Initial Considerations for Establishing Small-Scale Organic Olive Orchards in the Pacific Northwest West of the Cascades

eOrganic authors: Tessa Barker, Oregon State University
Javier Fernandez-Salvador, Oregon State University
Neil Bell, Oregon State University
Heather Stoven, Oregon State University

Introduction

Oregon valleys west of the Cascades have a semi-Mediterranean climate with colder winters than California's warmer olive production regions. Olives are a non-traditional crop here, with slowly expanding acreage. Producers have been growing olives for nearly two decades, mostly in the north Willamette Valley and a few orchards in the southern Umpqua Valley (Fernandez-Salvador and Barker, unpublished data). The Oregon State University (OSU) Olea Research Project was started in 2017 to support this growing, innovative industry. Research efforts are currently focusing on propagation, cultivar evaluation for cold tolerance, orchard establishment, and protected overwintering culture for Oregon's climate.

Scope and Limitations

This article will focus on lessons learned in the first three years of the orchard establishment trial, and survey data from Oregon olive growers. The scope will be limited to preliminary research findings on orchard establishment in the unique climate of western Oregon. California guidelines for olive production will be referenced when appropriate. However, local guidelines still need to be published for Oregon. Future studies need to address irrigation, pollination, fruit set, yield, pest management, soil fertility, plant nutrition, and pruning.

Climate

Olives, native to North Africa and the Middle East, thrive in Mediterranean climates (Vossen, 2007a). Western Oregon has a temperate, semi-Mediterranean climate with relatively extended dry summers but low winter temperatures that can be damaging or lethal to olive trees (Rockey, 2017). Few studies on in situ winter cold damage of olives have been conducted, as olives have traditionally been grown in warmer climates with longer growing seasons. California may be used as an example, where the typical growing season lasts from an April bloom through October and November when fruit reaches its final weight and oil content (Vossen and Ravetti, 2019). In Oregon, olives bloom in mid-June, with harvest in late November unless an earlier frost is predicted (from late October to anytime in November)—often prior to reaching full maturity (Fernandez-Salvador and Barker, unpublished data). A record-breaking freeze in California's Sacramento and San Joaquin Valleys in 1990 demonstrated the difference between these two growing regions, where temperatures dropped to 20° F (-6.7° C) or below for two weeks at the end of December 1990 (Denney et al., 1993). While this could be considered a once-in-a-lifetime event for California, such temperatures could occur every 4 to 10 years in Oregon, making winter cold damage a potential problem for olive production, where thresholds for the depth and duration of winter freezes that injure olives still needs to be determined. Depending on cultivar, previous research has shown that smaller branches can be damaged or killed at temperatures below 22° F (-6 ° C), and larger branches and entire trees may be killed at temperatures below 15° F (-9° C) (Sibbett and Osgood, 2015). The stage of dormancy, preceding temperatures, and freeze duration are factors in winter freeze damage. Additionally, it is possible that cold temperatures could affect floral differentiation, which is thought to occur between December and February in California (Fabbri and Benelli, 2000), but is still undetermined in Oregon and needs to be a subject for future research. Winter cold damage as discussed above should not be confused with spring frost damage, which is a risk in warmer growing regions. In warmer regions, olives may flower in early spring when there is still a risk of frost, which can damage bloom. In Oregon, olives do not bloom until June, when risk of frost has passed. Even if temperatures do not drop below freezing, frost below 55° F (13° C) during bloom can slow bloom and/or destroy flowers, negatively impacting fruit set and yield (Sibbet and Osgood, 2015).

Site Selection and Preparation

Temperature and Microclimate

The most important site selection factor in Oregon is extreme winter low temperatures and their duration during winter, while a grower can also consider average temperatures during the key developmental stages of floral differentiation and bloom. Temperatures can vary significantly across small acreages, particularly with changes in elevation, where low spots can trap pockets of cold air. Tracking orchard site temperatures for multiple seasons with low-cost environmental sensors will greatly facilitate site selections. Cold-protection methods such as fans, overhead irrigation, or smudge pots (have not been used in Oregon olive production and, while their efficacy is unknown, the cost may be prohibitive). Additionally, these methods may not be viable strategies for preventing cold injury to shoots and leaves when temperatures drop below 22° F for longer periods, as they are unable to raise the temperature enough to make a difference. Wind patterns also impact site selection, as trees exposed to extreme winds need trellises, posts or stakes.

