Impact of Vine Vigor, Nitrogen, and Carbohydrate Status on Fruitfulness of Pinot noir

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Summary

The first year of a two-year research project was completed in 2014. The project involves three components, all analyzed within main plot vines managed with different vineyard floor management practices and different levels of vine vigor and nitrogen status. Preliminary results show that bud fruitfulness is not reduced at basal nodes for canes assessed within any of the vineyard floor treatments. Vines grown with cultivated alleyways (Tilled) were the most vigorous with the greatest leaf area and lowest light infiltration compared to vines with grass alleyways (Grass). Dormant buds collected in winter 2014 from Tilled treatment vines had the highest fruitfulness at several nodes along the cane. Primary bud necrosis was rarely found and did not differ between Tilled and Grass treatments. Grass vines had less leaf area, lower yields and higher fruit total soluble solids at harvest as was found in prior years of research in this block. Vine tissue N and carbohydrate analysis are still pending as of this reporting. The differences in nitrogen (%N) and total non-structural carbohydrates of bud, cane, shoot, trunk and root samples will be compared to bud fruitfulness data to understand the dynamic role of N and carbohydrates on bud development and fruitfulness.

Within the main plot vineyard floor management study, two experiments were conducted within sub-plots to evaluate the effect of canopy management practices on bud fruitfulness, including lateral removal and cluster zone leaf removal. Both included a time course study of lateral and leaf removal.

Lateral shoot removal treatments were imposed during one of three different time points (fruit set, pea-size and bunch closure) in 2014 and compared to a no lateral removal treatment. Timing of lateral removal did not increase light exposure to the upper canopy where laterals were removed, indicating that any differences in bud fruitfulness within apical sections of dormant canes may be due to internal differences such as nitrogen or carbohydrates rather than light or temperature effects. The main differences in canopy light were due to the main plot effect (Grass, Alternate and Tilled). There were no differences in photoassimilation rates of primary leaves with or without a lateral. Data collected from these experiments will be compared with bud fruitfulness that is currently being assessed for winter 2015.

Cluster zone leaf removal was applied to vines during one of three different time points during 2014 (bloom, fruit set, and pea-size), and these were compared to a no leaf removal treatment. Leaf removal increased light exposure to the buds in the fruit zone where leaves were pulled. Within the Grass vines, yields were higher with no leaf removal compared to those with leaf removal. Grass vines had lower total vine leaf area than Alternate and Tilled vines, and removal of leaves early season could have affected fruit set. Fruit set data are still being analyzed. Data collected from these experiments will be compared with bud fruitfulness that is currently being assessed for winter 2015.

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Objectives and Experiments Conducted to Meet Stated Objectives

Experiments outlined below were conducted in a research block located at Stoller Family Estate Vineyard in Dayton, OR. Vines were maintained per commercial standards except when noted below. The vineyard consists of Pinot noir clone 115 grafted to 101-14 rootstock planted at a 7'x 5' spacing (1245 vines/acre) in a N-S row orientation (planted 1998). The vines were trained to a cane-pruned double Guyot system. This block has been used for continuing research projects by the PI since 2007. The earlier stages of research were designed to achieve variable levels of vine vigor to allow for continued research. Three levels of vine vigor (high, moderate-high, and moderate based on vine balance metrics) resulted from three vineyard floor management practices: tilled between rows (Tilled), permanent grass between rows (Grass), and alternating tillage and grass between rows (Alternate). Maintaining perennial grass alleyways has been effective in decreasing vine vegetative growth as observed by decreasing pruning weight, leaf area, and tissue N compared to Alternate and Tilled treatments over the years. The main plot vineyard floor treatments are replicated in a completely randomized design. There are five replicates of each treatment with each plot consisting of 16 vines. The experimental plots were split into three sub-plots to allow experiments to take place in the 2014 and 2015 growing seasons per the objectives outlined below. Each subplot consists of eight vines used for Objective 1, and the remaining eight vines split into two subplots consisting of four vines each for Objectives 2 and 3.

Objective 1: Determine the relationships between vine vigor, tissue nitrogen (N) and carbohydrate status, and impact on both primary bud necrosis (PBN) and bud fertility.

To develop an understanding of nutrient dynamics in the early part of the growing season, tissue nutrient status was monitored within each vine vigor level (Grass, Tilled and Alternate). These measures were supplemented with spring vine growth measures. Small shoots post-bud break (<10 cm) were collected per plot, weighed, and reserved for analysis of N content and total non-structural carbohydrates (TNC). Tissues were cleaned, freeze-dried, ground and stored at -80°C until analysis. Nitrogen analysis (%N) will be run by combustion using a LECO TruSpec CN Analyzer (LECO Corp., St. Joseph, MI) through OSU Central Analytical Laboratory, and samples will be submitted in spring 2015.

