Testing the EarthBuster Device for Enhancing Soil Drainage through Severe Hardpan by Pneumatic Soil Fracturing

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ABSTRACT

This experiment examines the efficacy of the *EarthBuster Deep Soil Decompactor* for remediation of poor drainage in severe hardpan areas by the process of pneumatic soil fracturing. In these tests, the rate of surface water absorption in a field was measured in two groups: 1) a *Control Group* consisting of a row of ten surface spots on ground that had not been pneumatically fractured, and 2) an *Experimental Group* row of ten surface spots directly over pneumatically fractured soil. Results were dramatic, with the average *Control Group* spot draining 5 gallons of water in 00:17:30, and the average *Experimental Group* spot (over and around the probe hole) draining at 00:02:50. This represents a reduction in draining time to about 1/6 (or about 17%) of the *Control Group* average.

INTRODUCTION

Poor soil drainage causes many well-documented problems in such fields as agriculture, grounds maintenance, and septic system maintenance. In the interests of brevity, this report assumes that the reader is familiar with these problems, and is generally interested in finding better and more cost-effective methods of drainage problem remediation. For example:

1. Can an orchard or vineyard floor be safely and effectively decompacted *between* plantings?
2. Can a field be decompacted without the utter surface and capillary disruption and the time delays associated with deep ripping?
3. Can ponding/puddling be relieved without installing drainage systems, and without major damage to lawns?
4. Can septic drain fields and French drains be rejuvenated, so as to avoid replacement or duplication?

Pneumatic fracturing of compacted soils is generally attractive on account of the “green” nature of the process. It does not involve the introduction of chemicals or toxins into the environment, as it uses only compressed air (administered through a rigid probe) to fracture the soil. Further, it can be done by probing through and beyond the sod layer, resulting in little disturbance of the lawn itself, while restoring subsurface flow of water, minerals, and air.

The goal of the present experiment is to measure the extent to which the absorption of water through hardpan is increased by use of the *EarthBuster Deep Soil Decompactor*. (See *Image 1*.) The test site was chosen as a known example of a severe hardpan, with local farmers reporting a very thick hardpan over a base of soft sand. Just south of Laurel, MT, in the Yellowstone River Valley, where soils are known to be sandy, a 16-foot long observation trench of approximately 6 feet in depth was dug on site, revealing 6-10 inches of topsoil over an obvious hardpan that averages about 36 inches thick. Under the hardpan lies soft sand down to the bottom of the trench. (See *Image 2*.) The soil at the time of this test appeared to be very dry, both above and below the hardpan.

Image 1. EarthBuster device mounted on a skid-steer with air compressor in background.

Image 2. Extreme hardpan with soft sand beneath.

EXPERIMENTAL DESIGN

The design of the experiment called for two groups of test sites, a Control Group, and Experimental Group. The two groups were in close proximity to one another, under the assumption that underlying soil conditions would be as similar as possible. The Control Group consisted of 10 absorption test sites, spaced at 4 feet on center, along a straight line. For the Control Group row, no pneumatic fracturing was done. Meanwhile, the Experimental Group absorption test sites were laid out in identical fashion to the Control Group, with the Experimental Group site being parallel to and approximately 5 feet from the Control Group.

Each Experimental Group absorption test site was centered on a probe hole where the EarthBuster device had been used to pneumatically fracture the soil at depths of 2”, 4”, and 6”. The test sites of each group were labeled. Control group sites were designated as C1, C2, C3 etc., while Experimental Group sites were labeled as E1, E2, E3, etc.

These probe holes were spaced 4 feet apart, and oriented in a straight line. See **Image 3** below for a map of the test layout.

