Promoting Seedless Table Grapes for Wisconsin Growers and Consumers

Abstract

Years of breeding efforts, from both public and private institutions in places such as Wisconsin, Minnesota, New York, and Arkansas have resulted in a host of seedless table grape cultivars that are hardy for extremely cold climates such as Wisconsin and Minnesota. This has increased interest in growing seedless table grapes in the Upper Midwest over the last few decades. In the present study, attributes including winter injury, phenological stages, and fruit quality measures of sugar and titratable acidity, were observed for several cold-climate seedless table grapes in order to build up the base of knowledge available for growers. Extremely cold back-to-back winters affected all cultivars in the trial, but most were able to recover in the following year, with varying levels of hardiness among the cultivars. Bud break began with two of the seven cultivars, with the others following approximately a week later, while the harvest window lasted two to four weeks, depending on heat accumulations in a season. Brix measurements at maturity ranged from 17 °brix to 20 °brix, but all could be higher depending on environmental factors, while titratable acidity usually less than 10 g/L for most cultivars, with the exception of 'Montreal Blue' near 15 g/L. In addition, tastings were offered both as fresh fruit and as raisins to increase public awareness of the quality and array of flavors these cold-hardy seedless table grapes have to offer. Enthusiasm was high and responses were very favorable.

Introduction

Nationally, grapes are the number one non-citrus fruit crop in both value and production terms (USDA 2017). On a regional level, grape production in areas such as the Upper Midwest is dramatically increasing in economic importance, with vineyard acreage increasing from a few hundred acres to nearly 5,900 acres in the past few decades alone, thanks to the development of cold-hardy cultivars (Tuck and Gartner 2013). While the majority of the acres are in wine grape production, these growers, along with backyard gardeners, have the potential to expand their interests to include table grapes, and not just the seeded varieties commonly grown in the past. For private growers, seedless table grapes grown in Wisconsin have an outstanding potential to attract consumers because of the local and sustainable aspect they have. A recent statewide survey of random households found that 61% would pay more for Wisconsin produce (Witzling *et al.* 2016). Growers adding seedless table grapes to their fresh-market portfolio would diversify the products offered, which currently are often mostly vegetables. However, a main challenge to growing grapes in Wisconsin and other temperate climate regions is the ability of the vines to survive the winters. Genetics and vine vigor, along with site, canopy management, and cropping loads can all influence a vine's survival chances. Breeding efforts from across the country and Canada, including public institutions such as University of Minnesota, University of Arkansas, Cornell University, and University of Guelph, along with private breeders (in particular Elmer Swenson), have resulted in many seedless table grapes, many of which are cold tolerant for areas of the Upper Midwest like Wisconsin. The main objectives of this study were to observe several cold-hardy seedless table grape varieties for cold tolerance in USDA hardiness zone 5, track springtime bud break and fall harvest windows, manage vines for persistence, quantify sugar and acid ripening patterns, and to provide both fresh and raisin tasting opportunities to the public.

Materials & Methods

Site Description

This experiment was conducted over three consecutive growing seasons, from 2015 to 2017, at two sites: a demonstration vineyard block at the University of Wisconsin's West Madison Agricultural Research Station (WMARS) served as the primary site, while two blocks at the University of Wisconsin's Peninsular Agricultural Research Station (PARS) offered secondary data using less intensive management. WMARS is located in Verona, Wisconsin (lat. 43°03'37"N, long. 89°31'54"W), having a deep, well-drained Griswold loam (fine loamy, mixed mesic, Typic Argiudoll) (USDA 2013) soil type, with moderate fertility and a 2 to 6% slope. The 30-year average annual ambient temperature, GDD, frost-free days, and precipitation at WMARS were 8.5 ^{o}C, 1425 GDD (Celcius), 174 days, and 907 mm, respectively (NOAA 2017). The PARS site is located in Sturgeon Bay, Wisconsin, (lat. 44°52'N long. 87°20'W), having Onaway-Ossineke fine sandy loams, moraine, with 1 to 6% slope. The 30-year average annual ambient temperature, GDD, frost-free days, and precipitation at PARS were 7.0 ^{o}C, 1317 GDD, 154 days, and 809 mm, respectively (NOAA 2017).

Plant material and vineyard management

The study included sixteen own-rooted seedless cultivars, grown on a VSP training system. Twelve cultivars were planted at WMARS in 2007 and four in 2011, while only nine cultivars were grown at PARS, planted between 2008 and 2011 (Table 3.1). Vines were grown with single or double trunks, with each trunk trained into a unilateral cordon about one meter above the ground. The cultivars were planted in one block, in a series of three adjacent vines per cultivar at WMARS, and in two blocks at PARS, in a series of three to seven adjacent vines per cultivar. At both sites, rows were oriented north-to-south with 3.0 and 3.4 m between rows, at WMARS and PARS, respectively, and 2.1 m between vines for a total density of 1536 plants ha^{-1} (622 vines acre^{-1}) at WMARS and 1400 plants ha^{-1} (566 vines acre^{-1}) at PARS.

The vineyard was subject to standard cultural practices for a commercial Midwest vineyard (Dami *et al.* 2005; Wolf 2008). Permanent sod alleyways and intra-row strips were maintained with post-emergence herbicide and wood chip mulch placed beneath the vines for weed control. Drip irrigation was installed at the time of planting and irrigation frequency was determined by tensiometer measurements.

To maintain vine balance, shoots were thinned (in May) to a density 13 to 18 shoots per meter of cordon, or less if in the process of cordon rejuvenation, which many were. This resulted in a potential of 50 to 70 clusters per vine for healthy vines. In addition, shoots were trained weekly as they grew, and tucked into the trellis system's multi-level catch wires, to keep each shoot in its own vine space and maintain optimal air flow. Two to three basal leaves were removed immediately after fruit set to allow more sunlight and air circulation in the fruit zone, helping to reduce drying time of leaves and fruit after dew or rain. Shoots were hedged when 30 cm above the top catch wire to prevent shading of the fruit zone.

Standard pest control practices were applied throughout the season based on weekly scouting reports. Using weather data such as temperature and humidity, a fungicide spray schedule was followed according to software-predicted disease infections. To reduce potential disease pressure, we applied a dormant lime-sulfur spray to the canes in April of 2016 and 2017.

Cold Hardiness and Winter Injury

Winter temperatures were tracked each year and the number of days below certain temperature thresholds was recorded. Grapevines have compound buds consisting of primary, secondary, and tertiary buds, which differ in fruitfulness and cold tolerance. Winter injury severity was measured by collecting 10 to 20 cane sections per vine, containing buds generally from the fourth node, in March of each spring. Buds were dissected and winter injury was assessed separately for primary, secondary, and tertiary buds. The dissection process was based on Pool and Martinson's (2011) winter injury assessment procedure, and consisted of using a razor blade to slice away thin layers of the bud, and using a hand lens for magnification (Figure 3.1). Care was taken not to slice too deeply as the base of all buds is green undifferentiated tissue.

Insects and Disease

Vines were monitored and treated with insecticide if pest (especially Japanese beetle) pressure was heavy. Disease pressure was tracked and scored weekly during the three growing seasons to determine if any cultivars were still susceptible despite regular pesticide applications. Ratings encompassed disease on canes and leaves, and ranged from 1 to 4 with 1 being no disease, 2= 'minor' (25% incidence), 3='moderate' or 26-50% incidence, and 4= 'severe' at >50% incidence. In addition, disease pressure on fruit at harvest was also noted. *Phomopsis*, downy mildew, (*Plasmopara viticola*), anthracnose (*Elsinoe ampelina)*, and black rot (*Guignardia bidwellii*) were the main diseases scouted for. If in doubt, we submitted samples to the UW-Madison Plant Disease Diagnostic Clinic (PDDC).

Sampling and Juice analysis for Brix, TA, and pH

As the vineyard started reaching veraison (~July 30, 2015; August 5, 2016, August 7, 2017), three to six berries, depending on cultivar's berry size, were collected randomly from eight to ten representative clusters for fruit chemical composition, every 7 to 14 days. Samples were collected in plastic Ziploc™ bags and kept on ice until processed in the lab, generally within 24 hours.

Each sample was juiced using a Wear-Ever aluminum hand juicer, and a minimum of 20 ml was collected for each sample. Soluble solids content (SSC), titratable acidity (TA), and pH were measured. SSC were measured in °Brix using the Hanna HI-96801 digital refractometer (Woonsocket, Rhode Island). Following SSC determination, TA was measured by using 10 ml of juice added to 55 ml distilled water; necessary dilutions were made. Titration with 0.1N of NaOH was applied, to a pH 8.2 end point, and expressed as g L^{-1} of tartaric acid equivalents, using a Hanna HI-902C automatic titrator (Woonsocket, Rhode Island).

Yield

Clusters were counted as they were harvested and weighed on a per vine basis. Crop weight and number of clusters were used to calculate average cluster weights. Some cultivars were harvested earlier than anticipated due to insects, sour rot, or other environmental concerns, but in general, most varieties were harvested when juice chemistry was above 17.5 °Brix and below 10 g/L TA. Fruit was kept in bins inside UW-Madison Horticulture food coolers until ready to use. Additionally, berry diameters of 15 representative berries as well as the lengths and weights of 15 representative clusters were measured on each vine. Finally, berry weights were collected on a set of 30 berries per vine (only 10 berries were used in 2015).

All vines were spur-pruned to three to four buds in early spring based on winter injury severity, dormant pruning weights, the previous season's fruit yield, and the cultivar's previous vigor. Cane biomass was weighed and used, in conjunction with the fruit yield the previous fall, to determine the current year's fruit load via the Ravaz Index (Ravaz 1911).

Raisins

The raisin making protocol was adapted from Savoy et al. (1983). In a food-safe kitchen, grapes were washed, dipped for 5-8 seconds into a in 0.3% lye solution at 203°F, to perforate skin and sanitize the grapes. After dipping, the grapes were immediately plunged into an ice bath and then rinsed a second time in another water bath. Berries were then destemmed and placed in an Excalibur table dehydrator (3926TB; Madisonville, Kentucky) and dried at 57°C from 24 to 48 hours based on berry size. Water activity data was recorded for five random sets of 4 to 5 raisins per vine in 2017, using an AquaLab instrument (40412, Pullman, WA).

Tasting Surveys
In addition to size and weight measurements at harvest, the fruit was also used either for fresh fruit tasting surveys or processed into raisins for tasting surveys. Tastings of each were held on the UW-Madison campus, both in classroom and tasting booths, and also at WMARS. We limited the number of cultivars per sampling event so as to not overwhelm the tasters, therefore not all cultivars were sampled in equal numbers or offered to the same audiences. IRB protocols were followed. Each year, over 200 surveys were filled out by consumers. Over the 3-year project, approximately 430 and 240 fresh grape and raison surveys, respectively. Questions relating to flavor, sweetness, acidity, texture, and local food preferences were asked. After 2015, which did not record user statistics, among other questions, the surveys were modified for both necessity and effectiveness (Figure 3.2). All varieties were not offered at once so as to not overwhelm the tasters. Therefore, each variety may have different audiences and differing numbers of tasters. We calculated percentages based on each cultivar's presence.

