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

Patricia A. Skinkis, Alison L. Reeve and R. Paul Schreiner

Interim Report Summary

A two-year field study was conducted from winter 2014 through spring 2016. The study involves three experiments within main plot vines managed with different vineyard floor management practices that result in different levels of vine vigor and nitrogen status. Vineyard floor treatments included Grass (perennial grass in alleys flanking the vine row), Tilled (alleys cultivated to be free of weeds), and Alternate (perennial grass in one alley and tilled soil in the other). Dormant bud data from 2014 and 2015 show that Primary Bud Necrosis (PBN) was not a major concern in those years, as less than 3% of buds had PBN. Bud fruitfulness in 2015 was found to increase from node 1 to 4, and no differences were found between vineyard floor treatments. Grass vines had lower integrated fruitfulness index (IFI) in some node positions compared to Alternate and Tilled vines. All vineyard floor treatments had similar ratios of bud inflorescence primordia counts to actual inflorescence counts in spring 2015 (~76%). However, Grass vines had lower actual fruitfulness than Tilled and Alternate, and inflorescences were smaller. The difference in fruitfulness was realized at harvest when Grass vines had lower yields. However, those yields were well above target yields for Oregon Pinot noir.

Given the same node position, buds at nodes with a lateral present had 25% to 83% higher FFL and 29% to 100% higher IFI than those without laterals. The increase in FFL and IFI was due to higher primary bud FFL and IFI at all nodes except node five and higher FFL and IFI in secondary buds at all nodes except nodes seven and ten. At a given node position, a heavier cane had a higher FFL and IFI than the same node on a lighter cane, given the presence (or absence) of a woody lateral at both nodes. These findings suggest that nodes with woody laterals at dormancy do not limit inflorescence primordia initiation or growth compared to nodes without a lateral at dormancy, possibly through increased photoassimilation of the subtending lateral.

During 2014 and 2015, 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. Lateral shoot removal treatments were imposed during one of three different time points (fruit set, pea-size and bunch closure) and compared to a no lateral removal. Lateral removal in 2014 did not have a major impact on 2015 winter bud fruitfulness, IFI, or actual fruitfulness observed in spring 2015.

Cluster zone leaf removal was applied to vines during one of three different time points (bloom, fruit set, and pea-size), and these were compared to a no leaf removal treatment during 2014 and 2015. Leaf removal treatments showed 0.2 to 0.3 more inflorescence primordia in buds and higher IFI than no leaf removal treatments. However, there were no differences with leaf removal on actual fruitfulness averaged over the vine in spring 2015.

This report provides work in progress, and further lab and statistical analysis work will continue through 2016.

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Principal Investigator:
Patricia A. Skinkis, Ph.D., Associate Professor & Viticulture Extension Specialist, Oregon State University, Department of Horticulture, 4017 ALS Bldg., Corvallis, OR 97331-7304; ph: 541-737-1411, fax: 541-737-3479, e-mail: Patricia.Skinkis@oregonstate.edu

Co-PIs:
Alison L. Reeve, Graduate Research Assistant, Department of Horticulture, 4017 ALS Bldg, Corvallis, OR 97331-7304; Email: reeveal@onid.orst.edu.

R. Paul Schreiner, Research Plant Physiologist, USDA-ARS Horticulture Crops Research Lab, 3420 NW Orchard Ave, Corvallis, OR 97330. Ph: 541-738-4084, Email: Paul.Schreiner@ars.usda.gov.

Objectives and Experiments Conducted to Meet Stated Objectives

Experiments within each objective 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 assess the presence of PBN and the fruitfulness of dormant buds, two canes per vine per plot were collected from each vineyard floor management treatment from late January to early February each year (2014-2016). In the second and third sampling seasons of the trial, one cane arising from renewal spurs on each vine were also collected, as we wanted to determine whether there were bud fruitfulness differences in the two types of canes that may be selected at pruning. Canes were brought back to the lab and buds were examined using hand-dissection under a stereoscope and the number of inflorescences per bud counted and presence of PBN noted. In 2015 and 2016, the diameter of floral primordia was also recorded, and the sum of inflorescence primordia per compound bud used to calculate the integrated fruitfulness index (IFI). Buds were assessed individually along the cane to determine if fruitfulness and PBN differ based on node position.