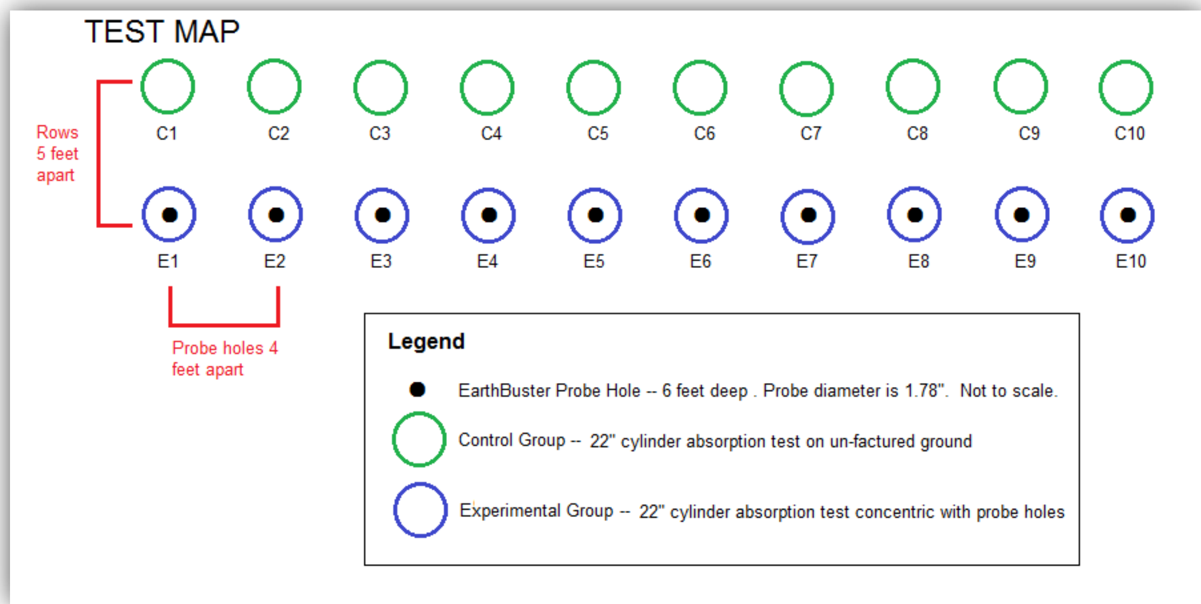

Image 3. Map of experiment design.

ABSORPTION TEST METHODOLOGY

Absorption was measured by placing a cylinder on the ground, sealing it against leakage, and then pouring in water and timing how long it took for all the water to absorb into the ground, such that all signs of puddling had disappeared. The cylinders used were made from a cut-down 55-gallon oil drum with a diameter of approximately 22 inches. (Seem *Image 4*.) Each cylinder

Image 4. Absorption test cylinder

was approximately 10 inches in height, and was rotated axially in order to cut like a hole saw along the ground surface until it had dug into the surface to a depth of approximately 1 inch. Loose dirt raised inside the cylinder by this sawing action was then pushed tight against the interior of the cylinder so as to block leakage. (Where significant leaks developed, test results were omitted from the data.)

Each of the two cylinders used have a volume of approximately 3,801 cubic inches, or just over 16 gallons, which is more than adequate to handle the 5 gallons of water applied at each site. Water was poured into each cylinder from a 5-gallon bucket, and as soon as it was all poured, a stopwatch was started to measure the absorption time. The stopwatch was not stopped until such time as no more puddles (of any size) could be seen at the ground surface.

Care was taken to fill each 5-gallon bucket fully with water. Data from cylinder tests where significant leakage occurred were ommitted from the results. Visible surface seepage of 1-2" was common around the cylinders, and was not considered significant. (See *Image 5*.)

Image 5. Seepage of 1-2" outside the cylinders was not considered significant.

Also considered insignificant were other factors, such as minor spillage from the fill buckets, the amount of vegetation present at each test site, the rock content of the soil below each test site, and the ever-changing weather effects on the rate of evaporation throughout the data collection period.

The absorption tests were conducted approximately 30 hours after the Experimental Group sites were probed and pneumatically fractured.

PNEUMATIC SOIL FRACTURING METHODOLOGY

The pneumatic soil fracturing was done by use of the *EarthBuster Deep Soil Decompactor*, manufactured by K&P Enterprises, LLC of Laurel, MT. US Patent No. 6,939,085. The EarthBuster device, weighing approximately 790 pounds, was mounted on a Bobcat T450, tracked skid-steer with a weight of approximately 5,899 pounds (with bucket removed), for a gross weight of 6,689 pounds. With its rubber tracks, the Bobcat T450 exerts approximately 4.7 psi of pressure on the ground. At no time did the tracks travel over the test sites.

The EarthBuster was pneumatically powered by an Airman PDS185S air compressor, which has a free air delivery of 185 CFM and a working pressure of 100 psi. The EarthBuster's integrated Sullair MPB 90a air hammer assists the tractor boom in driving the EarthBuster probe when required by ground hardness. The probe has an outer diameter of 1.75" and a length of 72". The operator ran the EarthBuster's onboard air tank at approximately 120 PSI and used air bursts of approximately 1 second duration.

When fracturing for this experiment, compressed air was blown into the probe shaft at a depth of approximately 2 feet, and then again at depths of 4 and 6 feet. The probe was then removed from the hole, and the tractor was advanced to the next probing site, 4 feet forward.

On this particular test, where extreme compaction required the use of the air hammer almost 100% of the time during probe insertion, the decompaction took approximately 78 seconds per hole. It is noted that on sites with softer and/or moister soil, the probe can often be inserted in a fraction of that time, and may not even require the air hammer at all.

RESULTS

Results of the absorption tests are recorded in *Table 1* and *Table 2* below, and then in a cartographic representation (*Image 6*).

