Use of Tile Drainage in Massachusetts Cranberry Production

This fact sheet is a summation of knowledge gained during research and outreach from 2012 through 2016. The work was undertaken with USDA funding through the Northeast Region SARE (Sustainable Agriculture Research and Education) Program, Project LNE 12-316.

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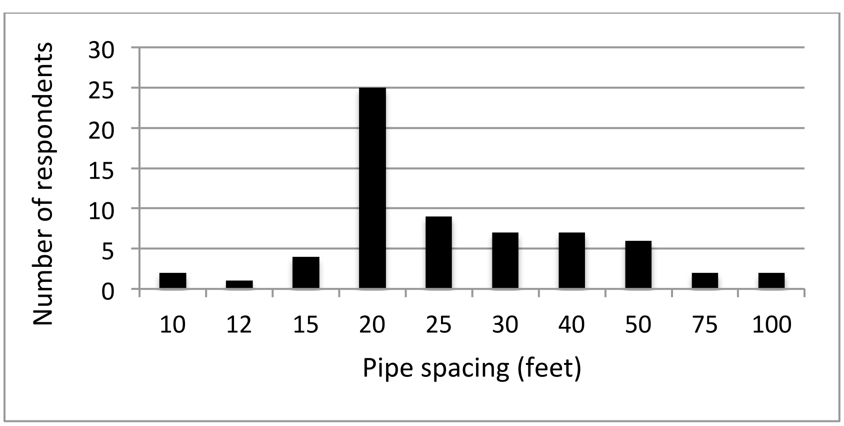
The project consisted of field studies (tile spacing, tile depth, tile function) and grower outreach (interviews, surveys, educational sessions, on-farm workshops). As part of the grower outreach, experiences were gathered and compiled into a best practices checklist. Below, we describe the information that resulted from this project and was used to produce the cranberry tile drain best practices document.

Tile spacing (horizontal):
The consensus of the advisory group was that 20 feet is the best spacing. The use of this spacing as an industry-wide preference was confirmed by the results of our initial 2012 survey (shown) and subsequent grower surveys.



Replicated research at sites with differential spacing (2011 and 2012) found that 15-foot spacing was associated with lower yield compared to spacings of 20, 25, or 30 feet. Since there was no yield or fruit quality differences among the 3 wider spacings, growers could choose among them based on logistical and financial considerations. Many have found that a 20-foot spacing is well suited to 40 x 50 sprinkler layouts.

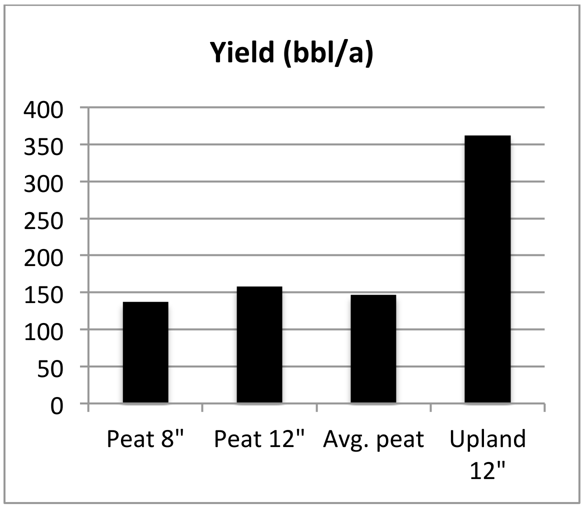
Tile depth (vertical spacing):

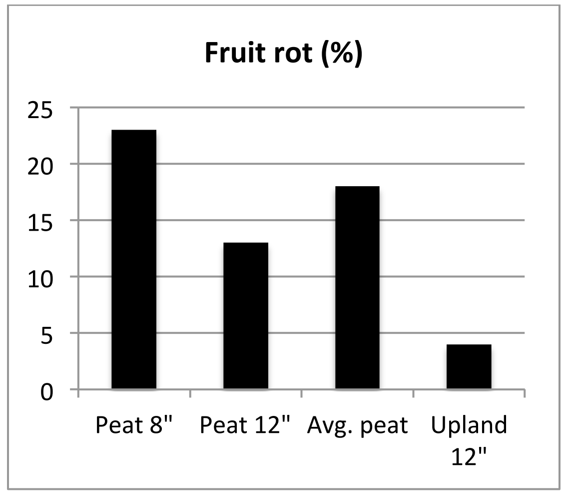
There is much less consensus regarding ideal depth for tile placement. Considerations that could affect choice of depth include sand texture, makeup and depth of subgrade, and depth to water table. The advisory group agreed that in the case of a new planting, a 12-inch depth to tile bottom (the tile is 4-inches in diameter) is commonly chosen. However, in a renovation or retro-fit (putting tile into an existing bed) situation, they were most concerned that the bottom of the tile was in the sandy layer of the bed, not in the underlying peat or muck - thus many use a shallower depth. Some use a 'keyhole' design, digging a trench into the subgrade to hold the tile, when renovating, if the sand layer on the bed will not be 12 inches deep. The trenches are filled and then the tile is installed over the trench, so that even if the tile is in the subgrade, it is surrounded by sand.

Trenching in a keyhole for tile in a renovation.

