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# **Soil Moisture-based Control Technology Testing**

Deliverable 6: Soil Moisture Sensor Testing Final Report

For

Innovative Conservation Program  
Agreement No. 180892

By

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July 29, 2019

Deliverable 6 for this project is the final report of four brands of soil moisture sensor (SMS) testing. One complete test consists of an SMS brand tested on two soil types, two water salinity levels and three soil moisture depletion amounts (12 individual tests). Each test of a brand consists of three sensors in a test box of a single soil, salinity, depletion level combination. This report integrates all work accomplished in this project.

This work was in parallel to the testing and committee analysis by the American Society of Agricultural and Biological Engineers (ASABE) X633, Testing Soil Moisture Sensors for Landscape Irrigation, committee. This committee has been developing the test protocol for the SMS testing.

As part of the test protocol the committee has developed an artificial soil media consisting of the following material:

- 60F fine silica sand
- 325 mesh silica flour
- Sodium bentonite

Details of these materials can be seen in Figs. 1-4.

The two soil media mixes were analyzed for textural class and had particle sizes and soil classifications as follows with proportions determined by weight:

6:2:2, coarse media (63%, 16%, 21%; sand, silt, clay)  
1:1:1, fine media (40%, 29%, 31%; sand, silt, clay)

Soil moisture sensor brands tested were as follows:

- Baseline S100 soil moisture sensors
- Irrrometer #WEM soil moisture sensors
- Rain Bird SMRT-Y soil moisture sensors
- Toro Precision soil sensors

### **Test Method**

Prior to testing, the sensors are read in the air and immersed completely in water to establish the range of readings for a sensor (Figs. 5-6).

The test consists of mixing the media mix in known proportions of air dried soil (Fig. 7). Next, a known amount of water is added to the soil mix to result in a depletion level relative to the media type field capacity (FC). For the 6:2:2 media, an FC of 20% by volume was used while an FC of 32% on the 1:1:1 media was used. As a result, depletion levels of 20%, 40% and 60% respectively of FC corresponded to:

|       |  |
|-------|--|
| Media | Water content at 20%, 40%, 60% depletion |
| 6:2:2 | 16%, 12%, and 8% by volume               |
| 1:1:1 | 25.6%, 19.2%, and 12.8% by volume        |

Once a given media/depletion level combination is mixed, the mixture is carefully packed to a known volume in containers in thin layers (Fig. 8). Once the container is packed approximately half full the sensors are placed in the container and wet media mixture is packed around the sensors (Fig. 9). Next, the container is covered and weighed (Fig. 10). Sensor readings are immediately taken along with the controller trigger on and trigger off readings. All three readings were then taken 24 hours later (Fig. 11).

## **Results and Discussion**

Test results are presented as raw data of probe response in tabular format for each brand. Sensor readings, and threshold on/off readings were tabulated for each of the three water depletion levels 20%, 40%, and 60% of field capacity. Results are presented in the following order as coarse media 0 dS/m four brands (Tables 1-12), fine media 0 dS/m four brands (Tables 13-24), coarse media 3 dS/m four brands (Tables 25-36) and fine media 3 dS/m four brands (Tables 37-48). In addition freeze test results are shown in Tables 49-52) for brands A-D, respectively.

Response curves across the three depletion levels are presented in a similar order as raw data with coarse media 0 dS/m four brands (Figs. 12-18), fine media 0 dS/m four brands (Figs. 19-25), coarse media 3 dS/m four brands (Figs. 26-32) and fine media 3 dS/m four brands (Figs. 33-39).

Generally brands A and B produced consistent results across all test conditions. Brands C and D had more variable test results. Brand C readings were only taken after 24 hr since this sensor requires a 24 hr equilibration period. Brand C had reasonably consistent response across the depletion levels though more variable than brands A and B. Brand D had reasonably consistent results at the 0 dS/m EC level but results were highly inconsistent at the 3 dS/m EC level with no response at 0 hrs and a variable response across sensors after 24 hrs. For all tests, brand D failed to switch off irrigation in the threshold decrease. In addition, this sensor essentially did not respond at the 60% depletion level.

Table 1. Brand A coarse media (6:2:2) 20% depletion test results, 0 dS/m water.

|                         | Box #: 1  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 1         | 2    | 3    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 98.9      | 99.1 | 96.7 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 11.8 | 11.9 | 11.6 |
| Threshold Increase-0 h (VMC): | 12.0 | 12.0 | 12.0 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 11.5 | 11.5 | 11.5 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 11.7 | 12.1 | 11.9 |
| Threshold Increase-24 h (VMC): | 12.0 | 12.5 | 12.0 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 11.5 | 12.0 | 11.5 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 2. Brand A coarse media (6:2:2) 40% depletion test results, 0 dS/m water.

|                         | Box #: 2  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 4         | 5    | 6    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 99.5      | 99.6 | 98.4 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 9.7  | 10.4 | 9.8  |
| Threshold Increase-0 h (VMC): | 10.0 | 10.5 | 10.0 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 9.5  | 10   | 9.5  |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 9.6  | 10.4 | 9.8  |
| Threshold Increase-24 h (VMC): | 10.0 | 10.5 | 10.0 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 9.5  | 10.0 | 9.5  |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 3. Brand A coarse media (6:2:2) 60% depletion test results, 0 dS/m water.

|                         | Box #: 3  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 7         | 8    | 9    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 98.8      | 99.0 | 99.6 |

|                               |     |     |     |
|-------------------------------|-----|-----|-----|
| Reading-0 h (VMC):            | 8.0 | 7.9 | 8.4 |
| Threshold Increase-0 h (VMC): | 8.5 | 8.0 | 8.5 |
| Allowed watering (Y/N):       | Y   | Y   | Y   |
| Threshold Decrease-0 h (VMC): | 7.5 | 7.5 | 8   |
| Allowed watering (Y/N):       | N   | N   | N   |

|                                |     |     |     |
|--------------------------------|-----|-----|-----|
| Reading-24 h (VMC):            | 8.0 | 8.1 | 8.8 |
| Threshold Increase-24 h (VMC): | 8.5 | 8.5 | 9.0 |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Threshold Decrease-24 h (VMC): | 7.5 | 8.0 | 8.5 |
| Allowed watering (Y/N):        | N   | N   | N   |

Table 4. Brand B coarse media (6:2:2) 20% depletion test results, 0 dS/m water.

|                         | Box #: 1  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 1         | 2    | 3    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 38.0      | 37.6 | 37.5 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 21.2 | 22.6 | 20.9 |
| Threshold Increase-0 h (VMC): | 21.3 | 22.7 | 21.0 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 21.1 | 22.5 | 20.8 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 21.1 | 22.6 | 21.3 |
| Threshold Increase-24 h (VMC): | 21.2 | 22.7 | 21.4 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 21   | 22.5 | 21.2 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 5. Brand B coarse media (6:2:2) 40% depletion test results, 0 dS/m water.

|                         | Box #: 2  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 4         | 5    | 6    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 37.8      | 37.7 | 38.0 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 19.5 | 19.2 | 18.5 |
| Threshold Increase-0 h (VMC): | 19.6 | 19.3 | 18.6 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 19.4 | 19.1 | 18.4 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 19.5 | 19.3 | 18.7 |
| Threshold Increase-24 h (VMC): | 19.6 | 19.4 | 18.8 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 19.4 | 19.2 | 18.6 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 6. Brand B coarse media (6:2:2) 60% depletion test results, 0 dS/m water.

|                                | Box #: 3  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 7         | 8    | 9    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 37.5      | 37.5 | 37.3 |
| Reading-0 h (VMC):             | 14.2      | 13.6 | 13.8 |
| Threshold Increase-0 h (VMC):  | 14.3      | 13.7 | 13.9 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 14.1      | 13.5 | 13.7 |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 14.6      | 14.1 | 14.3 |
| Threshold Increase-24 h (VMC): | 14.7      | 14.2 | 14.4 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 14.5      | 14.0 | 14.2 |
| Allowed watering (Y/N):        | N         | N    | N    |



Table 7. Brand C coarse media (6:2:2) 20% depletion test results, 0 dS/m water.

|                              | Box #: A       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 1              | 2  | 3  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 3              | 3  | 3  |
| Threshold Increase-24 h (#): | 4              | 4  | 4  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 2              | 2  | 2  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 8. Brand C coarse media (6:2:2) 40% depletion test results, 0 dS/m water.

|                              | Box #: B       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 4              | 5  | 6  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 5              | 5  | 5  |
| Threshold Increase-24 h (#): | 6              | 6  | 6  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 4              | 4  | 4  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 9. Brand C coarse media (6:2:2) 60% depletion test results, 0 dS/m water.

| Box #: C                     |    |    |    |
|------------------------------|----|----|----|
| Sensor pair #:               |    |    |    |
|                              | 7  | 8  | 9  |
| Reading-in Air (#):          | 11 | 11 | 11 |
| Reading-in Water (#):        | 1  | 1  | 1  |
| Reading-24 h (#):            | 6  | 5  | 3  |
| Threshold Increase-24 h (#): | 7  | 6  | 4  |
| Allowed watering (Y/N):      | Y  | Y  | Y  |
| Threshold Decrease-24 h (#): | 5  | 4  | 2  |
| Allowed watering (Y/N):      | N  | N  | N  |