Results and Discussion

Climate conditions at WMARS
Growing degree-day accumulation from April through September (bud swell through harvest) was 1458, 1580 and 1510 for 2017, 2016 and 2015, respectively (Figure 3.3). 2016 was the warmest year of the three, (and warmer than the long-term average), especially in August, when the mean maximum temperature was 27.2°C, compared to 25.4°C in 2015 and 24.3°C in 2017.
Precipitation patterns from April through September for the three years of the study were unique each year (Figure 3.4). Total precipitation from April through September was 728, 729 and 686 mm for 2017, 2016 and 2015, respectively. Rainfall accumulation during the first part of the growing season (April 1 through July 15) was higher during 2015 than 2016 (356 mm versus 260 mm). However, trends were inverted for the second half of the growing season (July 16 through September 30) with 330 mm in 2015, and 469 mm from the same time period in 2016. In 2017, from the second week of July through the middle of August, we experienced large amounts of rain, (98 mm fell in one event) and consequently caused some berry splitting, with 'Montreal Blue' having the most berry splitting of the seven varieties; from the middle of August to harvest, only 16 mm of rain was recorded.
Phenology stages were recorded weekly at WMARS (Table 3.2 and 3.3). Grapevines must undergo a certain amount of cold temperatures, a time when their buds remain dormant, known as a chilling requirement; decreases in photoperiod and cooling temperatures are signals the grapevine uses to start this process (Londo and Johnson 2014). Once chilling requirements are met, buds are capable of breaking if environmental conditions are favorable. Hence, bud break was the first stage we noted. In general, over the three years, bud break started in the first two weeks of May, with 'Somerset' and 'Montreal Blue' breaking the earliest, while the others broke about a week later. Cultivars in cold climates with larger chilling requirements, and with slow or delayed bud break, may be spared late spring frosts that may increase in frequency due to climate change (Londo and Johnson 2014; Read and Gamet 2014). The early bud breaking character of 'Somerset' and 'Montreal Blue' may be explained by their partial *V. riparia* background. Londo and Johnson (2014) found *V. riparia* to have a relatively low

chilling requirement among several North American species and hybrids they studied, followed by *V. labrusca*, 'Concord', and then *V. aestevalis*.

Temperatures near 0°C were recorded at WMARS (from an onsite logger) on several mornings in early May in 2017, and some frost damage was observed on May 9, especially for 'Montreal Blue', along with some lower lying young vines in the same vineyard block (but too young for this trial). Since 'Somerset' inflorescences were well exposed at that time, it is probable that it too experienced frost damage, although we did not record it.

Veraison generally started the first week of August in all three years, with 'Somerset' turning color first, followed by 'Trollhaugen' soon after, while 'Einset' and 'Reliance' reached veraison last, about one to two weeks later. Harvest dates ranged from August 19 to September 22 over the three-year trial, with 'Somerset' generally harvested the earliest and Mars the latest. The fruit at PARS was harvested the third week of September in 2015 and 2016, but no yield was collected in 2017.

Cold Hardiness and Winter Injury

Winter temperatures from 2009 to 2017 at WMARS were collected and summarized into the number of days below specified temperature ranges (Table 3.4). By 2015, of the 16 cultivars planted, seven and three remained alive at WMARS and PARS, respectively (Figure 3.5a-3.5b). The seven cultivars at WMARS survived these very cold winters, surviving several days of temperatures near -26.7°C and -29.4°C in 2009 and 2014, respectively, but sustained significant bud damage. As shown in Table 4, the winter (January) of 2014 exhibited the coldest temperatures in the nine-year span we tracked, with three consecutive days of temperatures dipping below -27.2°C (data not shown).

Buds were analyzed annually for winter injury from 2015 to 2017 at both sites, if possible (Figure 3.5a-3.5e). Although there was significant bud damage after two harsh winters (2014 and 2015), there was sufficient root survival for recovery. The 2015 bud analysis data demonstrated that all cultivars at WMARS exhibited significant winter damage. Likewise, significant damage occurred to all three cultivars at PARS. At WMARS, 'Himrod' suffered the most damage, exhibiting approximately 70% winterkilled buds; it was referred to as only moderately hardy in New York trials as well (Reisch *et al.* 1993). On the other end of the spectrum, at WMARS that same year, the blue varieties, 'Montreal Blue', 'Mars', and 'Trollhaugen' (sharing some of the same genetic background with 'Concord'), followed by 'Somerset' displayed the least amount of winter injury, near 25% winterkill. 'Einset' ranked midrange, in agreement with a New York trial that showed it was hardier than 'Himrod' but less hardy than 'Concord' (Reisch *et al.* 1985). Following the 2016 and 2017 winters, 10 to 30% bud death was observed in all cultivars, which is considered incidental in grapevines (Dami *et al.* 2005). Using observations from before and during this study, we observed that 'Himrod' was most sensitive to winter injury of the seven cultivars. We also noticed 'Reliance' as also being marginally hardy, as over 40% of buds were killed at both sites in 2015. This classification is further supported by Reisch's (1993) observations. From our data, 'Reliance's decreased cold hardiness could be related to improper vine balance, as it is capable of producing large fruit loads. However, Davenport et al (2008) disagree that fruit loads should affect vine cold hardiness, if the vine can ripen them in acceptable timeframes; yet they did see a slight trend for high crop loads to be associated with slower rates of bud cold acclimation, but a crop load effect on hardiness was not evident by mid-winter.

The remaining cultivars in this study (e.g. 'Somerset', 'Einset', 'Reliance', 'Himrod', 'Trollhagen', 'Mars', and 'Montreal Blue' can have *V. labrusca*, *V. riparia*, *V. vinifera* as part of their parentage (Smiley *et al.* 2016; NGR 2017) (Table 3.1). *V. riparia* in particular, can survive temperatures below -36°C, and is a main contributor to a cultivar's cold tolerance (Pierquet and Stushnoff 1980; Fennell 2004; Keller 2010); this is likely reflected in 'Trollhaugen' and 'Somerset's success at WMARS. Past research on 'Concord' (*V. labruscana* Bailey, a cross between *V. labrusca* and *V. vinifera*), demonstrated it can survive -20 to -30°C (Fennell 2004; Davenport *et al.* 2008; Keller 2010). While the other five cultivars may not have *V. riparia*

in their immediate background, they do have *V. labrusca*, which is likely why they have survived at one or both sites. However, vine survival at PARS exhibited a few differences from WMARS. While 'Einset', 'Mars', and 'Reliance' remained alive at both sites throughout this study, 'Himrod' and 'Trollhaugen', planted in 2011 and 2012, respectively, and 'Somerset', planted in 2008, did not survive after the cold spells of 2014 and 2009 at PARS, respectively. The combination of genetics, vine age, soil type, season length, and a vine's ability to acclimate may have been some of the differentiating factors that resulted in vine survival or death between the two sites (Seyedbagheri and Fallahi 1995; Zabadal *et al.* 2007), probably primarily due to differences in season length and vine age between the two sites.
'Montreal Blue' was only planted at WMARS, and although it seemed to be cold-hardy, based on bud assessment, it's health declined over the three-year trial. In the spring bud assessment of 2016, it exhibited almost 50% primary bud death; secondary buds remained for fruit production, but research has shown secondary buds can be 30 to 50% less productive than primary buds (Wiggans 1927; Stergios and Howell 1974). Furthermore, late spring frosts have been noted in the literature to reduce yields up to 52% for 'Concord' (Proebsting Jr and Brummund 1978), and we did observe a frost on May 9, 2017 with some damage to 'Montreal Blue' noted. In addition, in 2016, WMARS experienced a warm fall, with a killing frost occurring quite late, when temperatures fell to -7 °C on November 20; perhaps there was not enough time to harden off before winter, ultimately affecting 2017's yield. Years of winter damage and/or poor acclimation may be reasons that 'Montreal Blue' exhibited more bud damage in 2017 (the lowest amount of primary bud survival) compared to the other varieties.

Canopy Management
Although 13 to 18 shoots per meter of cordon was the goal, allowing for 50 to 70 clusters per vine, cluster counts were very variable, in a range of 17 to 52, as several cordons were in the process of rejuvenation throughout the three-year trial.

Insect Pressure and Disease Assessment
Insecticides were sprayed weekly through July to reduce pressure. However, Japanese beetles remained tenacious in both 2016 and 2017 summers with some leaf skeletonizing, but mainly in upper growth where the newest tissue was. 'Himrod' seemed to be a preferred variety among the Japanese beetles, resulting in an earlier than anticipated harvest in 2017.
Disease ratings showed 'Somerset', 'Trollhaugen', and 'Mars' to be fairly resistant to disease, which is supported by findings in the literature (Reisch *et al.* 1993; Smiley *et al.* 2016). 'Montreal Blue' exhibited minor to moderate downy mildew, and several submissions to PDDC did not find high levels of pathogens, however they did find evidence of a fungus that grows on declining plant tissues in which may be leaking nutrients. 'Reliance' exhibited low to moderate susceptibility to *Phomopsis,* and also showed some incidence of Anthracnose, with minor to moderate evidence on leaves and canes throughout the season, along with confirmation from PDDC; this is further supported in the literature (Clark 2002; Smiley *et al.* 2016), although the fruit in our trial remained in good shape (Figure 3.6). Furthermore, although we did not observe *botrytis* or black rot in anything but minor levels on 'Reliance', Reisch et al. (1993) note it is highly susceptible to both. 'Himrod' was moderately susceptible to *Phomopsis*, with evidence on leaves and canes throughout the season, and also had minor signs of black rot on berries and rachis noted at harvest, which is supported by others' research (Reisch *et al.* 1993). 'Einset' showed susceptibility to *Phomopsis*, observed in 2015 and also in 2017, which PDDC confirmed from deflated berries, although in minor levels, as there were only a few clusters in this condition (Figure 3.7a). Downy mildew and black rot were also observed on the foliage of 'Einset', and this was also confirmed by PDDC in 2015 (Figure 3.7b), but generally recorded as minor levels, although Reisch et al(1993) consider it highly susceptible to black rot and also powdery mildew. Powdery mildew was observed in the WMARS vineyard by a local pathologist in mid-September of 2017, and infection

levels were rated as light throughout the vineyard. Our findings of only minor levels of most pathogens can be attributed to the fungicide applications to the vineyard block.

Fruit Chemistry

In grapes, starting with verasion, sugars build while organic acids decline, giving mature fruit a sweet taste with some tartness. The amount of sweetness (measure in degrees brix) is one of the most important considerations in grape fruit quality. Acidity (measured as titratable acidity (TA)), is present in mature fruit in much smaller amounts than sugar yet is important for flavor and preservation. Both sugar and acidity are main contributors to taste and mouthfeel qualities of grapes (Ryan 1973). Over the three years of the trial, fruit chemistry was collected in terms of degrees brix, TA, and pH (Figure 3.8a-3.8c; Figure 3.9a-3.9c; Table 3.5). Over the three years, throughout the season and at harvest, 'Somerset' and 'Mars' exhibited the highest and lowest brix levels, with SSC at harvest averaging 19.6 and 16.4 brix respectively, while 'Montreal Blue' and 'Einset' presented the highest and lowest TA, averaging 14.3 and 6.0 g/L, respectively. However, if left to mature longer, 'Himrod' would have a very similar TA as 'Einset'. Smiley et al. (2016) reported 'Trollhaugen' being capable of reaching 22 °brix, while Clark (2002) stated 'Reliance' can reach 25 °brix. Our brix measurements were considerably lower for these two cultivars, however, acidity levels were low to moderate at harvest, and having less brix can be acceptable if acidity levels are also low; furthermore, some acidity is needed, as it offers a balance to sweetness, so letting the fruit ripen longer could result in low of acidity, possibly lending to a blander experience. Researchers at Cornell University, who developed 'Einset' and 'Himrod', have demonstrated brix of 20° and TA of 7 to 8 g/L for 'Einset' (which has a similar sugar to acid ratio as our results), and noted 'Himrod' to be sweet and slightly acidic (Slate *et al.* 1962; Reisch *et al.* 1985). Early research on 'Concord', which has some commonality to the genetic background of cultivars in this study, has demonstrated brix and TA at harvest to be approximately 20 °brix and 7 to 8 g/L TA (Gore 1909), while more recent research looked at several clones of V. *labruscana* Bailey, which includes 'Concord', over several years and found similar values, varying to some degree by year and clone; in addition, pH values ranged from 3.2 to 3.6 for most years (Reynolds *et al.* 1990). All varieties in this trial exhibited pH values between 3.0 and 3.4 at harvest.