Irrigation and Soil Drainage

After microclimate, access to irrigation—or the ability to set up a temporary irrigation system—is the second most important site selection factor. Even though western Oregon is cooler and wetter than California's olive production regions, preliminary research in this region's heavier soils still suggests that young olives establish best with irrigation. The suggested drip irrigation systems should be installed prior to planting the orchard. Fall and winter rains are not sufficient to establish the crop by themselves. Preliminary results show that the fall, winter, and spring soil water storage is not sufficient for young, newly established trees during the extended dry summers and they may begin to show water stress by the following July. Water sources need to be tested for quality and chemistry. High levels of boron (>2ppm), bicarbonate (>3.5ppm), and total salts (>3dS/m EC) may cause problems in olive production, though this is unlikely to be an issue in Oregon (Vossen and Ravetti, 2019). The third site selection factor is soil drainage, as olives do better on well-drained soil. Soils with a shallow hardpan that does not allow for drainage will produce saturated conditions that negatively impact plant establishment, limiting root growth and increasing the possibility of root rot (Frey and Davis, 1981). A soil penetrometer can be used to determine the hardpan depth prior to tillage. If a hardpan is found, options include plowing deeper to break the hardpan, or installing a tile drain to drain the water. Preliminary research has shown that raised beds may also be used to mitigate drainage issues. Bed shaping options will be discussed below.

Soil pH

Olives evolved on alkaline and calcareous soils (Vossen and Ravetti, 2019), unlike the acidic soils of our region. Olives are stated to tolerate a wide end range of soil pH (5 and 8.5), which include western Oregon's more acidic soils; however, agricultural lime applications can raise the pH to the preferred range of 6.5 to 7 (Anderson et al., 2013; Vossen, 2007b) . Before a fall lime application, test the pH to determine the amount of lime required, then apply the lime soon enough to ensure it has time to react with the soil before beginning fertilizer applications the following spring. Soil should be tested by collecting multiple soil cores at a depth of one to two feet. Multiple, sequential annual fall lime applications are best, as it can take years to change soil pH. As the orchard matures, monitor annually or every other year to determine the need to re-apply lime. Fall liming an established orchard can be done by side dressing along the rows, and should be incorporated into the soil for the greatest efficacy (Anderson et al., 2013).

Cover Cropping and Soil Preparation

The orchard site should be cover cropped in the fall/winter before establishing olives, as this practice may provide benefits such as the improvement of soil structure and addition of nitrogen and organic matter. Cover crops may also help prevent soil erosion, which is a risk in sloped plantings (Gómez et al., 2009). The cover crop should be flailed (chopped) and tilled in during soil preparation prior to planting. Depending on soil texture, how recently the field has been cropped, or the presence of a hardpan layer as discussed above, soil may need more or less tillage. Western Oregon's olive production regions have silt or clay loam soils, which are heavier than California's loamy clay or sand soils, suggesting more tillage may be required here.

Figure 1 (above): Planting with raised beds. Figure 2 (below): Planting on flat ground with cover cropped aisles. Photo credit: Tessa Barker, Oregon State University.

Bed Shaping and Orchard Floor Management

Olives may be grown on raised beds or on flat ground (Figs. 1 and 2). Field observations suggested that raised beds facilitate soil drainage, while flat-ground plantings may impede it, with water pooling during heavy rain events. There are multiple options for orchard floor management in-row including organic mulch, geotextile woven plastic mulch (weed mat), bare soils, or a cover crop and perennial grass planting. Between tree rows, a permanent grass groundcover or a rotational cover crop will prevent erosion and protect the soil. Each choice entails different weed management strategies.

Planting Season

The best time for planting an olive orchard in Oregon—fall or spring—is being investigated (Fernandez-Salvador and Barker, unpublished data). Spring planting, when irrigated, allows more time for root and foliage growth and development before the winter. A fall planting may expose unhardened trees to colder winter conditions quicker.