To develop an understanding of nutrient dynamics and how they relate to bud fruitfulness, various tissues were sampled from each of the vineyard floor management treatments (Grass, Tilled and Alternate) during 2014 and 2015. These measures were supplemented with vine growth measures to be mentioned later. 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. Trunk and root cores were excised from Grass and Tilled treatment plots at six time points during the growing season, including dormancy, bud break, bloom, véraison, harvest, and leaf fall. There were only two sampling points originally proposed, but more time points were added to better understand the dynamics of vine nutrient status and floral bud development throughout the year. 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 nitrogen and total non-structural carbohydrates (TNC). The TNC of these tissues will be analyzed using the method of Chow and Landäusser (2004) upon the completion of the field components of the study in spring 2016. Nitrogen analysis (%N) will be run by combustion using a LECO TruSpec CN Analyzer (LECO Corp., St. Joseph, MI) through OSU Central Analytical Laboratory. Samples are currently being freeze-dried and ground in preparation for both N and TNC analysis in spring 2016.

Nitrogen and carbohydrate analysis will be conducted on dormant tissues collected each year. During dormancy (Jan/Feb 2014-2016), one to two canes from each of the eight vines in each sub-plot were collected from each vineyard floor management treatment. During 2015 and 16, a cane was also collected from a renewal spur on each vine. Typically the cane arising from a renewal spur is more vigorous (larger cane diameter) than those in the canopy. Since both types of canes may be selected by pruning crews as the fruiting cane for the following season, it was important that we consider the bud fruitfulness (as mentioned earlier) and the nutritive concentration of N and TNC reserves. Buds were excised from each cane, and a 1 cm internode section obtained at the mid-point between each node. Tissues are stored at -80°C, and we are in the process of freeze-drying and grinding samples in winter 2016 for TNC and %N as described above.

Vine growth parameters, soil water content, midday stem water potential, and leaf gas exchange were monitored throughout the 2014 and 2015 seasons. In-row soil water content and midday stem water potential were measured from May to September in 2014 and June to September in 2015 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) within 1 hour of solar noon. Vine growth measures included number of shoots/vine, number of inflorescences/shoot (actual fruitfulness), shoot growth rate from shortly after bud break until hedging, percent fruit set, vine leaf area at bloom and véraison, yields at harvest, and dormant pruning weight. 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 (photosynthetically active radiation-PAR) in the canopy was measured 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, including pre-bloom, BB size, pea-size berries, bunch closure, véraison, and ripening.

Grass and Tilled treatment vines were monitored for photoassimilation and stomatal conductance using an infrared gas analyzer (LI-COR 6400 XT, LI-COR Biosciences, Lincoln, NE). Measures were taken on mature, fully sun-exposed leaves in the mid-canopy at key phenological stages, including bloom, fruit set, pea-size, bunch closure, véraison, and ripening. Only these two treatments could be measured efficiently within the time frame by which climatic conditions remained stable.

Yield components were measured on experimental vines within 1-2 days of commercial harvest each year. Whole vine yields were weighed and cluster counts recorded. 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 berry size, 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 from the upper half of the canopy or maintained on individual shoots of experimental vines within the three vineyard floor management treatments: Tilled, Alternate, and Grass. Four vine sub-plots separate from those used for Objectives 1 and 3 were used for this experiment. Lateral removal took place at one of three time points (fruit set, pea-size, and bunch closure) and were compared to vines with no lateral removal. Treatments were applied to single vines within the sub-plot with five field replicates of each sub-plot.

Vine growth measures included number of shoots/vine, number of inflorescences/shoot, vine leaf area at bloom and véraison, yield and yield components at harvest, and dormant pruning weights. To determine impacts on fruit set, percent fruit set was determined using the same method as in Objective 1. Vine leaf area was determined using a non-destructive method as described in Objective 1. Yield was recorded and fruit sampled at harvest as described in Objective 1.

Leaf photosynthetic assimilation and stomatal conductance were measured using an infrared gas analyzer (LI-COR 6400 XT, LI-COR Biosciences, Lincoln, NE) during multiple time points per season in 2014 and 2015. Four measurement dates occurred in 2015, with the earliest at bloom and the latest at véraison. Only Grass and Tilled treatments could be evaluated 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 (ceptometer level and sensor surface facing up) at the first catch wire (approximately mid-canopy height, where the treatments were implemented) 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.

