Which Barrels are Best for Holding Water and Heat in a Passively Heated Greenhouse?

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In the March, 2003 issue of *Small Farm Today*, we described in detail a solar-heated greenhouse that has, without fail, produced bountiful cool-season crops in southwest Missouri for 18 winters. This simple, inexpensive, 12 by 24-foot structure is energy-efficient and heated only by the sun. The greenhouse relies on its low-profile design, insulation, a double layer of plastic on the south side, and a large volume of stored water to regulate interior temperatures on cold winter nights. A winter greenhouse such as this can offer most anyone, from home gardener to serious commercial grower, the chance to extend the growing season and provide family or customer with abundant, tasty, and nutritious crops in winter.

Over the years, hundreds of people have visited this intrepid little greenhouse, located at the University of Missouri's Southwest Research Center near Mt. Vernon, and have asked every conceivable question. But one of the most frequently-asked questions has simply remained unanswered – or answered only by hunches: Are metal or plastic barrels better for storing water in a greenhouse and accumulating and holding solar energy and heat? Last winter we set out to finally answer this persistent, nagging, and potentially important question. We set up an experiment in the Southwest Center's solar-heated greenhouse to measure water temperatures in both types of barrels under various conditions over several weeks in winter. While not a high-tech, state-of-the-art scientific experiment, we did take great pains to set up the metal-versus-plastic barrel study as scientifically as possible so that we would be comfortable and satisfied with the results.

In the greenhouse, 20 plastic 55-gallon barrels, stacked two high, sit on a narrow concrete floor along the insulated north wall. This makes a tall "wall of water" to gather the sun's energy while not taking up too much precious interior space. For the study, we replaced two of these plastic barrels with metal ones. We drained the four test barrels (two plastic and two metal), re-painted them with the same glossy black paint, and re-filled each with exactly 56 gallons of fresh water. The test barrels were placed evenly and randomly across the top row of barrels; these steps ensured us that the only difference between barrels was their structural material of metal or plastic. In keeping with the low-tech nature of the greenhouse, the barrels we used were ordinary plastic and metal barrels that we found locally – nothing fancy. The metal barrels were obtained free, whereas the used plastic barrels were purchased for $5.00 each. Both were very similar in size and design, with sturdy reinforced rims on top and bottom, two horizontal ribs along the outside, presumably for added strength, and two top openings sealed with ordinary metal or plastic "bungs". One additional inherent difference, however, that may be worth noting is that our empty plastic barrels weighed 22.5 pounds while the metal barrels weighed 48.5 pounds.

We used an electronic thermometer with 0.1 ^{o}F precision to take water temperature readings. The central read-out unit was connected to a remote thermometer probe by a long wire. We attached this probe to a PVC pipe so that we could lower the thermometer down into each barrel at exactly the same position and level when measuring water temperatures. We took temperature readings in all 4 experimental barrels generally twice per day (except weekends) from January 26 until April 1, 2004. In the end, we had 66 different temperature datasets taken in all types of winter weather (cold, mild, sunny, cloudy, windy, snowy) and at different times of day.

Going into this, we suspected that metal barrels might have a slight advantage over plastic in accumulating heat because they tend to feel warmer to the human hand on sunny, cold days. It follows, we thought, that if the metal barrels seem to be warming up more when sunlight strikes them, perhaps that heat would transfer on into the water and accumulate for release back into the greenhouse at night. But our hunch was wrong!

Our experiment revealed no differences whatsoever in heat gain advantage by either type of barrel. Overall, after combining and averaging all of our measurements, we found the water in the plastic barrels 0.1 °F warmer than water in metal – virtually identical. The table below summarizes the results of our study. Statistically and realistically, there were simply no water temperature differences between metal and plastic barrels. The largest temperature difference we found when comparing all the various factors was in the mornings when plastic averaged 0.4 °F warmer than metal, but this was still a statistically insignificant difference. The lowest water temperature we recorded all winter was 41.9 °F on Feb. 7 after a period of several cloudy days; the highest water temperature was 80.9 °F on March 11. Since we now know that barrel structural material doesn't make any difference in terms of heat-holding capacity, let's look at the many other factors one might consider when procuring barrels for water storage in greenhouses.