Table 10. Brand D coarse media (6:2:2) 20% depletion test results, 0 dS/m water.

|                                | Box #: 1  |     |     |
|--------------------------------|-----------|-----|-----|
|                                | Sensor #: |     |     |
|                                | 1         | 2   | 3   |
| Reading-in Air (VMC):          | -1        | -1  | -1  |
| Reading-in Water (VMC):        | 150       | 150 | 150 |
| Reading-0 h (VMC):             | 19        | 25  | 26  |
| Threshold Increase-0 h (VMC):  |           |     |     |
| Allowed watering (Y/N):        | Y         | Y   | Y   |
| Threshold Decrease-0 h (VMC):  |           |     |     |
| Allowed watering (Y/N):        | Y         | Y   | Y   |
| Reading-24 h (VMC):            | 17        | 27  | 26  |
| Threshold Increase-24 h (VMC): |           |     |     |
| Allowed watering (Y/N):        | Y         | Y   | Y   |
| Threshold Decrease-24 h (VMC): |           |     |     |
| Allowed watering (Y/N):        | Y         | Y   | Y   |

Table 11. Brand D coarse media (6:2:2) 40% depletion test results, 0 dS/m water.

|                                | Box #: 2  |     |     |
|--------------------------------|-----------|-----|-----|
|                                | Sensor #: |     |     |
|                                | 4         | 5   | 6   |
| Reading-in Air (VMC):          | -1        | -1  | -1  |
| Reading-in Water (VMC):        | 150       | 150 | 150 |
| Reading-0 h (VMC):             | 9         | -1  | -1  |
| Threshold Increase-0 h (VMC):  |           |     |     |
| Allowed watering (Y/N):        | Y         | Y   | Y   |
| Threshold Decrease-0 h (VMC):  |           | NA  | NA  |
| Allowed watering (Y/N):        | Y         | Y   | Y   |
| Reading-24 h (VMC):            | 9         | -1  | -1  |
| Threshold Increase-24 h (VMC): |           |     |     |
| Allowed watering (Y/N):        | Y         | Y   | Y   |
| Threshold Decrease-24 h (VMC): |           | NA  | NA  |
| Allowed watering (Y/N):        | Y         | Y   | Y   |

Table 12. Brand D coarse media (6:2:2) 60% depletion test results, 0 dS/m water.

|                         | Box #: 3  |     |     |
|-------------------------|-----------|-----|-----|
|                         | Sensor #: |     |     |
|                         | 7         | 8   | 9   |
| Reading-in Air (VMC):   | -1        | -1  | -1  |
| Reading-in Water (VMC): | 150       | 150 | 150 |

|                               |    |    |    |
|-------------------------------|----|----|----|
| Reading-0 h (VMC):            | -1 | -1 | 0  |
| Threshold Increase-0 h (VMC): | NA | NA | NA |
| Allowed watering (Y/N):       | Y  | Y  | Y  |
| Threshold Decrease-0 h (VMC): | NA | NA | NA |
| Allowed watering (Y/N):       | Y  | Y  | Y  |

|                                |    |    |    |
|--------------------------------|----|----|----|
| Reading-24 h (VMC):            | -1 | -1 | -1 |
| Threshold Increase-24 h (VMC): | NA | NA | NA |
| Allowed watering (Y/N):        | Y  | Y  | Y  |
| Threshold Decrease-24 h (VMC): | NA | NA | NA |
| Allowed watering (Y/N):        | Y  | Y  | Y  |

Table 13. Brand A fine media (1:1:1) 20% depletion test results, 0 dS/m water.

|                         | Box #: 4  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 1         | 2    | 3    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 98.9      | 99.1 | 96.7 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 16.1 | 15.6 | 16.1 |
| Threshold Increase-0 h (VMC): | 16.5 | 16.0 | 16.5 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 16.0 | 15.5 | 16.0 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 16.2 | 15.5 | 16.0 |
| Threshold Increase-24 h (VMC): | 16.5 | 16.0 | 16.5 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 16.0 | 15.0 | 15.5 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 14. Brand A fine media (1:1:1) 40% depletion test results, 0 dS/m water.

|                         | Box #: 5  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 4         | 5    | 6    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 99.5      | 99.6 | 98.4 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 13.4 | 14.5 | 13.6 |
| Threshold Increase-0 h (VMC): | 13.5 | 15.0 | 14.0 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 13.0 | 14.0 | 13.5 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 14.0 | 14.8 | 14.2 |
| Threshold Increase-24 h (VMC): | 14.5 | 15.0 | 14.5 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 13.5 | 14.5 | 14.0 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 15. Brand A fine media (1:1:1) 60% depletion test results, 0 dS/m water.

|                                | Box #: 6  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 7         | 8    | 9    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 98.8      | 99.0 | 99.6 |
| Reading-0 h (VMC):             | 10.6      | 10.4 | 10.6 |
| Threshold Increase-0 h (VMC):  | 11.0      | 10.5 | 11.0 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 10.5      | 10.0 | 10.5 |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 10.8      | 11.0 | 10.7 |
| Threshold Increase-24 h (VMC): | 11.0      | 11.5 | 11.0 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 10.5      | 10.5 | 10.5 |
| Allowed watering (Y/N):        | N         | N    | N    |

Table 16. Brand B fine media (1:1:1) 20% depletion test results, 0 dS/m water.

|                         | Box #: 3  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 7         | 8    | 9    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 38.0      | 37.6 | 37.5 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 25.0 | 25.1 | 24.7 |
| Threshold Increase-0 h (VMC): | 25.1 | 25.2 | 24.8 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 24.9 | 25.0 | 24.6 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 25.8 | 26.0 | 25.6 |
| Threshold Increase-24 h (VMC): | 25.9 | 26.1 | 25.7 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 25.7 | 25.9 | 25.5 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 17. Brand B fine media (1:1:1) 40% depletion test results, 0 dS/m water.

|                         | Box #: 2  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 4         | 5    | 6    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 37.8      | 37.7 | 38.0 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 22.1 | 22.6 | 22.3 |
| Threshold Increase-0 h (VMC): | 21.2 | 21.7 | 21.4 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 21.0 | 21.5 | 21.2 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 23.2 | 23.6 | 23.2 |
| Threshold Increase-24 h (VMC): | 23.3 | 23.7 | 23.3 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 23.1 | 23.5 | 23.1 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 18. Brand B fine media (1:1:1) 60% depletion test results, 0 dS/m water.

|                                | Box #: 1  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 1         | 2    | 3    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 37.5      | 37.5 | 37.3 |
| Reading-0 h (VMC):             | 16.7      | 16.7 | 16.1 |
| Threshold Increase-0 h (VMC):  | 16.8      | 16.8 | 16.2 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 16.6      | 16.6 | 16   |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 18.0      | 17.8 | 16.9 |
| Threshold Increase-24 h (VMC): | 18.1      | 17.9 | 17.0 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 17.9      | 17.7 | 16.8 |
| Allowed watering (Y/N):        | N         | N    | N    |



Table 19. Brand C fine media (1:1:1) 20% depletion test results, 0 dS/m water.

|                              | Box #: A       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 1              | 2  | 3  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 3              | 4  | 3  |
| Threshold Increase-24 h (#): | 4              | 5  | 4  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 2              | 3  | 2  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 20. Brand C fine media (1:1:1) 40% depletion test results, 0 dS/m water.

|                              | Box #: B       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 4              | 5  | 6  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 7              | 7  | 7  |
| Threshold Increase-24 h (#): | 8              | 8  | 8  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 6              | 6  | 6  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 21. Brand C fine media (1:1:1) 60% depletion test results, 0 dS/m water.

|                              | Box #: C       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 7              | 8  | 9  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 10             | 9  | 8  |
| Threshold Increase-24 h (#): | 11             | 10 | 9  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 9              | 8  | 7  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 22. Brand D fine media (1:1:1) 20% depletion test results, 0 dS/m water.

|                         | Box #: E  |     |     |
|-------------------------|-----------|-----|-----|
|                         | Sensor #: |     |     |
|                         | 1         | 2   | 3   |
| Reading-in Air (VMC):   | -1        | -1  | -1  |
| Reading-in Water (VMC): | 150       | 150 | 150 |

|                               |    |    |    |
|-------------------------------|----|----|----|
| Reading-0 h (VMC):            | 74 | 67 | 56 |
| Threshold Increase-0 h (VMC): |    |    |    |
| Allowed watering (Y/N):       | Y  | Y  | Y  |
| Threshold Decrease-0 h (VMC): |    |    |    |
| Allowed watering (Y/N):       | Y  | Y  | N  |

|                                |    |    |    |
|--------------------------------|----|----|----|
| Reading-24 h (VMC):            | 78 | 71 | 71 |
| Threshold Increase-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |
| Threshold Decrease-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |

Table 23. Brand D fine media (1:1:1) 40% depletion test results, 0 dS/m water.