Fruit Harvest and Attributes

Yields generally trended downward over the three seasons at WMARS and upwards at PARS, but the year to year variance was large at both sites (Figure 3.10). WMARS variance was probably partially due to cordon renewals. 'Somerset' and 'Himrod', exhibited some of the lowest yields, with averages of 3.4 and 2.4 kg, respectively, while 'Reliance' produced the largest yields, being at or near the top, all three years at WMARS, with a three-year average of 8.3 kg.

In addition to fruit yields, berry diameters and weights, along with cluster lengths and weights were measured (Table 3.6). Sizes and weights were less in 2017 compared to the other two years. 'Somerset' and 'Trollhaugen' presented the smallest diameters, averaging approximately 12 and 14 mm, in 2017 and 2016, respectively, while 'Mars' stood alone for the biggest berry diameter, averaging 16.5 and 18.5 mm, in 2017 and 2016, respectively. Berry weights at WMARS followed the same pattern, with 'Somerset' and 'Trollhaugen' averaged together, presenting 1.5 grams across years, while 'Mars' averaged 3.8 grams. Additionally, 'Mars' presented a weight of 4.4 grams at PARS in 2015, the only year berry weight data was collected there. 'Himrod' exhibited the longest clusters with a two-year average shoulder-to-tip length of 206 mm and this is supported by past research (Slate *et al.* 1962; Pool *et al.* 1979), while the other six varieties exhibited more similar lengths averaging 148 mm over two years. (Cluster lengths were not measured in 2015). Cluster weights from cultivars measured at WMARS demonstrated 'Reliance', averaging 171 grams, across years, had the most mass because, although not measured, it was observed those clusters were very wide with a very high rate of fruit set; Clark (2002)

also noted 'Reliance' exhibiting large clusters, as fruit grown in Arkansas reached 300 grams. The other six cultivars at WMARS ranged from 52 to 145 grams, with an average of 92 grams, over the three-year trial.
These cultivars provided a wide array of color, shapes, sizes, and yield potential.

Wood Harvest
Dormant cane biomass from one-year old canes was collected each spring to assess vine vigor (Figure 3.11). Based on a 3-year average of cane biomass, the cultivars fell into three categories of vigor: High (>1.4 kg/vine): 'Trollhaugen' and Mars; Medium (0.91 to 1.4 kg/vine): 'Somerset Seedless', 'Montreal Blue', 'Reliance'; Low (<0.91 lbs/vine): 'Einset' and 'Himrod'. Since 2014's extremely cold weather, the remaining cultivars at both sites have shown a continued recovery each year.

Harvest Considerations
Deciding when to harvest will be based on several factors besides fruit quality observation, including logistics, cultivar genetic influences, weather, insects, and disease. In 2015, 'Somerset' had to be harvested a bit earlier than desired due to the onset of sour rot, a condition caused by yeasts and bacteria, especially if there is warm and rainy weather as harvest nears, that can cause the fruit to emit a vinegary odor and turn healthy berries to soft brown undesirable berries (McManus 2017). 'Somerset' can increase in sweetness by leaving it hang on the vine until its fully red (Smiley *et al.* 2016), but depending on the year, sour rot should be monitored. In 2016, we experienced almost 75 mm of rain in the 10 days prior to harvest season, along with a warmer August than the long-term average. Subsequently, 'Reliance' berries exhibited a large amount of cracking. This quickly became an inviting source of food for wasps, along with a noticeable amount of sour rot. The fruit quality and shelf life were considerably affected. Cracking due to thin skins and excessive rain at harvest is a characteristic that was noted as 'Reliance' was being evaluated in the breeding process in the 1960's (Clark 2002). Cultivar character can influence harvest as well. In 2016, which was the warmest year of the three-year trial, we held Mars on the vine the latest of the three seasons, (until September 22), but noticeable off-flavors were observed, likely methyl anthranilate, which is unique to *V. labrusca* (Keller 2010).
All fruit was stored in bins in our walk-in coolers, with 'Trollhaugen' a having a very long shelf life, looking and tasting fine after approximately a month in storage. Reisch et al. (1993) observed 'Einset' also capable of having a long shelf life (at least two months). In addition, Slate et al. (1962) also noted in the literature that 'Himrod' stored well. Overall, if the fruit was intact, the other cultivars held in storage for at least two weeks. Across cultivars, harvest windows were approximately four to five weeks, and with the extra storage life, having these cultivars as part of a grower's portfolio would give them options to have a marketable product for two to three months, depending on the season's heat accumulation and fruit quality.

Tastings
There was a large enthusiasm about locally-grown grapes and the audience was excited to try this trial's cultivars. When asked if the taster was familiar with Wisconsin grape cultivars, less than 10% said yes. This resonated loudly with us that this trial was important to promote cold-hardy seedless grapes. Without taking cultivar into account, of those surveyed who answered the question "Did you like this grape…?", there was an overwhelming 76% favorable response. Different audiences also proved to have differing tastes. Based on 2016 surveys, tasters attending horticultural events generally had more positive responses than the general public and students, with 78% saying they would pay more for Wisconsin-grown produce, whereas students on the UW Madison campus tended to like them but were a little less willing to pay extra for Wisconsin-grown produce, although still 59% said they would. We found varied tasting preferences among tasters. Some preferred the sweeter grapes, while others liked

the sour or tarter experience. Positive comments included such phrases as: “can I buy it now?”; “very good, nice tanginess”; “delicious; amazing taste “; and “I adore these”. Negative comments referred to partial seeds, textures, skins, small sizes. ‘Somerset’ presented the most comments about seeds and small berry size, while ‘Trollhaugen’ and then ‘Mars’ presented the most comments about skin texture or flavor being an issue to the taster. Percentages of likes and dislikes for each cultivar was recorded (Table 3.7). Overall, each cultivar was tallied based on if consumer liked it or did not like it; cultivars were not compared against other cultivars (Figure 3.12). Each cultivar had a favorable rating, but different palates and personal preferences to sweet and sour, among other attributes, resulted in each grape having a following. For example, although ‘Reliance’ scored the least percentage of likes, it was noted as having complex flavors that some tasters really enjoyed. The makeup of the audience on a given day also played a role. Offering a variety of grapes will give different consumers options to satisfy their many tastes.

Raisins

Today, the ‘Thompson Seedless’ grape, a *V. vinifera* cultivar, is the most commonly used grape in the United States for making raisins, making up 95% of California raisin production (Christensen 2000). Thanks to the recent development of cold-hardy seedless table grapes, places like the Upper Midwest can also be a part of the industry, especially for local business.

This research followed the fresh fruit surveys, and queried tasters on seven cultivars that were processed into raisins. As previously stated, dehydration times varied based on size, ranging from 26 to 48 hours. Water activity levels were measured in 2017 to ensure safe storage. Values ranged from 0.366 to 0.505, which reflected the berry size and time dried. Values of 0.6 are standard for raisins in the industry, as conditions for molds, yeasts, and bacteria are favorable above 0.6 (Murano 2003). Some survey comments noted some of the raisins were overdried, largely referring to ‘Somerset’ and ‘Trollhaugen’ of 2017, which did experience too much drying time for their size, as the berries were a bit smaller than previous years.

When asked if the taster was familiar with Wisconsin grape cultivars, about 16% said yes, up a bit from the fresh fruit surveys, likely reflecting their newly gained knowledge from our recent grape tasting events. Without taking cultivar into account, of those surveyed who answered the question “Did you like this raisin…?”, there was an overwhelming 72% favorable response. 80% of people not associated with being a student said they were willing to pay more for Wisconsin-grown produce, while only 52% of UW-Madison students were. Some positive comments include: “yum”; “maybe have to rethink my ‘No’ answer to the “do you like raisins” question; “beautiful floral quality”; “would eat raisins more often if like these”. Negative comments included: “stuck to teeth”; and “crunchy”. Interesting comments included flavors describing ‘Himrod’ raisins as having peppery, lemony, vanilla-like, or honey notes, while several people describe ‘Reliance’ as tasting like wine. ‘Einset’ had several comments that it was bland and tasted more like commercial raisins. Percentages of likes and dislikes for each cultivar’s raisin was recorded (Table 3.7). Overall, each cultivar was tallied based on if consumer liked it or did not like it; cultivars were not compared against other cultivars (Figure 3.13). Preserving part of the grape crop in the form of raisins can bring months of enjoyment, whether eating as is, or cooking and baking with them. Besides unique flavors, the different sizes each cultivar presented offers choices for bakers who may like smaller pieces, and for those who prefer bigger pieces. This research witnesses a lot of positive feedback on locally grown grapes preserved into raisins.

Conclusion

Results from this study demonstrate there are several choices for those interested in growing seedless table grapes in Wisconsin, with a large potential of having a responsive consumer base. Most of the cultivars in this study have survived for a decade, despite experiencing some extremely cold winters. However, with probable climate change bringing sporadic late spring frosts, choosing cultivars that break later should be considered. Furthermore, balanced crop loads will be critical to the winter hardiness.

Fruit chemistry measurements demonstrated favorable levels of sugars and acids are achievable. Harvest windows spanning several weeks, along with storage can provide at least two months of produce.

Consumers evaluated these fresh grapes and raisins and provided a largely positive response. With the local and sustainable movement behind it, growing these grapes in Wisconsin can be considered a good opportunity for growers and consumers. Given the seven cultivars in this trial, there are many options for different uses. For consumers that like a sweeter taste, 'Somerset' would lend itself well, offering overall low disease susceptibility, although breaking buds earlier than the rest may bring some risk; also sour rot and lower yields may need to be considered. For larger yields, 'Reliance' would be a good choice, and one that offers complex flavor, but balanced crop loads need to be maintained. 'Himrod' was the least hardy, but could be an option if a grower could provide extra attention, such as a more sheltered area.

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Figure 3.1. Compound bud dissected to assess winter injury. Middle bud, denoted with a "1" is the primary bud; right bud, denoted with a "2" is the secondary bud; and the leftmost bud, denoted with a "3" is the tertiary bud. Only the primary bud is dead in this image.

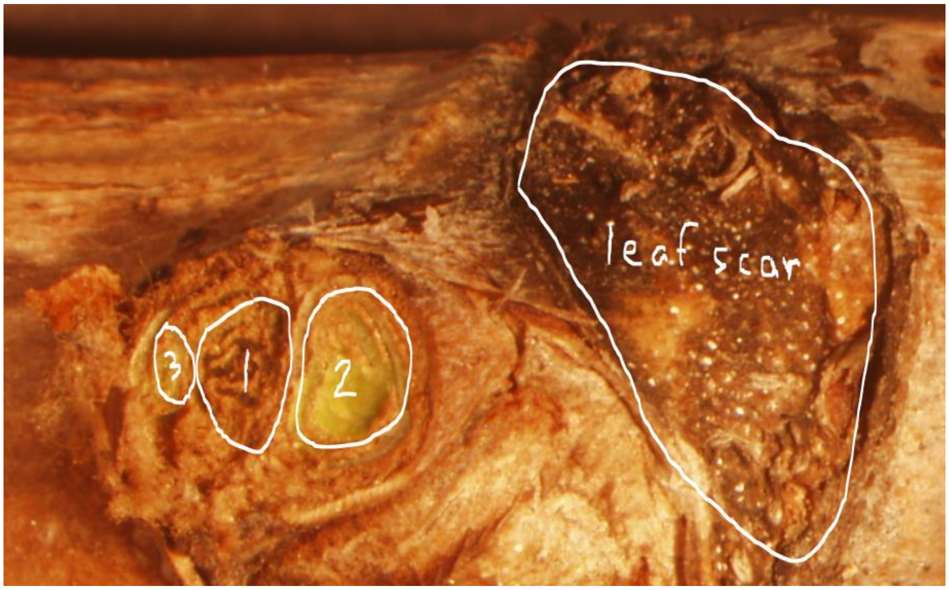


Figure 3.2. Questionnaire offered to participants during fresh grape tasting events.