Trunk and root cores were excised from each treatment plot during six time points during the growing season (dormancy, bud break, bloom, véraison, harvest, and leaf fall). There were only two sampling points proposed in the original proposal, but we opted for more time points as this was necessary to understand the dynamics of vine nutrient status and floral bud development. After samples were collected from the field, they were placed on ice and transported back to the lab where they were cleaned in distilled water, dried, and stored at -80°C until ready for analysis of TNC. The TNC of these tissues and the aforementioned shoot tissues will be analyzed using the method of Chow and Landäusser (2004) upon the completion of the field components of the study.

During dormancy, two canes from each of the eight vines in the sub-plot were collected from each vineyard floor management treatment (Grass, Tilled and Alternate). Two canes were randomly selected from the canopy and one from a renewal spur. The canes chosen from the canopy were divided into three sections (apical, mid-shoot, and basal) and buds were separated from the cane in each section. The cane that arose from the renewal spur will be divided into only bud and internode sections due to its location on the vine and our interest in understanding the difference in buds from the two types of canes. Typically the cane arising from a renewal spur is much more vigorous (larger cane diameter) than those in the canopy, and both types may be selected by pruning crews as the fruiting cane for the following season. Both buds and cane tissues from each section are being stored at -80°C and will be freeze-dried, ground, and subsampled for TNC and %N as described above.

Dormant buds from canes within each vine vigor level are being examined for fruitfulness. During late January-early February 2015, three canes per vine were collected as mentioned above for bud fruitfulness (potential fruitfulness) and PBN. These buds are currently being hand-sectioned for determining fruitfulness and PBN by a stereoscope. The individual nodes will be grouped into the same sections (basal, mid-shoot, and apical) to compare with the TNC and %N data. Since fruitfulness and PBN may differ along the cane, each node will be assessed separately.

We believe we have appropriate technique to assess bud fruitfulness after testing methods in 2013-2014. Over the past year, we have worked with collaborator Kathy Cook to assess microscopy methods and determine methods best suited to this project. During 2013 and 2014, dormant buds were prepared and sectioned using a microtome and observed through compound light microscopy. However, this work proved far too time-consuming for the size and scope of this project, and focus has shifted to hand dissection of buds under a stereomicroscope to determine fruitfulness and PBN in light of greater field sampling. Alison Reeve, graduate research assistant and co-PI on this project, received training by Dr. Luis Sanchez at the E&J Gallo laboratories in Modesto, CA during December 2014 to hone her skills in assessing bud fruitfulness, and she is currently working through samples from Year 1.

Vine growth, soil water content, and midday stem water potential were monitored throughout the 2014 season. In-row soil water content and midday stem water potential were measured during 15 dates from 23 May through 4 Sept 2014 to monitor impacts of vineyard floor management on the vines. Soil water content was measured to a depth of 75 cm using a capacitance probe (AquaPro Sensors, Ducor, CA), and midday stem water potential was measured using a pressure chamber (PMS Instruments, Albany, OR). To monitor vine N status, both leaf blades and petioles were collected at bloom and véraison each year, using established methods (Schreiner et al. 2013). Tissues were collected, cleaned in distilled water, oven-dried at 60°C for 48 hours, ground and archived for C and %N analysis through OSU Central Analytical Laboratory in winter 2015. Vine growth measures included shoots/vine, inflorescences/shoot (actual fruitfulness), shoot growth rate from shortly after bud break until hedging (12 May to the end of June 2014), percent fruit set, vine leaf area at bloom and véraison, yields at harvest, and dormant pruning weight (still pending, winter 2015). Vine leaf area was determined using a non-destructive method as outlined by (Schreiner et al. 2013). Percent fruit set was determined using digital images of tagged inflorescences before bloom as outlined by Poni et al. 2006 but modified to include images taken post-set to quantify the percent fruit set during the season.

Incident sunlight in the canopy was measured in 2014 using a ceptometer (LP-80, Decagon Devices, Pullman, WA). Measures were taken in three canopy zones, including basal, middle, and upper at 11:00 a.m., solar noon, and 3:00 p.m. during key phenological stages: pre-bloom, BB size, pea-size berries, bunch closure, véraison, and ripening.

Gas exchange measures (photosynthetic assimilation and stomatal conductance) using an infrared gas analyzer (LI-COR 6400 XT, LI-COR Biosciences, Lincoln, NE) were taken at key phonological stages, including bloom, fruit set, pea-size, bunch closure, véraison, and ripening. Only Grass and Tilled treatment vines could be measured to ensure that measures were taken efficiently within the time frame by which climatic conditions are stable.

Fruit was sampled just prior to commercial harvest for cluster weights and measures and basic ripeness. A total of seven clusters were randomly selected from the fruit harvested per plot, bagged, placed in a cooler and transported to campus. They were measured for cluster weight, berries per cluster, and then pressed to juice and analyzed for total soluble solids, pH and titratable acidity by titrating to an end point of pH=8.2 using 0.1 N NaOH.