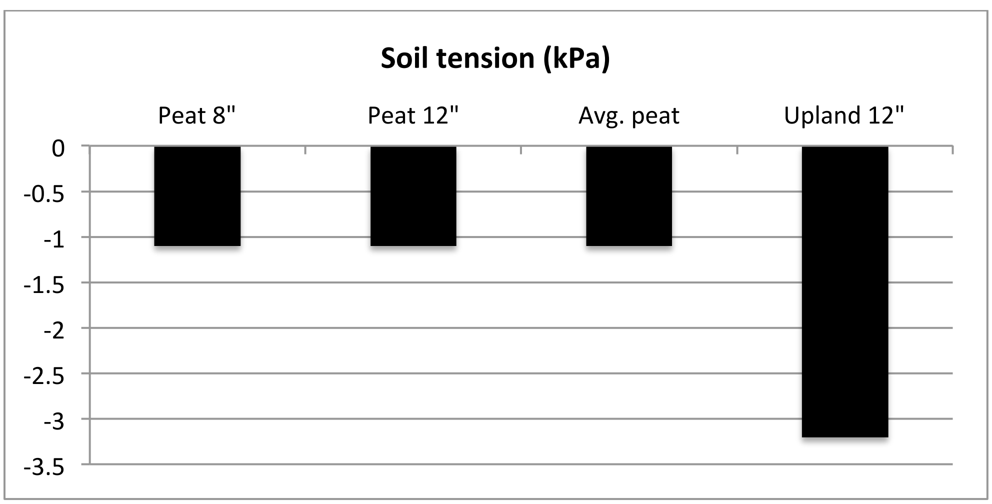
Finished grade showing tiles extending out of keyholes.

Since there was less certainty regarding the correct depth for tile placement, we designed a replicated depth experiment on a bed being renovated to 'Stevens'. The pictures above show the installation of tile drains in keyholes at two depths - 8 and 12 inches from the surface to the bottom of the tile. All drains were spaced at 20 feet with 3 tiles of the 8-inch depth alternating with 3 tiles of the 12-inch depth, so that there were 6 groups for each depth. This installation was done so that we could study response of the plants over the tiles at those depths as well as monitor the impact of tile depth on soil moisture. In the first crop year (2014), yield and fruit quality was better in the areas of the bed with the deeper tiles and those areas had more negative soil tensions (they were drier). However, the following year (data below), there was no difference in yield or soil tension between the two tile depths, while rot remained greater in the area with the shallower tiles. At this same site, there was an upland bog with 12-inch tile depth, renovated to 'Stevens' two years prior to the wetland bed renovation. In 2015, yield and fruit quality on this bed was substantially better than that on either treatment in the other bed.

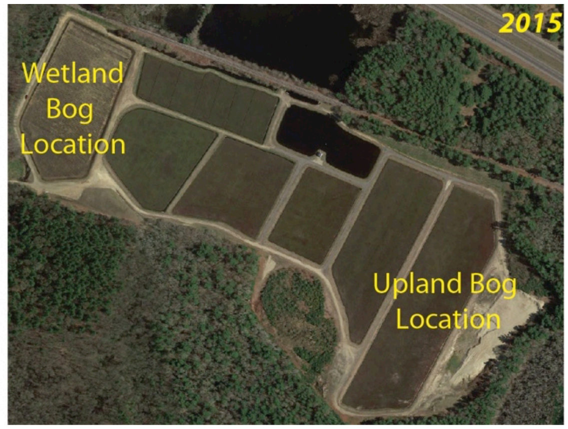




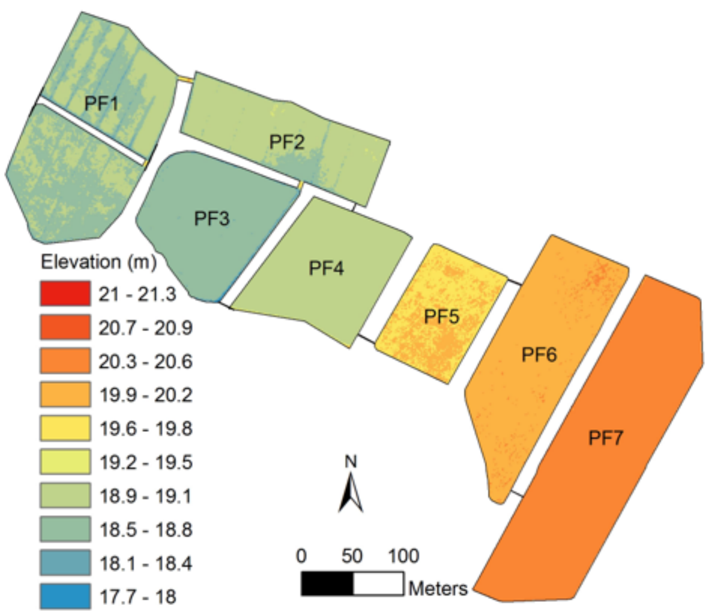
The upland bed also had much drier soil (more negative average tension over a four-week period in late summer).



The two beds being compared were at opposite ends of the bog system.



Based on NRCS soil maps, we assumed that the study bed, with tiles placed at differential depths (marked at Wetland Bog in the aerial views), was underlain by peat and that this peat layer was responsible for the wetter conditions compared to the Upland Bog at the other end of the system. However, when we tried to confirm the differences in subgrade using ground penetrating radar, we found that while a small area of the wetland bog was underlain by peat, most of that bed, as well as the upland bog, were underlain by a layer of glacial lake depositional material, a silty layer. Since the two beds have similar subgrade materials and since the entire system is irrigated as one, why is the 'wetland' bog wetter than the upland bog?



Surface elevation relative to sea level at the study site. PF1 (Wetland Bog) is the bed with differential tile depth, PF7 (Upland Bog) is the comparison, upland bed.