Cultivars and Pollination

Cultivar Suitability

Among the multiple olive cultivars, few may be suited to Oregon's climate. Cultivars thought to be cold-tolerant in the warmer growing regions of Spain, Italy, California, and Australia may be susceptible to cold damage during Oregon's winters (Gómez-del-Campo and Barranco, 2005).

Early western Oregon orchards were established with 'Arbosana', 'Arbequina', and 'Koroneiki'—cultivars tolerant to California's winter temperatures. Losses in some orchards planted with these cultivars ranged from 25-100% (Fernandez-Salvador and Barker, unpublished data). As a result, later orchards and replants at older orchards used the central and northern Italian cultivars 'Frantoio', 'Leccino', 'Moraiolo', 'Santa Caterina', 'Maurino', and 'Pendolino' and French cultivars 'Aglandau,' 'Cailletier,' and (Fernandez-Salvador and Barker, unpublished data). The OSU Olea Project is years away from being able to recommend cultivars suitable for Oregon's climate. However, based on grower surveys, currently the five most grown cultivars are 'Arbequina' (trees that have survived from original plantings in some sites), 'Aglandau', 'Frantoio', 'Leccino', and 'Pendolino' (Fernandez-Salvador and Barker, unpublished data) (Fig. 3). Growers purchase container trees from California nurseries, as there are no large-scale Oregon nurseries propagating Tuscan or French cultivars (Fernandez-Salvador and Barker, unpublished data).

Pollination

Olives are wind pollinated (Vossen and Ravetti, 2019). They are generally not self-fertile, but rather self-incompatible, meaning they often require another cultivar nearby for successful pollination. There are a few exceptions; 'Frantoio' is self-fertile (Farinelli and Tombesi, 2004). Orchards should include a selected cultivar's preferred pollinizers either interspersed within the primary cultivar or planted as full rows. The latter facilitates single cultivar oils. As with cultivars, pollinizer cold hardiness must be considered: 'Pendolino' or 'Sevillano' are more susceptible to winter cold damage than other cultivars (Denney et al., 1993) and may not survive Oregon's winters.

Figure 3. Cultivars clockwise from top left: 'Arbequina', 'Aglandau', 'Leccino', and 'Frantoio'. 'Arbequina' was initially the most widely-planted cultivars in the state, as it was thought to be less vulnerable to winter cold damage. However, many growers are now replacing cold-damaged 'Arbequina' with the Tuscan ('Leccino' and 'Frantoio') and French ('Aglandau') varieties (Fernandez-Salvador and Barker, unpublished data). Photo credit: Tessa Barker, Oregon State University.

Up-Potting and Overwintering in Protected Culture

Before field planting in Oregon, olive trees may benefit from overwintering in protected culture for one or more years, allowing them to reach an age/size that is less susceptible to cold damage. A current study is evaluating the optimal age/size of olive for orchard transplanting.

Trees may be purchased as one-year-old, single leader plants, typically one-foot tall in 4- or 6-inch pots, with trunks roughly the diameter of a pencil. These trees can be transplanted/repotted into one-gallon pots, kept in a protected structure for one or more years, and repotted into successively larger pots each year (Fig. 4). Plants should be kept in the protected structure from late fall to spring until the risk of freezing temperatures has passed, and then promptly moved into a structure with increased ventilation, as temperatures can increase rapidly in the spring. Potting media moisture should be monitored year-round to prevent drying out or saturation. Sprinkler irrigation can be uneven, so unless each pot is fitted with its own emitter, all trees should be periodically checked by weight to assess moisture levels. Pots that have become overly dry should be fully submersed in a bucket of water, as potting media can become hydrophobic, repelling water.

Figure 4. Plastic pot sizes used in our up-potting trial: A) year 1, 0.74 gal/2.8 L; B) year 2, 2.56 gal/9.7 L; C) year 3, 6.04 gal/22.9L. Often referred to as #1 deep, #3 deep, and #7 deep, respectively." Photo credit: Cora Bobo-Shisler.

Overwintering structures can be simple or complex, with options ranging from passive greenhouse/hoop houses, to climate-controlled greenhouses. The current Olea Project research project utilizes a 72′ x 10′ double-wall insulated passive hoop house (Fig. 5), with sprinkler irrigation and emergency backup heaters for nights when temperatures are forecast to drop below 24° F. Even on relatively cold nights (daily low of 25° F), without the heater on, the hoop house maintains a temperature at or above 30° F.