Answer these before tasting.....						Comments
Do you like grapes?	circle one	Yes	No			
How often do you eat grapes?	circle one	seldom	once a month	weekly	daily	
What colors are your favorite?	circle one	green	rose	red	deep purple	
What characteristics are most important to you? Please rank 1-5. 1=Most important. Comment if o	cost	color	plumpness	size	sweet/sourness	
Are you willing to pay more for Wis grown?	circle one	Yes	No			
Are you familiar with the variety of grapes available in Wisconsin?	circle one	Yes	No			
How many table grapes varieties do you know about (worldwide)? Can you list any?						
Where does your family buy fruits and vegetables?	circle any that	grocery	co-op	farmers' market	roadside stand	grow your own or other
What flavor(s) do you look for in a grape? Comment if other.	circle any that	sweet	sour	spicy		
As you taste today, make note of favorites & least favorites, for end of survey questions.						
Variety A						Comments
How did the grape pull off the stem?	circle one	too easily	just right	too difficult	no opinion	
What did you think of the color of this grape?	circle one	poor	good	excellent	no opinion	
Taste and chew, then select an answer.	---	---	---	---	---	---
How did you like the Texture/Mouthfeel of this grape?	circle one	poor	good	excellent	no opinion	
What did you think of the skin thickness?	circle one	very thin	thin	somewhat thick	thick	
How did you like the flavor of this grape?	circle one	poor	good	excellent	no opinion	
Score the sweetness	circle one	too little	just right	too much	no opinion	
Score the sourness	circle one	too little	just right	too much	no opinion	
Did you notice any off flavors?	circle one	low	med	high	no opinion	
yes/no...if yes, please comment.						
Did you like this grape, overall?	circle one	Yes	No			
Would you buy this grape?	circle one	Yes	No			

Figure 3.3. Heat unit accumulation (Growing degree days (GDD in °C) based on daily maximum and minimum temperatures over the 2015, 2016, and 2017 growing seasons. Data from Charmany Farm for NOAA Online Weather Data.

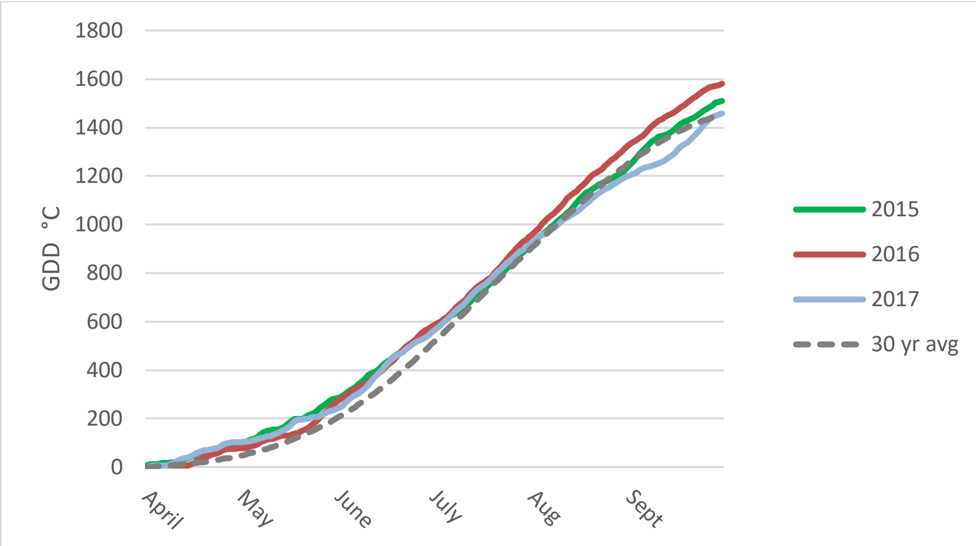


Figure 3.4. Rainfall accumulation (mm) over the 2015, 2016, and 2017 growing seasons. Data from Charmany Farm for NOAA Online Weather Data.

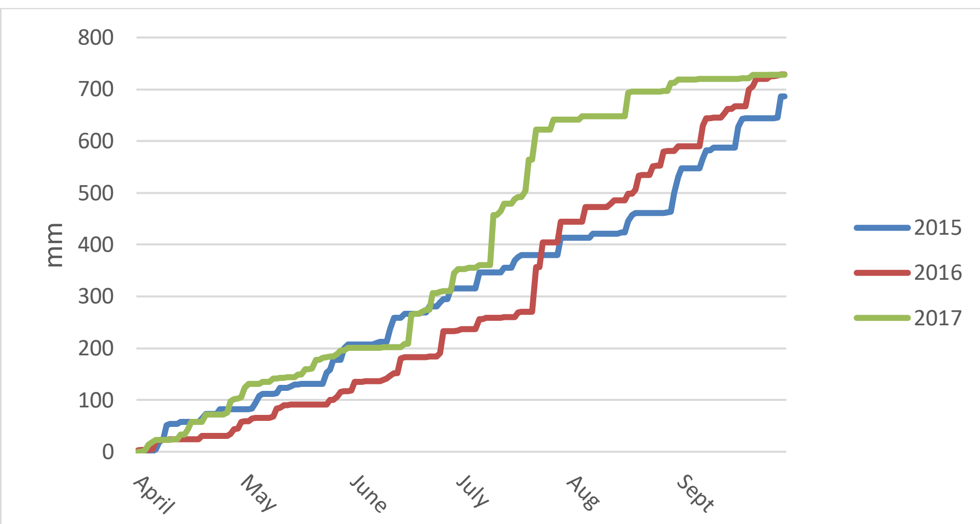


Figure 3.5a. Winter injury scores at WMARS, collected March 2015. P=Primary Bud; S=Secondary Bud; T=Tertiary Bud. These seven cultivars remained alive throughout the study.

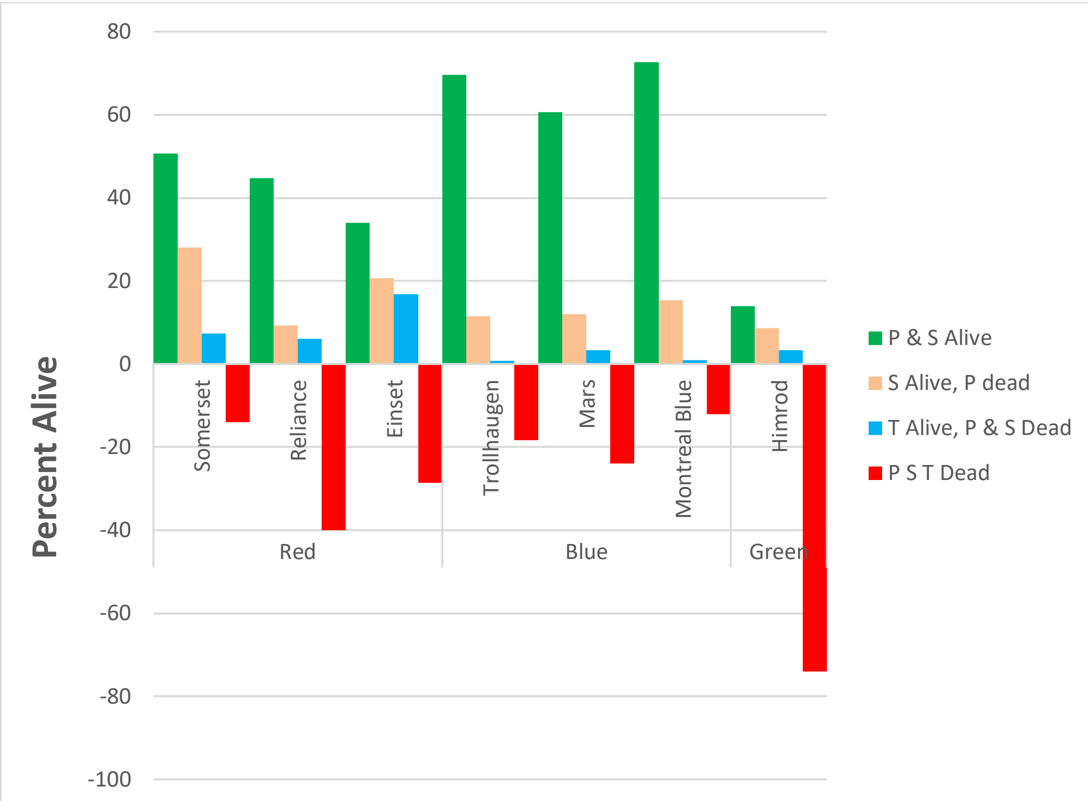
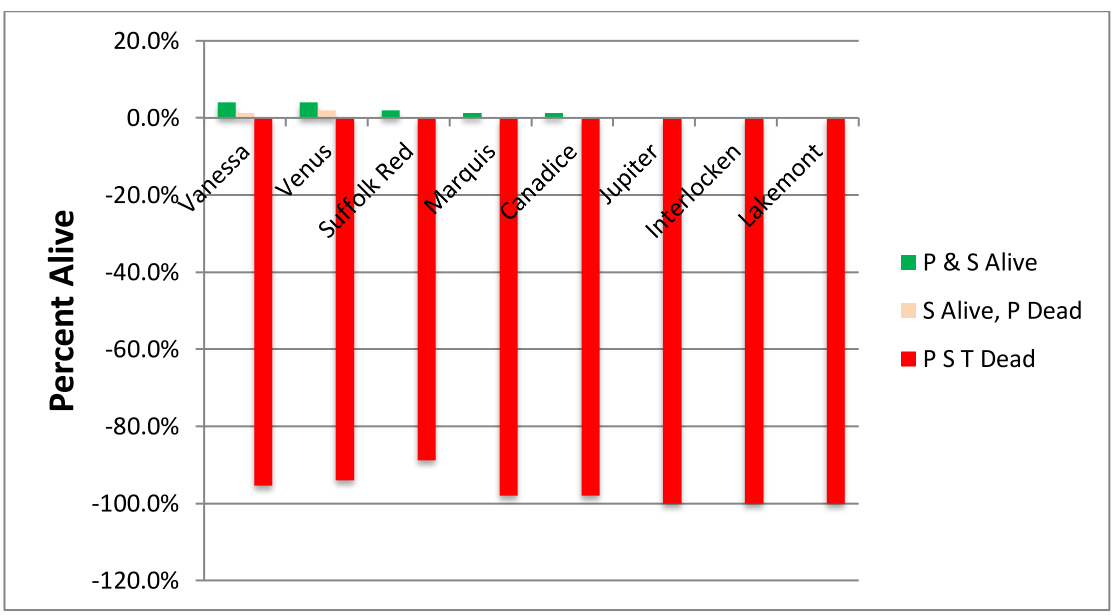


Figure 3.5a continued. Winter injury scores at WMARS, collected March 2015. P=Primary Bud; S=Secondary Bud; T=Tertiary Bud. None of these vines remained after the spring of 2015.