|                         | Box #: D  |     |     |
|-------------------------|-----------|-----|-----|
|                         | Sensor #: |     |     |
|                         | 4         | 5   | 6   |
| Reading-in Air (VMC):   | -1        | -1  | -1  |
| Reading-in Water (VMC): | 150       | 150 | 150 |

|                               |    |    |    |
|-------------------------------|----|----|----|
| Reading-0 h (VMC):            | 39 | 38 | 51 |
| Threshold Increase-0 h (VMC): |    |    |    |
| Allowed watering (Y/N):       | Y  | Y  | Y  |
| Threshold Decrease-0 h (VMC): |    |    |    |
| Allowed watering (Y/N):       | Y  | Y  | Y  |

|                                |    |    |    |
|--------------------------------|----|----|----|
| Reading-24 h (VMC):            | 42 | 35 | 50 |
| Threshold Increase-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |
| Threshold Decrease-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |

Table 24. Brand D fine media (1:1:1) 60% depletion test results, 0 dS/m water.

|                         | Box #: F  |     |     |
|-------------------------|-----------|-----|-----|
|                         | Sensor #: |     |     |
|                         | 7         | 8   | 9   |
| Reading-in Air (VMC):   | -1        | -1  | -1  |
| Reading-in Water (VMC): | 150       | 150 | 150 |

|                               |    |    |    |
|-------------------------------|----|----|----|
| Reading-0 h (VMC):            | 0  | 0  | 0  |
| Threshold Increase-0 h (VMC): |    |    |    |
| Allowed watering (Y/N):       | Y  | Y  | Y  |
| Threshold Decrease-0 h (VMC): | NA | NA | NA |
| Allowed watering (Y/N):       | NA | NA | NA |

|                                |    |    |    |
|--------------------------------|----|----|----|
| Reading-24 h (VMC):            | 0  | 0  | 0  |
| Threshold Increase-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |
| Threshold Decrease-24 h (VMC): | NA | NA | NA |
| Allowed watering (Y/N):        | NA | NA | NA |

Table 25. Brand A coarse media (6:2:2) 20% depletion test results, 3 dS/m water.

|                         | Box #: 4  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 1         | 2    | 3    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 98.9      | 99.1 | 96.7 |

|                               |      |       |      |
|-------------------------------|------|-------|------|
| Reading-0 h (VMC):            | 13.3 | 13.0  | 11.9 |
| Threshold Increase-0 h (VMC): | 13.5 | 135.0 | 12.0 |
| Allowed watering (Y/N):       | Y    | Y     | Y    |
| Threshold Decrease-0 h (VMC): | 13.0 | 12.5  | 11.5 |
| Allowed watering (Y/N):       | N    | N     | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 13.5 | 13.2 | 12.2 |
| Threshold Increase-24 h (VMC): | 14.0 | 13.5 | 12.5 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 13.0 | 13.0 | 12.0 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 26. Brand A coarse media (6:2:2) 40% depletion test results, 3 dS/m water.

|                         | Box #: 5  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 4         | 5    | 6    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 99.5      | 99.6 | 98.4 |

|                               |     |     |      |
|-------------------------------|-----|-----|------|
| Reading-0 h (VMC):            | 8.9 | 9.0 | 9.8  |
| Threshold Increase-0 h (VMC): | 9.0 | 9.5 | 10.0 |
| Allowed watering (Y/N):       | Y   | Y   | Y    |
| Threshold Decrease-0 h (VMC): | 8.5 | 8.5 | 9.5  |
| Allowed watering (Y/N):       | N   | N   | N    |

|                                |     |     |      |
|--------------------------------|-----|-----|------|
| Reading-24 h (VMC):            | 9.1 | 9.2 | 9.7  |
| Threshold Increase-24 h (VMC): | 9.5 | 9.5 | 10.0 |
| Allowed watering (Y/N):        | Y   | Y   | Y    |
| Threshold Decrease-24 h (VMC): | 9.0 | 9.0 | 9.5  |
| Allowed watering (Y/N):        | N   | N   | N    |

Table 27. Brand A coarse media (6:2:2) 60% depletion test results, 3 dS/m water.

|                         | Box #: 6  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 7         | 8    | 9    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 98.8      | 99.0 | 99.6 |

|                               |     |     |     |
|-------------------------------|-----|-----|-----|
| Reading-0 h (VMC):            | 7.7 | 6.9 | 7.8 |
| Threshold Increase-0 h (VMC): | 8.0 | 7.0 | 8.0 |
| Allowed watering (Y/N):       | Y   | Y   | Y   |
| Threshold Decrease-0 h (VMC): | 7.5 | 6.5 | 7.5 |
| Allowed watering (Y/N):       | N   | N   | N   |

|                                |     |     |     |
|--------------------------------|-----|-----|-----|
| Reading-24 h (VMC):            | 7.9 | 7.2 | 8.0 |
| Threshold Increase-24 h (VMC): | 8.0 | 7.5 | 8.5 |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Threshold Decrease-24 h (VMC): | 7.5 | 7.0 | 7.5 |
| Allowed watering (Y/N):        | N   | N   | N   |

Table 28. Brand B coarse media (6:2:2) 20% depletion test results, 3 dS/m water.

|                                | Box #: 1  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 1         | 2    | 3    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 38.0      | 37.6 | 37.5 |
| Reading-0 h (VMC):             | 24.6      | 24.0 | 24.0 |
| Threshold Increase-0 h (VMC):  | 24.5      | 24.1 | 24.1 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 24.5      | 23.9 | 23.9 |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 24.5      | 23.9 | 23.9 |
| Threshold Increase-24 h (VMC): | 24.6      | 24.0 | 24.0 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 24.4      | 23.8 | 23.8 |
| Allowed watering (Y/N):        | N         | N    | N    |

Table 29. Brand B coarse media (6:2:2) 40% depletion test results, 3 dS/m water.

|                                | Box #: 2  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 4         | 5    | 6    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 37.8      | 37.7 | 38.0 |
| Reading-0 h (VMC):             | 18.2      | 18.6 | 19.2 |
| Threshold Increase-0 h (VMC):  | 18.3      | 18.7 | 19.3 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 18.1      | 18.5 | 19.1 |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 18.4      | 18.9 | 19.3 |
| Threshold Increase-24 h (VMC): | 18.5      | 19.0 | 19.4 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 18.3      | 18.8 | 19.2 |
| Allowed watering (Y/N):        | N         | N    | N    |

Table 30. Brand B coarse media (6:2:2) 60% depletion test results, 3 dS/m water.

|                         | Box #: 3  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 7         | 8    | 9    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 37.5      | 37.5 | 37.3 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 13.8 | 14.0 | 13.4 |
| Threshold Increase-0 h (VMC): | 13.9 | 14.1 | 13.5 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 13.7 | 13.9 | 13.3 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 14.1 | 14.4 | 13.6 |
| Threshold Increase-24 h (VMC): | 14.2 | 14.5 | 13.7 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 14.0 | 14.3 | 13.5 |
| Allowed watering (Y/N):        | N    | N    | N    |



Table 31. Brand C coarse media (6:2:2) 20% depletion test results, 3 dS/m water.

|                              | Box #: 3       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 1              | 2  | 3  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 6              | 6  | 6  |
| Threshold Increase-24 h (#): | 7              | 7  | 7  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 5              | 5  | 5  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 32. Brand C coarse media (6:2:2) 40% depletion test results, 3 dS/m water.

|                              | Box #: B       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 4              | 5  | 6  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 5              | 5  | 5  |
| Threshold Increase-24 h (#): | 6              | 6  | 6  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 4              | 4  | 4  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 33. Brand C coarse media (6:2:2) 60% depletion test results, 3 dS/m water.

| Box #: 7                     |    |    |    |
|------------------------------|----|----|----|
| Sensor pair #:               |    |    |    |
|                              | 7  | 8  | 9  |
| Reading-in Air (#):          | 11 | 11 | 11 |
| Reading-in Water (#):        | 1  | 1  | 1  |
| Reading-24 h (#):            | 3  | 4  | 3  |
| Threshold Increase-24 h (#): | 4  | 5  | 4  |
| Allowed watering (Y/N):      | Y  | Y  | Y  |
| Threshold Decrease-24 h (#): | 2  | 3  | 2  |
| Allowed watering (Y/N):      | N  | N  | N  |

Table 34. Brand D coarse media (6:2:2) 20% depletion test results, 3 dS/m water.

| Box #: 4                       |     |     |     |
|--------------------------------|-----|-----|-----|
| Sensor #:                      |     |     |     |
|                                | 1   | 2   | 3   |
| Reading-in Air (VMC):          | -1  | -1  | -1  |
| Reading-in Water (VMC):        | 150 | 150 | 150 |
| Reading-0 h (VMC):             | 150 | 150 | 150 |
| Threshold Increase-0 h (VMC):  | NA  | NA  | NA  |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Threshold Decrease-0 h (VMC):  |     |     |     |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Reading-24 h (VMC):            | 10  | 36  | 30  |
| Threshold Increase-24 h (VMC): |     |     |     |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Threshold Decrease-24 h (VMC): |     |     |     |
| Allowed watering (Y/N):        | Y   | Y   | Y   |

Table 35. Brand D coarse media (6:2:2) 40% depletion test results, 3 dS/m water.