Figure 5: Greenhouse for overwintering. Photo credit: Tessa Barker, Oregon State University.

Soil Fertility and Plant Nutrient Requirements

Fertilizer requirements of newly established orchards differ from those of mature orchards. In young orchards, fertilizer is needed primarily to support vegetative growth, while in mature, productive orchards, nutrients are needed to support both fruit production and tree growth. Nutrient requirements are a function of tree size and bearing status, which is in turn a function of microclimate. Currently, there are no Oregon-specific fertilizer recommendations for either immature or mature olive orchards. General guidelines from California recommend 40-100 lb N/acre/year for mature orchards in a split application with 50% applied March-April, and 50% in June (Vossen, 2007b; Vossen and Ravetti, 2019). A rough guide for young trees is 50 lb N/acre as a maximum amount for trees planted at a 10 ft x 10 ft density (assumes 450 trees per acre) (Barker, personal communication with P. M. Vossen). These amounts and application dates should all be adjusted to reflect the different climate, orchard site soil nutrient availability, shorter growing season, and differing timeline of plant development. The Olea Project is not currently studying fertilizer rates and timing; however, we have found that the 50 lb N/acre/year, split between spring and summer applications, has resulted in leaf nitrogen levels within recommended levels for California (Fernandez-Salvador and Barker, unpublished data). Higher nitrogen rates and late summer applications are inadvisable, as olives have a slower growth rate in this climate, and higher amounts of nitrogen available late in the season may lead to new growth that will be damaged in the fall and winter.

Nutritional needs of a newly established organic olive orchard may be met with a combination of cover cropping and compost additions as well as solid and liquid fertilizer applications. Use of a legume cover crop prior to orchard establishment may provide considerable initial nitrogen. The OSU Cover Crop Calculator is a digital tool that can be used to get a more accurate estimate of the nitrogen provided by organic inputs (Sullivan et al., 2019b). In-season soil nitrate testing may be used to monitor current-season N mineralization and availability, and may help in adjusting fertilizer rates (Sullivan et al., 2019a).

As stated earlier, yearly soil and tissue testing is recommended for orchards of any age. While soil nutrient levels are helpful for assessing pH, and therefore nutrient availability, tree nutritional status, macro and micronutrients, are best measured through tissue testing. California guidelines state that leaves should be collected in July from the base to the middle portion of the current season's growth on a non-fruiting shoot. Leaves should be separated by cultivar (Lazicki and Geisseler, 2016). California's leaf levels are a useful guideline: 1.5-2% N; 0.1-0.3% P; greater than 0.80% K and 19-150 ppm B. However, these levels need to be calibrated for Oregon production systems (Vossen, 2007b). Fertilizer rates for mature, producing orchards will need to take into account soil and tissue test results, the amount of nutrients removed with harvested fruit, and biomass removed by pruning (Vossen and Ravetti, 2019). Finally, as you get closer to fruit production, you will want to be sure to monitor boron levels, as this micronutrient is crucial for fruit set. Micronutrient supplementation is only permitted in organic systems when there is a documented deficiency, such as deficient soil or leaf tissue nutrient levels (National Organic Program §205.601).

Irrigation and Water Requirements

Future research will address irrigation for olive production in Oregon. Irrigation requirements can be based on evapotranspiration (ET) calculations that incorporate expected crop water use and a crop coefficient. The best way to irrigate young orchards is to apply between 125–625 mL via a drip system per day, per tree, from May through September. This is based on ET-predicted crop water use and adjusted based on field observations and weekly soil probing for manual moisture determination. Sprinkler irrigation systems may be used, but drip is more precise, efficient, reduces water loss to weeds, and facilitates liquid fertilizer injection.

Weed Management

Organic weed control options will depend upon use of a weed barrier such as an organic or plastic mulch weed mat, and the weed population. Orchards with organic mulches will need to be hand-weeded periodically to remove weeds at the base of the trunk, as well as those that grow through the mulch. Organic mulches will also need to be reapplied every other year, requiring additional cost and labor. In plastic mulch/weed mat systems, the greatest problem areas for weeds are in the opening of the weed mat, near the tree trunk, and along the edges of the weed mat, where use of a string trimmer or mower would damage the weed mat. Organic herbicide options include soap-based products and products containing caprylic and capric acid, acetic acid, and eugenol. Most are post-emergent, contact, and non-selective. In general, organic weed control options work best when applied early (in terms of weed growth stage) and often. As with any product, consult your organic certifier and state/local regulations before use of any new product, and follow label instructions for application rate and the personal protective equipment required for applicators.