Objective 2: Evaluate the influence of lateral shoots on bud fruitfulness and incidence of PBN.

Laterals were removed or maintained on individual shoots of experimental vines within the three vigor classes created by Tilled, Alternate, and Grass plots (sub-plot separate from Objective 1). Lateral removal took place at one of three time points, including fruit set, pea-size, and bunch closure. These treatments were compared to vines with no lateral removal which served as a control. Five field replicates (four-vine plots) within the main plots were used for this experiment with one vine used for each lateral removal treatment. Laterals were removed from the upper half of the canopy.

Vine growth measures collected during 2014 included shoots/vine, inflorescences/shoot, vine leaf area at bloom and véraison, yields at harvest, and dormant pruning weights (still pending, winter 2015). To determine impacts on fruit set, percent fruit set was determined using digital images of tagged inflorescences before bloom as outlined by Poni et al. 2006 but modified to include images taken post-set to quantify the percent fruit set during the season. Vine leaf area was determined using a non-destructive method as outlined by (Schreiner et al. 2013).

Gas exchange measures (photosynthetic assimilation and stomatal conductance) using an infrared gas analyzer (LI-COR 6400 XT, LI-COR Biosciences, Lincoln, NE) were taken at the beginning (0-10% color) and end (90-100% color) of véraison. Only Grass and Tilled treatments could be measured to ensure that measures were taken efficiently within the time frame by which climatic conditions are stable. Measurements were made of fully sun-exposed leaves in the upper canopy (nodes 14-16). Incident sunlight into the canopy was measured in the upper canopy by placing the ceptometer (LP-80, Decagon Devices, Pullman, WA) parallel to the canopy at the first catch wire (approximately mid-canopy height) during key phenological stages (pre-bloom, BB size, pea-size, and bunch closure). This data will be used to understand the light environment as it relates to bud fruitfulness of canes in the zone of lateral removal.

Fruit was sampled at harvest for weights, measures and basic ripeness. A total of seven clusters were randomly selected from the fruit harvested for whole vine yields per plot, bagged, placed in a cooler and transported to campus. They were measured for cluster weight, berries per cluster, and then pressed to juice and analyzed for total soluble solids, pH and titratable acidity by titrating to an end point of pH=8.2 using 0.1 N NaOH.

Dormant canes will be collected in February 2015, and buds and internodes will be assessed for bud fruitfulness. Fresh weights of buds, nodal sections, and laterals were recorded before examination of the buds, and this data will be used to determine if there are relationships between these parameters and PBN or fruitfulness. Buds (with and without laterals) will be examined for the presence of PBN and fruitfulness through visual assessment of bud cross-sections under a stereomicroscope as described in Objective 1. Internodes will be combined from each treatment and analyzed for TNC following the methods described in Objective 1. The TNC of buds and internodes will be compared on shoots with and without laterals to determine the effect of laterals on TNC and the resulting effect on fruitfulness and PBN.

Objective 3: Evaluate the impact of cluster zone leaf removal on bud fruitfulness and incidence of PBN.

To examine the influence of cluster zone leaf removal on PBN and fruitfulness of buds, we are comparing buds from vines with leaf removal in the cluster zone with those with leaves retained. This experiment was conducted on the experimental vines within Tilled, Alternate, and Grass plots (sub-plot separate from Objectives 1 and 2). Hand leaf removal was performed by removing leaves from node 1 (base) to the node just above the second cluster at three time-points: bloom, fruit-set, and pea-size stage. There are four-vine plots with five field replicates, with one vine dedicated to each time point of leaf removal. Vine growth measures were collected during 2014, including, shoots/vine, inflorescences/shoot, vine leaf area at bloom and véraison, percent fruit set, yields harvest, and dormant pruning weight. Vine leaf area was determined using a non-destructive method as outlined by (Schreiner et al. 2013). To determine impacts of early leaf removal on fruit set, percent fruit set was determined using digital images of tagged inflorescences before bloom as outlined by Poni et al. 2006 but modified to include images taken post-set to quantify the percent fruit set during the season. In addition, berries per cluster and berry weights were quantified at harvest. Incident sunlight into the canopy was measured in the cluster zone using a ceptometer during key phenological stages: pre-bloom, BB, pea-size, and bunch closure.

Fruit was sampled at harvest for weights, measures and basic ripeness. A total of seven clusters were randomly selected from the fruit harvested per plot, bagged, placed in a cooler and transported to campus. They were measured for cluster weight, berries per cluster, and then pressed to juice and analyzed for total soluble solids, pH and titratable acidity by titrating to an end point of pH=8.2 using 0.1 N NaOH.

Dormant canes were collected in January 2015. Buds in the leaf removal and control treatment vines are currently being examined for the presence of PBN and number of inflorescences using visual assessment of bud cross-sections under a stereomicroscope. By looking at differences among treatments by node, we may be able to determine which buds were affected by leaf removal at a certain time. For each treatment, the internodes will be analyzed for TNC as described in Objectives 1 and 2.

