SOAKED

HOW DOES SOIL PORE SIZE AFFECT WATER RETENTION?

Introduction

This project helps desert homeowners know what soil to use for their backyard to eliminate runoff and lead to water uptake. One third of the modern world is desert, with inconsistent rainfall and for the most part, staggering heat and cold. In Tucson, most water from monsoon rainfall runs off into washes, or arroyos. Desert plants are always in need of more water and this project is highly relevant. It is known that soils with macropores absorb water more quickly, and soils with micropores absorb water more slowly but retain, or hold on to it, more efficiently. Loose soils tend to be more porous and have space between pores to absorb water. Water evaporates from the soil quickly in arid areas, leaving tightly packed, dry, and impermiable sand. Most soil in southwestern deserts also forms a biological crust, preventing a large portion of water from being absorbed.

Hypothesis

If the soil type used has larger pores then water will be absorbed more quickly because macropore soil types have more space in between pores to prevent pooling on the surface. However, if a macropore soil type is used, water won’t be retained as well because the water absorbs and drains swiftlybut little is held.

-The question: How does the variety of Sonoran landscaping soil used affect the amount of water absorbed and retained?

*Objective: find a combination of soil types that absorbs and holds runoff the most effectively. *

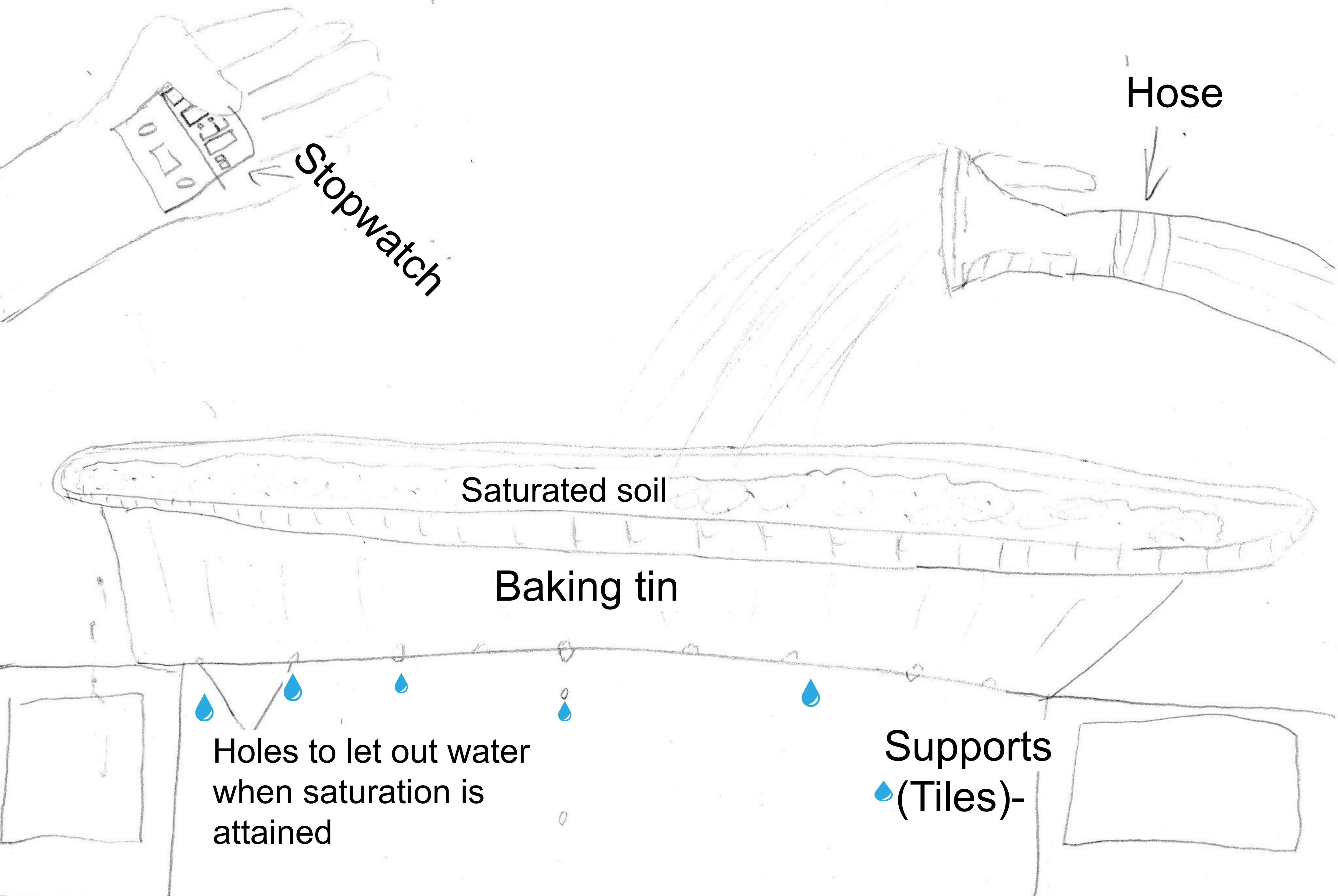
Procedure

Three types of landscaping material were tested on; filtered desert sand, clay topsoil (similar to sand, but more dense), and pea gravel.