In planting systems without weed mat, the greatest area of concern for weeds is also around the trunk of the tree. Clearing a square of around 2 ft x 2 ft centered on the tree can help eliminate weed competition for water. Another option is in-row cultivation between trees, which would be possible in systems with cover cropped aisles, or alternatively, cultivation of both in-row and between-row areas.

Pest Control

In Oregon, olives currently have few pests. The olive fruit fly (*Bactrocera oleae*), a major pest found throughout California olive production regions (Zalom et al., 2009), has not yet been detected in Oregon. It may not survive the colder winters. Branch and twig borers (*Melalgus confertus,* see Fig.6 for borer damage), black scale (*Saissetia oleae*) and leaf-roller (tortricid family) caterpillars have all been encountered in Oregon olive orchards. However, neither impact, range, or control methods have been determined. Vertebrate pests such as rodents, rabbits, and deer may also damage olives, though the extent has yet to be determined.

Figure 6: Twig Borer Damage: See arrow. Photo credit: Javier Fernandez-Salvador, Oregon State University.

In terms of pathogens, olive knot (*Pseudomonas savastanoi* pv.*savastanoi)* is common in California, but has not yet been identified in Oregon (Fichtner, 2011). *Xylella fastidiosa*, the bacterial infection devastating European orchards, has not been detected in Oregon's olive orchards (Abbott, 2018). Olive Peacock Spot, a fungal disease (*Spilocaea oleaginea*) has been identified. Most olive pests and diseases flourish in humid conditions. Depending upon seasonal precipitation and relative humidity, Oregon's olive orchards may develop foliar fungal and bacterial diseases.

Organic Certification

Growers wishing to certify their orchards as organic can either manage their fields organically from the start, or establish the orchard with conventional practices followed by a three-year transition to organic practices. Organic certification requires that growers not only avoid prohibited practices and substances, but also regulates production practices related to plant material sourcing, soil and fertility management, and weed, pest, and disease management. Farm managers intending to seek certification should maintain complete documentation of all plant materials, orchard inputs, and pesticide usage, as well as records stating previous land use and last date of the application of any prohibited substances.

IMPORTANT: Before using **any** pest control product in your organic farming system:

1. Read the label to be sure that the product is labeled for the crop and pest you intend to control, and make sure it is legal to use in the state, county, or other location where it will be applied.
2. Read and understand the safety precautions and application restrictions.
3. Make sure that the brand-name product is listed in your Organic System Plan and approved by your USDA-approved certifier. If you are trying to deal with an unanticipated pest problem, get approval from your certifier **before** using a product that is not listed in your plan—doing otherwise may put your certification at risk.

Note that, although OMRI and WSDA lists are good places to identify potentially useful products, all products that you use **must** be approved by your certifier. For more information on how to determine whether a pest control product can be used on your farm, see the related article, Can I Use This Input On My Organic Farm?

Acknowledgements

This material is based upon work that is supported by the USDA National Institute of Food and Agriculture under award number 201207-549 through the Western Sustainable Agriculture Research and Education program under subaward number SW18-057. USDA is an equal opportunity employer and service provider.

Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the view of the USDA.

References and Citations

- Abbott, A. 2018. Deadly olive-tree disease spreads. Nature 563:306—307. (Available online at: https://media.nature.com/original/magazine-assets/d41586-018-07389-8/d41586-018-07389-8.pdf (verified 30 Dec 2020).
- Anderson, N. P., J. M. Hart, D. M. Sullivan, N. W. Christensen, D. A. Horneck, and G. J. Pirelli. 2013. Applying lime to raise soil pH for crop production (Western Oregon). OSU Extension Publication, EM 9057.

(Available online at: https://catalog.extension.oregonstate.edu/em9057) (verified 30 Dec 2020).