Results of this experiment will help determine if there are any issues with basal node fruitfulness when leaf removal practices are employed. This is important information for growers who wish to convert to spur pruning for vineyard efficiency. The majority of Oregon growers do not prefer spur pruning as they believe it will lead to significant reduction in fruitfulness and crop yield.

Summary of Major Research Accomplishments and Results by Objective

Objective 1: Determine the relationships between vine vigor, tissue nitrogen (N) and carbohydrate status, and impact on both primary bud necrosis (PBN) and bud fertility.

Bud fruitfulness was highest in the Tilled treatments at node positions 1 (most basal bud), 3, 4, and 7 (Figure 1). When statistically analyzing node position and vineyard floor management treatments on bud fruitfulness, only node position influenced fruitfulness, with fruitfulness decreasing from the basal most bud up to node 11 ($p=0.0093$). Actual fruitfulness was reduced in Grass treatments at node positions 4, 5, and 11 (Figure 2). When statistically analyzing the effects of node position and floor management together, both affect actual fruitfulness (model $p<0.0001$). All vineyard floor management treatments showed a decrease in fruitfulness as node position increased, and Grass had the lowest fruitfulness along the cane. Primary bud necrosis was minimal with only 0.7-0.8% of the buds in Grass and Tilled treatments showing signs of Primary Bud Necrosis from samples collected in late January to early February 2014. The reduced fruitfulness associated with vines grown with grass in the alleyways suggests that initiation of inflorescence primordia may be the cause of lower cluster numbers per vine.

Nitrogen and total non-structural carbohydrates of dormant tissues (buds and internodes), small shoots, trunk and roots have not been analyzed at this point of reporting. Samples have been collected per project timeline and are being stored at -80°C until analysis.

Grass vines had shorter shoot lengths than Tilled vines, starting on our measurement date of 2 May 2014 and at each weekly measurement up until the first hedging at the end of June 2014. Shoot elongation rates were reduced starting 12 May 2014 and were reduced during the same time frame with the exception of 12 June to 18 June 2014. The number of nodes present was counted on each measurement date to determine if the reduction in shoot length resulted from a reduced number of nodes or a delay in node development since this may impact fruitfulness. The first difference in number of nodes per shoot occurred on 23 May 2014 and was lower in Grass vines through the last day of measurement with the exception of 18 June 2014. By 30 June 2014, Grass vines had 16 nodes per shoot while Tilled vines had 21 nodes (p=0.0038). Grass vines had 1 fewer node per shoot by the end of May 2014 but 5 fewer nodes per shoot by June 2014, showing that later developed nodes on Grass vines are not the same age as nodes of the same position on Tilled vines.

At bloom, Grass vines had 40% shorter shoot lengths, 2 fewer leaves, and 40% less leaf area per shoot than Tilled vines. There were no differences in the number of shoots per vine (p=0.0508) nor the cumulative length of lateral shoots per shoot (p=0.3646). By véraison, Grass vines had 45% less leaf area per shoot (p=0.0025) than Tilled vines, and vines under the Alternate treatment had similar leaf area as Tilled vines. The lower leaf area per shoot on Grass vines was due to a smaller leaf size (p=0.0007) and fewer lateral leaves (p=0.0274) compared to other treatments. Grass vines also had one fewer shoot per vine than Tilled vines which also contributed to the lower whole vine leaf area (p=0.0021). The impact on shoot growth and canopy size between the vineyard floor management treatments is likely related to vine N status. There was reduced %N in petiole and leaf blade tissues collected at bloom and véraison in Grass vines compared to Tilled vines, with Alternate having intermediate N concentrations.

There were no differences in the soil water content measured at six depths in the soil profile (from 15 to 75 cm) during 15 dates between 23 May 2014 and 4 September 2014. Stem water potential was measured bi-weekly from 18 June to 4 Sept. Differences among floor treatments were only found on two dates. Grass vines had a more negative stem water potential on 18 June 2014 (-0.56 MPa) compared to Alternate and Tilled vines (-0.38 and -0.39 MPa) but had a less negative stem water potential (-0.78 MPa) on 4 September 2014 as compared to the Alternate and Tilled treatments (-1.0 and -0.97). The higher water potential early in the season may be due to the grass growth and competition for water, but later in the season the grass is quiescent and is less competitive. Alternatively, the Grass vines may have been more efficient in water use due to nearly half the canopy size compared to Tilled vines. Nonetheless, vine water status never fell below -1.2 MPa throughout the season, which is considered the point at which irrigation would be required.