- There were 6 varieties of soil used in the project. They were tested in the in the following order: 100% sand, then 50% clay and 50% gravel, then 50% sand and 50% clay, then 50% sand and 50% chat. The last two mixtures used all three. Mixture 5 used 70% sand, 15% clay, and 15% chat, and Mixture 6 used 70% clay, 15% sand, and 15% chat.
- First, the combination of soils were measured out into a baking tin, always 2,600 grams each. This tin had a grid of holes, 9 in total, poked each about an inch apart in the bottom of the tin. The tin was rested on tiles, so that the bottom was visible.
- A hose was turned on, always shower setting, and pointed upwards to simulate a rainstorm. The tin containing the soil would receive water until the first drop of water is observed exiting the tin through the bottom. When the first drop exited, a timer for 5 minutes was set.

Procedure Continued

- After the first drop water exits the tin, the hose is turned off, and a timer for 5 minutes is set. The soil sits for the 5 full minutes, and at the end, the batch is set on a scale and weighed. Most batches only received about 45 seconds of water, for that was their full potential for absorption.
- The average soil batch also gained only about 200 grams, or 7-8% more than their original weight. Of course, after an average monsoon, in which the rain is falling more quickly and with more force, the soil would probably as much as a third more than it's original weight. For each of the 6 soil types, there were 3 trials, totalling 18 separate batches.


Hose
Stopwatch
Saturated soil
Baking tin
Holes to let out water when saturation is attained
Supports (Tiles)-

Materials

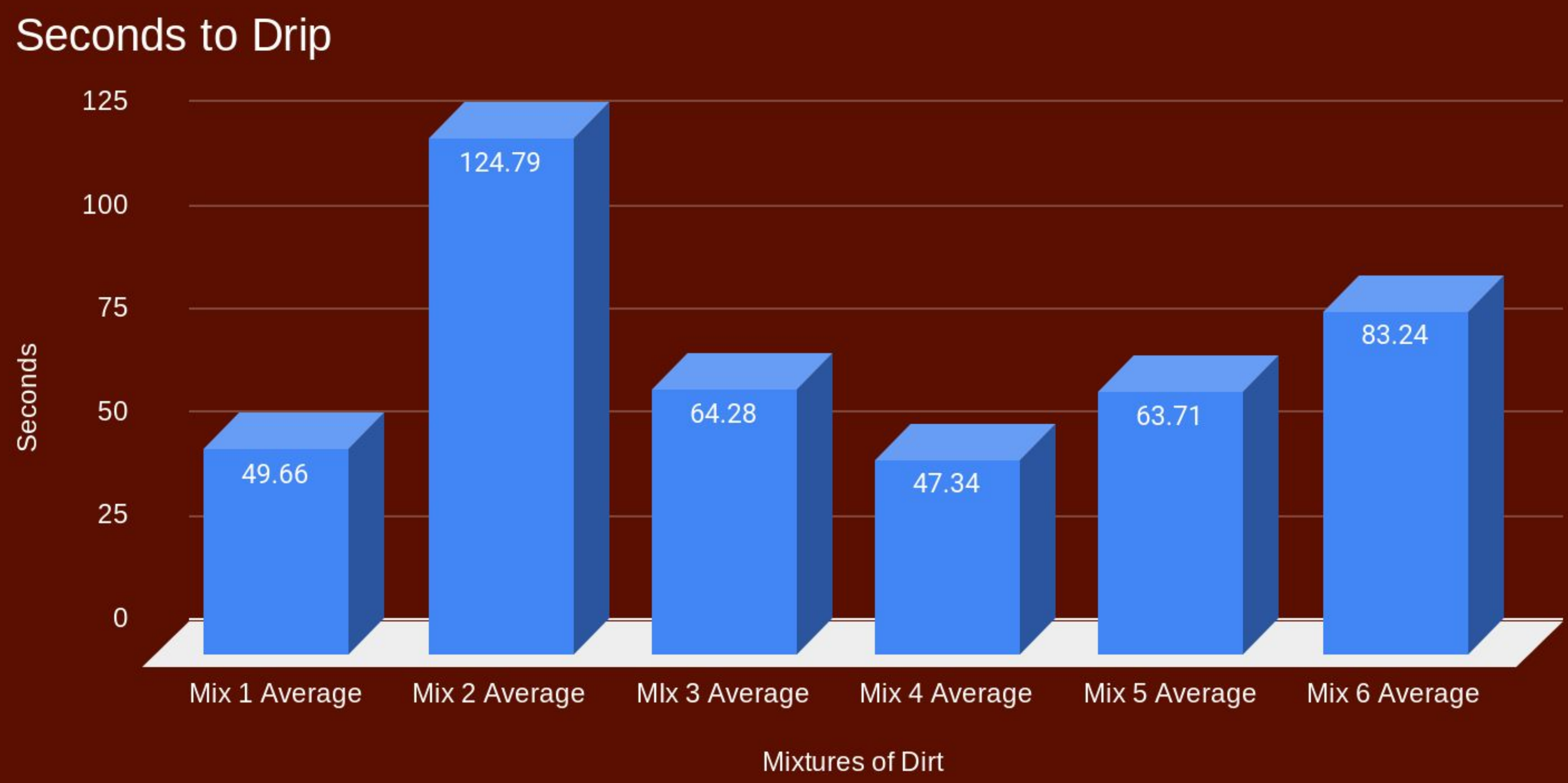
- 30 9 by 9 inch measuring tins
- Hose
- 60 lbs of clay, sand, chat soil
- Scale
- Tiles
- Timer
- Bounty paper towels
- Computer