- Denney, J. O., G. C. Martin, R. Kammereck, D. O. Ketchie, J. H. Connell, W. H. Krueger, J. W. Osgood, G. S. Sibbett, and G. A. Nour. 1993. Freeze damage and coldhardiness in olive: Findings from the 1990 freeze. California Agriculture, 47(1), Special. (Available online at: http://calag.ucanr.edu/Archive/?article=ca.v047n01pS1#Calag-Authors) (verified 30 Dec 2020).
- Fabbri, A., and C. Benelli. 2000. Flower bud induction and differentiation in olive. Journal of Horticultural Science and Biotechnology, 75:131&Mdash;141. (Available online at: https://doi.org/10.1080/14620316.2000.11511212 (verified 30 Dec 2020).
- Farinelli, D., and A. Tombesi. 2004. Self-sterility and cross-pollination responses of nine olive cultivars in Central Italy. Acta Horticulturae 791:127—136. (Available online at: http://www.actahort.org/books/791/791_16.htm (verified 30 Dec 2020).
- Fichtner, E. J. 2011. Olive knot [Online]. UC Statewide IPM Program, University of California, Davis, CA. Available at: http://ipm.ucanr.edu/PMG/PESTNOTES/pn74156.html (verified 30 Dec 2020).
- Frey, L. S., and W. B. Davis. 1981. Garden and landscape plantings on hardpan soils. UC ANR Environmental Horticulture Notes, EHN 53. (Available online at: http://sacmg.ucanr.edu/files/163130.pdf) (verified 30 Dec 2020).
- Gómez-del-Campo, M., and D. Barranco. 2005. Field evaluation of frost tolerance in 10 olive cultivars. Plant Genetic Resources: Characterization and Utilization 3:385—390. (Available online at: https://doi.org/10.1079/PGR200592) (verified 30 Dec 2020).
- Gómez, J. A., M. G. Guzmán, J. V. Giráldez, and E. Fereres. 2009. The influence of cover crops and tillage on water and sediment yield, and on nutrient, and organic matter losses in an olive orchard on a sandy loam soil. Soil and Tillage Research, 106:137—144. (Available online at: https://doi.org/10.1016/j.still.2009.04.008) (verified 30 Dec 2020).
- Lazicki, P., and D. Geisseler. 2016. Plant tissue sampling in orchards and vineyards. University of California, Davis. (Available online at: https://apps1.cdfa.ca.gov/FertilizerResearch/docs/Orchard_Tissue_Sampling (verified 30 Dec 2020).
- Rockey, C. 2017. Portland daily temperatures [Online]. Available at: https://www.wrh.noaa.gov/pqr/pdxclimate/pg6.pdf (verified 30 Dec 2020).
- Sibbett, G. S., and J. Osgood. 2015. Site selection and preparation, tree Spacing, and design, planting, and initial training (Chapter 5). *In*: G. S. Sibbett, L. Ferguson, J. L. Coviello, and M. Lindstrand (eds.) Olive production manual, 2nd ed. University of California Agriculture and Natural Resources, Richmond, CA.
- Sullivan, D. M., N. Andrews, A. Heinrich, E. Peachey, and L. J. Brewer. 2019a. Soil nitrate testing for Willamette Valley vegetable production. Oregon State University Extension Service (EM 9221). (Available online at: https://catalog.extension.oregonstate.edu/sites/catalog/files/project/pdf/em9 (verified 30 Dec 2020).
- Sullivan, D. M., N. Andrews, C. Sullivan, and L. J. Brewer. 2019b. OSU organic fertilizer and cover crop calculator: Predicting plant-available nitrogen. Oregon State University Extension Service (EM 9235). (Available online at: https://catalog.extension.oregonstate.edu/em9235/html) (verified 30 Dec 2020).
- Vossen, P. 2007a. Olive oil: History, production, and characteristics of the world's classic oils. HortScience 42:1093—1100. (Available online at: https://doi.org/10.21273/hortsci.42.5.1093) (verified 30 Dec 2020).
- Vossen, P. 2007b. Organic olive production manual. UCANR Publication 3505, University of California Agriculture and Natural Resources.
- Vossen, P., and L. Ravetti. 2019. Olive growing for oil course handbook. UC Davis Olive Center at the Robert Mondavi Institute.

Published January 15, 2021