Differences in surface elevation may provide the explanation. The elevation of the upland bed is higher than that of the wetland bed so water drains towards the wetland bed, which is also closer to the water table. So adding the same amount of irrigation to the two beds will result in a wetter soil in PF1, as we saw in this study. Depending on the year and environmental conditions, this may overshadow any differences between the two tile depths. However, even with these factors in play, we did see better fruit quality at the 12-inch depth in the wetland bed in both 2014 and 2015, compared to that in at the 8-inch depth. While this study was somewhat confounded by hydrologic factors (drainage direction due to elevation and water table), there is a good indication that better drainage is associated with better fruit production and quality. It is also obvious that drainage does not operate in a vacuum - irrigation and water table depth (site hydrology) and site geology (composition of the subgrade) play a role. Therefore, water management must be approached holistically.

Because of the high water table at the wetland bog in the depth experiment site, the tiles likely played only a minor role in controlling soil moisture. A reduction in the impact of drains would also be expected if tiles were to be installed too deeply on a naturally wet bed. If the tile is in the water table, as it likely would be if pulled into the underlying peat, it will not function to improve drainage.

Take home message:
Tile depth must be adjusted to suit site conditions at any given bog. Realistically, in Massachusetts bogs, this will probably be between 8 and 16 inches deep.

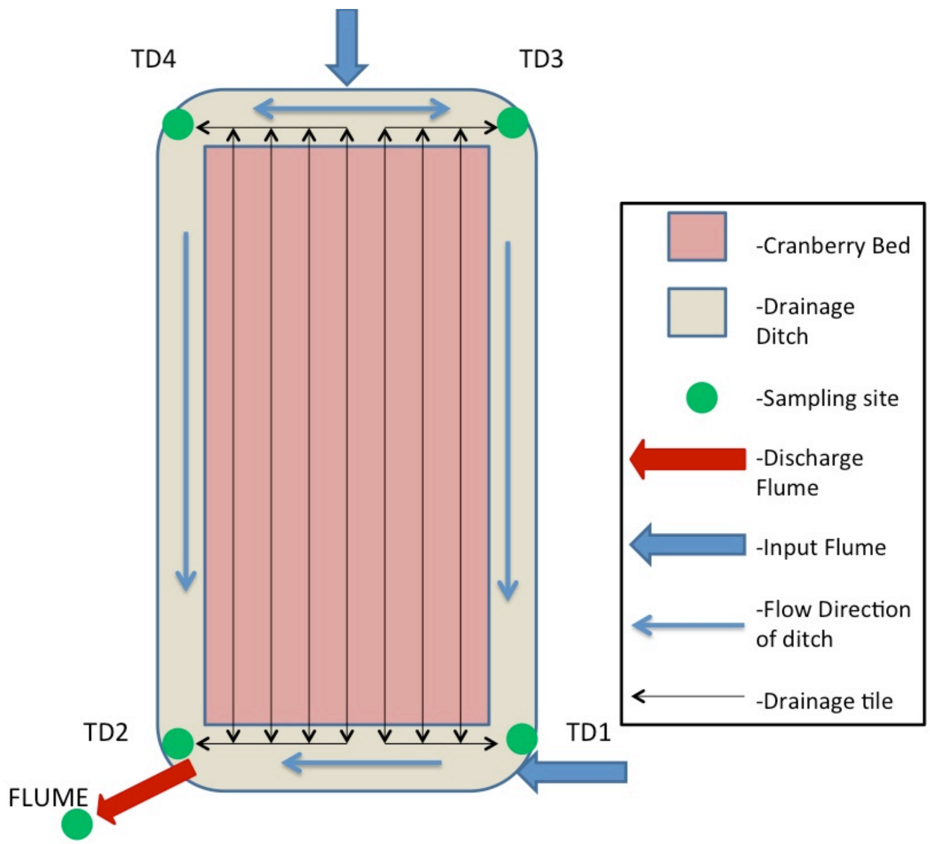
Tile layout:

Most growers run tile the long way down a rectangular bed (starting and ending at the short sides). However, design specifics vary. For example, at the site with our depth study, the grower ran tile in from each long end of the bed towards the middle and capped the end closest to the center. There is a space left between the tiles at the center to accommodate the main line for the sprinkler system. The image to the right shows this layout. Whatever layout is selected must be able to accommodate the sprinkler system main and lines.

While the most common horizontal spacing is 20 feet, this may be adjusted based on the width of a specific bed. Since most beds are 'crowned' to facilitate drainage, if the tile depth is uniform in relation to the surface, the drains will slant towards the edge ditches.

In addition to whole bed tile installations, some growers pull tile from wet areas out to the closest ditch as a solution to a wet area in a bed. Interestingly, at least one grower installs full tiles during renovations and later adds short open ditches for wet areas.

