Berry Crops and Flooding

Parts of the Pacific Northwest experienced significant flooding in late Fall 2021 with some farms experiencing standing water in their fields for weeks. Questions are surfacing about the impacts of flooding on berry crop production and what to expect in 2022. Below is a list of questions and responses by regional experts to aid in planning for the upcoming production season.

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What are the impacts of flooding on berry crops?

Dormant berry plants are relatively tolerant of flooding. Many plants were acclimating or close to peak endodormancy (coincident with leaf drop) when flooding started in Nov. 2021, so the likelihood of plant death due to flooding was at a minimum. However, root respiration will be reduced due to flooding given oxygen diffusion to root systems is limited when submerged in water. This can result in anaerobic conditions where free oxygen is absent. Oxygen demand and root respiration is lowest when plants are dormant, but some yield declines may occur the following year in fields with prolonged flooding. Extended flooding (>1 week) will likely lead to progressive and cumulative root damage, increasing with duration of flooding and the proportion of root damage being greater in young plants versus older ones. Furthermore, flooded plants with buds submerged in water may also experience damage given respiration in these aboveground tissues will also be limited. Bud damage is expected to be more severe for younger plants given a greater proportion of these plants are under water. Note that any period of flooding can be detrimental when plants are actively growing and have higher demand for oxygen for growth and metabolism.

Are there diseases or pests to be more concerned about after flooding?

Risk of Phytophthora root rot will be greater in fields with previous medium-to-high root rot pressure. Risk is low to negligible in fields with low root rot pressure or no history of root rot. Phytophthora is active at lower temperatures in the fall, so activity in winter is reduced.

Modifications to fungicide application strategies post flooding will depend on the original history of root rot in a given field, plant age (younger, recently planted plants will fare worse than older, established plants), and how long the soil was saturated. For fields with medium-to-high root rot history, proactive disease management should pre-empt potential deterioration of the aboveground plant parts arising from a compromised root system. Root rot fungicide applications should be considered when conditions permit, but growers should be careful about applying fungicides when the soil is saturated because this will dilute the fungicide and decrease its effectiveness. Furthermore, wait to apply fungicides until just before root growth resumes in the spring, which coincides with bud swell. Applications made before root growth have a greater likelihood of leaching away during the winter as precipitation continues. Rotations of fungicide products should include metalaxyl, oxathiapiprolin, and phosphites (e.g., Orondis, Ridomil Gold, and Fosphite products). As always, double-check labels prior to application.

Risks from other diseases are largely unknown as there is minimal research published on the subject. Flooding may introduce plant pathogens from other areas and physiological stress from flooding may weaken plants, increasing their susceptibility to disease. Regular scouting for diseases and pests will be important so appropriate and timely management steps can be taken.

Flooding can also introduce new weeds into fields that were not previously present. Seeds and perennating plant parts can be carried long distances by water, deposited into fields, and become established. Changes to herbicide programs to address these new weeds may be needed. It is recommended to monitor fields frequently for these changes, particularly next spring and summer. Additionally, pre-emergent herbicides that are applied in the fall will become ineffective or less effective in fields with standing or flowing water, leading to more annual weeds this winter.

Are there concerns related to existing or new nematode populations after flooding as it relates to future root decline?

The impact of flooding may have had positive or negative impacts on plant-parasitic nematodes. Flooding has the potential to cause anaerobic conditions in soil, or the absence of free oxygen. Like all animals, nematodes require oxygen to survive. Therefore, flooded soil can be detrimental to the survival of nematodes. In fact, anaerobic soils have been proposed as a means to control nematodes in places such as the Netherlands where soils are purposefully flooded for prolonged periods to control nematodes and other soilborne pathogens. However, it is unclear if the duration of the flooding in Washington and British Columbia resulted in conditions detrimental to nematodes (or other plant pathogen for that matter). Another potential outcome of the flooding was the movement of nematodes across the landscape. At the field level, this might not be important due to the widespread distribution of nematodes within infested fields. However, if flooding expanded beyond an individual field, there is a high likelihood that these aquatic organisms could have moved to adjacent fields if flooding was extensive. No plant-parasitic nematode management practices are recommended in response to the flooding. Continue with routine monitoring of plant-parasitic nematode populations to

inform management approaches in your fields. Note that spring sampling tends to underestimate nematode densities compared to late summer sampling.

If there are dairies or other livestock operations near farms, is there concern about food borne illness from transported manure?

The risk of food-borne illness due to contamination of berry fields with fecal matter from livestock operations is minimal if there are several months between flooding and harvest. In other words, it is unlikely that potential food-borne pathogens will survive being exposed to the environment between the time of flooding and berry crop development in the 2022 season. Depending on the certification program, guidelines range from 4 to 6 months between manure application and harvest. Farms in the region are outside of that timeframe and therefore food-borne risks are minimal. However, it is advised growers confirm the specific requirements of their certifier or auditor as well as their packer or processor. A greater concern is contamination from industrial chemicals and potential harvest contaminants that may have entered the flood waters and carried to the farm. Impacts of this will likely be site-specific.

How will bee pollinators be impacted?