| Box #: C                       |     |     |     |
|--------------------------------|-----|-----|-----|
| Sensor #:                      |     |     |     |
|                                | 4   | 5   | 6   |
| Reading-in Air (VMC):          | -1  | -1  | -1  |
| Reading-in Water (VMC):        | 150 | 150 | 150 |
| Reading-0 h (VMC):             | 150 | 150 | 150 |
| Threshold Increase-0 h (VMC):  | NA  | NA  | NA  |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Threshold Decrease-0 h (VMC):  |     |     |     |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Reading-24 h (VMC):            | 12  | 0   | 0   |
| Threshold Increase-24 h (VMC): |     |     |     |
| Allowed watering (Y/N):        | Y   | Y   | Y   |
| Threshold Decrease-24 h (VMC): |     | NA  | NA  |
| Allowed watering (Y/N):        | Y   | Y   | Y   |

Table 36. Brand D coarse media (6:2:2) 60% depletion test results, 3 dS/m water.

|                         | Box #: D  |     |     |
|-------------------------|-----------|-----|-----|
|                         | Sensor #: |     |     |
|                         | 7         | 8   | 9   |
| Reading-in Air (VMC):   | -1        | -1  | -1  |
| Reading-in Water (VMC): | 150       | 150 | 150 |

|                               |     |     |     |
|-------------------------------|-----|-----|-----|
| Reading-0 h (VMC):            | 150 | 150 | 150 |
| Threshold Increase-0 h (VMC): | NA  | NA  | NA  |
| Allowed watering (Y/N):       | Y   | Y   | Y   |
| Threshold Decrease-0 h (VMC): |     |     |     |
| Allowed watering (Y/N):       | Y   | Y   | Y   |

|                                |    |    |    |
|--------------------------------|----|----|----|
| Reading-24 h (VMC):            | -1 | -1 | -1 |
| Threshold Increase-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |
| Threshold Decrease-24 h (VMC): | NA | NA | NA |
| Allowed watering (Y/N):        | Y  | Y  | Y  |

Table 37. Brand A fine media (1:1:1) 20% depletion test results, 3 dS/m water.

|                         | Box #: 4  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 1         | 2    | 3    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 98.9      | 99.1 | 96.7 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 22.8 | 21.3 | 21.5 |
| Threshold Increase-0 h (VMC): | 23.0 | 21.5 | 22.0 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 22.5 | 21.0 | 21.0 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 22.8 | 21.6 | 21.6 |
| Threshold Increase-24 h (VMC): | 23.0 | 22.0 | 22.0 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 22.5 | 21.5 | 21.5 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 38. Brand A fine media (1:1:1) 40% depletion test results, 3 dS/m water.

|                         | Box #: 5  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 4         | 5    | 6    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 99.5      | 99.6 | 98.4 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 14.1 | 14.8 | 15.8 |
| Threshold Increase-0 h (VMC): | 14.5 | 15.0 | 16.0 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 14.0 | 14.5 | 15.5 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 14.0 | 14.9 | 16.0 |
| Threshold Increase-24 h (VMC): | 14.5 | 15.0 | 16.5 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 13.5 | 14.5 | 15.5 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 39. Brand A fine media (1:1:1) 60% depletion test results, 3 dS/m water.

|                         | Box #: 6  |      |      |
|-------------------------|-----------|------|------|
|                         | Sensor #: |      |      |
|                         | 7         | 8    | 9    |
| Reading-in Air (VMC):   | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC): | 98.8      | 99.0 | 99.6 |

|                               |      |      |      |
|-------------------------------|------|------|------|
| Reading-0 h (VMC):            | 11.4 | 11.9 | 12.1 |
| Threshold Increase-0 h (VMC): | 11.5 | 12.0 | 12.5 |
| Allowed watering (Y/N):       | Y    | Y    | Y    |
| Threshold Decrease-0 h (VMC): | 11.0 | 11.5 | 12.0 |
| Allowed watering (Y/N):       | N    | N    | N    |

|                                |      |      |      |
|--------------------------------|------|------|------|
| Reading-24 h (VMC):            | 11.3 | 12.0 | 12.0 |
| Threshold Increase-24 h (VMC): | 11.5 | 12.5 | 12.5 |
| Allowed watering (Y/N):        | Y    | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 11.0 | 11.5 | 11.5 |
| Allowed watering (Y/N):        | N    | N    | N    |

Table 40. Brand B fine media (1:1:1) 20% depletion test results, 3 dS/m water.

|                                | Box #: 3  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 7         | 8    | 9    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 38.0      | 37.6 | 37.5 |
| Reading-0 h (VMC):             | 27.3      | 27.4 | 27.1 |
| Threshold Increase-0 h (VMC):  | 27.4      | 27.5 | 27.2 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 27.2      | 27.3 | 27.0 |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 27.3      | 27.4 | 27.2 |
| Threshold Increase-24 h (VMC): | 27.4      | 27.5 | 27.3 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 27.2      | 27.3 | 27.1 |
| Allowed watering (Y/N):        | N         | N    | N    |

Table 41. Brand B fine media (1:1:1) 40% depletion test results, 3 dS/m water.

|                                | Box #: 2  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 4         | 5    | 6    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 37.8      | 37.7 | 38.0 |
| Reading-0 h (VMC):             | 26.0      | 26.0 | 25.7 |
| Threshold Increase-0 h (VMC):  | 26.1      | 26.1 | 25.8 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 25.9      | 25.9 | 25.6 |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 26.0      | 26.0 | 25.7 |
| Threshold Increase-24 h (VMC): | 26.1      | 26.1 | 25.8 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 25.9      | 25.9 | 25.6 |
| Allowed watering (Y/N):        | N         | N    | N    |

Table 42. Brand B fine media (1:1:1) 60% depletion test results, 3 dS/m water.

|                                | Box #: 1  |      |      |
|--------------------------------|-----------|------|------|
|                                | Sensor #: |      |      |
|                                | 1         | 2    | 3    |
| Reading-in Air (VMC):          | 0.0       | 0.0  | 0.0  |
| Reading-in Water (VMC):        | 37.5      | 37.5 | 37.3 |
| Reading-0 h (VMC):             | 19.2      | 19.4 | 19.0 |
| Threshold Increase-0 h (VMC):  | 19.3      | 19.5 | 19.1 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-0 h (VMC):  | 19.1      | 19.3 | 18.9 |
| Allowed watering (Y/N):        | N         | N    | N    |
| Reading-24 h (VMC):            | 19.9      | 20.3 | 19.5 |
| Threshold Increase-24 h (VMC): | 20.0      | 20.4 | 19.6 |
| Allowed watering (Y/N):        | Y         | Y    | Y    |
| Threshold Decrease-24 h (VMC): | 19.8      | 20.2 | 19.4 |
| Allowed watering (Y/N):        | N         | N    | N    |



Table 43. Brand C fine media (1:1:1) 20% depletion test results, 3 dS/m water.

|                              | Box #: A       |     |     |
|------------------------------|----------------|-----|-----|
|                              | Sensor pair #: |     |     |
|                              | 1              | 2   | 3   |
| Reading-in Air (#):          | 11             | 11  | 11  |
| Reading-in Water (#):        | 1              | 1   | 1   |
| Reading-24 h (#):            | 1              | 1   | 1   |
| Threshold Increase-24 h (#): | 2              | 2   | 2   |
| Allowed watering (Y/N):      | Y              | Y   | Y   |
| Threshold Decrease-24 h (#): | OFF            | OFF | OFF |
| Allowed watering (Y/N):      | NA             | NA  | NA  |

Table 44. Brand C fine media (1:1:1) 40% depletion test results, 3 dS/m water.

|                              | Box #: B       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 4              | 5  | 6  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 2              | 3  | 3  |
| Threshold Increase-24 h (#): | 3              | 4  | 4  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 1              | 2  | 2  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 45. Brand C fine media (1:1:1) 60% depletion test results, 3 dS/m water.

|                              | Box #: C       |    |    |
|------------------------------|----------------|----|----|
|                              | Sensor pair #: |    |    |
|                              | 7              | 8  | 9  |
| Reading-in Air (#):          | 11             | 11 | 11 |
| Reading-in Water (#):        | 1              | 1  | 1  |
| Reading-24 h (#):            | 8              | 7  | 8  |
| Threshold Increase-24 h (#): | 9              | 8  | 9  |
| Allowed watering (Y/N):      | Y              | Y  | Y  |
| Threshold Decrease-24 h (#): | 7              | 8  | 7  |
| Allowed watering (Y/N):      | N              | N  | N  |

Table 46. Brand D fine media (1:1:1) 20% depletion test results, 3 dS/m water.

|                         | Box #: 3  |        |        |
|-------------------------|-----------|--------|--------|
|                         | Sensor #: |        |        |
|                         | 7         | 8      | 9      |
| Sensor ID (#)           | 038849    | 038851 | 038648 |
| Reading-in Air (VMC):   | -1        | -1     | -1     |
| Reading-in Water (VMC): | 150       | 150    | 150    |

|                               |    |   |   |
|-------------------------------|----|---|---|
| Reading-0 h (VMC):            | 0  | 5 | 1 |
| Threshold Increase-0 h (VMC): |    |   |   |
| Allowed watering (Y/N):       | Y  | Y | Y |
| Threshold Decrease-0 h (VMC): | NA |   |   |
| Allowed watering (Y/N):       | NA | Y | Y |

|                                |    |    |    |
|--------------------------------|----|----|----|
| Reading-24 h (VMC):            | 22 | 54 | 36 |
| Threshold Increase-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |
| Threshold Decrease-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |

Table 47. Brand D fine media (1:1:1) 40% depletion test results, 3 dS/m water.