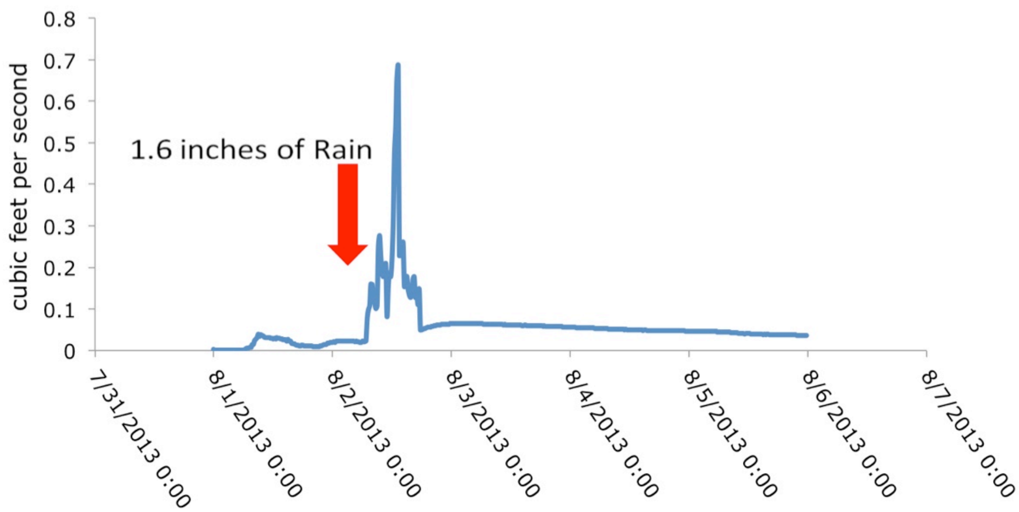
Tile functionality:
Part of our tile work was a study conducted by Nick Alverson to characterize the function of tiles in a renovated bed. The diagram below shows the study design.

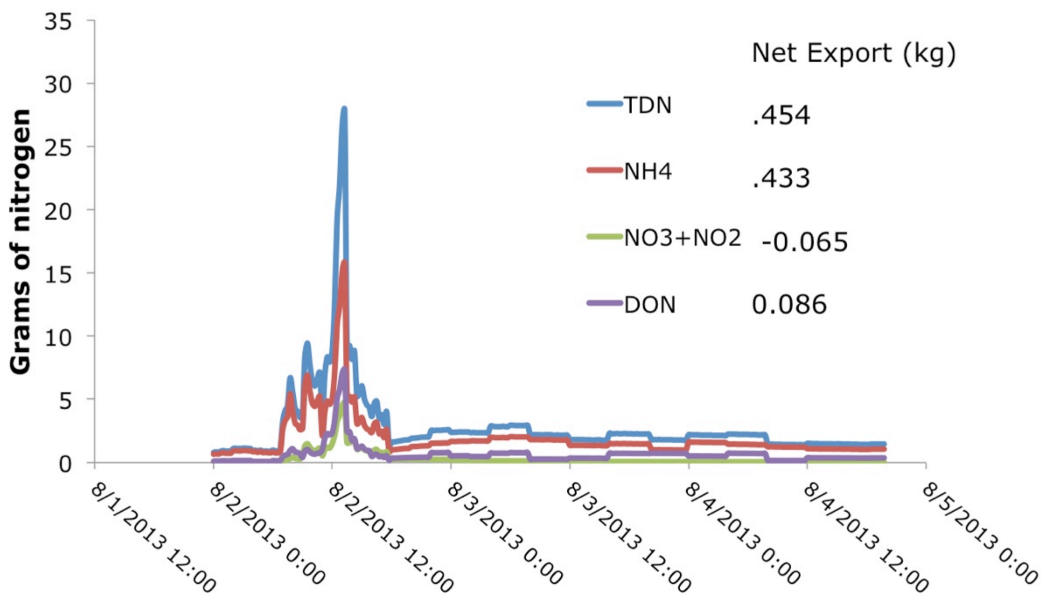


TD1-4 are groups of tiles joined by a pipe. The pipe is used to connect groups of drains that can then be sampled using automated equipment. See the picture below.

The tiles in this bed were 25 feet apart and about 2 feet deep. For two years, flow data were gathered as were samples to quantify nitrogen in the drainage leaving the tiles.

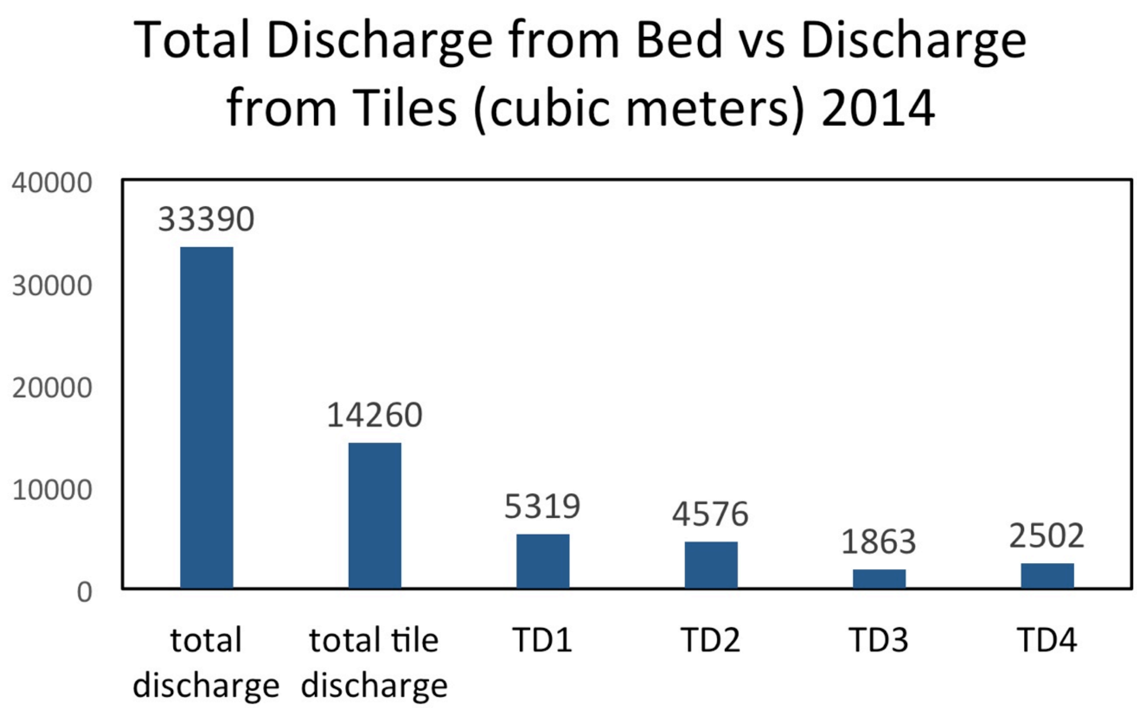
The graphic below shows that water rapidly drained from the bed after a 1.6 inch rain event. However, the tiles also acted to convey nitrogen, particularly ammonium, from the bed following this large rain event. This is likely nitrogen released from applied fertilizer or mineralized organic nitrogen based on the predominance of ammonium in the drainage water.