Solar radiation was measured in the cluster zone (east and west sides) on six dates during the 2014 season. The percent of ambient PAR reaching the cluster zone differed among the floor management treatments in the morning on the west side of the canopy (Figure 3) and in the afternoon on the east side of the canopy (Figure 4). Grass vines had less dense canopies which increased the percentage of solar radiation passing through the canopy. Solar radiation was also measured in the lower (0-50 cm), mid (51-100 cm), and upper (101-150 cm) zones of the canopy during the last three dates. These data will be used to compare to bud fruitfulness in each of these three zones to determine if light interception relates to bud fruitfulness. The basal zone had the highest % PAR in the morning on the east side and in the afternoon on the west side, which is likely because of leaf removal on the east side of the basal zone of the canopy. The apical zone had the highest % PAR at solar noon and in the morning on the west side and the afternoon on the east side as expected for a vertically shoot positioned canopy.

Cluster thinning was not performed on vines in 2014, and yields ranged from 4.49 to 6.45 kg per vine among the vineyard floor management treatments. The difference in yield was due to differences in the number of clusters per vine ($p=0.0247$) and cluster weights ($p<0.0001$). Grass vines had 7 fewer clusters and clusters weighed 25 to 27 g less than Tilled and Alternate treatments. Despite drastically different yields, there were no differences in total soluble solids of fruit at harvest. The only basic ripening parameter to differ among floor management treatments was titratable acidity, which was lowest in Grass (6.8 g/L) and highest in Tilled (7.7 g/L).

As expected from the leaf area data collected at veraison, pruning weights measured in dormancy (winter 2014/15) were lowest in the Grass treatment and highest in the Alternate and Tilled treatments. Cane weights were also lowest in the Grass treatments and were approximately 45 g, which is slightly above the recommended 20-40 grams associated with vines of moderate vigor. In terms of vine balance, Grass vines had the highest Ravaz Index at 5.7, while Tilled vines had the lowest at 4.2. Another metric used to measure vine balance metric is the ratio of leaf area to yield. However, floor management treatments did not affect this metric and ranged from 0.62-0.81 m^2/kg. These values are lower than any of our other leaf area to yield measures collected in prior years from this study or in other Pinot noir studies conducted by this lab. This is likely due to the higher-than-normal yields in 2014. Despite the lower leaf area to yield ratio, soluble solids ranged from 21.6 – 22.0° Brix among the different treatments at harvest.

Senescence was tracked weekly post-harvest by observing canopy yellowing and leaf abscission to determine the length of the post-harvest carbohydrate accumulation period for each treatment. Grass vines had significantly lower SPAD values (measure of leaf greenness) in all zones of the canopy (basal, mid-shoot, and apical) from harvest to early November when leaves started abscising. Nearly 100% of the basal leaves of Grass vines had abscised by 11 Nov 2014 and all leaves had abscised by 18 Nov 2014. In Tilled vines, leaf abscission was delayed in all zones of the canopy and about 75% of the leaves had abscised by 18 Nov 2014 (as an average over three canopy zones). We hypothesize that the delay in leaf yellowing and abscission may contribute to increased carbohydrates being assimilated and stored in Tilled vines compared to Grass vines. However, temperatures in November are low and the little canopy that was left during this time period may not have contributed much to additional vine carbohydrate assimilation and storage. We will be analyzing vine tissues for carbohydrates in 2015/2016, and this information will be useful in understanding carbohydrate dynamics.

Objective 2: Evaluate the influence of lateral shoots on bud fruitfulness and incidence of PBN.

Vine growth data were collected for the lateral removal treatments applied in 2014. Tilled vines had 40% greater primary leaf area at véraison compared to Alternate and Grass ($p=0.0458$). The larger leaf area in Tilled vines is explained by larger leaf size. There were no differences in primary leaf area between lateral removal treatments. Fruit set was quantified in all treatments during 2014, but the data are not yet statistically analyzed as of this reporting. However, at harvest, lateral removal treatments did not result in differences in number of berries per cluster or cluster weight.

Canopy light data gathered from measurements of the mid-canopy at the BB-size, pea-size and bunch closure stages indicates no effect of timing of lateral removal on light exposure of the canopy. This was expected as shoots overlap. For Grass vines, there was increased light exposure on the west side of the canopy in the morning, the east side at solar noon, and in the afternoon. Despite the higher light exposure in Grass vines, photoassimilation rates were not different from Tilled vines when measured at the start or end of véraison. Furthermore, the timing of lateral removal did not result in any differences in photoassimilation.

Some studies suggest that lateral leaf area is important to vine productivity and fruit ripening. However, lateral removal did not influence fruit ripening, including total soluble solids, pH or titratable acidity at harvest in 2014. Total soluble solids ranged from a low of 20.0 °Brix for the early lateral removal timing (fruit set) to 20.7 °Brix for the control (no laterals removed). However, there was no statistical difference by timing or lateral removal. Main plot vineyard floor treatment had a greater impact on ripeness than did lateral removal with Tilled vines having lower total soluble solids than Alternate or Grass. Tilled vines had 26% higher yields compared to Grass and Alternate vines, and this may explain some of these differences in total soluble solids.