Data courtesy of Andrew Maule

Figure 3.5b. Winter injury scores at PARS, collected April 2015. P=Primary Bud; S=Secondary Bud; T=Tertiary Bud. These three cultivars remained alive throughout the study at this site.

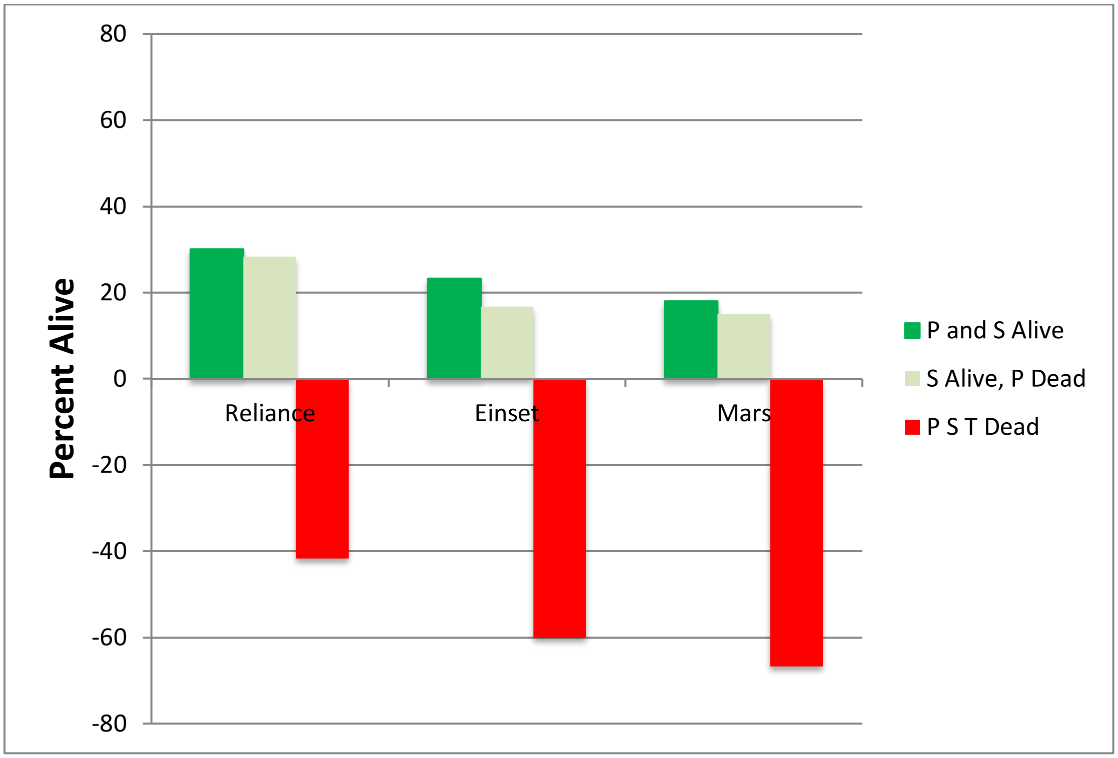
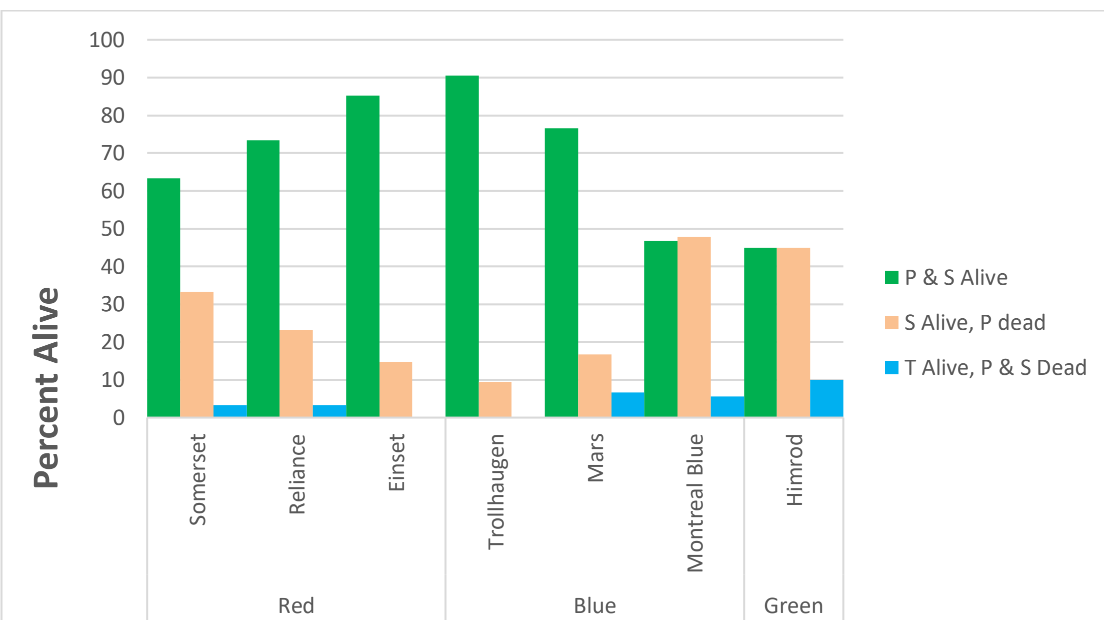


Figure 3.5c. Winter injury scores at WMARS, collected March 2016. P=Primary Bud; S=Secondary Bud; T=Tertiary Bud



Winter bud injury data not collected at PARS in 2016.

Figure 3.5d. Winter injury scores at WMARS, collected March 2017. P=Primary Bud; S=Secondary Bud; T=Tertiary Bud

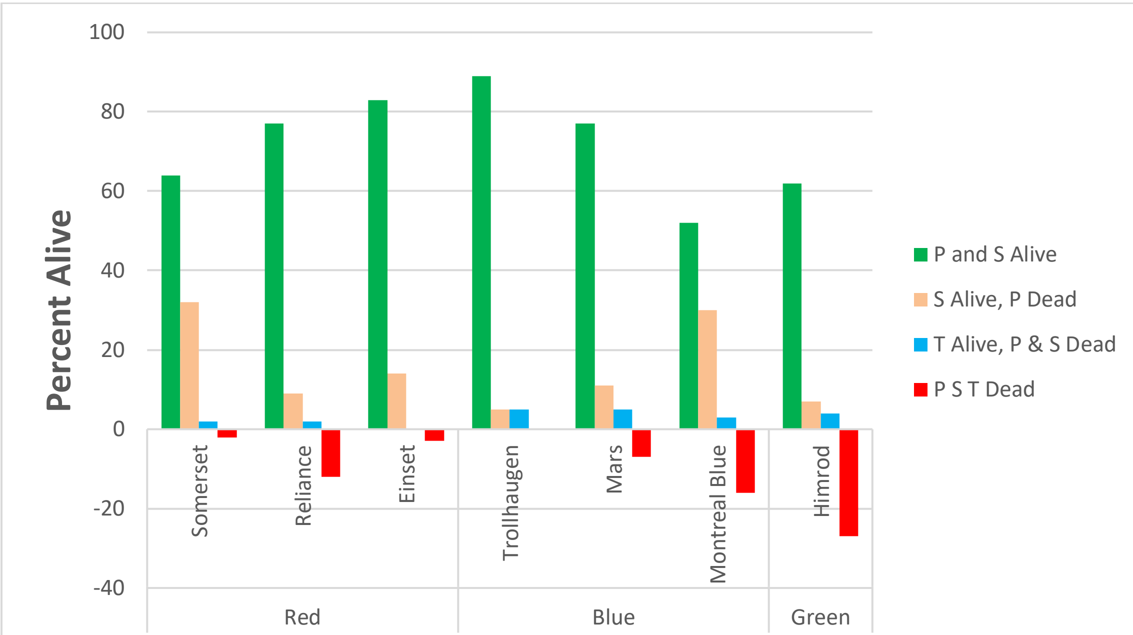
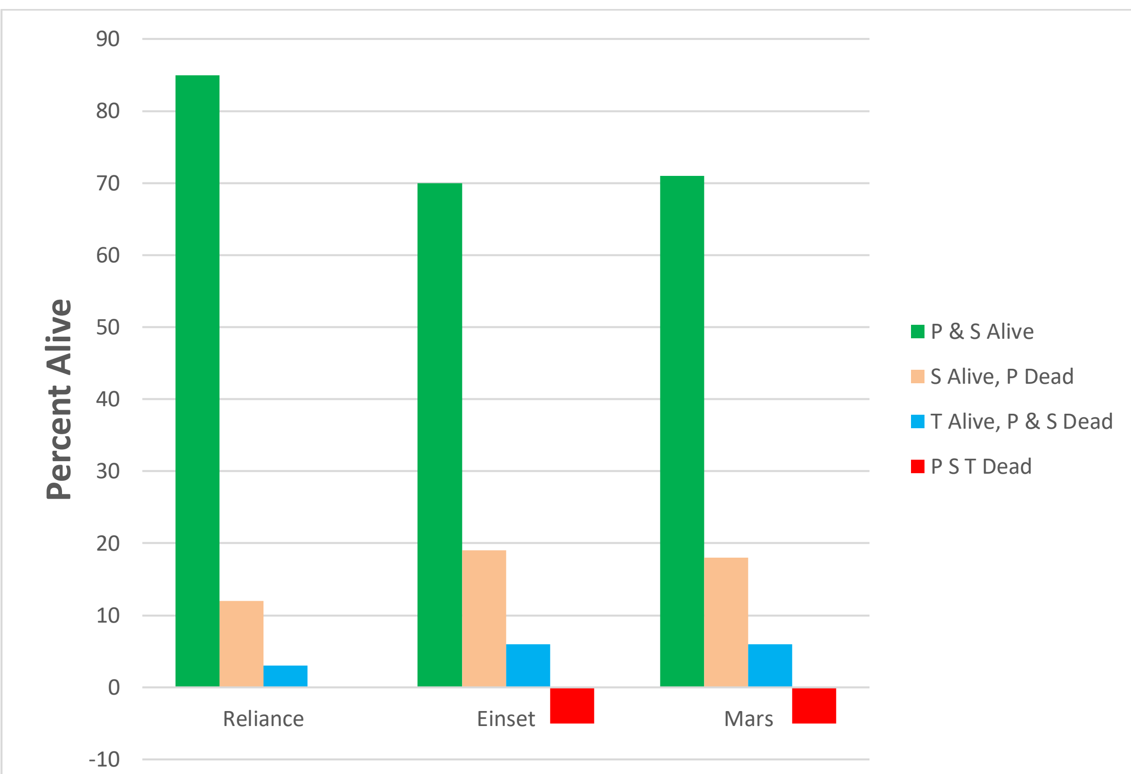


Figure 3.5e. Winter injury scores at PARS, collected April 2017. P=Primary Bud; S=Secondary Bud; T=Tertiary Bud



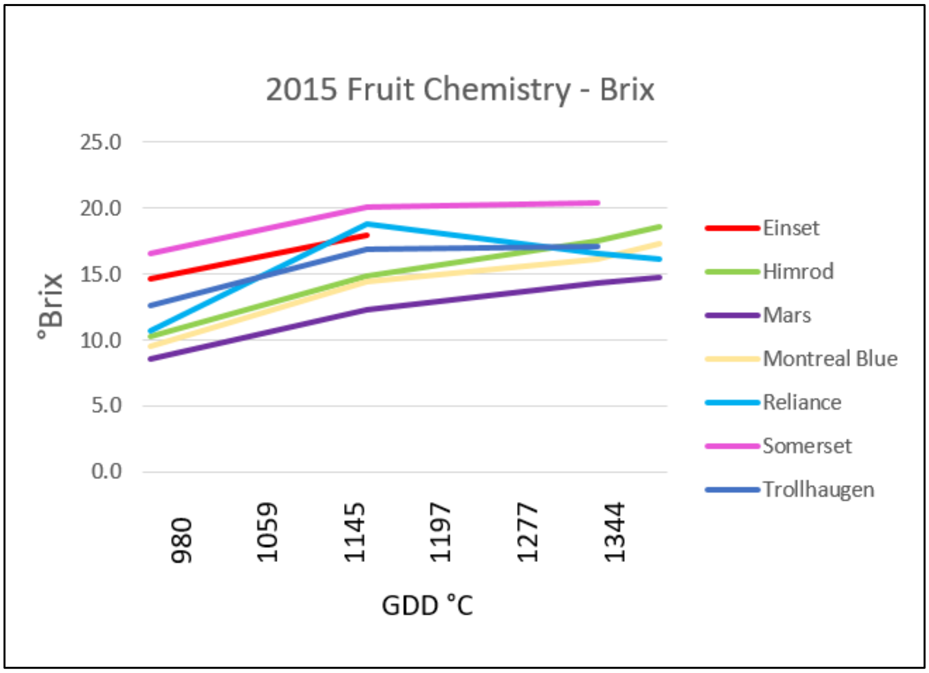
Data courtesy of Matt Stasiak

Figure 3.6. 'Reliance' fruit in good shape despite low levels of Phomopsis and Anthracnose.