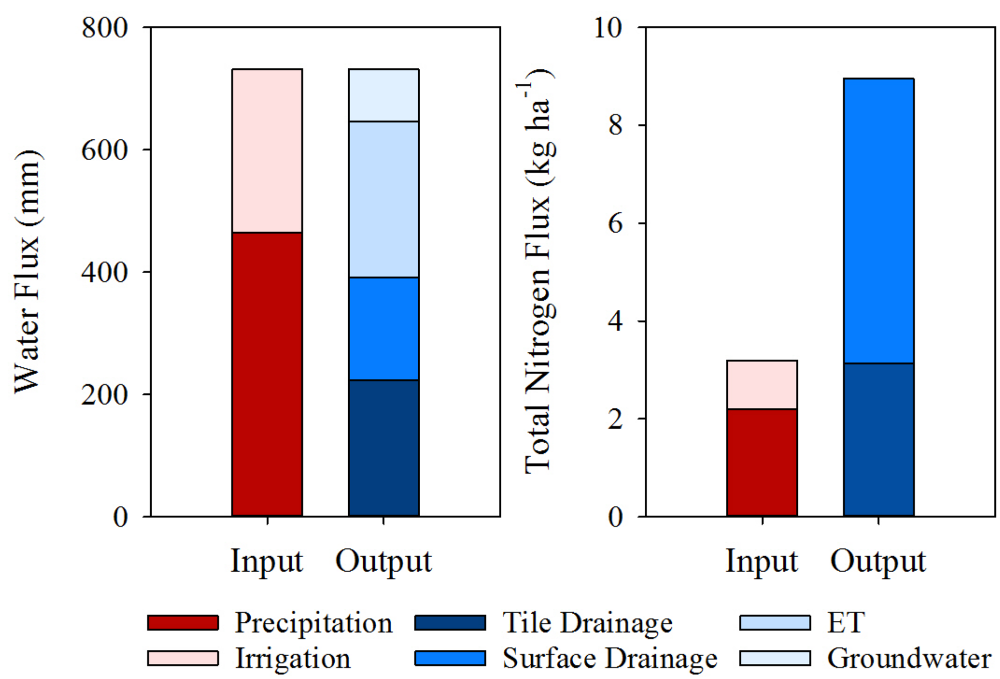


Water flow from tile drains following a large rain event (top). Nitrogen in tile drainage (bottom).

Rapid drainage via tiles after a heavy rain has been readily observed on beds where vines have not yet been planted or have been recently planted because puddles form in the bed but not in the area over the tiles.



This graph shows the total drainage from this bed in 2014, including flood discharges. About 42% of the total discharge was through the tiles. As one might expect, the groups of tiles at the down-slope end of the bed (TD1 and TD2) discharged more water than those up slope. We then looked at the water and nitrogen budgets for the summer of 2014 (rainfall and irrigation drainage, no floods).



Summer season water and nitrogen budgets for year 2014.

For the summer season of 2014, we found similar patterns in water and nitrogen export by tile drainage, which accounted for about one-third of all water and nitrogen outputs. We calculated that tile drainage removed 169 mm of water and exported 3.1 kg N ha^{-1} on a seasonal basis. These values are likely on the high end of the normal range, as summer rainfall in 2014 was 23% higher than the 20-year average for East Wareham, Massachusetts.

Maintenance:

Maintaining proper tile function can be an issue. In our final project survey (January 2016), 35% of the respondents who have tile in their bogs reported having some decline in function over time. However, a majority did not report this and a few commented that they have had no problems after many years of use. Most users have reported that putting a 'sock' (mesh cloth sleeve) around the tile pipe seems to cause problems with clogging and most have abandoned this practice. In addition to those using the keyhole approach to keeping the pipe surrounded by sand, a few growers installed the pipe in gravel. This practice is a hybrid of tile and a gravel 'ditch', often used in the past to serve a similar purpose. Regardless of what material surrounds the tile, it should be coarse enough to allow for proper tile function.

Compressed air has been used to clear or prevent clogs in tile by Joe Darlington and Brenda Connor of J. J. White Cranberry in New Jersey.

Sub-irrigation:

Several of the project advisors used tiles for sub-irrigation during plant establishment in renovated beds. This allowed them to keep a shallow water table as the cuttings root and then they could gradually lower the water table to encourage deeper root growth. Using tile for sub-irrigation is often less common once beds are well established but is worthy of consideration. By periodically raising water in the ditches and thus in the drains, moisture may be more evenly distributed across the bed. However, care must be taken to avoid overly saturated conditions.

The ability to incorporate sub-irrigation into the management of an established bed will depend on the depth of the drains and properties of the soil and the subgrade. Freely draining coarse sands are good candidates - the water level can be raised and then lowered to minimize the time that the soil is saturated. If the soil drains slowly, the same action could lead to extended periods of saturated conditions, which is not ideal. If the subgrade layer does not allow the formation of a perched water table when flooding the tiles, then sub-irrigation will be less successful.

