CONSTRUCTION, INSTALLATION, AND USE OF WATER LEVEL FLOATS

Cranberry Environmental Physiology

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These instructions describe the construction, assembly and use of a water level float that can be installed in a traditional cranberry bed to monitor the water table level. The water level float can be constructed from locally available materials. It consists of a perforated pipe that is installed to a depth of about three feet into the bed and a float that rides on the water table within the perforated pipe. The float has a fiberglass rod attached to indicate the water level.

The idea of monitoring the water table level as a means of assessing crop water needs in cranberry grew out of work showing that on a typical traditional Massachusetts cranberry bed under most conditions, capillary rise can reliably move water up into the root zone from a water table at a depth of about 18 inches. By maintaining a water table beneath the bed at a sufficient depth to provide water to the root zone by capillary rise while avoiding water logging in the root zone, cranberry irrigation needs can be met. A water table that fluctuates between 6" and 18" works well for most traditional Massachusetts cranberry beds. However, since the distance that capillary rise can lift water depends on soil texture, organic matter, soil compaction etc., it is important to know your own cranberry bed before relying on capillary rise to provide irrigation water.

A water level float installed on cranberry bog in bloom.

While either a water level float or tensiometer can be used for irrigation scheduling purposes the water level float offers several advantages over tensiometers on traditional cranberry beds in Massachusetts. The float is less expensive, less prone to problems, requires less maintenance, and is more sensitive to water table fluctuations than a tensiometer. Another advantage of the float is that it does not require you to walk out on the bog to read as does a tensiometer. After a rainfall event, you can look at the float and instantly assess the effective rainfall received on that particular bed. The water level float functions as an on-site evaporation gauge, integrating water gains from irrigation and rainfall as well as losses from evapotranspiration, runoff, and drainage.

Note: The water level float will not work on beds such as upland mineral beds where no water table is maintained below the surface. For these situations, a tensiometer is a better choice for irrigation scheduling.

Parts List- Purchase the following items:

To construct perforated pipe assembly

1) 1½" PVC pipe, Schedule 40, 10 foot length (enough to make 3 perforated pipes)
   Source - hardware or plumbing supply store
2) 1½" PVC endcap
   Source - hardware or plumbing supply store
3) Roll of weedblock landscaping fabric (e.g., Easy Gardener Weedblock® 3 ft x 50 ft roll- enough to wrap about 60 pipes)
   Source - hardware or garden supply store (only available during spring and summer in many stores)
4) Duct tape
   Source - hardware store

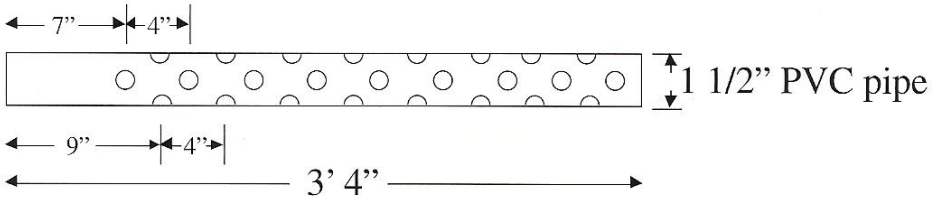
To construct one float assembly

1) One 48" driveway marker with ¼" fiberglass stake (actual stake length is usually about 44")
   Source - hardware or auto parts store
2) Lightweight 1¼" PVC tubing for float (e.g., slip joint extension tube- 1¼" by 12" [e.g., Ace Hardware Part 44029] found in sink drain plumbing section). If 1¼" lightweight tubing is not available at your hardware store, you can substitute 1½" lightweight tubing but you will have to increase the diameter of the rubber stoppers, perforated pipe and endcap to accomodate the larger float diameter. The larger the diameter of the perforated pipe, the longer it will take the water level in the tube to equilibrate with water table level changes so use the smaller diameter if possible.
   Source - hardware store
3) Two #6 rubber stoppers
   Source - hardware store or scientific supply company
4) One can each green and orange spray paint (fluorescent is easy to see initially but fades quickly in sunlight)
   Source - hardware store

Construction

Perforated pipe and end cap

1) Cut a 10' length of 1½" PVC pipe into 3 equal parts (each will be 3' 4" long)
2) Starting about 7" from one end, drill ½" holes every 4 inches through both walls of pipe (this is most easily done on a drill press if one is available). Be sure to wear safety goggles and do not attempt to drill too fast or the PVC tube may shatter.