|                         | Box #: 6  |        |        |
|-------------------------|-----------|--------|--------|
|                         | Sensor #: |        |        |
|                         | 4         | 5      | 6      |
| Sensor ID (#)           | 038621    | 038624 | 038711 |
| Reading-in Air (VMC):   | -1        | -1     | -1     |
| Reading-in Water (VMC): | 150       | 150    | 150    |

|                               |   |    |    |
|-------------------------------|---|----|----|
| Reading-0 h (VMC):            | 4 | 51 | 24 |
| Threshold Increase-0 h (VMC): |   |    |    |
| Allowed watering (Y/N):       | Y | Y  | Y  |
| Threshold Decrease-0 h (VMC): | 3 | 50 | 23 |
| Allowed watering (Y/N):       | Y | Y  | Y  |

|                                |    |    |    |
|--------------------------------|----|----|----|
| Reading-24 h (VMC):            | -1 | 35 | -1 |
| Threshold Increase-24 h (VMC): |    |    |    |
| Allowed watering (Y/N):        | Y  | Y  | Y  |
| Threshold Decrease-24 h (VMC): | NA |    | NA |
| Allowed watering (Y/N):        | NA | Y  | NA |

Table 48. Brand D fine media (1:1:1) 60% depletion test results, 3 dS/m water.

|                                       |               |               |               |
|---------------------------------------|---------------|---------------|---------------|
| <b>Box #: 7</b>                       |               |               |               |
| <b>Sensor #:</b>                      |               |               |               |
|                                       | <b>1</b>      | <b>2</b>      | <b>3</b>      |
| <b>Sensor ID (#)</b>                  | <b>038529</b> | <b>038650</b> | <b>038671</b> |
| <b>Reading-in Air (VMC):</b>          | -1            | -1            | -1            |
| <b>Reading-in Water (VMC):</b>        | 150           | 150           | 150           |
| <b>Reading-0 h (VMC):</b>             | 37            | 25            | 16            |
| <b>Threshold Increase-0 h (VMC):</b>  |               |               |               |
| <b>Allowed watering (Y/N):</b>        | Y             | Y             | Y             |
| <b>Threshold Decrease-0 h (VMC):</b>  |               |               |               |
| <b>Allowed watering (Y/N):</b>        | Y             | Y             | Y             |
| <b>Reading-24 h (VMC):</b>            | 0             | -1            | 0             |
| <b>Threshold Increase-24 h (VMC):</b> |               |               |               |
| <b>Allowed watering (Y/N):</b>        | Y             | Y             | Y             |
| <b>Threshold Decrease-24 h (VMC):</b> | NA            | NA            | NA            |
| <b>Allowed watering (Y/N):</b>        | NA            | NA            | NA            |

Table 49. Freeze test results for brand A.

| Box #: 5                             |      |      |      |                  |       |
|--------------------------------------|------|------|------|------------------|-------|
| Sensor #:                            |      |      |      |                  |       |
|                                      | 4    | 5    | 6    | Temperature (°C) |       |
| Reading-in Air (VMC):                | 0.0  | 0.0  | 0.0  |                  |       |
| Reading-in Water (VMC):              | 99.5 | 99.6 | 98.4 | Air              | Soil  |
| Reading Pre-Freeze Test (VMC):       | 14.0 | 14.7 | 14.1 | 23.0             | 22.0  |
| Threshold Increase-0 h (VMC):        | 14.5 | 15.0 | 14.5 |                  |       |
| Allowed watering (Y/N):              | Y    | Y    | Y    |                  |       |
| Threshold Decrease-0 h (VMC):        | 13.5 | 14.5 | 14.0 |                  |       |
| Allowed watering (Y/N):              | N    | N    | N    |                  |       |
| Reading-3 days after freezing (VMC): | 4.1  | 0.9  | 3.5  | -18.0            | -18.0 |
| Threshold Increase-24 h (VMC):       | 4.5  | 1.0  | 4.0  |                  |       |
| Allowed watering (Y/N):              | Y    | Y    | Y    |                  |       |
| Threshold Decrease-24 h (VMC):       | 4.0  | 0.5  | 3.0  |                  |       |
| Allowed watering (Y/N):              | N    | N    | N    |                  |       |
| Reading-48 h after Thaw (VMC):       | 14.5 | 14.6 | 14.3 | 23.0             | 21.5  |
| Threshold Increase-24 h (VMC):       | 15.0 | 15.0 | 14.5 |                  |       |
| Allowed watering (Y/N):              | Y    | Y    | Y    |                  |       |
| Threshold Decrease-24 h (VMC):       | 14.0 | 14.5 | 14.0 |                  |       |
| Allowed watering (Y/N):              | N    | N    | N    |                  |       |

Table 50. Freeze test results for brand.

| Box #: 2                             |      |      |      |                  |       |
|--------------------------------------|------|------|------|------------------|-------|
| Sensor #:                            |      |      |      |                  |       |
|                                      | 4    | 5    | 6    | Temperature (°C) |       |
| Reading-in Air (VMC):                | 0.0  | 0.0  | 0.0  |                  |       |
| Reading-in Water (VMC):              | 37.8 | 37.7 | 38.0 | Air              | Soil  |
| Reading Pre-Freeze Test (VMC):       | 24.4 | 24.7 | 24.4 | 23.0             | 22.0  |
| Threshold Increase-0 h (VMC):        | 24.5 | 24.8 | 24.5 |                  |       |
| Allowed watering (Y/N):              | Y    | Y    | Y    |                  |       |
| Threshold Decrease-0 h (VMC):        | 24.3 | 24.6 | 24.3 |                  |       |
| Allowed watering (Y/N):              | N    | N    | N    |                  |       |
| Reading-3 days after freezing (VMC): | 6.3  | 1.5  | 7.8  | -18.0            | -18.0 |
| Threshold Increase-24 h (VMC):       | 6.4  | 1.6  | 7.9  |                  |       |
| Allowed watering (Y/N):              | Y    | Y    | Y    |                  |       |
| Threshold Decrease-24 h (VMC):       | 6.2  | 1.4  | 7.7  |                  |       |
| Allowed watering (Y/N):              | N    | N    | N    |                  |       |
| Reading-24 h after Thaw (VMC):       | 26.9 | 23.5 | 25.8 | 23.0             | 22.0  |
| Threshold Increase-24 h (VMC):       | 27.0 | 23.6 | 25.9 |                  |       |
| Allowed watering (Y/N):              | Y    | Y    | Y    |                  |       |
| Threshold Decrease-24 h (VMC):       | 26.8 | 23.4 | 25.7 |                  |       |
| Allowed watering (Y/N):              | N    | N    | N    |                  |       |

Table 51. Freeze test results for brand C.

| Box #: B                           |    |    |    |  |      |
|------------------------------------|----|----|----|--|------|
| Sensor #:                          |    |    |    |  |      |
|                                    | 4  | 5  | 6  |  |      |
| Reading-in Air (#):                | 11 | 11 | 11 | Temperature (°C)                               |      |
| Reading-in Water (#):              | 1  | 1  | 1  | Air  | Soil |
| Reading Pre-Freeze Test (#):       | 7  | 7  | 7  | 22   | 21   |
| Threshold Increase-0 h (#):        | 8  | 8  | 8  | Cannot increase threshold beyond set point #11 |      |
| Allowed watering (Y/N):            | Y  | Y  | Y  |  |      |
| Threshold Decrease-0 h (#):        | 6  | 6  | 6  |  |      |
| Allowed watering (Y/N):            | N  | N  | N  |  |      |
| Reading-3 days after freezing (#): | 11 | 11 | 11 | 23   | -18  |
| Threshold Increase-24 h (#):       | NA | NA | NA | Cannot increase threshold beyond set point #11 |      |
| Allowed watering (Y/N):            | NA | NA | NA |  |      |
| Threshold Decrease-24 h (#):       | 10 | 10 | 10 |  |      |
| Allowed watering (Y/N):            | N  | N  | N  |  |      |
| Reading-24 h after Thaw (#):       | 9  | 9  | 9  | 22   | 21   |
| Threshold Increase-24 h (#):       | 10 | 10 | 10 |  |      |
| Allowed watering (Y/N):            | Y  | Y  | Y  |  |      |
| Threshold Decrease-24 h (#):       | 8  | 8  | 8  |  |      |
| Allowed watering (Y/N):            | N  | N  | N  |  |      |

Table 52. Freeze test results for brand D.

| Box #: B                           |     |     |     |                  |      |
|------------------------------------|-----|-----|-----|------------------|------|
| Sensor #:                          |     |     |     |                  |      |
|                                    | 4   | 5   | 6   |                  |      |
| Reading-in Air (#):                | -1  | -1  | -1  | Temperature (°C) |      |
| Reading-in Water (#):              | 150 | 150 | 150 | Air              | Soil |
| Reading Pre-Freeze Test (#):       | 42  | 35  | 50  | 22               | 21   |
| Threshold Increase-0 h (#):        |     |     |     |                  |      |
| Allowed watering (Y/N):            | Y   | Y   | Y   |                  |      |
| Threshold Decrease-0 h (#):        |     |     |     |                  |      |
| Allowed watering (Y/N):            | Y   | Y   | Y   |                  |      |
| Reading-3 days after freezing (#): | 33  | 30  | 38  | 22               | -18  |
| Threshold Increase-24 h (#):       |     |     |     |                  |      |
| Allowed watering (Y/N):            | Y   | Y   | Y   |                  |      |
| Threshold Decrease-24 h (#):       |     |     |     |                  |      |
| Allowed watering (Y/N):            | Y   | Y   | Y   |                  |      |
| Reading-24 h after Thaw (#):       | 43  | 25  | 43  | 22               | 21   |
| Threshold Increase-24 h (#):       |     |     |     |                  |      |
| Allowed watering (Y/N):            | Y   | Y   | Y   |                  |      |
| Threshold Decrease-24 h (#):       |     |     |     |                  |      |
| Allowed watering (Y/N):            | Y   | Y   | Y   |                  |      |

Figure 1. Particle size analysis of 60F sand.