	Trial 1	Trial 2	Trial 3	
Mix 1	46.62	46.53	55.83	seconds
	2720	2698	2734	Weight (g)
Mix 2	128.76	122.01	123.61	seconds
	2930	2958	2931	Weight (g)
Mix 3	61.95	67.45	63.45	seconds
	2745	2734	2713	Weight (g)
Mix 4	38.85	64.75	38.43	seconds
	2982	2774	2667	Weight (g)
Mix 5	60.39	64.75	66	seconds
	2828	2774	2669	Weight (g)
Mix 6	85.74	76.34	87.65	seconds
	2951	2922	2910	Weigh (g)

The average trial's saturation was 72.17 seconds. The average post-trial soil weight was 2,813 grams, 213 more than the start. No desert soil will be completely saturated after a rainstorm, and most water will run off. It was noticed that most of the time, only the top ⅛ of the soil was damp post-trial. The simulated shower was relatively short and only produced about a tenth of an inch of rain, a fraction of the average monsoon storm.

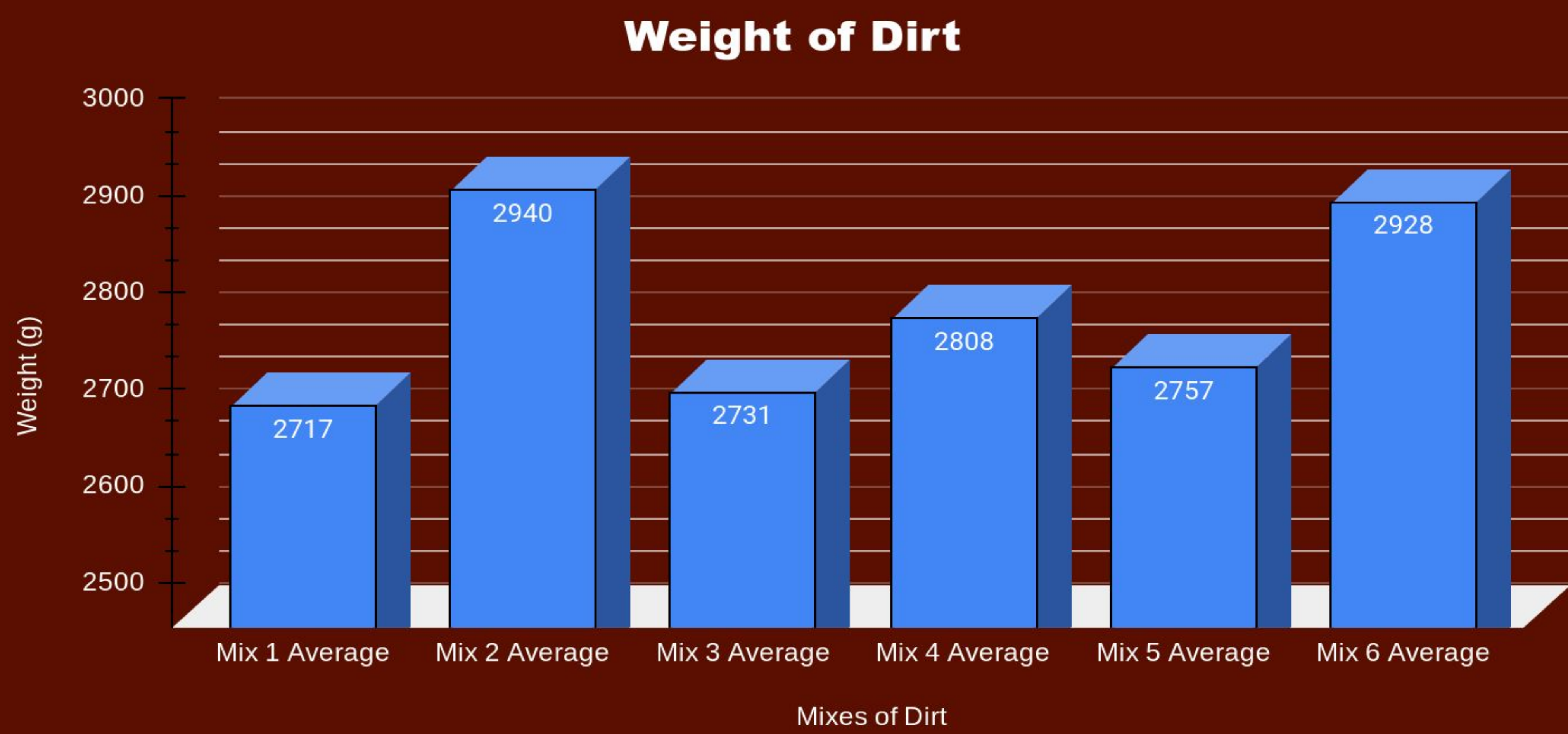
Results

Mixture two took the longest to drip from the bottom of the tin. The mixture two 124.79 seconds until water started to come out. The mixtures that had clay held the most amount of water. Mixtures two, three, five, and six all had clay and absorbed the most amount of water. The longest time until saturation was 124.79 seconds (mixture 2) and the shortest time was 47.34 (mixture 4). The graphs tell us that the mixture with clay on the bottom and chat on top held the most water.



Results Continued

The combination of 1300 grams of pea gravel and 1300 grams of clay topsoil, or mixture two, weighed an average of 2940 grams after the trial, 340 grams more than the start, and 12-223 grams more than the other trials. The trials with clay weighed on average more than trials with clay absent. Also, a trend seen was the trials that contained more gravel could absorb more water, and it didn't pool on the top as fast. The data tells us that gravel can absorb water on contact and the clay underneath can retain most of the water until the end of the 5 minutes.



Conclusion

- In this experiment, it was concluded that sand does not retain water as well as clay, and gravel aids both of them in the process.