Dormant canes were collected in 2015 and 2016 (in progress), and buds were assessed for bud fruitfulness and PBN as described in Objective 1. 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 size of tissue (associated with vigor) and PBN or fruitfulness. Notation was made for buds at nodes with and without laterals for the presence of PBN and fruitfulness. Due the amount of work required to conduct TNC assays, tissues were not reserved from this Objective to analyze for TNC and %N as originally proposed.

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, buds from vines with leaf removal are compared to those with leaves retained. Leaf removal treatments were implemented on 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 at the base of the shoot to the node just above the second cluster at three time-points: bloom, fruit-set, and pea-size stage. Treatments were applied to single vines within 4-vine sub-plots that had five field replicates. Vine growth measures were collected each season, including number of shoots/vine, number of inflorescences/shoot, vine leaf area at bloom and véraison, percent fruit set, yield at harvest, and dormant pruning weight. Methods followed those described in Objectives 1 and 2. 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 cluster weights, berry counts, and basic ripeness analyses as outlined in Objective 1. Dormant canes were collected in January 2015 and 2016 (in progress). Buds were examined for the presence of PBN and number of inflorescences and size according to methods outlined in Objective 1. Due the amount of work required to conduct TNC assays, tissues were not reserved from this Objective to analyze for TNC and %N as originally proposed.

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.

Less than 3% of dormant bud samples monitored in winter 2014 and 2015 had PBN, and there were no differences in presence/absence of PBN for the three vineyard floor management treatments, despite different levels of canopy growth, vine vigor, and seasonal %N between treatments in the seasons prior (2013 and 2014). Among all treatments measured in winter 2015, fruitfulness gradually increased from node 1 to node 4 (1 being basal most node) with varying levels of fruitfulness in nodes 5 to 15 (Figure 1). Tilled vines had very little decrease in bud fruitfulness after node 4, and Grass vines had greater decreases in fruitfulness and these same nodes. However, differences were only found for fruitfulness at nodes 6, 8, 13 and 15 (Figure 1).

Inflorescence diameter measured in addition to counts of inflorescence primorida per bud in 2015 gives some information on the size of the primordia and possibly greater yield potential. There were no differences in the integrated fruitfulness index (IFI – the sum of diameters of inflorescences in the first compound bud) between floor management treatments from nodes 2 to 5 and node 9. However, Tilled vines had higher IFI at nodes 1, nodes 6 to 8 and nodes 10 to 14 than Grass and Alternate vines. Essentially, Tilled vines had the most and/or largest inflorescence primordia at those nodes. When buds on the cane arising from the renewal spur were analyzed between floor treatments, there were fewer differences in IFI. These data suggest that larger cane diameters (and thus cane weights) have greater potential for fruitfulness and size of inflorescence primordia. Primordia size is being measured in 2016 buds being assessed currently, and these additional data will add further information to the 2015 findings.

There were no differences between floor management treatments in the percent of inflorescence primordia observed in the bud compared to inflorescences observed on shoots in spring during 2015. In addition, there were no differences found for percentage by node position (Figure 2). Overall, the ratio of bud to actual fruitfulness was 76%. Buds being assessed in 2016 and subsequent actual fruitfulness post bud break 2016 will provide further information on the percentage of bud to actual fruitfulness for this spring.

Fruitfulness assessed post-bud break provided information on the number of inflorescences per shoot and per vine. There was lower fruitfulness in Grass vines; however, the increased number of nodes per vine made up for this difference as Grass vines had shorter internodes, allowing more nodes to be laid out at pruning. There was no difference in the number of inflorescences per vine due to floor management treatments when assessed in spring. However, the inflorescences in Grass vines were smaller than those in Alternate and Tilled. There were no differences in the floor management treatments for the percent of nodes that had multiple buds that pushed post-budbreak. On average, 13% of all nodes in the trial had two primary shoots that pushed per node, and these were often a result of double compound buds at nodes. An average of 11% of all nodes in the trial had a primary and secondary shoot pushing from the same bud. This information is important for us to consider in this research because of the shoot thinning practices used by industry and determining potential drivers of multiple shoots per node often observed in Pinot noir as well as the impact of shoot thinning on regulating yield. It was interesting to find few differences in number of buds pushing per node despite differences in vine vigor between Grass and Tilled, suggesting that something else is driving multiple bud growth than just vigor alone.

