Automatic Gravity Feed Drip Irrigation for Smallholders with a Farm Pond or a Rainwater Tank

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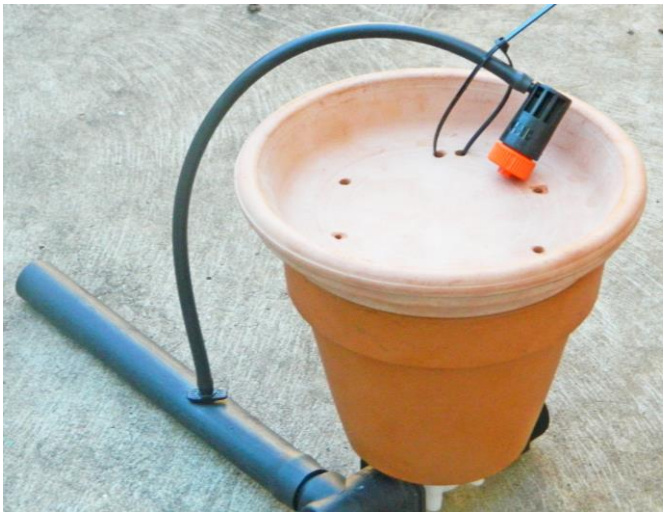
19 watt 12 volt submersible pump



Unpowered Terracotta Irrigation Controller

Unpowered Pitcher Drip Irrigation Controller

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1. Introduction

This article addresses the question of how to water your garden automatically using gravity feed drip irrigation from a farm pond or rainwater tank when you are away from the garden for months on end.

If your tank is at ground level, the water pressure may be inadequate when the tank is almost empty. The conventional solution to the problem is to use a pump. However, a suitable pump may be expensive and there will be ongoing costs for power. A less expensive approach is to use a small header tank and to use a small inexpensive solar-powered transfer pump to slowly refill the header tank between irrigation events. If you use a conventional programmed irrigation controller with gravity feed irrigation, the dripper discharge will vary as the water level in the header tank changes. This is not the case with measured irrigation

This article demonstrates that automatic gravity feed drip irrigation from a farm pond or a rainwater tank does not require access to mains power or batteries. Details are available for two unpowered controllers, namely, the Unpowered Terracotta Irrigation Controller and the Unpowered Pitcher Drip Irrigation Controller.

It is recommended that you use mulch to minimise evaporation.

2. Choosing between the Unpowered Terracotta Irrigation Controller and the Unpowered Pitcher Drip Irrigation Controller

.**Unpowered Terracotta Irrigation Controller**	**Unpowered Pitcher Drip Irrigation Controller**
Plants in the zone may have different irrigation requirements	All plants in the zone should have the same irrigation requirements
Adjust the water usage rate by adjusting the control dripper	The water usage rate is controlled by the demand from the plants. The discharge from each dripper during an irrigation event is the same as the on-demand discharge from the subsurface clay pot since the previous irrigation event
Adjust the interval between irrigation events by adjusting the float. A tap timer may be used so that irrigation is only available between sunset and sunrise	The interval between irrigation events may be less than a day. A tap timer may be used so that irrigation is only available between sunset and sunrise
As the water needed by your plants changes as the plants grow, the discharge from each dripper during the irrigation event needs to be adjusted manually by adjusting the control dripper	As the water needed by your plants changes as the plants grow, the discharge from each dripper during the irrigation event adjusts automatically

Contents of kit for automatic gravity feed drip irrigation for smallholders using an Unpowered Terracotta Irrigation Controller.

- Unpowered Terracotta Irrigation Controller
- 12 volt 14 watt submersible pump with 2 waterproof electrical conectors

Contents of kit for automatic gravity feed drip irrigation for smallholders using an Unpowered Pitcher Drip Irrigation Controller.

- Unpowered Pitcher Drip Irrigation Controller
- 12 volt 14 watt submersible pump with 2 waterproof electrical connectors

3. Installation of a header tank

To have enough pressure to operate the Unpowered Terracotta Irrigation Controller or the Unpowered Pitcher Drip Irrigation Controller, the bottom of the header tank should be at least 1 metre higher than your garden.