- Mixture number 2 (50% pea gravel and 50% clay topsoil), saturated more slowly and absorbed more water than any other mixture in the experiment. The results also concluded that mixtures containing more clay had higher water holding capacity than mixtures with more sand.
- Pea gravel could slow down the water on contact, and the results show that the sand/clay at the bottom of the pan could hold the water if slowed down. Our hypothesis predicted, based on research on pore size, that larger pores could prevent pooling at the top and that smaller pores at the bottom could prevent water from running off into surrounding soil and, eventually, washes.
- The results indicated that gravel, with very large pores, let almost all of the water in on contact, and very little water was visible on the surface at the end of the experiment. Furthermore, clay, with small and tightly packed pores, had less air space between particles but could trap the water as it rushes through the gravel and prevent it from leaking out the bottom. In the most effective trial two, it was noticed no water leaked out the bottom of the tin in the five minutes after the hose was turned off. This indicates incredible water holding capabilities.

Conclusion

- Overall, it was a relatively flawless procedure. It was efficient, and the testing for the groups of three batches, for one type of soil, took about an hour each. The simulated rainstorm worked well, and when the soil was being disposed of, it was noticed that the most successful batch was entirely saturated, while some that did not have the absorbent gravel layer at the top were only partially saturated, the soil being almost entirely dry below the first half inch.
- One change that could have benefited the experiment was testing all three batches of one soil type together, staggering 30 seconds apart so that one batch could be weighed before the five minutes had ended on the next one. However, this would have been more difficult and could have resulted in errors.

