ($P > 0.05$).
[w] Not applicable ("n/a"). 'Hope' and 'Lakemont' were not planted at LB.
[v] 'Sweet Magic' was not harvested in 2016; mean separation not possible due to missing data.
[u] *P*-value provided when significant by analysis of variance.
[t] Established cultivars were not replicated so no statistical analysis could be performed. Means are provided for comparison.

year and location. The warmest season was in 2015, with the greatest growing degree day (GDD) accumulation, while 2016 was the coolest at both locations (Table 1). Precipitation during the June bloom period could have impacted fruit set and ultimately yield (Vance, 2012; Vasconcelos et al., 2009) and was higher at NWREC in 2014 and 2016, but higher at LB in 2015 (Table 1). Overhead irrigation was used at LB in July and August, but the additional water applied to fruit did not appear to impact disease or quality although no statistical comparison to NWREC (where no irrigation was used) could be made. Precipitation in September, which can impact fruit quality and harvest timing, was quite similar between locations, but there was much more rainfall in September in 2015 at both locations than in the other years.

Cluster fill and plant vigor. Despite differences in weather conditions during the bloom period for the years of study, cluster fill was most affected by cultivar (data not shown), in agreement with past work in grapes (Constantini et al., 2007; Ewart and Kliewer, 1977). No cultivars had clusters that were too tight, which can cause increased disease within the cluster or be difficult to handle without damaging berries on the cluster. Of the "new" cultivars, 'Sweet Magic', 'Faith', and 'Joy' tended to have the loosest clusters while 'Passion' and 'Hope' had the tightest (Table 2), resulting in full clusters with fewer shot berries (small green berries that never fully develop or ripen). Similar results for 'Joy' and 'Hope' were reported by Clark and Moore (2013). 'Faith' had good cluster fill in 2 of 3 years at NWREC but had poor cluster

Fig. 1. The table grape 'Faith' exhibits both parthenocarpy and stenospermocarpy, resulting in a mix of large and small berries on the same cluster.

fill at LB, and exhibited both parthenocarpy (fruit development does not require fertilization) and stenospermocarpy (fruit development requires fertilization but the embryo later aborts) resulting in very inconsistent berry size (Fig. 1). This has not been noted in past plantings of 'Faith', and may require some cultural manipulation to correct. "Established" cultivars with good cluster fill included 'Neptune' and 'Canadice'. 'Jupiter' consistently had the poorest fill with many aborted and shot berries (Table 2).

Plant vigor among "new" cultivars was impacted by year, with lower vigor in 2015 than 2014 or 2016, and there was a year by cultivar interaction at both locations (data not shown); however, there was no consistent effect of which cultivars had higher or lower vigor in a particular year. 'Sweet Magic' generally had among the highest ratings of plant vigor. Among "established" cultivars, 'Neptune' and 'Reliance' generally were less vigorous than other cultivars (Table 2).

Harvest dates and GDD accumulation. Harvest occurred between late Aug. and late Sept. of each year (Table 3). Early season cultivars (based on average GDD accumulation from 1 Jan. until harvest across both locations) included 'Interlaken', 'Jupiter', and 'Faith'; mid-season cultivars included 'Passion', 'Canadice', 'Reliance', 'Joy', and 'Lakemont'; and late-season cultivars included 'Gratitude', 'Sweet Magic', 'Neptune', 'Remaily Seedless', and 'Hope'. In general, early season cultivars were harvested as clusters ripened, whereas mid- and late-season cultivars were occasionally harvested prior to full maturity due to anticipated rain events, splitting, or heavy disease presence. Cumulative GDD at harvest was lower at LB for most cultivars despite later harvest dates, potentially impacting ripeness at that site.

Table 3. Average harvest date (listed in approximate order of ripening) and growing degree day (GDD) accumulation from 1 Jan. to harvest of grape cultivars grown at Oregon State University's Lewis Brown (LB, Corvallis, OR) and North Willamette Research and Extension Center (NWREC, Aurora, OR), 2014-2016.

	Harvest date		GDD[z]	
Cultivar	LB	NWREC	*LB*	*NWREC*
Interlaken	27 Aug	25 Aug	2242	2381
Jupiter	27 Aug	25 Aug	2242	2381
Faith	4 Sep	31 Aug	2368	2495
Passion	2 Sep	4 Sep	2332	2552
Canadice	13 Sep	30 Aug	2509	2484
Reliance	7 Sep	5 Sep	2426	2588
Joy	9 Sep	5 Sep	2441	2588
Lakemont	n/a[y]	4 Sep	n/a	2573
Gratitude	15 Sep	14 Sep	2544	2718
Sweet Magic	20 Sep	11 Sep	2647	2691
Neptune	20 Sep	17 Sep	2607	2756
Hope	n/a	17 Sep	n/a	2757
Remaily Seedless	20 Sep	16 Sep	2647	2770

[z] Growing degree days using base 50°F (10°C) and maximum temperature of 86°F (30°C).