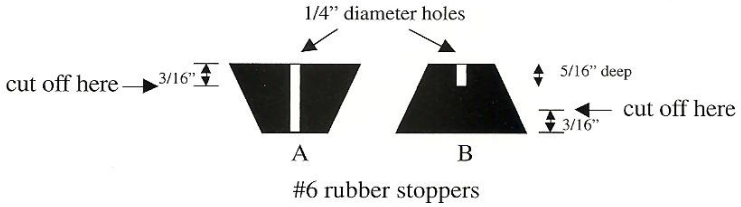


3) Turn pipe 90° and starting 9" from the end, drill a second set of ½" holes every 4 inches through both walls of pipe.
4) Thoroughly clean all PVC shavings from the holes and pipe interior to allow free movement of the float.
5) Drill an 11/32" hole in the center of the 1½" PVC cap (the size of this hole may need to be modified depending on the thickness of the paint you apply to the fiberglass rod).

Float - the key to an effective float is to keep it as light as possible

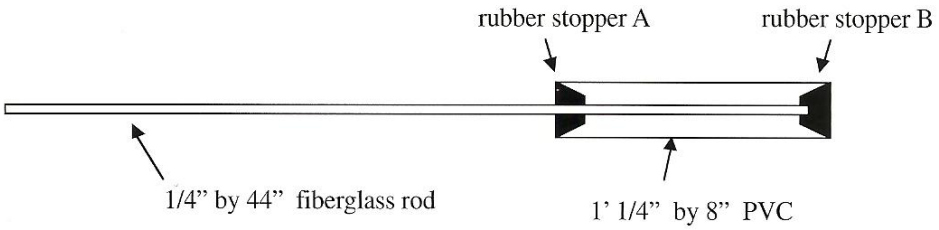
1) Cut 1 1/4" light-weight PVC tubing (e.g. slip joint extension tube) to approximately 8" in length.

2) Drill 1/4" holes all the way through the center of one rubber stopper and approximately 5/16" deep into center of the **smaller diameter end** of the second rubber stopper. This is most easily done with a drill press while holding the rubber stopper with a pair of pliers or vise grips. Cut off 3/16" from the **wide end** of each rubber stopper using a sharp utility knife.



#6 rubber stoppers

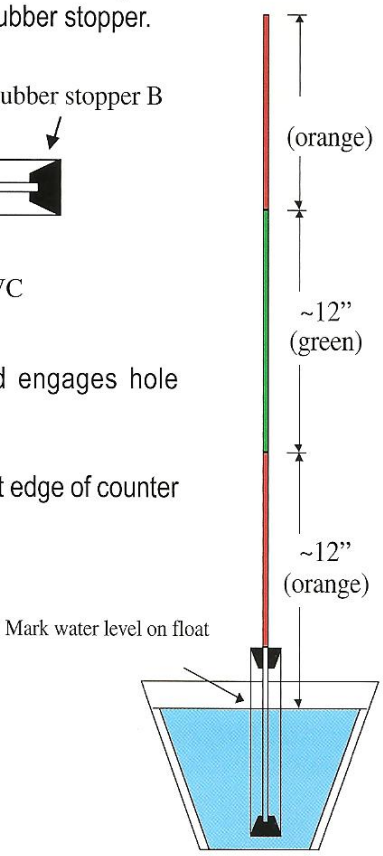
3) Slide rubber stopper A approximately 8" onto fiberglass rod and slide 8" length of 1 1/4" pipe (cut from slip joint extension tube in step 1 above) onto rubber stopper.



4) Slide rubber stopper B on being sure that the fiberglass rod engages hole in rubber stopper.

5) Work rubber stoppers tightly into 1 1/4" PVC tube by pressing against edge of counter while turning assembly (counter must be higher than 36" to allow clearance for fiberglass rod). The rubber stoppers should be pushed in until they are approximately even with the end of the 1 1/4" PVC tube. If desired, you can use silicone sealant around the rubber stoppers although it is probably not necessary.

6) Place float assembly into bucket of water and while carefully balancing float to avoid putting downward pressure on it, mark level at which float sits in water. Be sure that the float assembly is floating freely and not touching the bottom of the bucket.



7) Make marks at 12" and 24" above the mark you made in step 6 above. Paint the tube orange from the float level mark up to the 12" mark. From the 12 to 24" marks, paint the tube green. Then above the 24" mark, paint the fiberglass rod orange again. The 24" mark may need to be adjusted up or down for your individual situation (see section on determining the height of capillary rise on your bed for details).