Implications for future research

One third of Earth's land surface is desert. This means that unpredictable rainfall and temperatures threaten crops and wildlife as global warming becomes more severe. Specifically in Tucson, a foot of rainfall was seen in Tucson this monsoon season, on of the highest in recorded history. Most of this water drained into washes, and Tucson didn't see another major rainstorm until December. Landscaping techniques that could trap rainwater will be effective and surprisingly cheap (70 pounds of soil can be purchased for $8). A combination of pea gravel and clay could trap rainwater, and the use of plants native to the desert could also slow down errant rainwater runoff. Studying the use of plants to prevent erosion and trap rainwater would be another interesting topic to study. Using both techniques aforementioned, almost anyone can trap runoff rainwater and use it for their own purposes. Based on the results of this experiment, studying how vegetation traps rainwater and the general water cycle would be interesting topics to study next. Soil erosion and how plants prevent it would also be something worth learning more about.

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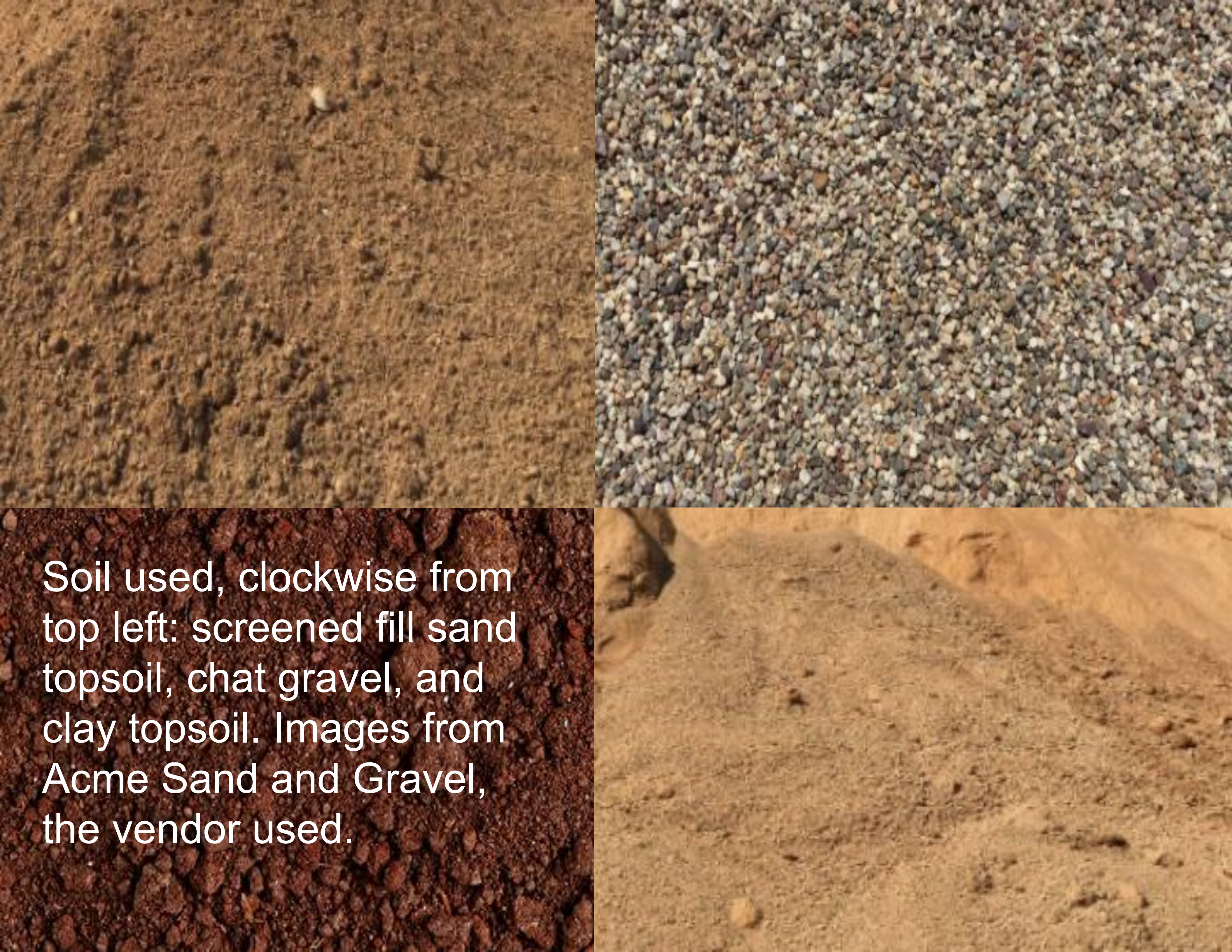

Soil used, clockwise from top left: screened fill sand topsoil, chat gravel, and clay topsoil. Images from Acme Sand and Gravel, the vendor used.