Figure 3.7a-7b. Phomopsis and black rot on 'Einset' berries and leaves, respectively, observed at West Madison Ag Research Station in 2017.

Note, the pathogens found on ‘Einset’ were the minority. Most of the fruit was fine.

Figure 3.8a. Means for soluble solids content (SSC, measured in °brix) for the seven cultivars at WMARS in 2015.



Note, samples were collected across vines, giving only 1 juice sample for analysis, therefore no error bars.

Figure 3.8b. Means (±SD) for soluble solids content (SSC, measured in °brix) for the seven cultivars at WMARS in 2016.

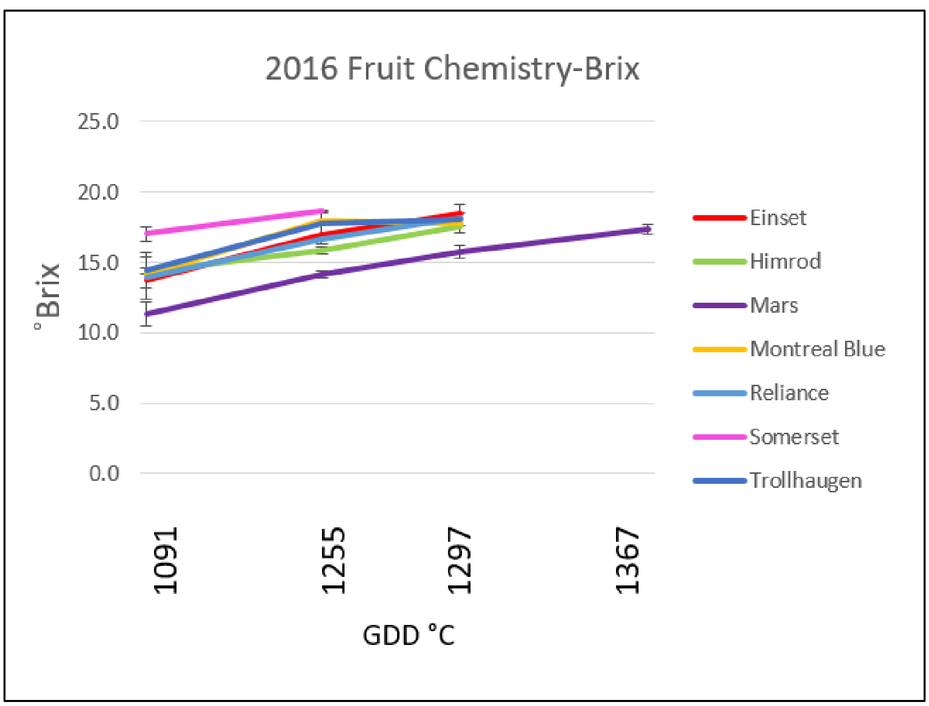


Figure 3.8c. Means (±SD) for soluble solids content (SSC, measured in °brix) for the seven cultivars at WMARS in 2017.

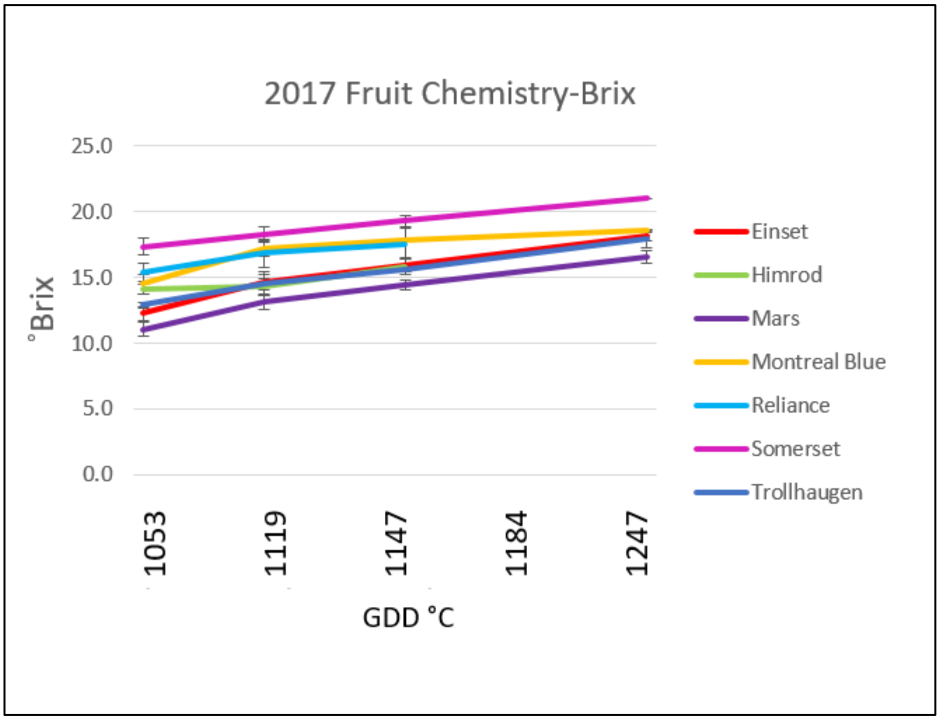
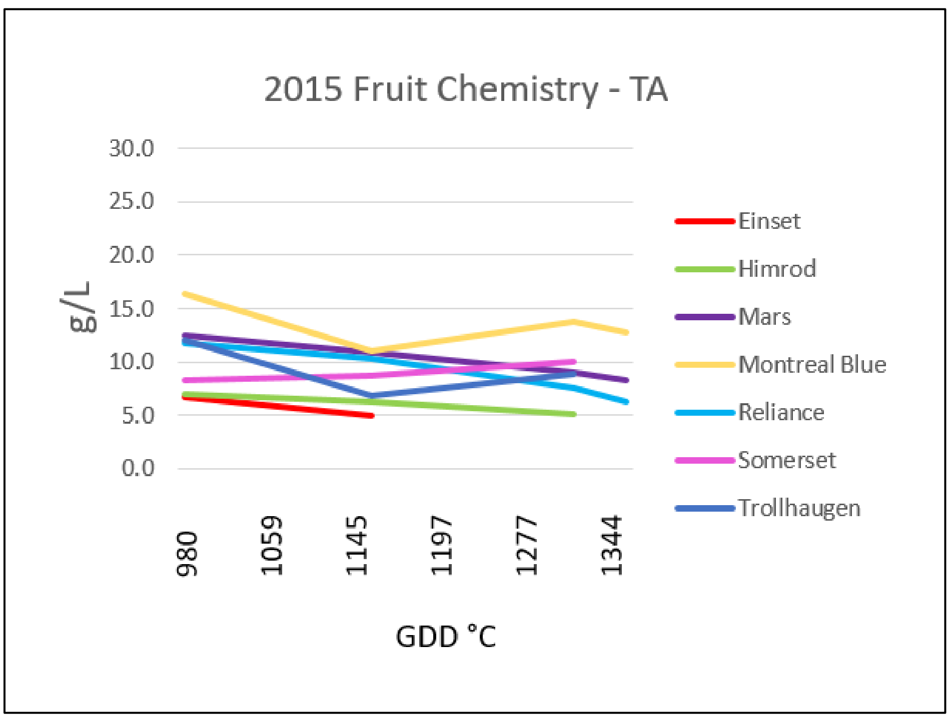


Figure 3.9a. Means for titratable acidity (TA, measured in g/L) for the seven cultivars at WMARS in 2015.



Note, samples were collected across vines, giving only 1 juice sample for analysis, therefore no error bars.

Figure 3.9b. Means (±SD) for titratable acidity (TA, measured in g/L) for the seven cultivars at WMARS in 2016.

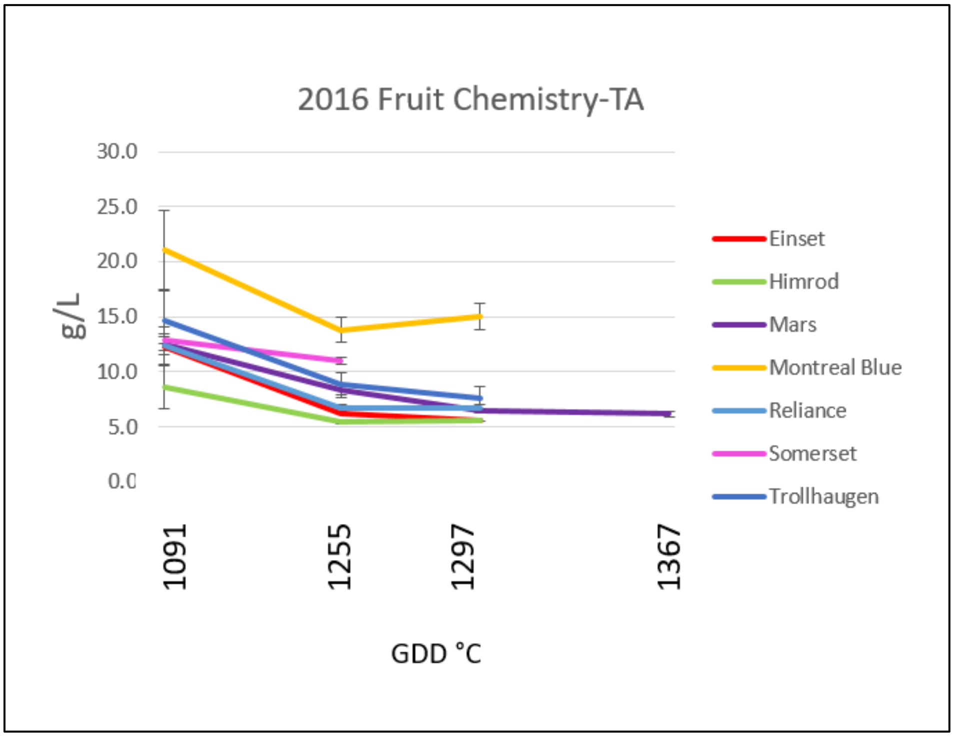


Figure 3.9c. Means (±SD) for titratable acidity (TA, measured in g/L) for the seven cultivars at WMARS in 2017.