Selecting locations for water level floats

Following irrigation or rainfall, water drains off of a level cranberry bed with a uniform soil in a predictable fashion. Shortly after irrigation or rainfall, the highest water level is generally in the center of the bed, since as water moves towards the ditches to drain, the water in the center has to move the greatest distance. If the water in the ditches is maintained at a level that provides adequate water for the bed edges by capillary rise, then by monitoring and adjusting the level in the center of the bed you can assure adequate water across the entire bed. Therefore, in most cases it is best to place a float in the center of the bed.

If the bed is substantially out of grade (more than one foot), you will probably need to monitor the water level or tension in both the high and low areas of the bed to assess crop water needs more precisely. The water level float works well for low areas. However, if the difference in elevation between the high and low area is more than a foot, it is difficult to provide water to the high areas by capillary rise without creating excessively wet conditions in the low area. In this situation, a water level float alone will not work well, but rather, a float placed in the low area and a tensiometer placed in the high area is a better solution. Remember that the high area is most likely not getting water supplied to the root zone by capillary rise and is therefore dependent on rainfall and/or irrigation alone to provide plant water needs. This will most likely necessitate a more frequent irrigation schedule.

Installation of perforated pipe

1. Wrap the perforated pipe with a 36" by 10" piece of weed block landscaping fabric and secure with duct tape. The fabric should be held down about 7-8 inches from the top of the tube with the duct tape being attached so that the top of the duct tape is about 5 1/2" down from the top of the tube (this will serve as the reference mark for the depth of installation). The excess weed block fabric at the bottom of the tube can be pushed up inside the bottom of the tube. The bottom piece of duct tape should be placed so that it laps over the bottom lip of the tube (this helps to keep the fabric intact and in place when the tube is placed in the ground). Then, a third piece of duct tape should be wrapped around the middle of the tube.

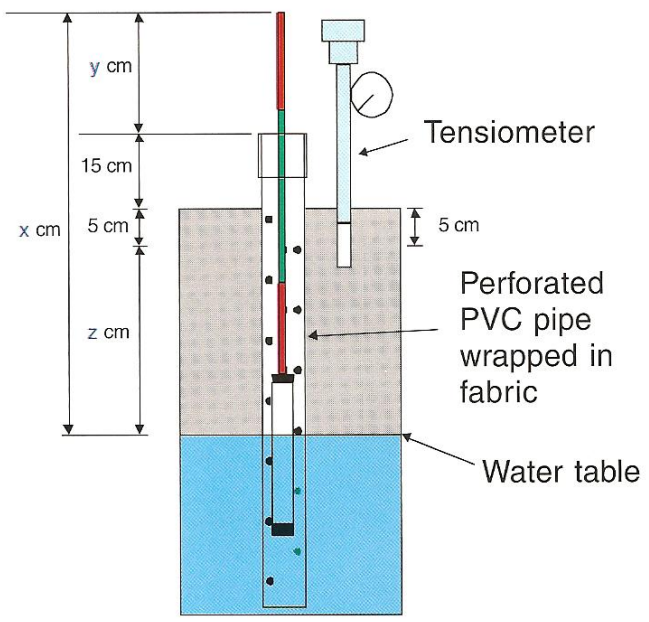
2. Make a hole in the bed down to the level that the tube will be installed (~2'10"). It is generally easier to install tubes when the water table is relatively low since the hole is less likely to slough off when the soil is drier. The hole can be made with a piece of 1 1/2" PVC pipe or a piece of 1 1/2" metal pipe (such as electrical conduit available from electrical supply stores). A length of pipe about 4' long works well for making the hole. Placing a piece of wood over the pipe (to prevent damage) and pounding on it with a small sledgehammer works well. It works best if you pound the pipe down about 6" at a time and then pull it out and clean it. You may need a smaller diameter pipe to insert into the 1 1/2" pipe to remove the material that gets stuck (this is particularly a problem when you reach peat). If the PVC or metal pipe gets stuck while making the hole, you can tighten two pipe wrenches on the pipe to provide a place to hold and pull the pipe out. The ease of installation varies greatly depending on soil texture, moisture content, etc. Sometimes it is easier to make a smaller hole first using a soil probe and then enlarge the hole using the PVC or metal pipe. Once the hole is clear down to the 2' 10" depth, you can then insert the weed block-wrapped perforated pipe into the hole leaving a little less than 6" protruding above the soil surface. It can take several hours for the water level in the tube to equilibrate with the soil water level initially.