Vine growth differed between the vineyard floor management treatments in 2014 and 2015. Grass vines had shorter shoot lengths than Tilled vines during 2014, starting on the first measurement date of 2 May 2014 and at each weekly measurement up until the first hedging at the end of June 2014. At bloom 2014, Grass vines had 40% shorter shoot lengths and 40% less leaf area per shoot than Tilled. There were no differences in the number of shoots per vine. By véraison, Grass vines had 45% less leaf area per shoot than Tilled vines, and vines under the Alternate treatment had similar leaf area as Tilled vines. However, in 2015 there were no differences in shoot length between vineyard floor management treatments measured from shortly after bud break (16 April) to 2-days prior to hedging (15 June), and there were no differences in leaf area per vine found at bloom 2015. However, by véraison 2015 Grass vines had 30-40% less leaf area than Alternate and Tilled vines. In both 2014 and 2015, the differences in vine growth observed are attributed to the differences in %N of leaf blade and petioles. 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 in 2014. In 2015, Grass vines had the lowest %N in petioles at bloom (but no differences in leaf blade %N) and in both leaf blade and petioles at véraison. The lack of difference in leaf blade N at bloom may suggest why leaf area differences weren't observed during that time point in 2015.

There was no difference between floor management treatments in plant water stress, measured as stem water potential during the majority of the 2015 growing season. The only date where differences were measured was the latest measure of the season on 9 Sept 2015, and Grass vines had a less negative stem water potential (-0.8 MPA) than Alternate vines (-0.95 MPA), and Tilled vines (-0.90 MPA) had intermediate measures. Nonetheless, vine water status never fell below -1.2 MPa throughout the season, which is considered the point at which irrigation would be required. These findings are similar to 2014, indicating that there was no differential water stress created by vineyard floor management practices, even under the hot, dry conditions of the 2015 season.

Solar radiation was measured in the cluster zone (east and west sides) on multiple dates during the 2014 and 2015 seasons. The percent of ambient PAR reaching the cluster zone differed among the floor management treatments depending on the time and location (E or W side of canopy) of various treatments. These measures are currently being statistically analyzed from 2015, and the data will be used to understand how the vine growth differences in the main plot floor management treatments compare to light environment and nutrient status, all of which can play a role in bud floral primordia development. Because of the multitude of data (time points and locations within the canopy), these data are not discussed at length here but a synopsis will be presented in a future report.

No cluster thinning was performed on these vines so that yield potential could be fully quantified. At harvest, there were 5 to 7 more clusters in Alternate and Tilled vines compared to Grass. Cluster weights were 150 g for Grass and 170 g for Tilled treatments, but these were not considered different statistically. The high fruit set year may suggest why we saw no difference in cluster weight overall by harvest. Vine yields were lowest in Grass vines with 5.2 kg/vine and Alternate and Tilled vines had 6.5 and 7.2 kg/vine, respectively. It appears that the lower fruitfulness and IFI in Grass buds assessed during early 2015 led to differences in yield at harvest

2015. The yields for Grass, Alternate and Tilled vines averaged 7.2, 8.9 and 9.9 tons/acre, respectively. What may seem like a small difference based on number of inflorescences in the bud or in spring (per shoot) can equate to more than a two ton difference per acre. We plan to analyze those data more carefully to determine which factors may be influencing final yield. It is important to consider that there were no difference in percent fruit set between the vineyard floor treatments in 2015.

Despite the 1 to 2 ton/acre differences in yield between treatments, there were no differences in total soluble solids, pH or TA. The mean TSS was 23.1°Brix, pH of 3.3, and TA of 6.5 g/L. This suggests that the conditions of the season and the vine health allowed adequate ripening of fruit. Further analysis of TNC and %N of trunk, root and dormant tissues will provide further insight into the impacts on reserves and bud fruitfulness. The two high yield years of 2014 and 2015 provide interesting insights into the bud development and will be interesting to compare final data from winter 2015 and 2016 buds.

Given the same node position, buds at nodes with a lateral present had 25% to 83% higher FFL and 29% to 100% higher IFI than those without laterals. The increase in FFL and IFI was due to higher primary bud FFL and IFI at all nodes except node five and higher FFL and IFI in secondary buds at all nodes except nodes seven and ten. At a given node position, a heavier cane had a higher FFL and IFI than the same node on a lighter cane, given the presence (or absence) of a woody lateral at both nodes. These findings suggest that nodes with woody laterals at dormancy do not limit inflorescence primordia initiation or growth compared to nodes without a lateral at dormancy, possibly through increased photoassimilation of the subtending lateral.