**Edgar Minerals**

(352) 481-2421 Office  
(352) 481-2334 Fax

**Particle Size Analysis and Properties**  
60F

| US Standard Sieve | Individual % Retained |
|-------------------|-----------------------|
| 40                | 0.1                   |
| 50                | 0.4                   |
| 70                | 7.09                  |
| 100               | 35.1                  |
| 140               | 25.4                  |
| 200               | 22.7                  |
| 270               | 4.9                   |
| 325               | 2.5                   |
| PAN               | 0.9                   |

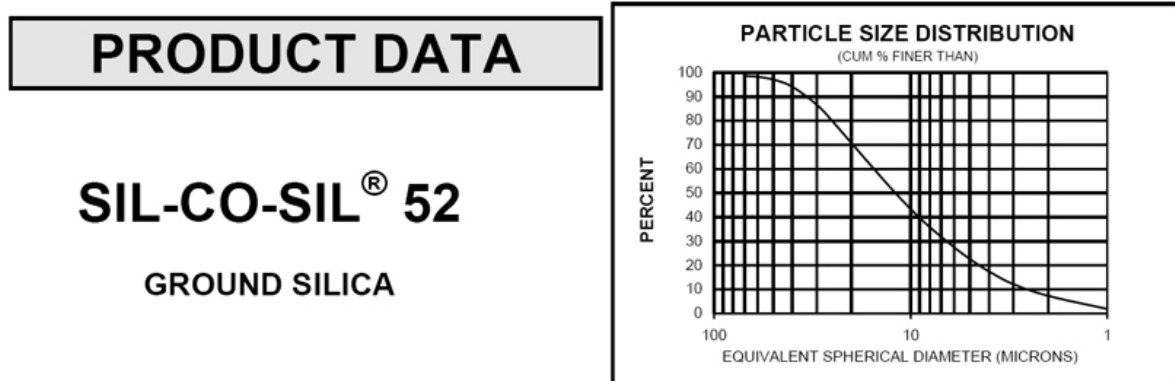
These do not represent a specification

**Plant Office**  
651 Keuka Road  
Edgar, FL 32149



**Corporate Office**  
Post Office Box 3033  
Davenport, FL 33836

Figure 2. Particle size analysis 325 sand.



| USA STD SIEVE SIZE |         | TYPICAL VALUES |            |            |
|--------------------|---------|----------------|------------|------------|
|                    |         | % RETAINED     |            | % PASSING  |
| MESH               | MICRONS | INDIVIDUAL     | CUMULATIVE | CUMULATIVE |
| 100                | 150     | 0.0            | 0.0        | 100.0      |
| 140                | 106     | 0.0            | 0.0        | 100.0      |
| 200                | 75      | 0.3            | 0.3        | 99.7       |
| 270                | 53      | 1.7            | 2.0        | 98.0       |
| 325                | 45      | 2.5            | 4.5        | 95.5       |

### TYPICAL PHYSICAL PROPERTIES

|                      |        |                        |      |
|----------------------|--------|------------------------|------|
| HARDNESS (Mohs)..... | 7      | REFLECTANCE (%) .....  | 89   |
| MINERAL .....        | QUARTZ | YELLOWNESS INDEX.....  | 3.8  |
| pH.....              | 7      | SPECIFIC GRAVITY ..... | 2.65 |

### TYPICAL CHEMICAL ANALYSIS, %

|  |       |  |      |
|--|-------|--|------|
| SiO <sub>2</sub> (Silicon Dioxide) .....             | 99.5  | MgO (Magnesium Oxide) .....              | 0.01 |
| Fe <sub>2</sub> O <sub>3</sub> (Iron Oxide).....     | 0.022 | Na <sub>2</sub> O (Sodium Oxide) .....   | 0.01 |
| Al <sub>2</sub> O <sub>3</sub> (Aluminum Oxide)..... | 0.3   | K <sub>2</sub> O (Potassium Oxide) ..... | 0.01 |
| TiO <sub>2</sub> (Titanium Dioxide).....             | 0.01  | LOI (Loss on Ignition).....              | 0.2  |
| CaO (Calcium Oxide).....                             | 0.02  |  |      |

January 27, 1999





Figure 4. Bentonite technical details.



# AQUAGEL GOLD SEAL®

Premium Sodium Bentonite

**Description** AQUAGEL GOLD SEAL® is a premium, Wyoming sodium bentonite that contains no polymer additives of any kind. AQUAGEL GOLD SEAL is a 200 mesh dry-powdered clay that can be added directly to fresh water or freshwater drilling fluids. AQUAGEL GOLD SEAL functions as a viscosifier and filtrate reducer in freshwater drilling fluids.

- Applications/Functions**
- Can viscosify freshwater drilling fluids
  - Can reduce filtration by forming a thin filter cake with low permeability
  - Can improve hole cleaning capabilities
  - Promotes hole stability in poorly consolidated formations

- Advantages**
- NSF/ANSI Standard 60 certified
  - Ideal for geotechnical drilling and environmental monitoring well drilling applications
  - Helps develop gel structure for cuttings suspension
  - Filter cake easily removed from formation by the back flow
  - Helps provide lubricity in drilling fluids

- Typical Properties**
- |                                    |                                       |
|------------------------------------|---------------------------------------|
| • Appearance                       | Variable-colored powder (gray to tan) |
| • Bulk density, lb/ft <sup>3</sup> | 68 to 72 (as packaged)                |

**Mixing Instructions** Mix slowly through a jet mixer or sift slowly into the vortex of a high-speed stirrer.

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Rev. 09/2015

Because the conditions of use of this product are beyond the seller's control, the product is sold without warranty either express or implied and upon condition that purchaser make its own test to determine the suitability for purchaser's application. Purchaser assumes all risk of use and handling of this product. This product will be replaced if defective in manufacture or packaging or if damaged. Except for such replacement, seller is not liable for any damages caused by this product or its use. The statements and recommendations made herein are believed to be accurate. No guarantee of their accuracy is made, however.

Figure 5. Soil moisture sensors readings while immersed in water.



Figure 6. Soil moisture sensor reading in air.





Figure 7. Mixing soil components.



Figure 8. Packing soil in layers.