3. Place the float into the perforated pipe and make sure that the pipe is clear all the way to the bottom. If it is not clear, use a soil sampling tube or a piece of smaller diameter PVC pipe to clean it out (you can use your hand to apply suction to the end of the small PVC pipe to clean out a water filled tube). When the perforated pipe is clean, thread the fiberglass rod of the float through the hole in the 1 1/2" PVC cap and insert the assembly into the perforated pipe. It is best not to push the PVC cap on very tightly since it can be difficult to remove (the final distance from the top of the cap to the soil surface should be 6"). Make sure the float moves freely up and down without binding on the side of the perforated pipe or cap.

4. It is a good idea to check the float periodically to be sure it is floating freely and not binding on the sides of the perforated pipe or PVC cap. At the same time, you should check that the hole is clear all the way down to the bottom, and if not, clean it out as described above.

Determining the height of capillary rise on your bed

Since, as mentioned earlier, the distance that capillary rise can lift water depends on soil texture, organic matter, soil compaction, etc., it is important to know your own cranberry bed before relying on capillary rise to provide irrigation water. Establishing the height of the bottom of the green band at 12" (30 cm) in the float assembly instructions earlier was based on allowing 6" (15 cm) for the height the perforated pipe sticks above the bed surface and 6" (15 cm) clearance for drainage in the root zone. Then, a low water table depth of 18" (45 cm) below the soil surface was assumed for the upper edge of the green band at 24" (61 cm) above the float line. However, capillary rise may be more or less than this on any individual bed so you may want to establish more accurate values for your individual situation.



z (Distance to water table) = x - y - 15 - 5
assuming x = 100 and y = 25 then z = 100 - 25 - 15 - 5 = 55 cm

To do a rough assessment of the distance capillary rise can lift water on your bed, begin by installing a water level float on the highest, driest area of the bed. It is important to choose the highest area to avoid potential water stress damage to the bed as you let it dry down during the test. Place a properly calibrated tensiometer with the ceramic cup centered at 5 cm below the surface next to the water level float (see figure at right). Let the water table drop on the bed (by withholding irrigation) while observing and recording the tension as well as the depth (in centimeters) from the tensiometer cup to the water table level. To calculate the distance to the water table (**z**), measure from the top of the fiberglass rod to the top of the PVC cap (**y**), add 15 cm for the distance to the soil surface plus 5 cm for the tensiometer depth, then subtract this number from the total length of the float assembly - from the line at which the device floated on the water to the top of the fiberglass rod (**x**). In order to get a conservative estimate of the capillary rise on your bed, these tests should be done at midday during warm weather to assure that plant water use is high.

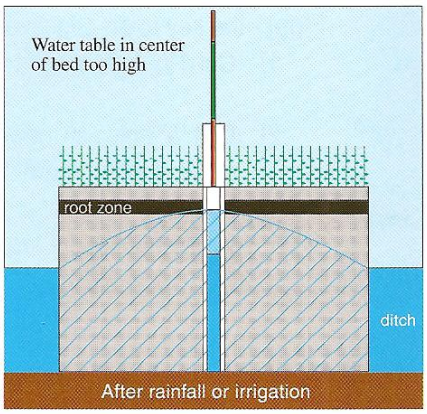
Depth to water table (cm)	Midday tension (mbar)	Depth-tension
-20	-20	0
-25	-25	0
-30	-30	0
-35	-35	0
-40	-40	0
-45	-50	5
-50	-105	55
-55	-150	95