Pruning weights from the 2015/2016 were lower in Grass versus Tilled vines and this was also reflected in cane weights (34 g versus 51 g). The Ravaz Index was largest for Grass vines at 8.1 and lower for Alternate and Tilled vines, 6.6 and 6.9, respectively. Leaf area:yield ratios were not different among floor management treatments and ranged from 0.40 to 0.50 m^2/kg. These growth affects will be statistically analyzed with bud and fruitfulness data as we progress with the work.

Nitrogen and total non-structural carbohydrates of dormant tissues, trunk and roots have not been analyzed at this point of reporting. Samples have been collected and stored at -80°C, and we are in the process of freeze-drying and grinding samples for TNC and N analysis in summer 2016.

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

Lateral shoots were removed from node 11 upward on all treatments in 2015. Bud fruitfulness seemed higher in buds assessed in winter 2015 when laterals were removed at node 11 and 13, but the data were not found to differ statistically. Similarly, IFI seemed higher in lateral pulled treatments between nodes 13 and 19, but the data were not found to differ statistically. There were no differences observed for level of PBN, and the overall total percentage of buds with PBN was very low. Actual fruitfulness assessments showed that there was no impact of floor management or lateral removal on total inflorescences per shoot, as only about 10 buds were laid down, in which nodes that received the lateral removal treatment were not retained after pruning.

During the 2015 growing season, there were some differences observed in percent fruit set, with Alternate having lower percentages and Tilled having the highest. We are unsure why this may have been observed. There were no differences in total vine leaf area at bloom or véraison with lateral removal, and this may be due to the fact that not all laterals were removed from the vine and total contribution of laterals was small compared to the primary leaf area. Lateral removal did not influence cluster number per vine, cluster weight and yield. Furthermore there was no impact of lateral removal on TSS or pH, but there was an interactive effect of floor management x lateral removal on TA.

There were no differences in winter 2015/2016 dormant pruning weight or cane weights by floor management treatment or timing of lateral removal. Pruning weights ranged from 0.71 to 0.96 kg/vine and cane weights ranged from 38 g to 50 g. Vine balance measures also did not differ by either treatment factor. Ravaz Indicies ranged from 6.4 to 11.1 while leaf area:yield ranged from 0.36 to 0.45 m^2/kg. These growth affects will be statistically analyzed with bud and fruitfulness data as we progress with the work.

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

Leaves were removed from the first four nodes in 95% of the leaf removal treatments during 2014, and we are interested in the results of fruitfulness of these basal dormant buds (as measured in winter 2015) since the presence or absence of leaves could influence floral primordial development, particularly through carbon availability. Dormant buds measured in 2015 at nodes 1 to 4 showed that buds from leaf removal treatments had 0.2 to 0.3 more inflorescence primordia than those that had no leaf removal. The IFI, which takes into account the size of the inflorescences, was 21% to 40% higher compared to the no leaf removal treatments. However, actual fruitfulness did not reveal differences in number of inflorescences per shoot in spring 2015 for nodes 1 to 4. There were interactive effects for floor management and leaf removal at nodes 2 and 3. There was no effect of any leaf removal treatment on actual fruitfulness averaged over the whole vine.

During 2015, leaf removal and vineyard floor management treatments resulted in some growth differences. There were interactive effects of main and sub-plot treatments on vine leaf area at bloom and véraison. Tilled-Fruit set leaf removal vines had the highest leaf area at bloom while Grass-No leaf removal had the lowest. By véraison, Tilled-fruit set leaf removal vines and Alternate-no leaf removal vines had the greatest amount of leaf area while Grass-bloom leaf removal had the lowest leaf area.

As expected, there was a lower percentage of ambient light reaching the cluster zone of vines with no leaf removal. The percent ambient light was lower on the east and west sides of the canopy during solar noon and during the afternoon on the west side.

There were no differences in percent fruit set between floor management and leaf removal treatments. However, there were differences in cluster weight at harvest, with leaf pulling at bloom and fruit set having 10 to 20 g smaller clusters, respectively than leaf pulling at the pea-size stage or no leaf removal treatment. The number of berries per cluster and berry weight did not differ statistically among leaf removal treatments, despite there being a trend of lower berry weights with the earliest leaf removal treatment. There were no differences in yield based on leaf removal treatment, but there was an interactive effect of vineyard floor management and leaf removal treatments for yield at harvest. Grass treatments generally had the lowest yields while Alternate and Tilled had the highest. There were no differences in ripening parameters such as TSS, pH and TA.