Bud fruitfulness is currently being assessed on dormant cane tissues that were collected in January 2015. Results from bud dissections will be analyzed with and compared to vine growth and canopy light data collected in 2014 to understand impacts of this practice on vine yield and productivity.

There was no difference in pruning weights between treatments with laterals removed and no laterals removed. Similar to the findings in Objective 1, the main plot effect (floor management) influenced pruning weights, cane weights, and Ravaz. There was no difference in the ratio of leaf area to yield in both the main plot treatment and sub-plot treatment (timing of lateral removal). Leaf area to yield values (0.38-0.55 m^2/kg) were lower than in the study for Objective 1, as were the soluble solids, which may suggest that higher leaf area to yield values are needed than in this objective for Pinot noir soluble solid accumulation in this region.

Objective 3: Evaluate the impact of cluster zone leaf removal on bud fruitfulness and incidence of PBN.

Leaf removal had no impact on vine growth parameters measured, including leaf area at bloom or véraison, cluster weight, berries per cluster, yield, or fruit composition at harvest (total soluble solids, pH, or titratable acidity). During the bloom timing of leaf removal, between 5 and 6 primary leaves were removed which accounted for 43-47% of the total leaf area removed at that time. However by véraison, there were no differences in total leaf area between any of the leaf removal treatments. There was slightly more leaf area removed in the fruit set compared to the timing other two time points, but total leaf area per vine at véraison was slightly higher in these vines, although not significant statistically ($p=0.6885$).

Most of the vine growth differences were due to the main plot vineyard floor management treatments. At bloom, Grass vines had 44% less leaf area than Tilled, as they had fewer and smaller primary leaves. At véraison, Grass vines had similar primary leaf area per vine, but lateral leaf area was three times less than Tilled vines. Overall, total leaf area was reduced by 52% in Grass vines, but the result was not significant ($p=0.0807$), likely due to vine to vine variability. There were differences in cluster weight and yield with Grass vines having 25% lower cluster weights (p=0.0045) and 36% lower yield (p=0.0030) than Alternate and Tilled. Cluster weights were lower due to fewer berries per cluster in Grass compared to Alternate and Tilled (p=0.0009). This was expected as the main plot treatments have influenced inflorescence size and clusters size in prior years of this research, likely due to the impact of lower vine N status.

As expected, cluster zone leaf removal had an impact on light environment in the cluster zone compared to the no leaf pull treatment. Light measurements at bunch closure, showed that all leaf pull treatments had between 1.9 to 2.4 times higher light exposure in the fruiting zone in the morning on the east side of the canopy compared to no leaf pulled vines. Grass vines had between 1.6 and 3.3 times higher light exposure in the fruiting zone at the same time than Alternate and Tilled treated vines due to the smaller vine size.

Grass vines that had no leaves pulled had higher yields than any of the Grass vines that had their leaves pulled at bloom, fruit set, or the pea-size stage. This may have been due to differences in fruit set. Fruit set was quantified in 2014, but the data has yet to be analyzed statistically. By harvest, total soluble solids of fruit was highest in the Grass (22:2 °Brix) and Alternate (21.9 °Brix) compared to Tilled vines (20.9 °Brix) (p=0.0115). This suggests that the vine canopy size in Grass did not limit fruit ripening.

Bud fruitfulness is currently being assessed on dormant cane tissues that were collected in January 2015. There are no results to report at this time. Results from bud dissections will be analyzed with and compared to vine growth and canopy light data to understand impacts of this practice on vine yield and productivity.

Pruning weights and cane weights only differed by floor management treatment, following similar trends as the studies outlined in Objectives 1 and 2. There was no influence of floor management treatment or leaf pulling on the Ravaz Index or the ratio of leaf area to yield.

Outside Presentations of Research

Since we are still completing Year 1 of this research project, no formal presentations of this work has been made. However, a poster summarizing Year 1 findings will be presented at the Oregon Wine Research Institute Grape Day on March 31, 2015 in Corvallis, OR. This work will also be prepared and presented either as a poster or oral presentation at the *International Cool Climate Symposium* to be held in England during 2016. The PI will use information generated from this research when presenting at industry workshops and seminars, and she will include it in Extension outreach materials, such as newsletters, technical updates, etc. Since the PI also teaches courses in the viticulture curriculum at OSU, she will include information in lectures and teaching modules.

Research Success Statements

There is a lack of scientific data on bud fruitfulness in cool climate grape cultivars. Much of the bud developmental work that has been conducted focused on small, controlled studies and was not conducted under commercial production situations to understand influences of commercial production and climate on bud development and yield. Furthermore, some studies suggest a lack of fruitfulness of lower (basal) buds, and this has driven grower preference for cane pruning over spur pruning, despite more labor required. If we can determine the causes of poor fruitfulness or methods by which to enhance fruitfulness in Pinot noir, then growers may be able to modify their vineyard practices (such as leaf removal or lateral removal) to increase vine productivity and avoid problems with annual variability in vine yield. This work may lead to better measurements to estimate yield earlier in the season, particularly when they are developing contracts in winter before the start of the season. If fruitfulness is found to be sufficient at lower nodes, it may be possible for grape growers to switch to the more efficient pruning method provided by spur pruning and reduce vineyard production costs.