Control Group Absorption Test Sites	**Seconds for Drainage** (Non-fractured soil)
C1	863
C2	1685
C3	656
C4	771
C5	901
C6	969
C7	1112
C8	1053
C9	1130
C10	1362
Average Seconds	1050
Avg. Min:Sec	17:30

Table 1. Control Group Absorption Values

Experiment Group Absorption Test Sites	**Seconds for Drainage** (Over fractured soil)
E1	101
E2	44
E3	59
E4	148
E5	120
E6	215
E7	105
E8	108
E9	287
E10	517
Average Seconds	170
Avg. Min:Sec	2:50

Table 2. Experiment Group Absorption Values

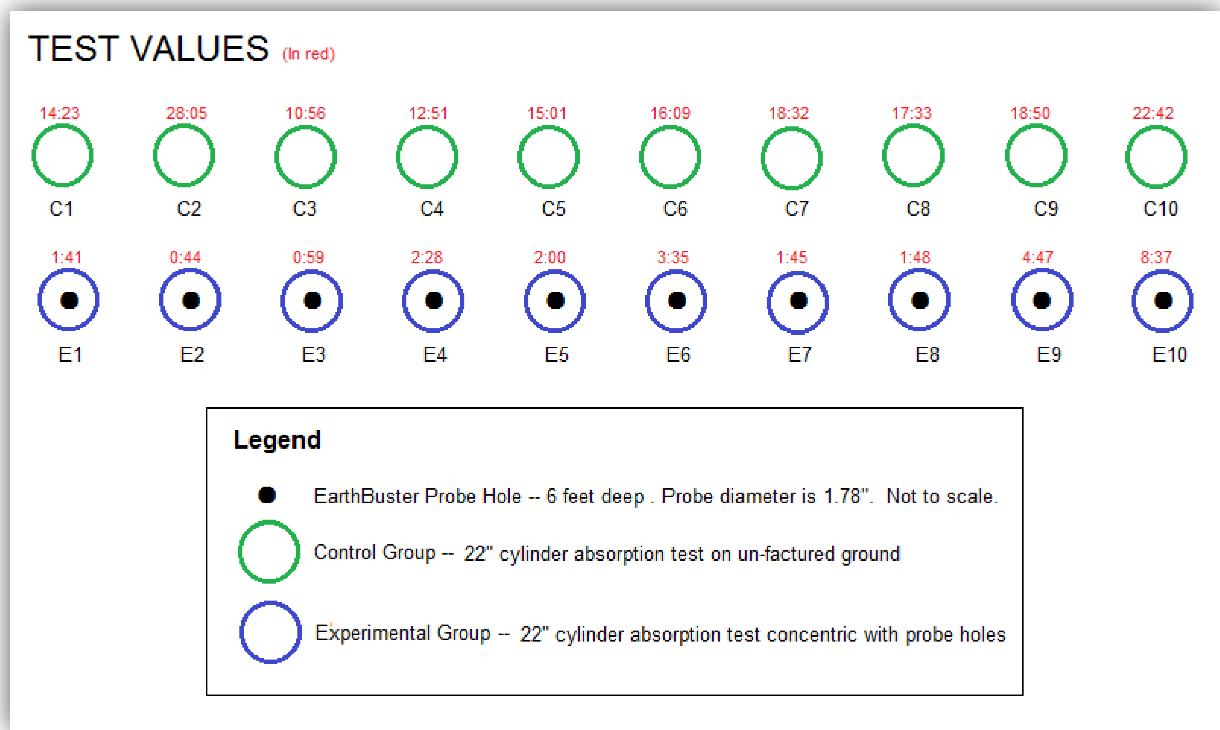

Image 6. Test Values Map

DISCUSSION

With the fractured sites absorbing water six times faster than the non-fractured sites, the results were compelling. Whether the problem is water, nutrients, and oxygen being blocked by hardpan from reaching the lower roots of orchards and vineyards, slow-draining water in a field, or poorly-draining and poorly-aerated septic drain fields, these results are obviously promising, and the discussion likely turns quickly to cost-effectiveness.

This present experiment was carried out in a location known to have extreme hardpan that is both thick and dry, with an average annual rainfall of 14.77”. [1] The test row of 10 fracturing sites spanned 36 feet from the first hole to the last, and took about 13 minutes to fracture. At this rate, 100 sites over extreme hardpan could be fractured in 130 minutes, or 2 hours and 10 minutes. In ground that is less compact and/or has greater moisture, the EarthBuster probe is known to be insertable without the help of the air hammer. Rather, it will often press immediately into the soil, requiring much less time. While no such formal study has been done to measure such times, they are believed to be 30 seconds per hole, or less, in some cases. Assuming a per-hole range of 30 to 78 seconds per hole, a row of 100 fracture sites could be created in 50 to 130 minutes.