Vine pruning weights measured in winter 2015/2016 differed by floor management treatments but not by timing of leaf removal. Vine pruning weights were lowest in Grass, intermediate in Alternate, and highest in Tilled, 0.59 kg, 0.88 kg, and 0.94 kg, respectively. Cane weights did not differ by either floor management treatment (P=0.0782) or timing of leaf removal (P=0.9370). Vine balance metrics did not differ by floor management or timing of leaf removal treatments. Ravaz Indices ranged from 6.8 to 11.3 and leaf area:yield ranged from 0.65 to 0.88 m^2/kg.

Overall, pruning weights were lower than they have been in the previous year of the study (and prior years in this plot). This was likely due to the two consecutive high yielding years and no cluster thinning. Consequently, Ravaz Indicies were the highest seen for this plot since recording in 2011 and leaf area:yield were the lowest. Also, due to the nature of single vine replicates in Objectives 2 and 3, and variability in the plot, floor management treatment differences less often found than in Objective 1. Additionally, larger ranges of values can be seen for Objectives 2 and 3.

Further data analysis will continue for this Objective to determine the impacts of data collected in 2014 and 2015, including canopy light data as impacted by leaf removal.

Outside Presentations of Research

A poster summarizing Year 1 results was presented by Alison Reeve at the Oregon Wine Research Institute Grape Day in spring 2015 in Corvallis, OR. A poster will be presented for this work at the *International Cool Climate Symposium* to be held in England during May 2016 (authors will not be attending, but poster has been accepted), and an oral presentation is being planned for the 2016 American Society for Horticulture Science Annual Conference in Atlanta, Georgia for August 2016. Results from this work will be published in peer-referred journals, such as *HortScience* or the *American Journal of Enology and Viticulture*. This is part of Alison Reeve's PhD research and results will be included in her thesis. 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. Many of the studies investigating bud development have been conducted on a small scale (random sampling of vines) or under controlled conditions and were not conducted in the vineyard to understand influences of commercial production and climate on bud development and yield. Some studies suggest a lack of fruitfulness of lower (basal) buds, and this has driven grower preference for the more labor-intensive cane pruning method over spur pruning which requires less labor and may be mechanized. The research suggests that basal buds are fruitful and that spur pruning should not cause significant yield reduction for Oregon Pinot noir growers. Because spur pruning requires fewer labor steps and can be mechanized, it may be a way for growers to reduce vineyard production costs. Results of this work also suggest that bud fertility is related to increased vine N status and that it increases with vine vigor. Although reductions in bud fruitfulness and yield were found with lower vigor vines (and lower N) grown with a perennial grass sward, the benefits of reduce canopy management and potential increases in fruit and wine quality (per prior study findings) may more than compensate the yield loss, particularly when yield exceeded typical yield targets. Also, this study found that bud fruitfulness is highly correlated with actual fruitfulness and may be possible for growers to use this method to get an early estimate of yield potential during winter, rather than waiting for mid-late summer to gather those preliminary estimates as they currently do. Having this data earlier may help growers identify a potential problem with low fruitfulness and make necessary adjustments. For example, they may alter pruning timing and intensity (number of buds retained) to ensure adequate yields or consider changes in management (fertilization, irrigation, etc.) to potentially enhance fruitfulness in future years.

Fund Status

Funds from this grant were used to support the salary and benefits 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 2016 to finalize laboratory analyses following the final field sampling in spring 2016.

The project outlined in Objective 1 was partially funded by a seed grant provided by the Agricultural Research Foundation. The combined funds allowed for expansion of the project as outlined in this report. 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