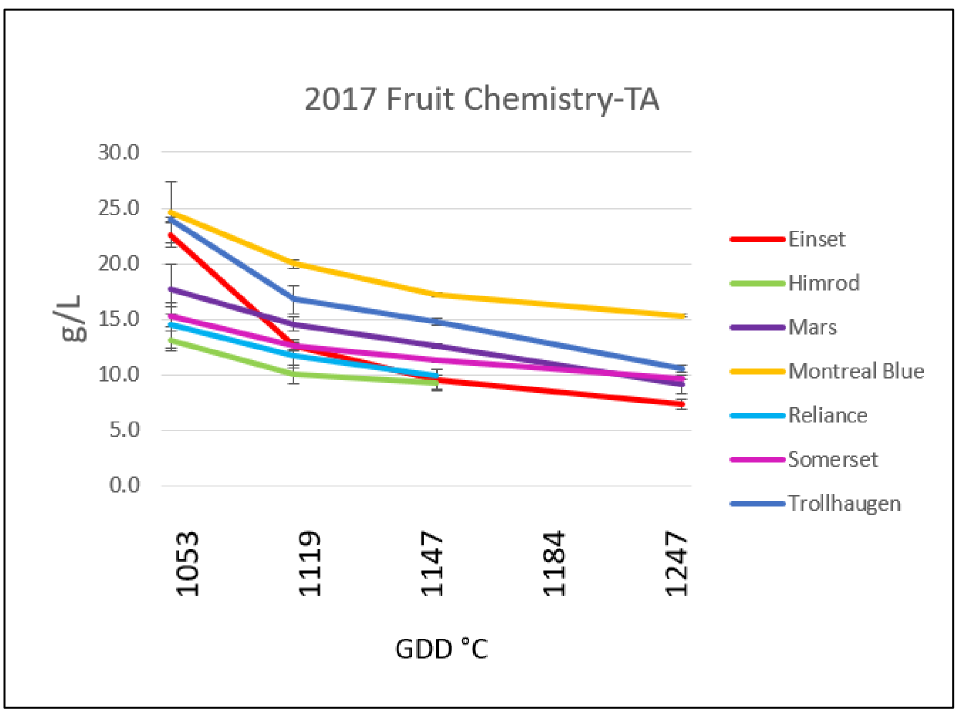
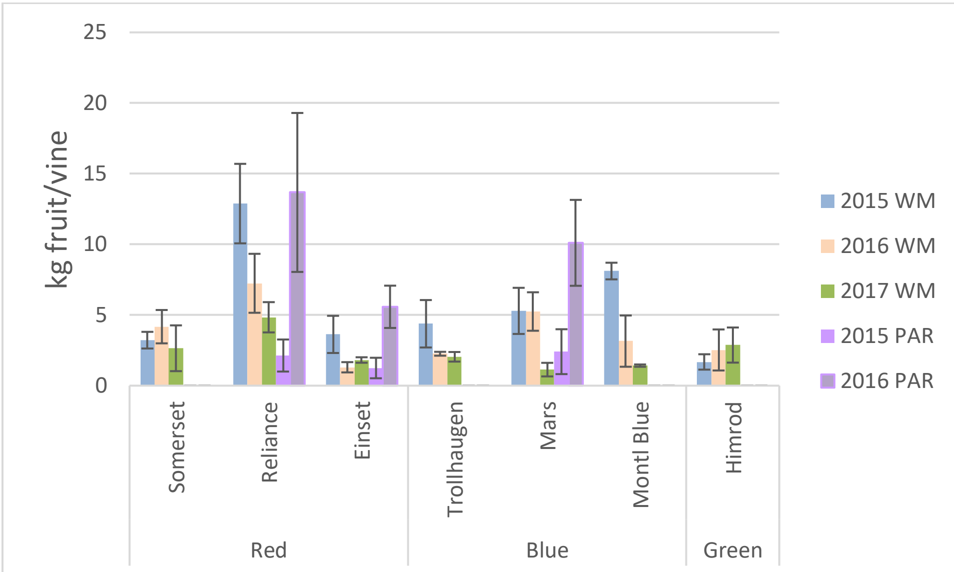
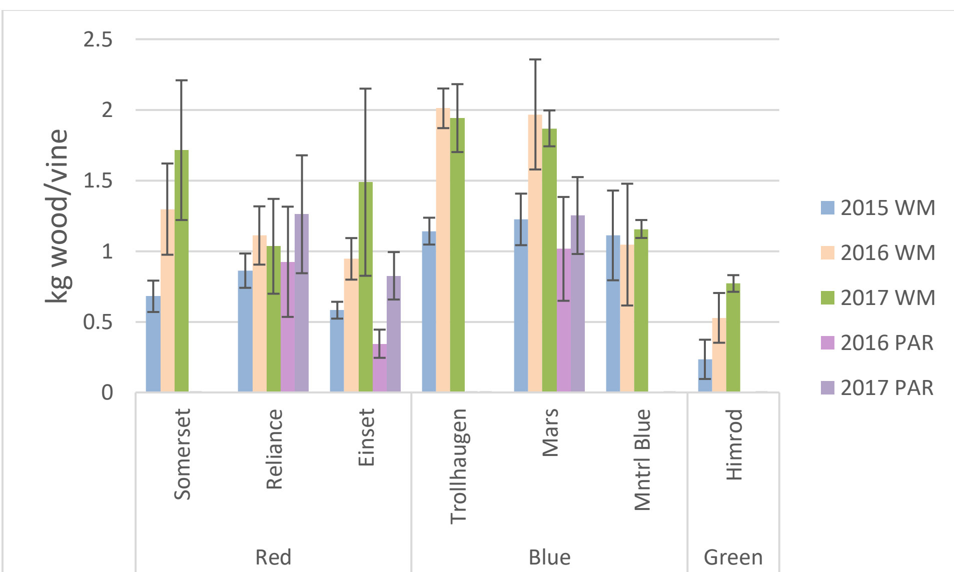


Figure 3.10. Means (±SD) of fruit yields (kg) collected at WMARS (WM) over 2015, 2016, and 2017, and PARS collected over 2015 and 2016.



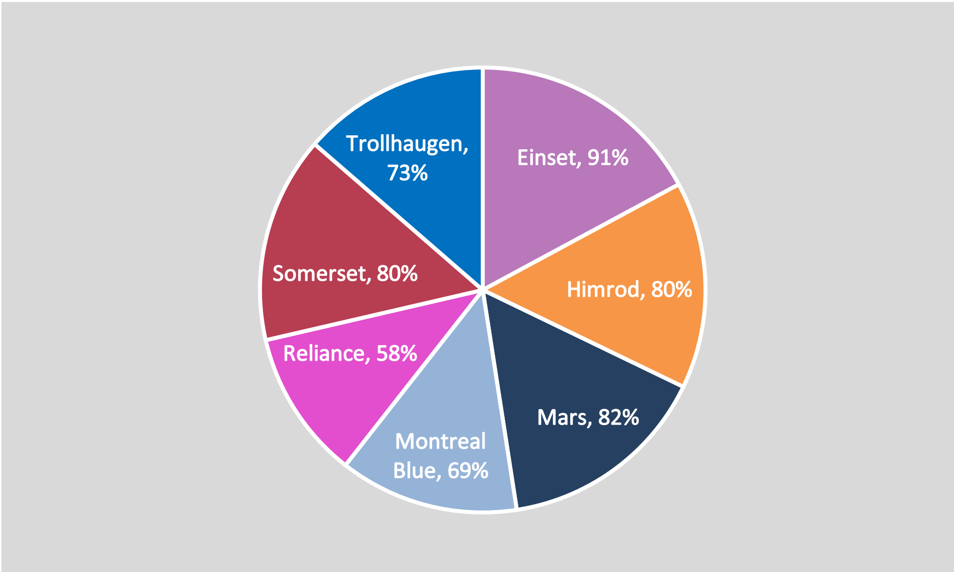
WMARS=West Madison Agricultural Research Station, in Verona, WI; PARS=Peninsular Agricultural Research Station, in Sturgeon Bay, WI.

Figure 3.11. Means (±SD) of pruning weights (kg), collected in Spring of 2015, 2016, and 2017 at WMARS (WM), and in Spring of 2016 and 2017 at PARS.



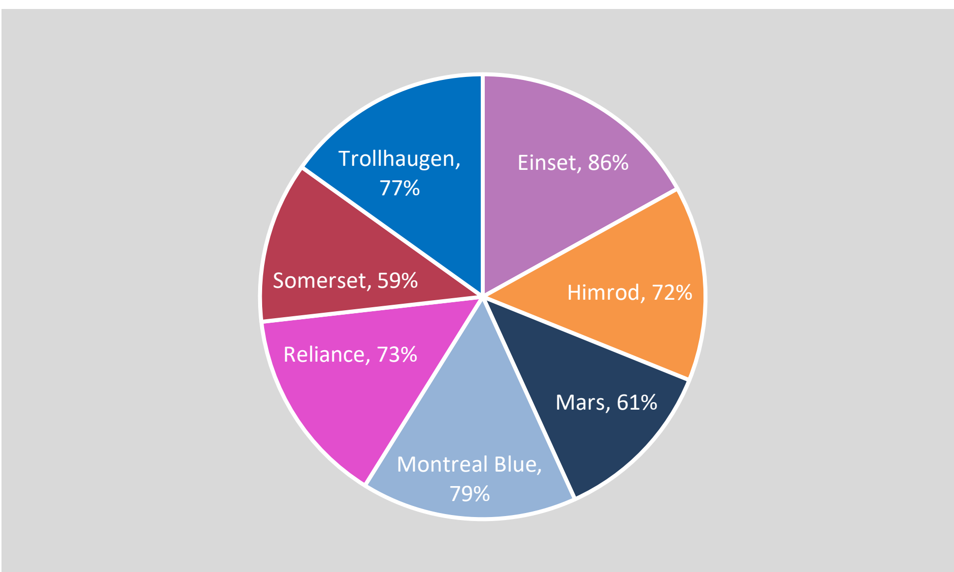
WMARS=West Madison Agricultural Research Station, in Verona, WI; PARS=Peninsular Agricultural Research Station, in Sturgeon Bay, WI.

Figure 3.12. Each cultivar's rating (out of 1.00) to the question, "Did you like this grape, overall?". No association was inferred between cultivars.



From fresh grape survey, encompassing 2015-2016 fruit.

Figure 3.13. Each cultivar's rating (out of 1.00) to the question, "Did you like this raisin, overall?". No association was inferred between cultivars.



From raisin survey, encompassing 2015-2017 fruit.

Table 3.1. Description of the table grape cultivars included in this study, grown at the West Madison Agricultural Research Station (WMARS) in Verona, Wisconsin, and at Peninsular Agricultural Research Station (PARS) in Sturgeon Bay, Wisconsin. Compiled from Smiley et al. (2016), NGR (2017), Reisch et al. (1985), Pool et al, (1979), Oregon State University (1976), Ramming (2008), and chateaustripmine.info.