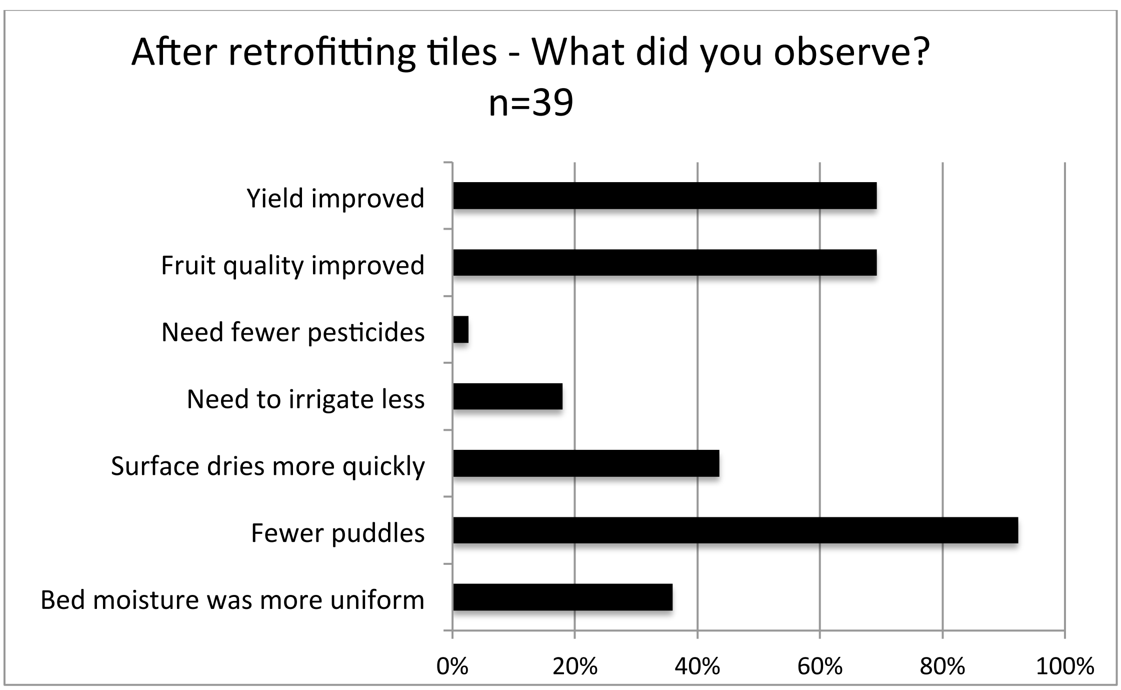
Depending on the distance between tiles and soil characteristics in the bed, the areas between tiles may not get sufficient water via sub-irrigation. In an established bed, sub-irrigation should probably be used in concert with overhead irrigation, taking care to avoid soil saturation. The fact sheet by Bruce Lampinen, detailing the use of water level floats (Constructing Water Level Floats: http://ag.umass.edu/cranberry/fact-sheets), has a good discussion of how sub-irrigation (in his example using ditches) and overhead irrigation work together.

Interaction with pest management:
The foremost pest management benefit of good drainage using tile is in disease management. It is well known that good drainage is essential in the management or prevention of Phytophthora root rot. However, as we saw in our tile depth study, good drainage in concert with proper irrigation can lessen the incidence of fruit rot as well. While growers generally did not report using fewer pesticides once tile was installed, the potential to decrease fungicide use is real. This is an important consideration as the industry becomes more focused on fruit quality and fungicide choices become more limited.

If after installing tiles, a cranberry bed has less soil saturation, the population of weeds may shift as wetland weeds like rushes and sedges become less favored. On the downside, some growers have noticed an increase in weeds along tile lines when tiles have been pulled into an existing bed. This is likely due to disturbing weed seeds in the soil resulting in increased germination.

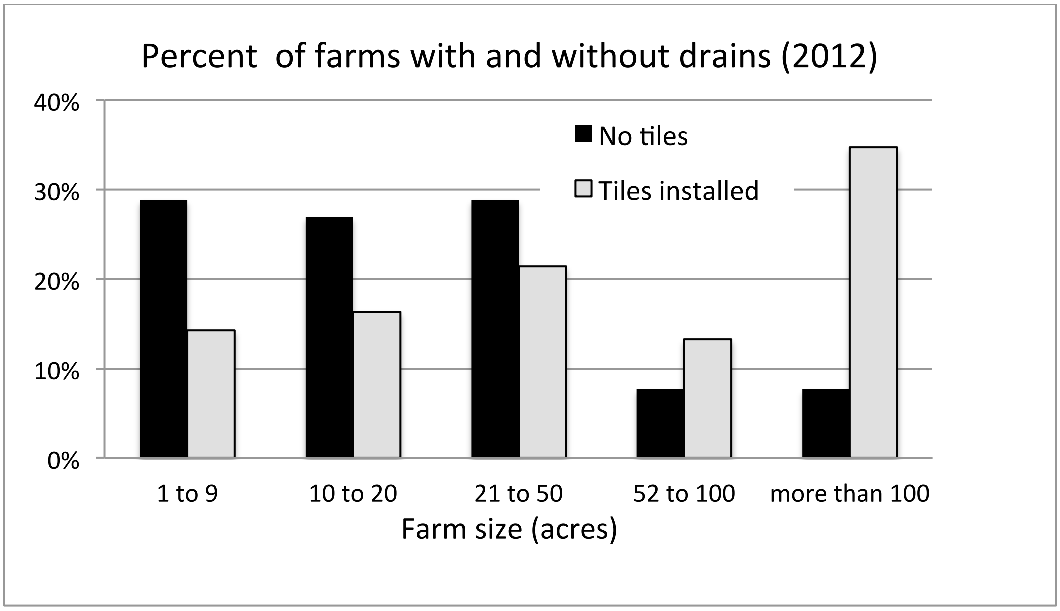
Benefits of tile drainage:
When surveyed, growers overwhelmingly indicated that the main reason for using tiles is for decreasing soil moisture (saturation) and to eliminate wet spots (puddling). One noted that uniformity in soil moisture was as important as total drainage. Others cited the value of tiles in sub-irrigation.