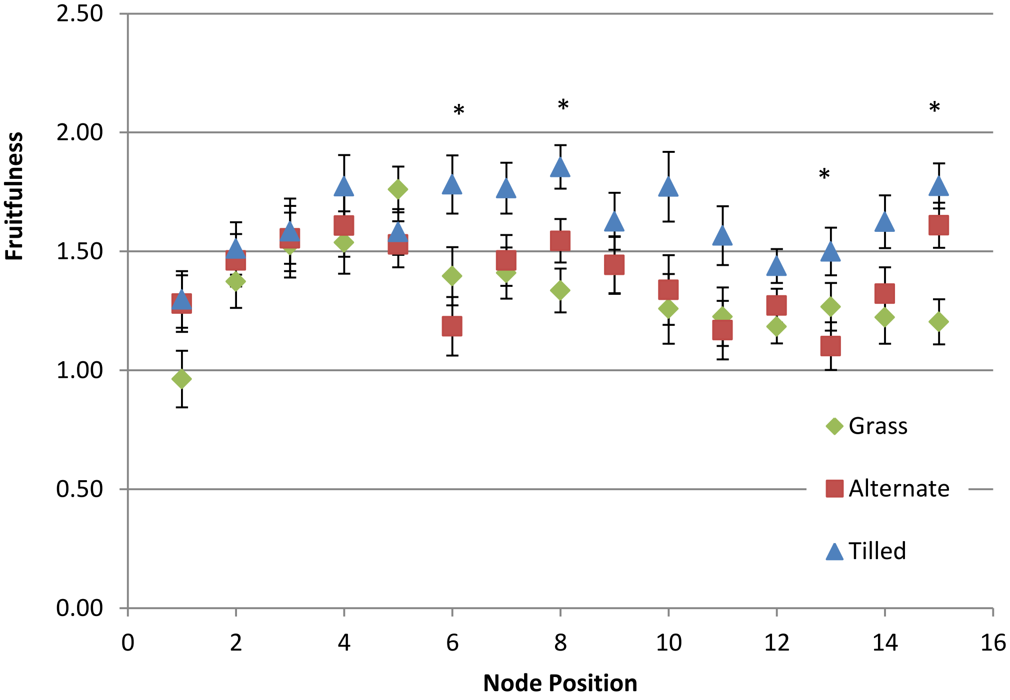

Figure 1. Mean (+SE) dormant bud fruitfulness (number of inflorescence primordia per bud) of the first compound bud measured along 15 node positions, with node 1 being at the base of the shoot and subsequent nodes moving distally along the cane. Buds were measured in winter 2015 from three vineyard floor management treatments, including Grass – perennial grass grown in both alleys flanking the vine row, Tilled – soil rototilled to be free of vegetation in both alleys flanking the vine row, and Alternate – perennial grass in one alley and bare soil in the other alley flanking the vine row.

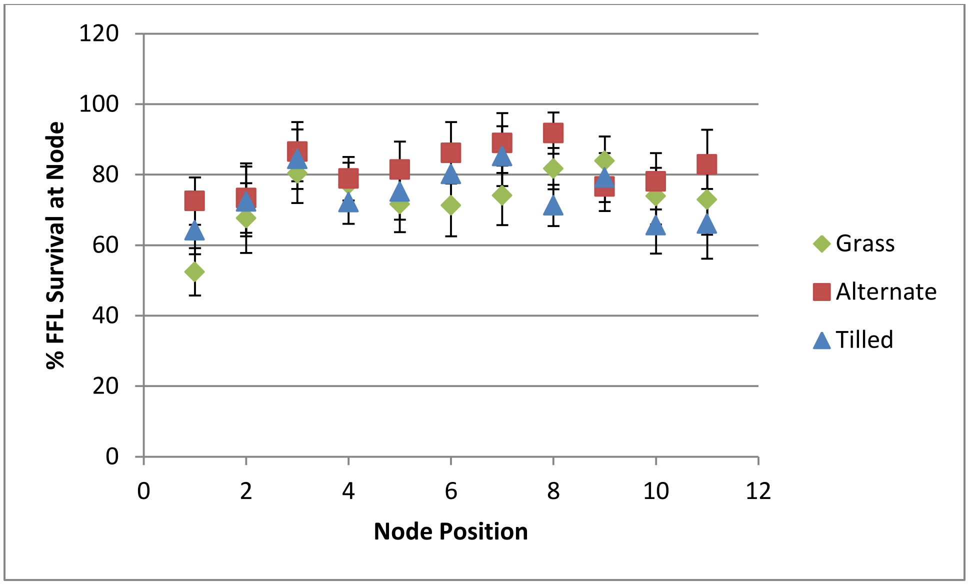

Figure 2. Mean (±SE) percent fruitfulness survival, determined as percentage of bud fruitfulness compared to actual fruitfulness at 11 node positions within vineyard floor management treatments, including Grass – perennial grass grown in both alleys flanking the vine row, Tilled – soil rototilled to be free of vegetation in both alleys flanking the vine row, and Alternate – perennial grass in one alley and bare soil in the other alley flanking the vine row. No differences were observed between treatments or between node (p=0.0069, when data combined across treatments by node).