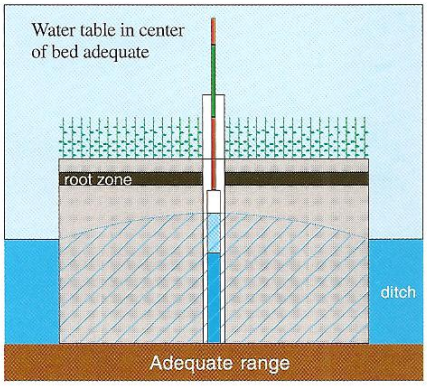
Next, compare the depth to the water table in centimeters (**z**) to the tensiometer reading in millibars (convert to millibars by multiplying the cbar reading on the tensiometer gauge by 10). If capillary rise is supplying adequate water to the root zone, the two numbers should be approximately equal. As the water table drops, at the point where the midday tensiometer reading (in mbars) is substantially less the water table level (in cm), then the water table is most likely too low to supply water to the root zone by capillary rise. In the example in the table, as the water table drops from -40 to -45 cm, the ability of capillary rise to move water up into the root zone is no longer keeping up with plant demands as evidenced by the fact that the depth minus tension value is greater than 0. In this example capillary rise appears able to keep up with plant demands down to a water table at a depth of 40 cm (40 cm x 0.393 inches/cm = ~16 inches). To calculate the distance to the top of the green painted region on the float you need to add 40 cm (the distance from the capillary rise test) plus 5 cm (to account for the 5 cm depth of the tensiometer cup in the test), and 15 cm (to allow for the distance the perforated PVC pipe sticks above the bed surface). Therefore, the top of the green painted region on the float assembly should be set at 40 + 5 +15 = 60 cm (24") above the level of floatation in this example.This should provide a conservative estimate of the height capillary rise can lift water since it is based on lifting water up to the soil surface while the roots should actually be considerably deeper. When conducting the test, be sure to irrigate before the difference between the depth and the tension gets too large (>100), since stress related damage can occur rapidly once capillary rise is no longer supplying water to the root zone.

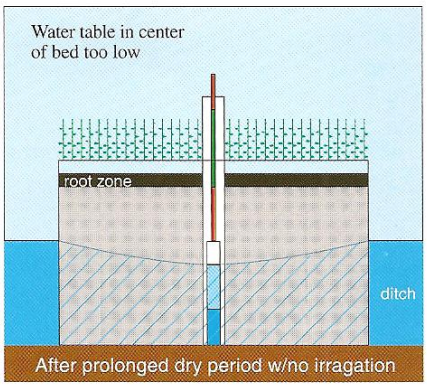
Using the float to schedule irrigation

In order to use the float to schedule irrigation effectively, it is essential to pay attention to the level of the water table across the entire bed. Since water must be able to drain from the bed center during unexpected rainfall events, it is best to maintain the ditch levels at the lower end of the adequate range for capillary rise. By observing the level of water in the ditches and the level of water in the center of the bed (as indicated by the float), irrigation can be more carefully controlled to avoid waterlogging conditions.

In the figures to the right, the ditch water level is assumed to stay at an adequate level while the water table in the center of the bed varies. If the level of water in the center of the bed is too high (see top figure on right), then no irrigation is needed but you may need to lower the ditch water level to enhance drainage. As the water table in the center of the bed falls through the green region on the float (center figure), no irrigation is needed. As the float falls so that the green zone is no longer visible (bottom figure), sprinkler irrigation is needed to replenish the water table in the center of the bed.







If the level of water in the ditches falls too low , but the float indicates that the level of water in the center of the bed is adequate, then if possible, the level of water in the ditches should be pumped up without running the sprinklers. If both the water level in the ditches and the water table in the center of the bed drop too low, then the sprinklers should be used to replenish the water table. By alternating pumping up the ditches and running the sprinkler system, the frequency of sprinkler irrigation should be decreased. By sprinkling less frequently, disease and weed pressure may be reduced as well.

By maintaining the water table at a lower level, over time you should achieve deeper rooting depth. Deeper rooting increases the volume of soil the roots have access to for the uptake of water and nutrients. Rooting depth can be assessed by digging a small hole and observing the roots along the sides of the hole or alternatively, by using a soil sampling tube and measuring the rooting depth in the tube. If rooting depth is substantially increased, you may be able to gradually lower your water table (i.e., paint green higher on the float).

Glossary

capillary rise - the physical process by which water will rise from a water table up through the soil towards the surface. The smaller the soil pores, the higher the water can rise by this process. Fine textured and organic soils have smaller pores than coarse sands. Therefore, water can rise to the surface from a deeper water table in fine textured soils.

cbars - centibars, a unit of measurement for soil tension. Equal to 10 mbars. Often expressed as a negative number.

sub-irrigation - manipulation of the water table by controlling depth of water in the ditches in order to supply water needs in the root zone. Water level is maintained so that the soil is moist but not saturated at the bed surface. Supplements overhead irrigation. Depends on the process of capillary rise.

tensiometer - a device that measures soil tension, a measurement of the availability of moisture in the soil to the plant. Readings are usually in cbars. Used to schedule irrigation.

water table - The depth beneath the soil surface where the soil is saturated with water.

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