Survived to 2017	Cultivar	Color	Pedigree	Release/Introduction	Institution/Breeder	Year Established WMARS	Year Established PARS
Yes	Einset	Red	'Fredonia' x 'Canner' includes V. vinifera and V. labrusca	1985	Cornell University	2007	2008 & 2009
Yes	Reliance	Red	'Ontario' x 'Sufflolk Red' includes V. labrusca and V. vinifera	1983	University of Arkansas	2007	2008 & 2009
Yes	Somerset Seedless	Red	'E.S. 5-3-64' x 'Petit Jewel' includes V. labrusca, v. riparia, V. vinifera, et al American Vitis spp	2002	Elmer Swenson	2007	2008
Yes	Mars	Blue	'Island Belle' x 'Arkansas 1339' includes V labrusca and V. vinifera	1984	University of Arkansas	2007	2008 & 2009
Yes	Trollhaugen	Blue	'MN 78' x 'Venus' includes V. labrusca and V. riparia	2000	Elmer Swenson	2007	2012
Yes	Montreal Blue	Blue	'Kandiyohi' x 'E.S. 24-52' includes V. riparia, V. labrusca, V. vinifera; synonym ES 6-4-47	unknown	Elmer Swenson	2011	---
Yes	Himrod	Green	'Ontaria' x 'Thompson' includes V. labrusca and V. vinifera	1952	Cornell University	2007	2011
No	Canadice	Red	'Bath' x 'Himrod' includes V. labrusca and V. vinifera	1962	Cornell University	2007	2011
No	Vanessa	Red	'Seneca' x 'New York 45910' includes V. labrusca and V. vinifera	1983	Horticultural Research Institute of Canada	2007	2011
No	Suffolk Red	Red	'Fredonia' x 'Russian Seedless' includes V. labrusca and V. vinifera	1972	Cornell University	2011	---
No	Venus	Blue	'Alden' x 'NY4000' includes V. labrusca and V. vinifera	1978	University of Arkansas	2007	---
No	Jupiter	Blue	'Arkansas selection 1258' x 'Arkansas Selection 1762' includes V. labrusca and V. vinifera	1998	University of Arkansas	2011	---
No	Thomcord	Blue	'Thompson Seedless' x 'Concord' includes V. labrusca and V. vinifera	2003	San Joaquan Valley Ag Sciences Center Parlier, CA	2011	---
No	Interlaken	Green	'Ontaria' x 'Thompson' includes V. labrusca and V. vinifera	before 1968	Cornell University	2007	---
No	Lakemont	Green	'Ontaria' x 'Thompson' includes V. labrusca and V. vinifera	1972	Cornell University	2007	---
No	Marquis	Green	'Athens' x 'Emerald Seedless' includes V. labrusca and V. vinifera	1996	Cornell University	2007	2008 & 2009

Table 3.2. Main phenological stages, dates, and growing degree days (GDD in °C) for the seven cultivars remaining at West Madison Agricultural Research Station (WMARS) over the 2015, 2016, and 2017 growing seasons. Approximations were made based on cultivars reaching ~50% of a stage, based on weekly scoutings.

Cultivar	Color	Bud Break 2015	GDD °C 2015	Bud Break 2016	GDD °C 2016	Bud Break 2017	GDD °C 2017
Einset	Red	May 1	91	May 11	117	May 9	126
Reliance	Red	May 7	134	May 11	117	May 9	126
Somerset	Red	May 1	91	May 4	86	April 25	90
Mars	Blue	May 7	134	May 11	117	May 9	126
Montreal Blue	Blue	May 7	134	May 4	86	May 2	104
Trollhaugen	Blue	May 1	91	May 11	117	May 9	126
Himrod	Green	May 7	134	May 11	117	May 9	126
Cultivar	**Color**	**Veraison 2015**	**GDD °C 2015**	**Veraison 2016**	**GDD °C 2016**	**Veraison 2017**	**GDD °C 2017**
Einset	Red	August 13	1059	August 16	1151	August 22	1131
Reliance	Red	August 6	980	August 19	1192	August 15	1053
Somerset	Red	July 31	910	July 29	929	August 3	951
Mars	Blue	August 6	980	August 5	1015	August 10	1011
Montreal Blue	Blue	August 6	980	August 5	1015	August 10	1011
Trollhaugen	Blue	July 31	910	July 29	929	August 10	1011
Himrod	Green	August 6	980	August 12	1107	August 15	1053
Cultivar	**Color**	**Harvest 2015**	**GDD °C 2015**	**Harvest 2016**	**GDD °C 2016**	**Harvest 2017**	**GDD °C 2017**
Einset	Red	September 8	1344	September 7	1395	September 9	1247
Reliance	Red	September 8	1344	August 29	1297	August 30	1193
Somerset	Red	August 28	1203	August 19	1192	August 26	1159
Mars	Blue	September 8	1344	September 22	1531	September 14	1284
Montreal Blue	Blue	September 8	1344	September 1	1333	August 30	1193
Trollhaugen	Blue	August 31	1233	August 29	1297	September 9	1247
Himrod	Green	September 8	1344	August 27	1275	August 24	1147

Table 3.3. Main phenological stages in simplified groupings for the seven cultivars remaining at West Madison Agricultural Research Station (WMARS) over the 2015, 2016, and 2017 growing seasons. B=bud break, V=veraison, H=-Harvest.

Cultivar	B 2015	B 2016	B 2017	V 2015	V 2016	V 2017	H 2015	H 2016	H 2017
Einset	early	mid	mid	late	mid-late	late	mid	mid	mid
Reliance	mid	mid	mid	mid	late	mid-late	mid	early-mid	early-mid
Somerset	early	early	very early	early	early	early	early	early	early
Mars	mid	mid	mid	mid	mid	mid	mid	late	mid-late
Montreal Blue	mid	early	early	mid	mid	mid	mid	early-mid	early-mid
Trollhaugen	early	mid	mid	early	early	mid	early	early-mid	mid
Himrod	mid	mid	mid	mid	mid-late	mid-late	mid	early-mid	early

Table 3.4. Number of days in selected temperature (°C) ranges with average lows for 2009 to 2017 (Dec1-Feb28) at WMARS. Year label denotes Jan/Feb.

Temperature range (°C)	2009	2010	2011	2012	2013	2014	2015	2016	2017
	---------------------# of days in temperature range---------------------------								
-18 to -22.8	16	10	9	5	8	**32**	23	10	8
-23.3 to-28.3	5	0	4	0	0	**6**	3	0	0
-28.9 to-33.9	0	0	0	0	0	**2**	0	0	0
below -34.4	0	0	0	0	0	**0**	0	0	0
Low Temp	-26.7	-22.2	-23.9	-20	-22.8	**-29.4**	-24.4	-22.8	-22.2

Table 3.5. Average fruit composition at harvest for the seven cultivars at WMARS, for 2015, 2016, and 2017.

Cultivar	Harvest/ Sample Date	Avg Brix	Avg pH	Avg TA g/L
Einset	9/8/2015	18	3.1	4.9
	9/5/2016	18.5	3.3	5.6
	9/9/2017	18.2	3.2	7.4
Himrod	9/8/2015	18.6	3.3	5.1
	9/6/2016	17.6	3.3	5.5
	8/24/2017	15.9	3.1	9.3
Mars	9/8/2015	14.8	3.1	8.3
	9/20/2016	17.4	3.2	6.2
	9/14/2017	16.9	3.2	9.0
Montreal Blue	9/8/2015	17.3	3.0	12.7
	9/1/2016	17.8	3.1	15.0
	8/30/2017	18.6	3.0	15.3
Reliance	9/8/2015	16.1	3.0	6.3
	8/29/2016	18.1	3.2	6.7
	8/30/2017	17.5	3.1	9.9
Somerset Seedless	8/28/2015	20.4	3.4	10.0
	8/19/2016	18.6	3.0	10.9
	8/28/2017	19.7	3.4	10.7
Trollhaugen	8/31/2015	17.1	3.3	8.9
	8/29/2016	18.0	3.2	7.5
	9/9/2017	17.9	3.3	10.5

Table 3.6. Means (±SD) for berry diameters (mm) and weights (grams), and cluster lengths (mm) and weights (grams) at WMARS and PARS, during the 2015, 2016, and 2017 growing seasons.

Site	Cultivar	Year	Berry Diameter		Berry Weight		Cluster Length		Cluster Weight	
WMARS	Somerset	2017	11.9	1.2	1.2	0.17	138.2	18.8	61.8	5.4
WMARS	Reliance	2017	14.5	1.2	2.4	0.06	174.8	24.4	164.7	10.2
WMARS	Einset	2017	14.5	1.4	2.5	0.24	167.1	30.7	91.3	14.2
WMARS	Trollhaugen	2017	11.4	1.0	1.3	0.03	156.7	24.1	58.7	6.1
WMARS	Mars	2017	16.5	1.7	3.1	0.07	119.4	24.6	78.5	1.3
WMARS	Montreal Blue	2017	14.2	1.4	2.1	0.07	153.2	29.7	66.6	7.2
WMARS	Himrod	2017	13.5	1.5	2.1	0.14	237.7	35.1	95.3	12.5
WMARS	Somerset	2016	13.7	1.9	1.7	0.09	140.5	17.0	100.6	19.4
WMARS	Reliance	2016	16.3	1.5	2.7	0.16	153.4	24.6	140.6	29.5
WMARS	Einset	2016	15.5	1.1	2.7	0.28	145.5	24.4	58.1	17.5
WMARS	Trollhaugen	2016	14.2	1.6	1.7	0.08	140.2	27.7	52.4	6.6
WMARS	Mars	2016	18.5	1.6	3.8	0.26	145.3	23.4	145.2	9.1
WMARS	Montreal Blue	2016	16.5	1.5	2.8	0.05	143.5	20.3	114.8	7.6
WMARS	Himrod	2016	13.7	1.5	1.8	0.21	174.5	36.3	136.9	34.8
WMARS	Somerset	2015	---	---	1.5	0.09	---	---	57.6	9.3
WMARS	Reliance	2015	---	---	2.6	0.00	---	---	207.2	15.6
WMARS	Einset	2015	---	---	3.1	0.00	---	---	106.9	19.6
WMARS	Trollhaugen	2015	---	---	1.8	0.06	---	---	71.7	6.4
WMARS	Mars	2015	---	---	4.6	0.00	---	---	99.8	19.9
WMARS	Montreal Blue	2015	---	---	3.0	0.00	---	---	143.5	5.1
WMARS	Himrod	2015	---	---	2.3	0.00	---	---	112.0	19.1
PARS	Reliance	2017	---	---	---	---	---	---	---	---
PARS	Einset	2017	---	---	---	---	---	---	---	---
PARS	Mars	2017	---	---	---	---	---	---	---	---
PARS	Reliance	2016	---	---	---	---	---	---	221.7	71.5
PARS	Einset	2016	---	---	---	---	---	---	171.2	47.0
PARS	Mars	2016	---	---	---	---	---	---	146.0	29.6
PARS	Reliance	2015	---	---	2.3	0.26	---	---	110.0	28.4
PARS	Einset	2015	---	---	2.1	0.51	---	---	70.9	28.9
PARS	Mars	2015	---	---	4.4	0.37	---	---	88.7	28.2

Table 3.7. General likes and dislikes per cultivar, both as fresh and in raisin form, based on tasting surveys across 2015-2017.

Form	Cultivar	Answered	Liked	Did not like	% liked	% not
Fresh	Einset	93	85	8	91%	9%
	Himrod	137	110	27	80%	20%
	Mars	84	69	15	82%	18%
	Montreal Blue	72	50	22	69%	31%
	Reliance	130	75	55	58%	42%
	Somerset	191	153	38	80%	20%
	Trollhaugen	139	101	38	73%	27%
	Across all	846	643	203	76%	24%
Raisin	Einset	141	121	20	86%	14%
	Himrod	82	59	23	72%	28%
	Mars	137	84	53	61%	39%
	Montreal Blue	68	54	14	79%	21%
	Reliance	150	109	41	73%	27%
	Somerset	145	86	59	59%	41%
	Trollhaugen	128	98	30	77%	23%
	Across all	851	611	240	72%	28%