Fund Status

Funds from this grant were used to support the salary and OPE of a graduate research assistant, Alison Reeve, who is currently a Ph.D. candidate in the Skinkis Lab and co-PI on this project. This project is a major component of her Ph.D. thesis work. Funds were also used to conduct the research, including in-state travel to the research site, purchase of lab consumables, reagents, and supplies, and costs incurred for nutrient analyses through OSU Central Analytical Lab. We will continue to use funds through August 2015 to finalize data collection from Year 1 of the project.

The project outlined in Objective 1 is partially funded by a seed grant provided by the Agricultural Research Foundation. That funding combined with this funding provided by the Oregon Wine Board for 2014/15 allowed for expansion of the project as outlined in this report (more sampling time points, etc.).

The research team thanks the Oregon Wine Board for the financial support of this research project and for their continued support of other research within the program of the PI.

Literature Cited

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Figures

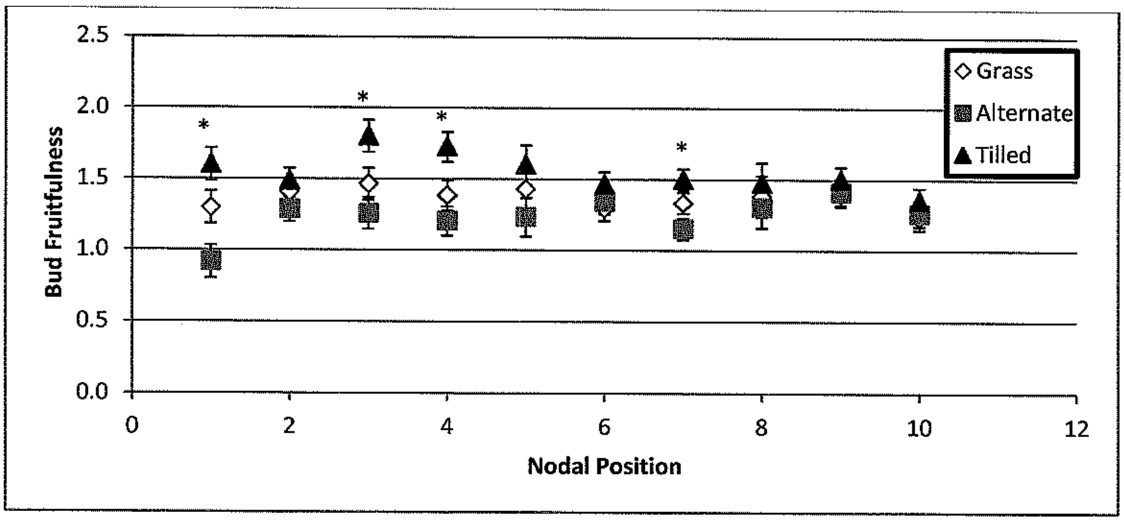

Figure 1. Bud fruitfulness (mean ± SE) measured during dormancy prior to the 2014 season in vines managed with different vineyard floor treatments. Bud fruitfulness was determined by slicing a bud with a razor under a stereoscope and counting the number of inflorescence primordia in the primary bud at each node. Nodal position refers to bud location on a cane, starting from the base of a cane (0) and moving to apical positions (up to 12). *Denotes a statistical difference among vineyard floor management treatments using Tukeys HSD for mean separation at α=0.05.