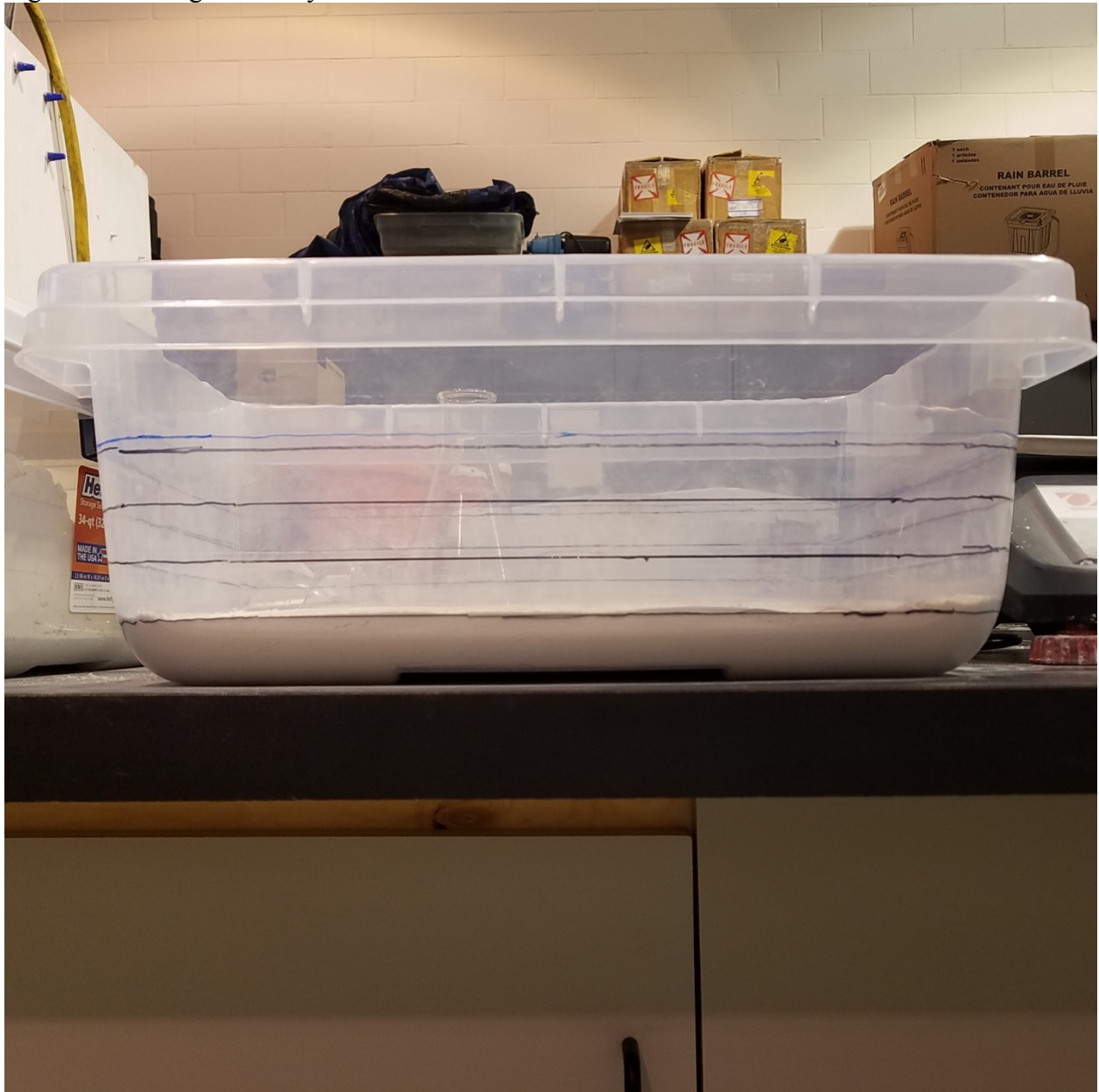




Figure 9. Inserting sensors in box and packing in preparation to pack soil around them.



Figure 10. Weighing test boxes to verify packed weight.



Figure 11. Sensors in packed boxes and connected to controllers.

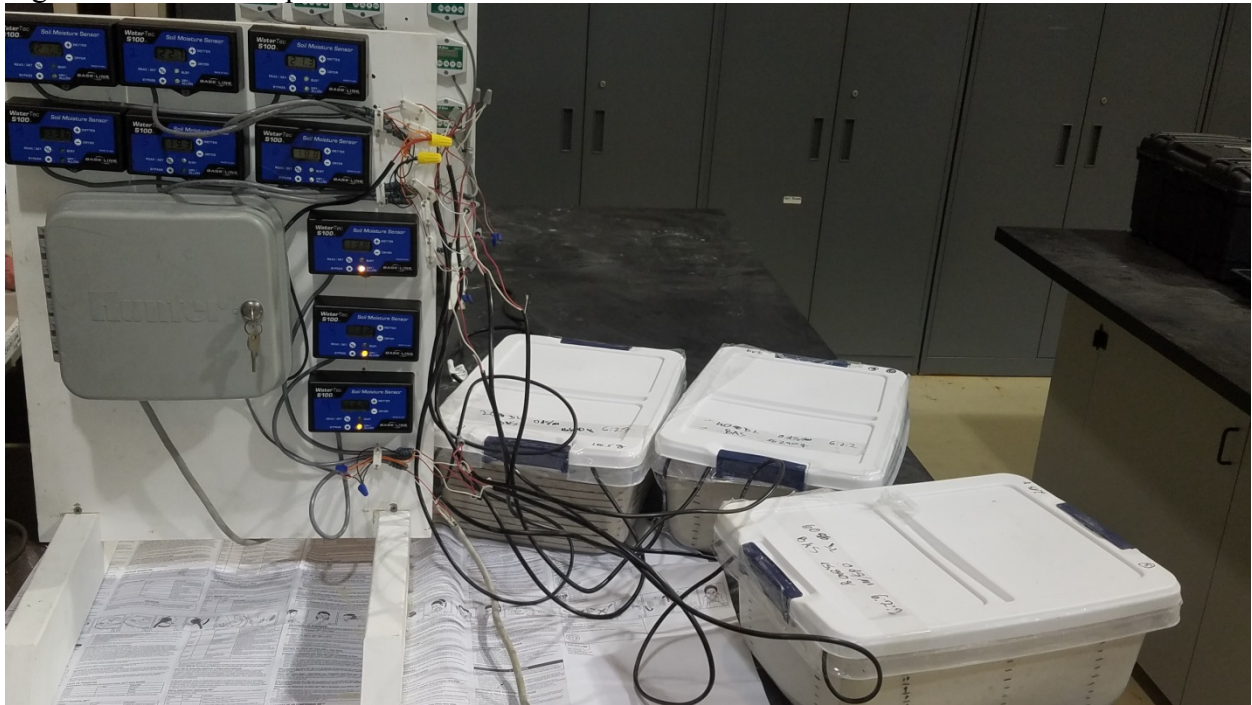


Figure 12. Brand A coarse media (6:2:2) test response curve 0 hours after packing, 0 dS/m water.

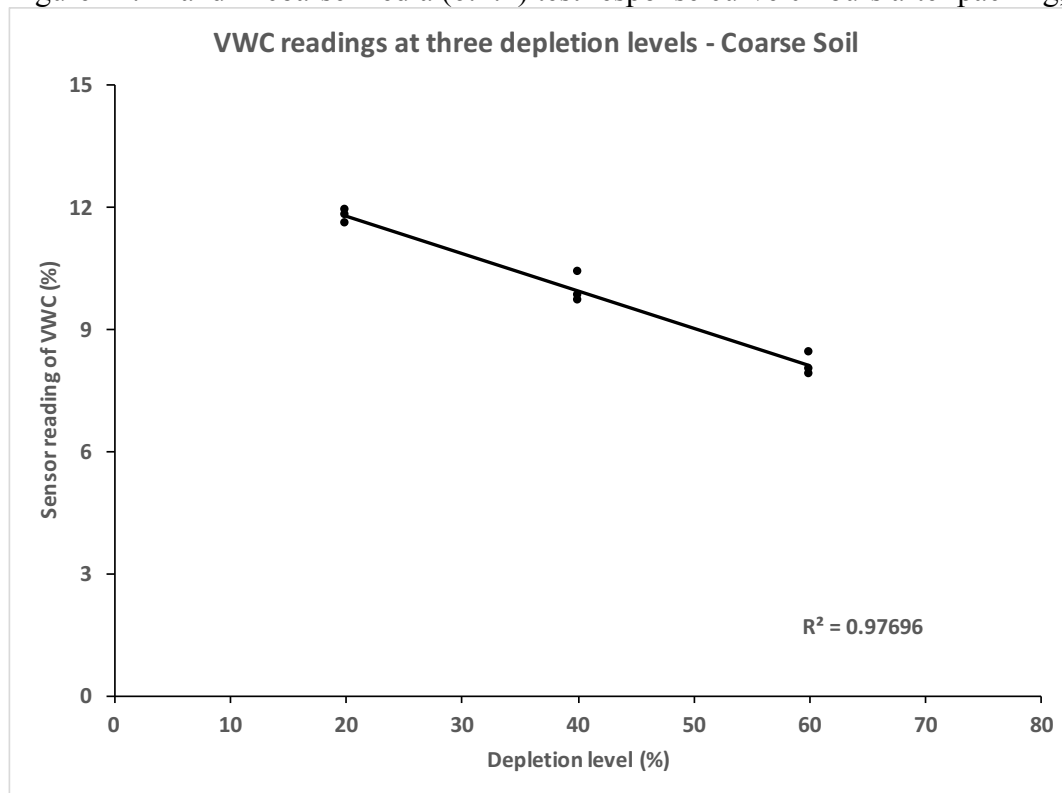


Figure 13. Brand A coarse media (6:2:2) test response curve 24 hours after packing, 0 dS/m water.

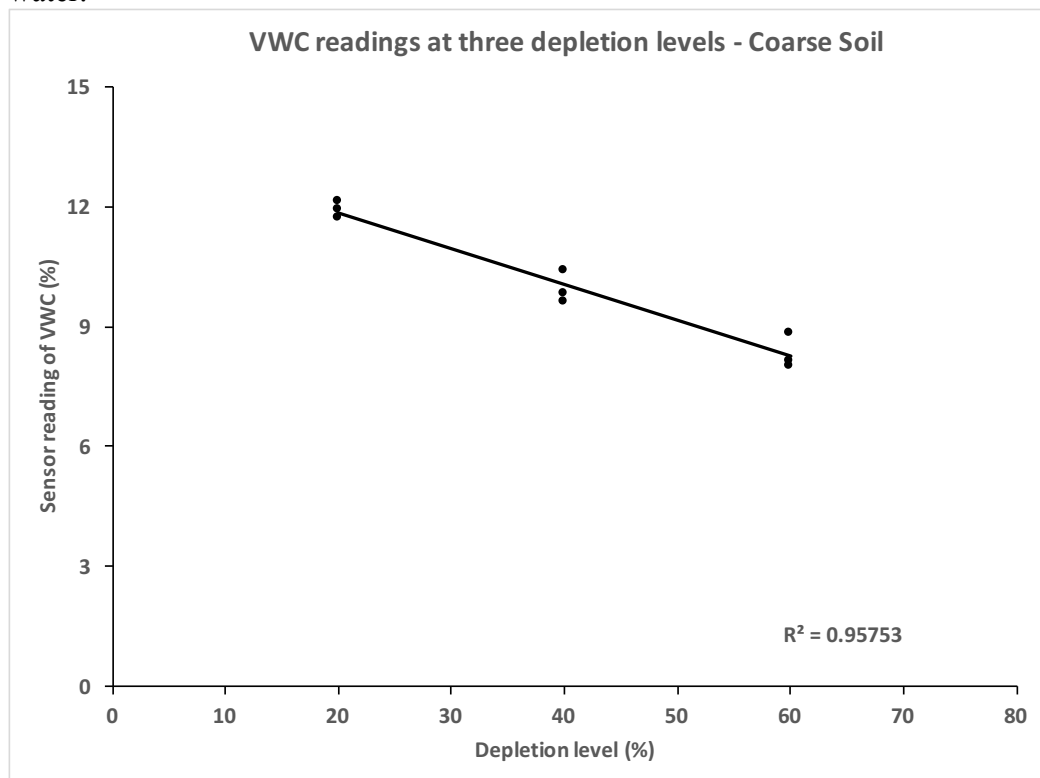




Figure 14. Brand B coarse media (6:2:2) test response curve 0 hours after packing, 0 dS/m water.