A very cheap header tank may simply be a modified 240 litre wheelie bin mounted on a 1 metre high bench. Another cheap option is to use a 1000 litre IBC (Intermediate Bulk Container) mounted on another IBC. The bottom IBC is just a stand and so the plastic part can be damaged.

A suitable small solar-powered transfer pump is available from the Measured Irrigation website. This is a 12 volt 19 watt pump and it can be operated directly from a 20 watt solar panel (no battery required). You can save money by importing the pump directly from China

1. Depending on water quality, connect a suitable inline filter to the inlet of the pump.
2. Submerge the pump in the farm pond or connect the pump to the outlet of the rainwater tank.
3. Connect the solar panel directly to the pump. The pump will operate whenever there is enough sunlight on the solar panel.
4. Connect the outlet on the pump to the inlet on the header tank.
5. Connect the overflow from the header tank to the farm pond or the inlet of the rainwater tank.

If you have a farm pond with a depth of 4 metres, you should use 2 pumps connected in series to transfer water to the header tank. In this case. a 40 watt solar panel can be connected directly to the pumps. Note that single pump can lift water a maximum of 5 metres, and two pumps connected in series can lift water a maximum of 10 metres.

4. Installation of the Unpowered Terracotta Irrigation Controller

Position the Unpowered Terracotta Irrigation Controller in a suitable location in your garden so that the evaporation matches the evaporation at your plants.

Connect the water supply from the header tank to the controller inlet and connect the irrigation application to the controller outlet (note that an arrow under the controller indicates the direction of flow).

Place the terracotta saucer on the terracotta pot so that the control dripper drips water into the pot. The control dripper should be at the same level as the irrigation drippers in your application.

Turn the terracotta pot until the heads of the 4 screws are aligned with the 4 recesses in the bottom of the terracotta pot.

Connect the water supply to the controller inlet

Connect the irrigation application to the controller outlet

Place the terracotta saucer on the terracotta pot so that the control dripper drips water into the pot

5. How to use the Unpowered Terracotta Irrigation Controller

Turn on the water supply and the irrigation starts immediately. The control dripper drips water into the terracotta pot during the irrigation. The **control volume** is the volume of water that drips into the pot during the irrigation event. It is also the volume of water that seeps through the terracotta pot between irrigation events.

The irrigation stops automatically when the control volume of water has dripped into the pot. The irrigation starts again automatically after the control volume of water has seeped through the pot and evaporated. The cycle continues indefinitely and so you can leave your garden unattended for months on end. A saucer sits on top of the pot so that the water in the pot is protected from algae, mosquitoes, and thirsty animals. There are small drain holes in the saucer.

When using a conventional irrigation controller, you need to set the start time and the run time for each irrigation event. However, with the Unpowered Terracotta Irrigation Controller you don't need a timer. The duration of the irrigation event is the time it takes for the control volume of water to drip into the pot, and the interval between irrigation events is the time it takes for the control volume of water to seep through the pot.

It is important to note that the control dripper is adjustable. If you reduce the flow rate of the control dripper, it takes a lot longer for the control volume of water to drip into the pot and so the duration of the irrigation event increases and your plants get more water. On the other hand, if you increase the low rate of the control dripper, the control volume of water drips into the pot more quickly and so the duration of the irrigation event decreases and your plants get less water. Adjust the control dripper so that the irrigation delivers the appropriate amount of water to your plants at their current stage of growth.

The time it takes for the control volume of water to seep through the pot depends on the prevailing on-site weather conditions. When it is hot and dry, the water seeps more quickly and so the interval between irrigation events is shorter. When it is cool and overcast, the water seeps more slowly and so the interval between irrigation events is longer.

If it rains, rainwater collects in the saucer and drains into the pot. This means that the start of the next irrigation event is delayed. In addition to the control volume of water that needs to seep through the pot between irrigation events, any rainwater that has entered the pot between irrigation events also needs to seep through the pot.