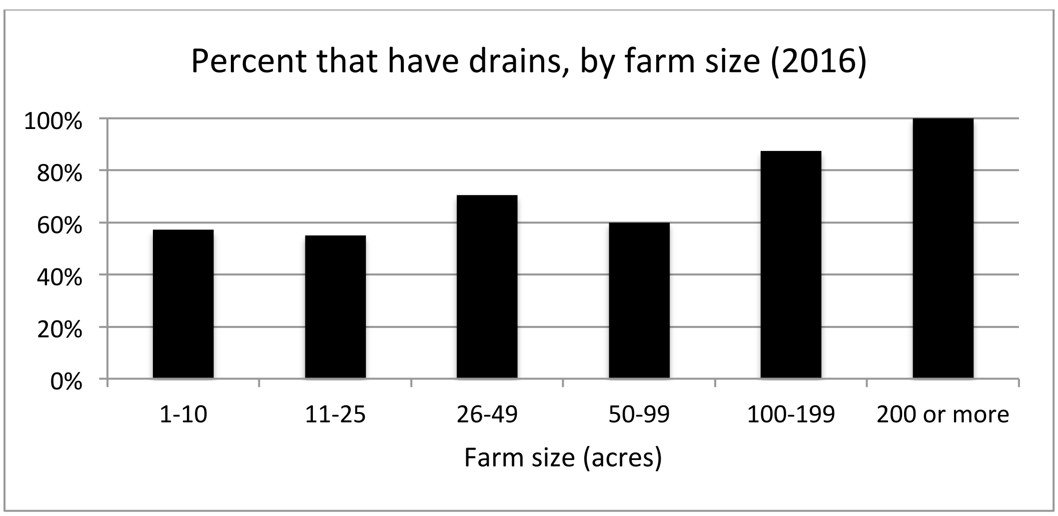
In January 2016, we specifically asked growers about their experiences with drainage tiles that were retro-fitted into existing beds. Of the 57 respondents that used tiles, 39 had retro-fitted tiles into existing beds. In addition to improvements in drainage and soil moisture, 70% reported observing increased yield and reduced fruit rot. This reinforces the case that we have been making for more than 10 years that saturated soils lead to reduced yield and quality.



Project surveys - demographics:
We surveyed cranberry growers at our January meetings each year. Since 2012, we have included specific questions regarding use of and experiences with tile drains.

Large acreage growers were more likely to have tiles installed on at least some of their acreage (similar in 2012 and 2016 surveys - see data below). Respondents in the 2012 survey were using tiles on renovations, new plantings, and established beds (retro-fitting tile into the beds). More than 80% responded that they were very likely or likely to include tiles in any renovation.





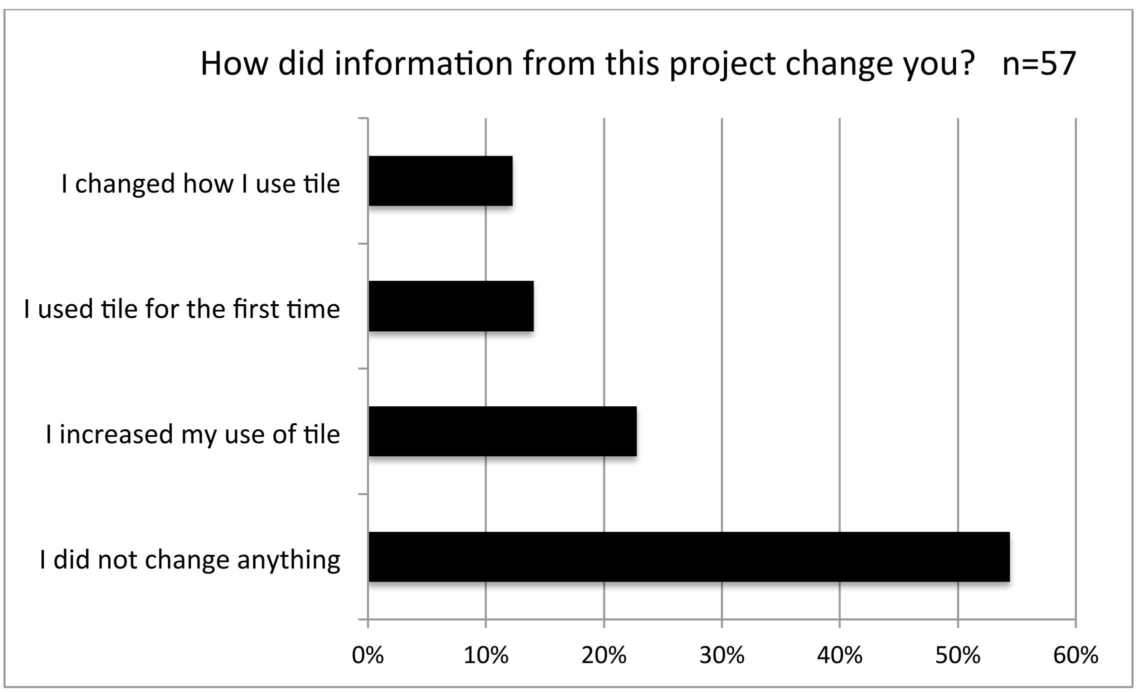
In our 2013 survey, 60% of respondents, representing 83% of the acreage reporting, had tile on 30% of their acres. By 2016, 67% of respondents, representing 91% of the acreage reporting, had tile on more than 25% of their acreage (7 of 57 did not report acres in tile). Of course, these are not necessarily the same respondents. In 2013, 1956 of the 7600 acres reporting were tiled. In 2016, 1726 of 8013 acres reported tile installation. Seven growers who reported having tile did not report the number of tile acres out of their total reported acreage. These data alone do not indicate an increase in tile use.