[y] Not applicable ("n/a"), as 'Lakemont' and 'Hope' were not planted at LB.

Yield and berry characteristics. Yield ranged from 8.3 to 24.8 kg/plant at LB and 6.6 to 19.6 kg/plant at NWREC (Table 4). Among the "new" cultivars at both locations, yield was highest in 2016 and lowest in 2014 and there were year and cultivar effects, but no year by cultivar interactions (data not shown). 'Faith', 'Joy', and 'Sweet Magic' had the highest yield at LB while 'Faith', 'Hope', and 'Joy' were highest in yield at NWREC (Table 4), similar to findings in Arkansas where 'Faith' was among the highest yielding cultivars tested in 2 of 3 years (Clark and Moore, 2013). 'Gratitude' and 'Passion' had the lowest yields of the "new" cultivars at both locations, but were comparable to many of the existing cultivars such as 'Interlaken', 'Remaily Seedless', and 'Jupiter'. 'Canadice' had the second highest yield of all the cultivars at LB but had a moderate yield at NWREC. 'Neptune' had amongst the highest yield at both locations.

Cluster weight increased from 2014 to 2016 for all "new" cultivars except for 'Passion', which decreased from 2015 to 2016 at NWREC (data not shown). Higher cluster weights overall likely contributed to the higher yields seen in 2016 even though berry weights were slightly higher in 2014. Interactions between year and cultivar were significant at both locations for TSS (data not shown). The TSS was lower for most of the "new" cultivars in 2015, especially at NWREC, even when accumulated GDD from 1 Jan. to harvest was greater. 'Sweet Magic' and 'Hope' did not consistently reach a TSS level (Table 4) that made the fruit palatable before it deteriorated on the vine as compared to 'Neptune', another late-season cultivar, that maintained fruit integrity late in the season and likely would have continued to increase in TSS on the vine had it not been harvested. TSS was lower for most cultivars at LB compared to NWREC, potentially related to the lower GDD associated with the harvest dates at that site (Table 3).

Berry weight varied widely from 1.8 to 4.7 g at LB and 2.0 to 5.1 g at NWREC across all cultivars (Table 4). Cultivars with the largest berries included 'Passion', 'Neptune', and 'Sweet Magic'. In contrast, 'Canadice' and 'Interlaken' had the smallest berries, even though they produced larger berries than reported in New York (Reisch et al., 1993).

Table 4. Average yield and berry characteristics of "new" and "established" table grape cultivars grown at Lewis Brown (LB, Corvallis, OR) and/or North Willamette Research and Extension Center (NWREC, Aurora, OR), averaged over 2014-2016.

	Yield/plant (kg)		Berry weight (g)		TSS (%)		Cluster weight (g)		Berry Diameter (mm)		Berry Length (mm)	
New	*LB*	*NWREC*	*LB*	*NWREC*	*LB*	*NWREC*	*LB*	*NWREC*	*LB*	*NWREC*	*LB*	*NWREC*
Passion	10.6 b[z]	8.8 c	3.4 ab	5.1 a	19.9 a	19.8 a	316 a	391 c	15.3 a	17.7 a	22.0 a	27.0 a
Faith	21.8 a	17.3 ab	2.6 b	3.2 c	20.9 a	18.0 ab	257 a	329 c	15.0 a	15.7 b	18.7 b	20.3 d
Gratitude	9.1 b	11.5 bc	2.9 ab	4.0 b	17.6 b	18.5 a	283 a	434 a	15.0 a	16.7 b	21.0 ab	24.7 bcd
Hope	n/a[y]	14.6 ab	n/a	2.9 c	n/a	16.2 b	n/a	412 ab	n/a	15.0 c	n/a	22.0 c
Joy	24.4 a	15.1 ab	2.6 b	2.8 c	16.7 b	18.5 a	327 a	358 bc	14.7 a	15.0 c	20.7 ab	22.0 c
Sweet Magic	24.8 .[x]	13.0 .	4.7 .	4.8 .	15.1 .	15.0 .	451 .	454 .	18.5 .	18.5 .	27.5 .	24.5 .
Significance[w]	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Established[v]												
Canadice	24.5	10.1	1.8	2.0	20.9	25.0	279	256	14.0	14.3	15.3	15.7
Interlaken	8.3	6.6	2.3	2.0	20.4	22.1	247	171	15.0	14.0	16.0	15.3
Jupiter	12.6	8.6	3.5	3.4	19.9	21.0	228	172	17.3	17.0	21.7	21.3
Lakemont	n/a	6.5	n/a	2.9	n/a	21.3	n/a	399	n/a	16.5	n/a	17.5
Neptune	20.5	19.6	4.7	4.7	19.0	19.5	472	555	18.3	17.7	25.3	26.0
Reliance	13.5	16.7	3.2	3.3	21.2	21.7	298	338	16.7	17.3	17.0	18.0
Remaily Seedless	10.0	4.8	3.3	2.5	20.1	21.6	353	231	16.0	15.0	23.0	20.5

[z] Means followed by the same letter within treatment are not significantly different (LSMeans) ($P > 0.05$).