Beekeepers that set up their wintering yards in flooded areas are expected to have high colony losses. The impact on colony supplies for blueberry pollination in 2022 is expected to be minimal, however, given that most of the honey bees that pollinate Pacific Northwest fields are imported from outside the region. It is still recommended that growers contact their beekeeper and determine whether they have had flood damage and whether they expect to have trouble fulfilling their contracts next spring. Native bees provide a smaller, although in some locations, significant level of pollination. Most wild pollination comes from bumble bees and solitary ground nesting bees. Both groups of bees can overwinter in the ground and are expected to suffer losses due to flooding, although bumble bees typically have large dispersal ranges, and fields will likely be repopulated in the spring from areas not flooded. In large open flood plains, this may take longer than areas with more varied terrain. In contrast, ground nesting solitary bees, like spring mining bees in the Family Andrenidae, take a few years to build populations back up. Last year's drought and heat is expected to impact the overall health of bees, however, so bounce backs in honey bee stocks and native bee populations may largely depend on climatic conditions this spring.

What about the impacts of flooding on soils?

Submergence in water is well-understood to decrease soil aggregation. In fact, the most common tests to measure aggregate stability involve submerging a soil aggregate in standing water (the slake test) or repeated submergence of a soil sample (wet-sieving). Under laboratory conditions, short-term (14-day) flooding has been shown to decrease the aggregate stability of soils by up to 21%[1], which is likely to have meaningful impacts on infiltration, runoff, and

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[1] De-Campos et al. **Short-Term Reducing Conditions Decrease Soil Aggregation**. *Soil Science Society of America Journal*, 2009; 73 (2): 550 DOI: 10.2136/sssaj2007.0425

[2] Liu et al. **Disentangling the effects of edaphic and vegetational properties on soil aggregate stability in riparian zones along a gradient of flooding stress**. *Geoderma*, 2021, 385, 114883. https://doi.org/10.1016/j.geoderma.2020.114883

erosion. Likewise in field studies, negative effects on aggregate stability were greater as flooding intensity increased (measured as the proportion of flooded days to total days).[2] In addition to the effects of decreased soil aggregation on water movement into and within the soil profile, floodwaters typically contain substantial amounts of suspended sediments, mostly clay-sized particles. The deposition of these clays, while an important soil-forming process, may clog pores on the soil surface and create a layer of reduced hydraulic conductivity, thereby reducing water infiltration. Most management practices to improve infiltration and soil aggregate stability, such as cover cropping and application of soil amendments composed of organic matter, are longer-term investments. For blueberry plantings grown on raised beds with grassed alleyways, the impacts of flooding on infiltration and soil aggregation are likely to be less severe and may not require any action. However, in raspberry fields with bare soil in the alleyways, mechanical ripping or chiseling may provide pathways for water movement through a limiting surface layer, providing that it is done at the right soil moisture content in order to avoid causing further deterioration of soil structure. Practices like cover cropping, which create channels for water movement along living and decaying roots, may also help increase water movement through a limiting surface layer.

What should growers do to recover as floodwaters recede?

Stay alert of disaster aid relief. Berry crop commissions/councils and local extension specialists should be able to connect growers with aid options as they become available.

Repair field damage and carefully consider options for managing plants that have been uprooted or that have some of their roots exposed due to erosion. Depending on the age of the planting, duration of flooding, and degree of uprooting and/or root exposure due to erosion, replacing plants may be more practical than trying to re-establish severely affected plants. For example, a new planting with significant uprooting/erosion may be repairable by simply returning plants to their original locations and covering the roots with soil and mulch. In contrast, a mature plant that has been uprooted may have sustained sufficient damage to the root system to warrant replacement, while less severe erosion from the top of the root system may be repairable. Caring for uprooted plants in pots or temporarily healing them in with soil or sawdust is a good option for taking care of plants while beds are reshaped and prepared for replanting. In general, replacing soil and mulch to ensure roots do not remain exposed at the time of bud break should be a priority and should also take into consideration replacement of lost nutrients to meet crop requirements for the following season.

The basics of nutrient and irrigation management plans for 2022 may be largely unaffected if erosion is not excessive. The exception to this is for granular fertilizers (e.g., P and K) applied in fall 2021. These fertilizers will have been lost due to flooding and should be reapplied in the spring. In situations where erosion is more substantial, the loss of several years of lime applications may have occurred, meaning that long-term pH management plans should be re-evaluated via soil sampling prior to the 2022 season and routine tissue testing during the season. When warmer and drier weather occurs, plants most afflicted by the flooding will show signs of vascular stress due to root damage. Carefully monitor those plants and minimize

stresses by following good horticultural practices and ensure that supply of irrigation water is not limited as plants recover from root damage.

Pruning should be modified based on the age of the plant as well as the duration and severity of flooding in a particular field. Changing pruning practices in fields that are mature and experienced <1 week of flooding is not recommended. In fields with >1 week of flooding, some level of root damage is expected and plants should be pruned hard during the dormant season to encourage new root growth and more vigorous shoot growth the following year. Harder pruning will also result in a lighter crop, relieving the burden from damaged root systems and facilitating plant recovery through encouraging root and shoot growth. Younger plantings should be pruned even harder if exposed to flooded conditions for >1 week, given the proportional damage to root systems and buds is expected to be greater than for larger plants.

Information on how diseases and pests are impacted by flooding is minimal. Closely monitor for diseases and pests given flooding may increase the risk of certain diseases like root rot among susceptible species and/or cultivars.

The flooding experienced in the region was exceptional, and the full extent of the damage will not be known until late spring. Furthermore, many of the areas impacted by flooding also experienced heat stress due to the summer heat dome. As a result, it may be difficult to attribute observed plant problems to heat or flood stress.

In addition to your regional extension experts and consultants, the individuals below may be contacted if you have further questions:

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