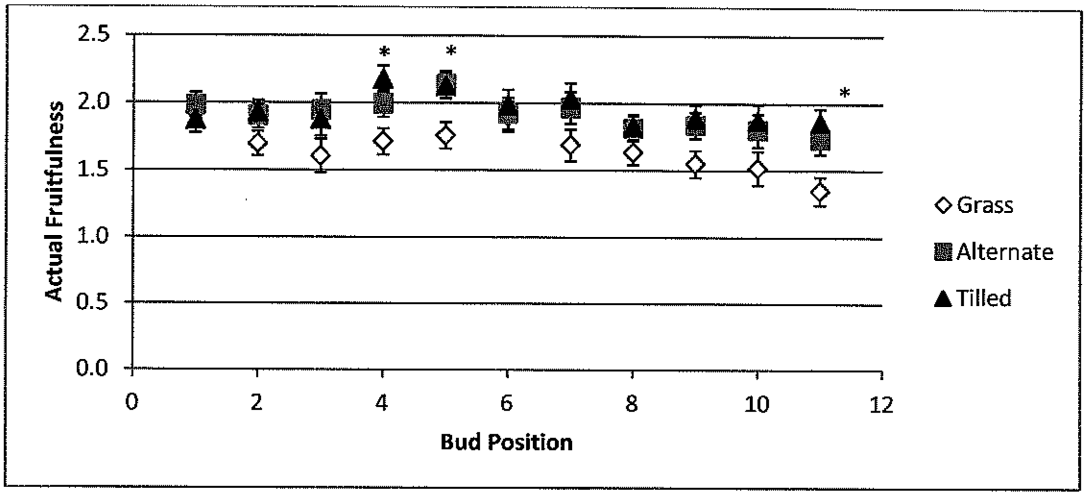

Figure 2. Actual fruitfulness (mean ±SE) measured six weeks post-bud break 2014 in vines managed with different vineyard floor treatments. *Denotes a statistical difference among vineyard floor management treatments using Tukeys HSD for mean separation at α=0.05.

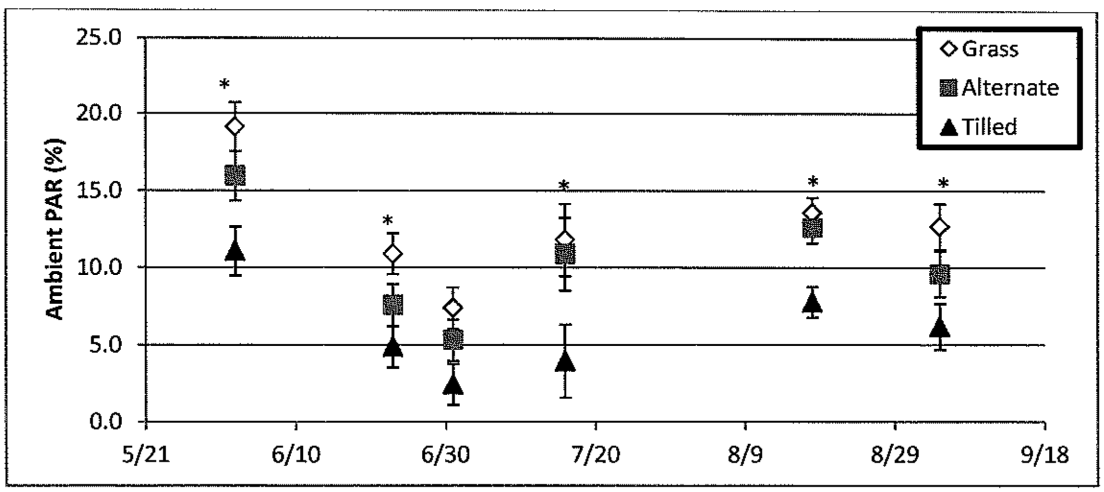

Figure 3. Mean percent of ambient Photosynthetically Active Radiation (PAR) on the west side of the cluster zone at 11:00 a.m. PST (mean ±SE) during six dates in 2014. *Denotes a statistical difference among vineyard floor management treatments using Tukeys HSD for mean separation at α=0.05.

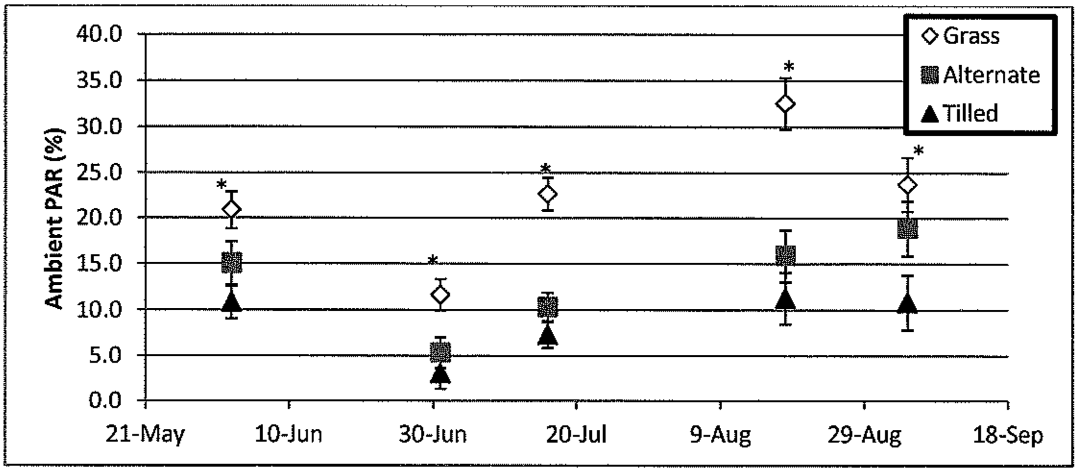

Figure 4. Percent of ambient Photosynthetically Active Radiation (PAR) on the east side of the cluster zone at 3:00 p.m. PST (mean ±SE) during five dates in 2014. * Denotes a statistical difference among vineyard floor management treatments using Tukeys HSD for mean separation at α=0.05.