[y] Not applicable ("n/a"). 'Lakemont' and 'Hope' were not planted at LB.

[x] 'Sweet Magic' was not harvested in 2016; thus mean separation was not possible due to missing data.

[w] *P*-value provided when significant by analysis of variance.

[v] Established cultivars were not replicated so no statistical analysis could be performed. Means are provided for comparison.

Table 5. Subjective ratings of berry characteristics of table grape cultivars grown at Oregon University's Lewis Brown Farm and North Willamette Research and Extension Center 2014-2016, averaged over location and years.

Cultivar	Flavor intensity[z]	Skin thickness	Seed traces	Disease presence
Passion	3	5	2	2
Canadice	4	3	2	1
Faith	1	1	1	3
Gratitude	1	5	2	4
Hope[y]	1	2	1	2
Interlaken	5	2	2	2
Joy	3	1	1	3
Jupiter	5	4	4	4
Lakemont[y]	2	3	1	3
Neptune	2	5	2	1
Reliance	5	3	3	5
Remaily Seedless	2	3	1	5
Sweet Magic	1	3	1	5

[z] Ratings are on a 1 to 5 scale with 1 being low (flavor intensity, disease presence), thin (skin), small/not noticeable (seed traces) and 5 being high (flavor intensity, disease presence), thick (skin), or large/very noticeable (seed traces).
[y] 'Hope' and 'Lakemont' were only harvested from NWREC (Corvallis, OR).

Cultivars with the largest berries were generally more oblong in shape (berry length greater than berry diameter) whereas the smaller berries were generally more round, perhaps because of breeding efforts that have focused on large berries with an oblong shape (J.R. Clark, personal observation). Cultivars with larger berries also tended to have heavier clusters. For example, 'Neptune' had the greatest cluster weight at both locations, even larger than reported by Clark and Moore (1999b). There were some exceptions however, including 'Jupiter', that had large berries, but low cluster weights due to very poor fruit set. In other regions, 'Jupiter' has had better set (Clark and Moore, 1999a), perhaps indicating an issue with timing of bloom and climate differences. 'Canadice' had very high fruit set and many berries per cluster (visual assessment) resulting in large clusters despite low berry weights.

Earlier ripening cultivars (i.e. Interlaken, Faith, and Jupiter) tended to have higher TSS at harvest whereas late-season cultivars were sometimes harvested earlier than at peak ripeness due to forecasted rain events and fruit deterioration from splitting and disease. The commercial standards for TSS at harvest vary by cultivar and production region because the perception of sweetness also relies on berry acidity (Jayasena and Cameron, 2008; Nelson, 1979), which was not measured in this study. However, the average TSS of 'Sweet Magic' and 'Hope' in particular were at or below 16° Brix (Table 4), which can be considered a low threshold for consumer acceptability (Jayasena and Cameron, 2008; Wang et al., 2017).

Flavor and texture. Fruit flavor varied widely from those with a strong fruity flavor ('Reliance', 'Jupiter', and 'Interlaken') to those with a mild flavor ('Faith', 'Gratitude', 'Hope', and 'Sweet Magic'; Table 5). Several other cultivars had pleasant moderately fruity flavors including 'Passion', 'Canadice', and 'Joy'. Many of the "new" cultivars were bred to have a mild flavor in order to be more palatable to a broad range of consumers (Clark

and Moore, 2013).

Skin thickness contributed to the overall berry texture. 'Gratitude' and 'Passion' had the thickest skin and crispiest texture of the "new" cultivars and were similar to 'Neptune' (Table 5). This could be related to maturity, as 'Neptune' in Arkansas has been observed to have markedly improved skin texture when fully mature, compared to fruit at an early stage of maturity (J.R. Clark, personal observation). Both 'Gratitude' and 'Neptune' were rated highly for good texture in the past, though 'Gratitude' was noted to have thin skin (Clark and Moore, 2009b; 2013), contrary to the findings here. None of the "new" cultivars had slip skins as reported for some of the "established" cultivars like 'Canadice' which have tender slip skins (Pool et al., 1977). 'Faith' and 'Joy' had the thinnest skins which resulted in a berry that was easy to bite into without being soft. 'Hope' berries had a moderately thick skin but a soft texture that was not as crisp, which has been evaluated as less preferable in past trials (Clark and Moore, 2013). Seed traces were generally minimal (a good trait), but were most noticeable in 'Jupiter' and 'Reliance' (Table 5).