To avoid irrigating during the heat of the day, you can turn off the water supply. Alternatively, a tap timer can be used so that water is only available between sunset and sunrise.

The Unpowered Terracotta Irrigation Controller uses on-site weather data (namely, evaporation and rainfall). Most smart irrigation controllers do not use on-site weather data. Instead, they use weather data from the Bureau of Meteorology.

You can irrigate directly from a rainwater tank by gravity feed without using a pump provided that the water level in the tank is at least 1 metre higher than the controller.

Note that the term **water usage rate** refers to the number of litres per week used by the irrigation system.

How to adjust the interval between irrigation events

You can adjust the interval between irrigation events by adjusting the gap between the upper and lower float. The interval between irrigation events is the time it takes for the control volume of water to seep through the porous terracotta pot. To adjust the gap by 4 mm, rotate the upper float by two and a quarter turns.

Adjusting the interval between irrigation events does not change the water usage rate. For example, if you increase the interval between irrigation events by increasing the gap between the upper and lower float, the amount of water used during the irrigation event increases automatically to ensure that the water usage rate remains the same.

To adjust the interval between irrigation events, adjust the gap between the upper and lower float

gap between the upper and lower float	control volume
zero gap	95 ml
4 mm	128 ml
8 mm	161 ml
12 mm	194 ml
16 mm	227 ml
20 mm	261 ml
24 mm	294 ml
28 mm	327 ml
32 mm	360 ml

Table 1. Control volume for various gaps between the upper and lower float

The gap between the upper and lower float should be chosen so that the next irrigation event starts when there is no further soil moisture available to the plants. Soil moisture sensors or probes may be used to determine the soil moisture profile.

You can start the irrigation at any time by pushing the float down. You can stop the irrigation at any time by lifting the float up.

How to adjust the water usage rate

If your plants are not getting enough water, reduce the flow rate of the control dripper. Reducing the flow rate of the control dripper increases the duration of the irrigation event and so your plants get more water. If your plants are getting too much water, increase the flow rate of the control dripper.

Adjusting the water usage rate does not affect the interval between irrigation events.

You may wish to position an empty measuring container under one of the drippers so that water drips into the container during the irrigation event. The amount of water in the container is the amount of water discharged by each irrigation dripper during the irrigation event.

6. How to make DIY low cost pitchers for irrigation

Small pitcher made from two 9cm terracotta pots
Medium pitcher made from two 12cm terracotta pots

Step 1. Select two identical unglazed terracotta pots and seal one of the drain holes (for example, use silicone adhesive or masonry adhesive)

Step 2. Apply a bead of silicon sealant or masonry adhesive to the rim of the pot with the sealed drain hole

Step 3. Carefully position the upper pot directly above the lower pot

Step 4. Gently press the pots together and allow 24 hours for the sealant to cure

Step 5. Connect a 13mm barbed poly tee to the pitcher using a 13mm rubber grommet. A 13mm rubber grommet requires a 16mm hole. Attach an 8cm length of 13mm polypipe to provide an air inlet/outlet for the pitcher.

7. Installation of the Pitcher Drip Irrigation Controller

Select a drip irrigation zone where all the plants in the zone have the same irrigation requirement and each plant is watered by a single dripper.

1 Select a control plant and replace its dripper by one or more subsurface pitchers. Note that the corn seedling will draw more water from the pitchers as the corn grows.

2 Connect the pitcher to the controller so that water can flow from the controller to the pitcher.

3 Connect the water supply from the header tank to the inlet of the controller.

4 Connect an irrigation dripper inside the controller.

5 Connect the drip irrigation application to the outlet from the controller

6 Turn on the water supply and all the plants will be watered automatically with the water they need and without power.

8. How to use the Pitcher Drip Irrigation Controller

The discharge from each dripper during an irrigation event is the same as the on-demand discharge from the subsurface pitcher (or pitchers) since the previous irrigation event.

If the control plant starts to look unhealthy, move the subsurface pitcher (or pitchers) to a healthy control plant.

Use mulch to reduce evaporative losses.