The spacing between facture holes seems to be a function of the level of ground compaction. In looser soils, the EarthBuster’s bursts of air are witnessed to create surface vents at distances up to 5 to 10 feet away from the probe placement. In the harder soil of this present test, witnesses noted that a great deal of air was venting back up through the probe shaft, with smaller amounts being vented within a radius of about one foot from the probe. The lateral range of the fracturing should be the strongest determinant in the planned spacing of the fracture holes.

In this present case, for example, an ancillary test conducted on the day after, and otherwise not reported herein, measured the absorption between (and not over) the probe holes (see Image 7) and returned values quite similar to those of the Control Group, where no fracturing had been done. In other words, no increase in absorption rate was found in the 22”-diameter areas between those 22”-diameter areas (concentric with the probe holes) that had been measured the day before. This is to be expected, of course, in a case in which the compaction is so severe that the lateral impact of the fracturing is minimized, and most of the air vents straight upward, or nearly straight upward.

Image 7. Absorption test being conducted between probe sites that were tested the day before. Note that there is no probe hole under the water in the cylinder. Absorption rate values for these in-between sites were similar to those of the Control Group in this test, suggesting that in this particualr soil, it would be ideal to fracture every 2 feet, rather than every 4. In soils of less compaction and greater moisture, however, distances of over 4 feet may well be adequate.

In this particular test, therefore, an ideal spacing between fracture sites would be closer to 2 feet, rather than to the 4 feet called for in the experiment design—provided that the goal of the process were to maximize absorption rates. Depending on the real-world purpose for such a fracturing operation, however, it could well be that 4-foot centers are adequate to achieve the drainage improvement necessary to solve the problem at hand. Some trial and error may be called for, depending on the purpose for the fracturing.

For the purpose of gathering an estimate of efficiency, therefore, the probing span of 4 feet between holes seems reasonable. In this case, a row crop, such as in an orchard or vineyard (where roots are deeper than with crops such as wheat or hay), could be treated at a rate of 400 row feet in 50 to 130 minutes, depending on moisture and compaction. While row spacing various considerably from one orchard or vineyard to another, we can arbitrarily pick a row width of 10 feet in order to derive a rough per-acre time model for the EarthBuster. In the case of a perfectly squared acre (209' x 209'), for example, there would be approximately 19 crop rows at 209 feet each. At 4' centers, each row would have 52 fracture holes, for a total of 988 holes per acre. Not accounting for row-end turning, our previous range of 30 to 78 seconds per hole gives us a time range of between 494 minutes (8 hours, 15 minutes) and 1,284 minutes (21 hours, 24 minutes) per acre—depending on moisture content and compaction. Put more simply, the range would be from 1 to 3 work days per acre for a row crop treated at every 4 feet, depending on soil conditions.

Meanwhile, septic contractors using the EarthBuster report 1 to 2 hours to treat a typical drain field of 4,500 square feet. A similar time would be expected to treat a 4,500-square-foot area in a slow-draining field.

In agriculture, the return on investment for any field treatment is generally calculated in terms of increased yield after a treatment. Due to the long term of crop cycles, however, the benefits of pneumatic soil fracturing should not be expected to be immediately obvious, and make take from 1-3 years to document. Meanwhile, in septic use, restored drain field function can be witnessed immediately, starting on the very day of treatment. Similarly, puddling/ponding remediation success can become obvious within just minutes or hours of EarthBuster fracturing.

CONCLUSIONS

In this experiment, the EarthBuster Deep Soil Decompactor was demonstrated to increase the absorption rate of water through severe hardpan to six times faster than the rate of the Control Group. This work, commissioned by K&P Enterprises, LLC, the manufacturer of the EarthBuster [2], is very encouraging, and it is hoped that academic institutions will conduct their own experimentation into the EarthBuster's efficacy. K&P Enterprises, LLC will continue to conduct such studies, including, but not limited to a repeat of this same study in different soil types, and studies of before/after compaction levels using soil penetrometers. Further needful studies include long-term and short-term measurements of the increase in soil oxygen levels and soil moisture levels, as well as in the time it takes for soil to recompact, requiring a subsequent treatment. Similarly, puddling/ponding remediation studies, as well as septic drain field remediation studies are needful. Additionally, a multitude of studies are called for regarding the establishment of best practices for use of the EarthBuster device on various crop types.

REFERENCES

[1] *"Average Weather for Laurel, MT - Temperature and Precipitation". Weather.com. Retrieved August 4, 2010.* http://www.weather.com/weather/monthly/l/USMT0198

[2] EarthBuster.com. http://earthbuster.com