Disease and splitting. Susceptibility and presence of disease, as well as fruit splitting, had a strong impact on harvest time and quality of fruit at harvest and after storage. Splitting was the most problematic in 'Sweet Magic', which resulted in this cultivar being dropped from the trial in 2016. Splitting was also common in 'Reliance', as has been noted in Arkansas (Moore, 1982), and was sometimes seen in 'Joy'. The NWREC trial was sprayed for fungi minimally, which allowed for some observations on natural disease resistance. 'Canadice' and 'Neptune' had the lowest overall disease presence on fruit, as reported for other growing regions (Clark and Moore, 1999b; Pool et al., 1977). Many other cultivars had a low enough disease presence that fruit quality was not affected ('Passion', 'Hope', 'Interlaken', 'Faith', 'Joy', and 'Lakemont'; Table 5). 'Sweet Magic', 'Reliance', and 'Remaily Seedless' had the highest presence of disease, even at LB where a regular fungicide spray schedule was implemented. 'Remaily Seedless' and 'Lakemont' were also removed from the trial in 2016 due to low fruit quality and yield. 'Gratitude' did not have severe disease, but did have irregular brown spotting on the fruit that was not typical of any known disease or physical damage and was not noted during cultivar development (Clark and Moore, 2013). The spotting was present at both locations in all years, making the fruit unattractive to consumers (Figure 2). This has been observed in

Fig. 2. A) The table grape 'Gratitude' had irregular brown spotting on the fruit that was not typical of any known disease or physical damage and B) A close-up of the spotting on 'Gratitude' berries.

Arkansas also, and often is more pronounced when clusters are exposed to direct sunlight (J.R. Clark, personal observation).

Storage. Cultivars with more natural disease resistance in the field and those with thicker skins tended to maintain fruit quality better during storage (i.e. 'Neptune' and 'Passion'). However, some cultivars with smaller berries and thinner skins such as 'Canadice' and 'Interlaken' stored well, likely in part because of low disease presence at harvest. Cultivars that stored poorly included 'Reliance', 'Jupiter', Sweet Magic', and 'Remaily Seedless'. Past work on 'Reliance' showed it had more decay after controlled atmosphere storage than another cultivar, though its flavor was still acceptable (Morris et al., 1992), and may indicate that this cultivar is best for immediate consumption. Of the "new" cultivars tested, 'Passion' stored the best, followed by 'Gratitude' and 'Hope'. 'Joy' and 'Faith' both had thinner skins which led to a softer texture after storage and berries that sometimes shattered easily from the rachis.

Summary

Several of the cultivars tested were suitable for production in the Willamette Valley, and some "new" cultivars exceeded the performance of "established" cultivars. Of the "established" cultivars, 'Canadice' and 'Neptune' had the most reliable yield, fruit quality, and storage quality over the three seasons studied, though 'Neptune' would be better suited to warmer locations as it requires more heat units to ripen fully. 'Interlaken', though it had lower yields in this trial, has outstanding flavor, good disease resistance, stores well, and fills the early season niche which is desirable for growers due to potential price premiums (Cain, 2010). Of the "new" cultivars, 'Passion' is the most promising for this region, as it had excellent fruit quality and well-shaped, attractive clusters, and stored well. While 'Passion' had average yield, it is possible that production practices such as cane instead of spur pruning might increase yield and this should be tested in the future. 'Faith' and 'Joy' show promise as they have high yield and good fruit quality overall. Some cultural manipulation may help with the issues of uneven berry size and occasional splitting in these cultivars.

'Sweet Magic', 'Remaily Seedless', 'Lakemont', and 'Jupiter' stand out as the poorest performing cultivars due to susceptibility to common diseases, lower yield ('Lakemont', 'Remaily Seedless', and 'Jupiter'), and uneven ripening ('Sweet Magic'). 'Jupiter' is a flavorful grape with good berry size, but its poor cluster fill led to unattractive clusters with many shot berries. It is possible that use of gibberellic acid will improve the performance of this cultivar (Harrell and Williams, 1987; Zabadal et al., 2002). 'Reliance' is a popular cultivar due to its intense flavor, but is prone to splitting after rain and has uneven coloration of berries within the cluster despite sufficient TSS. 'Gratitude' was a good cultivar with crisp texture and mild flavor, but the brown spotting on berry skins would make this cultivar less desirable to consumers. 'Hope' had good yield and disease resistance but ripened very late in the season and had an inferior quality compared to 'Neptune', another green-fruited late-season cultivar. 'Neptune' is thus a better late-season option for growers in this region.

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About The Cover:

'Sweetie Pie' is a new thornless blackberry (*Rubus* L. subgenus *Rubus* Watson) cultivar developed and released by the USDA-ARS Thad Cochran Southern Horticultural Laboratory (TCHSL).