If you decide that your plants are not receiving enough water by drip irrigation, you can increase the water usage by opening the lid of the controller. In this case the discharge from each dripper during an irrigation event is the same as the on-demand discharge from the subsurface pitcher (or pitchers) since the previous irrigation event plus the net evaporation (evaporation minus rainfall) from the controller since the previous irrigation event.

The water usage can be adjusted by replacing the dripper inside the controller with an adjustable dripper. Increase the water usage by decreasing the flow rate of the adjustable dripper, and decrease the water usage by increasing the flow rate of the adjustable dripper.

9. Key features of the Unpowered Terracotta Irrigation Controller and the Unpowered Pitcher Drip Irrigation Controller

Unpowered Terracotta Irrigation Controller	**Unpowered Pitcher Drip Irrigation Controller**
Plants in the zone may have different irrigation requirements	All plants in the zone should have the same irrigation requirements
Unpowered	Unpowered
Use for subsurface or surface drip irrigation	Use for subsurface or surface drip irrigation
Adjust the interval between irrigation events by adjusting the float	The interval between irrigation events adjusts automatically
The discharge from each dripper during the irrigation event is adjusted by adjusting the control dripper	The discharge from each dripper during an irrigation event is the same as the on-demand discharge from the subsurface pitcher (or pitchers)
As the water needed by your plants changes as the plants grow, the discharge from each dripper during the irrigation event must be adjusted manually	As the water needed by your plants changes as the plants grow, the discharge from each dripper during the irrigation event adjusts automatically
Responds automatically to on-site evaporation and rainfall	The water usage increases significantly during a heat wave
Water in the controller is protected from debris, algae, mosquitoes and thirsty animals	Water in the controller is protected from debris, algae, mosquitoes and thirsty animals
Provided the water supply is continuous, you can leave your irrigation application unattended for months on end	Provided the water supply is continuous, you can leave your irrigation application unattended for months on end
A tap timer may be used so that irrigation is only available between sunset and sunrise	A tap timer may be used so that irrigation is only available between sunset and sunrise
Increase the diameter of the wetted area by placing a paper towel under the dripper	Increase the diameter of the wetted area by placing a paper towel under the dripper

10. Conclusion

The technique of using pitchers to water plants has been known for at least 2000 years. It is well known in India where it is called pitcher irrigation. Round porous clay pots are buried into the soil near the crop and filled with water. The water seeps out slowly through the porous walls of the pot and reaches the roots of the plants. As the plants consume the water, more water will seep out from the pot.

A major advance in drip irrigation can be achieved by integrating drip irrigation and pitcher irrigation. This remarkable irrigation technology is called **pitcher drip irrigation.** Compared with the most sophisticated drip irrigation technologies, pitcher drip irrigation is far more water efficient and at a fraction of the cost.

Conventional drip irrigation controllers are either sensor-based or weather-based. The most water-efficient sensor-based controllers use expensive soil moisture probes to determine the start time and the run time of next irrigation event. With pitcher drip irrigation the soil moisture probes are replaced by pitchers. Instead of using soil moisture to control irrigation scheduling, plant demand for water is used.

As the crop grows, the demand for water will also grow, and so the crop can be left unattended throughout the growing season.

Conventional weather-based irrigation controllers use reference evapotranspiration data from the Bureau of Meteorology to determine irrigation scheduling. This means that the water usage needs to be adjusted whenever the crop coefficient changes. There are 2 major disadvantages of weather-based irrigation controllers.

- The weather conditions at a weather station of the BOM may differ significantly from the on-site weather conditions.
- To determine the water usage required by your crop at its current stage of growth, the reference evapotranspiration *from* the BOM is multiplied by your best estimate of the crop coefficient. The irrigation scheduling needs to be adjusted manually as the crop grows and the crop coefficient changes. Furthermore, the theoretical evapotranspiration is a crude estimate of the actual evapotranspiration.

For pitcher drip irrigation, the irrigation scheduling is controlled by the water demand of the plants, and so the two major disadvantages of weather-based irrigation controllers become irrelevant.

For drip irrigation or crops, pitcher drip irrigation may be the most water-efficient and cost-effective technology ever.