However, in January of 2016, we specifically asked respondents how much of their drainage was installed after we began this project in 2012. Of their 1726 acres of tiled bog, 43% of the tile was installed since 2012. Those growers also planned to install tile on an additional 347 acres in 2016-2017.

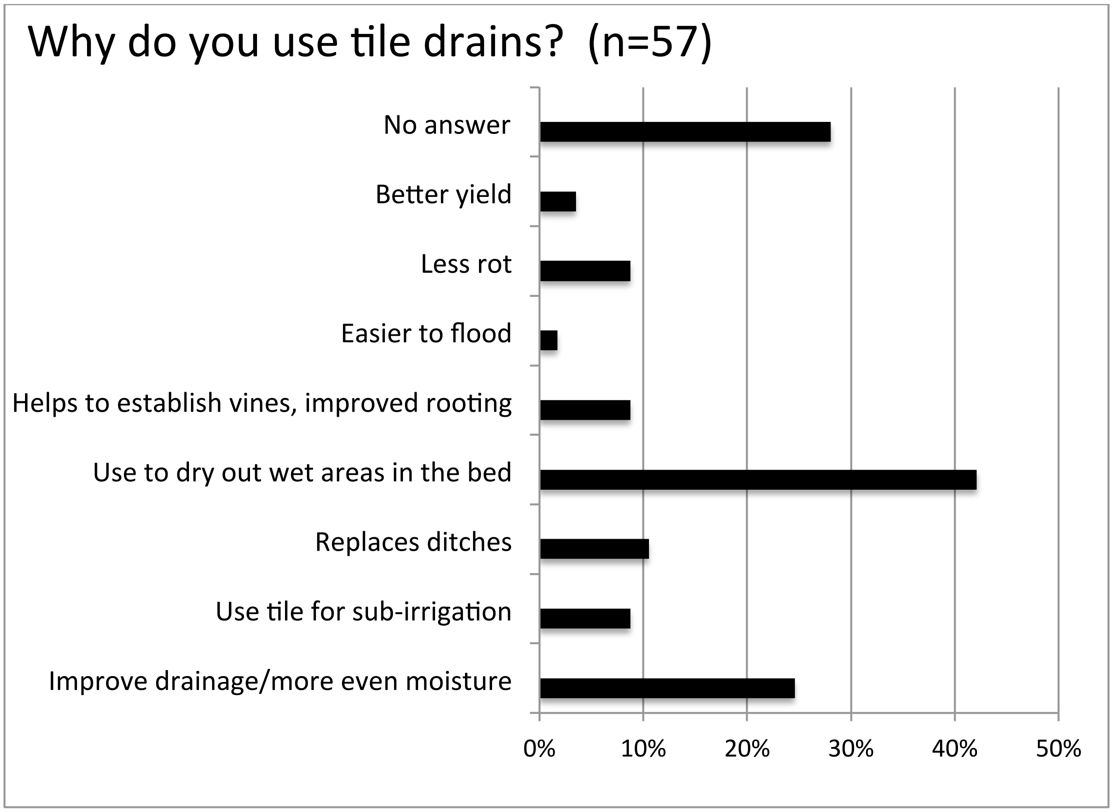
The pace of installation of drains for those growers who already have installed some drains appears to be steady. However, growers without drains installed are less likely to install them. Is this due to lack of interest, or conviction? This is uncertain since we did not ask that question. In 2014, reasons for not installing were split between financial constraints and lack of conviction (bad experiences, not convinced, adding ditches instead - likely less expensive).

Those with drains that plan to install more are most likely satisfied with the practice and they plan to install more. However, current financial times are hard in the cranberry industry, so it makes sense that since those with drains are mostly larger growers with better access to capital and equipment, they are more likely to be able to afford the cost of new tile installations. This also follows from the results of our first survey: a major reason to install was to maximize the benefits of renovating or planting new beds; 59% cited this as their motivation in 2015. Again, renovation and new plantings are not likely options for small growers in the current financial climate.

In our final survey, we asked growers how the knowledge from this project had changed their use of tile drainage. While many did not attribute the change in their tile use directly to the work of our research and grower team, there was measurable change: 21 of 57 respondents (37%) that had tile had either used it for the first time or increased their use based on project information.



Those 57 growers were also asked why they use tile drainage. As was the case when we started in 2012, drying out beds and evening out soil moisture remained the primary reasons cited for using tile. While less than 10% cited improved yield or decreased rot as primary motivators, 70% of those that installed tiles reported improvements in both (see previous section).



August 2016. UMass Amherst Cranberry Station. East Wareham MA 02538.

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