Mean temperatures of water held in metal and plastic barrels at the Southwest Center's solar-heated greenhouse, recorded under various weather conditions and times of day, Jan. 26-Apr.1, 2004.

	Metal	Plastic	Mean	Difference*
Sunny	66.4°F	66.3°F	66.4°F	0.1°F
Sun/Clouds	65.4	65.6	65.5	0.2
Cloudy	63.7	64.0	63.9	0.3
Morning	61.1	61.5	61.3	0.4
Afternoon	69.5	69.2	69.4	0.3
Overall Mean	65.3°F	65.4°F	65.4°F	0.1°F

*None of these values are statistically different.

Perhaps the most important feature is how much water a barrel will hold. We were surprised to find that our plastic barrels each held 4.3 gallons more water than our metal barrels. When multiplied by the 20 barrels we have in the greenhouse, that adds up to an extra 86 gallons of important heat-holding water. By using these particular plastic barrels, we have literally added the equivalent of another 1½ barrels to the greenhouse without taking up any more space! In terms of BTU's, that may not be a tremendous amount of heat, but when the greenhouse is hovering around freezing on a bitter winter night, the additional heat released by those extra 86 gallons of water can only help.

Anastasia (Becker) checks water temperature in the barrels.

But before we begin to think too favorably of plastic, we did have a problem with them. In summer, 2003, two plastic barrels on the bottom layer collapsed. Presumably the plastic material weakened due to constant exposure to ultraviolet radiation and the heavy unrelenting weight they were bearing. Water weighs 8.3 pounds per gallon so the bottom barrel supports about 500 pounds when a 60-gallon barrel is stacked upon it. It is unlikely that this type of plastic barrel is designed to be UV-resistant, nor designed for heavy-duty long-term use. Therefore, they simply may not last a long time in the greenhouse.

On the other hand, our metal barrels can, and did, rust. When the greenhouse was first built, metal barrels were set on wooden planks resting directly on the soil floor. Over time, the wood sank and rotted away leaving the barrels in direct contact with the moist soil and prone to rust and shifting. Also, when full of water and placed in a humid greenhouse, both types of barrels sweat, but metal barrels tend to sweat more than plastic. This additional frequent exposure to exterior moisture from sweating may make metal barrels even more vulnerable to rusting. The tiniest rust hole in the bottom of a metal barrel will eventually allow all the water to drain out, and you may not even know it (this happened to us). During renovations in 2000, a narrow concrete pad was poured inside the greenhouse for the barrels to rest upon (instead of soil), so that rust problems with metal barrels should have been reduced.

The conclusion of all this is that neither metal nor plastic barrels seem to have a clear advantage in this type of greenhouse setting. Because we now know that there is virtually no difference in thermal characteristics between the two types of barrels, and keeping in mind that no barrel will last forever, probably three main criteria will determine which type of barrels you choose: cost, availability, and size. Knowing that they may need to be replaced periodically, cost and availability may be especially important. Whatever type of inexpensive barrels is locally available will likely suffice. It is probably not worthwhile to go to great expense and effort to obtain a particular kind of barrel if some sort of sturdy barrel can be obtained easily, locally, and cheaply. If, however, one can determine that a particular type of barrel can hold more water than another, the larger barrel will likely be a better choice. Beyond these little nuances, the real bottom line is that it really doesn't matter which barrel we use as long as we are able to store water in some sort of safe and efficient manner. We are quite glad to finally put this persistent question to rest so that we can focus our energy and curiosity on more important components of this amazing solar-heated winter greenhouse system.

Reprinted from *Small Farm Today* magazine, November, 2004. Contact Small Farm Today, 3903 W. Ridge Trail Rd., Clark, MO 65243; 1-800-633-2535; www.smallfarmtoday.com