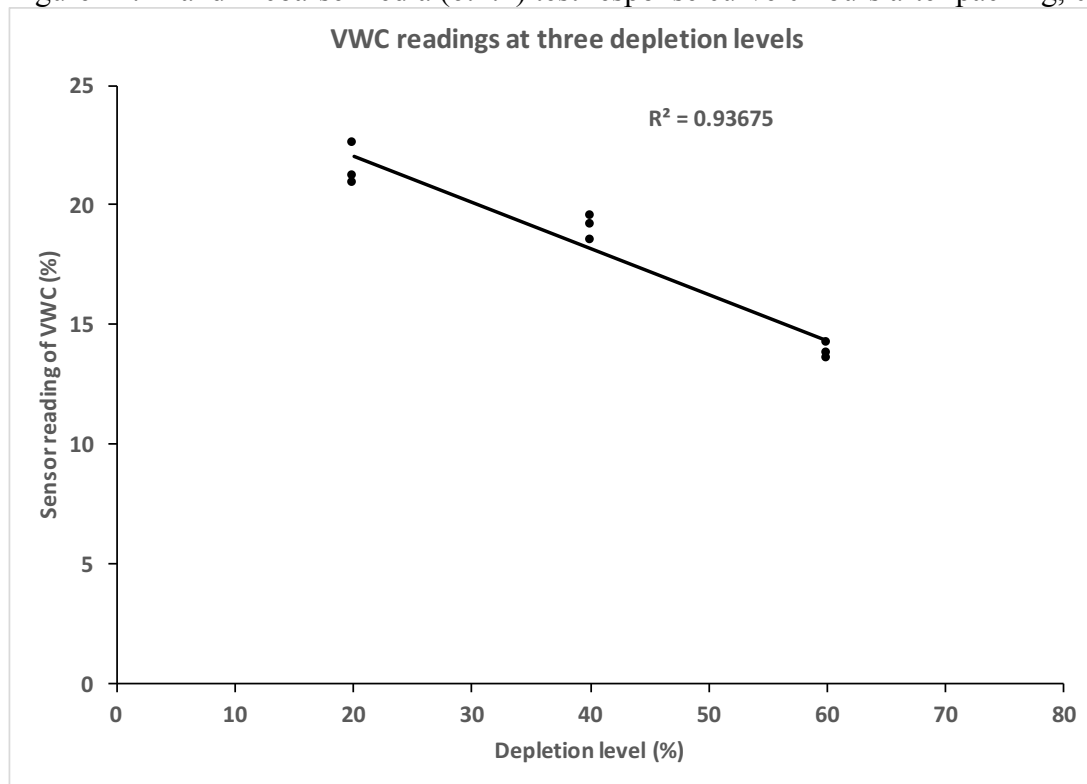


Figure 15. Brand B coarse media (6:2:2) test response curve 24 hours after packing, 0 dS/m water.

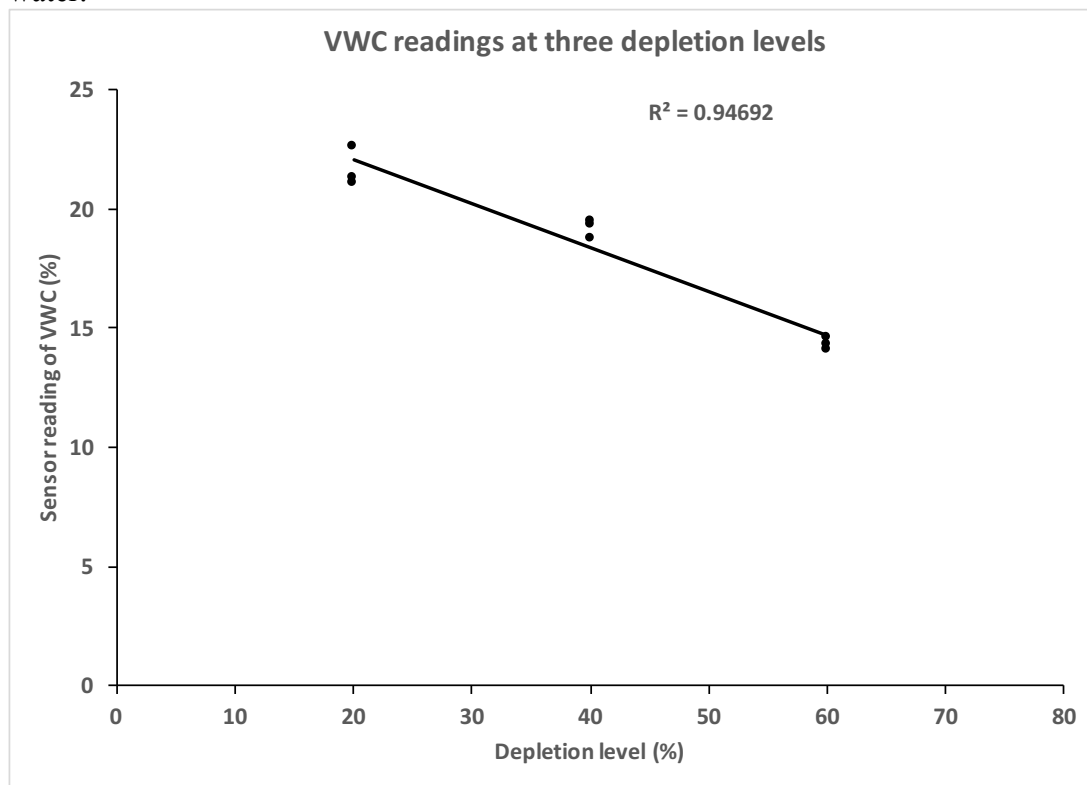


Figure 16. Brand C coarse media (6:2:2) test response curve 24 hours after packing, 0 dS/m water.

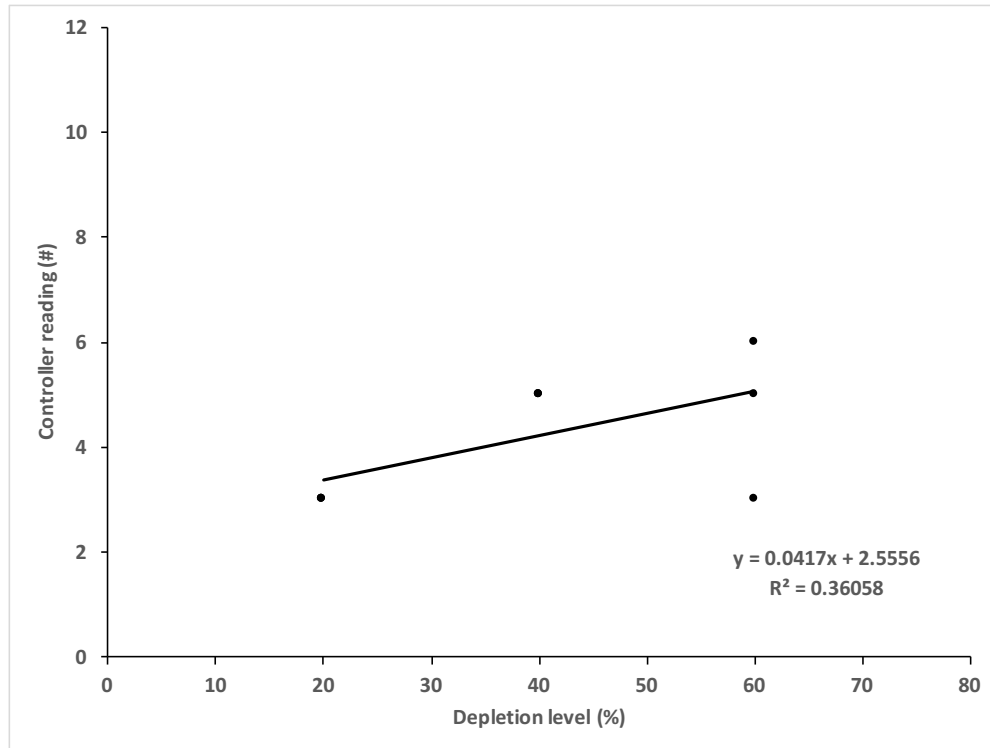


Figure 17. Brand D coarse media (6:2:2) test response curve 0 hours after packing, 0 dS/m water.

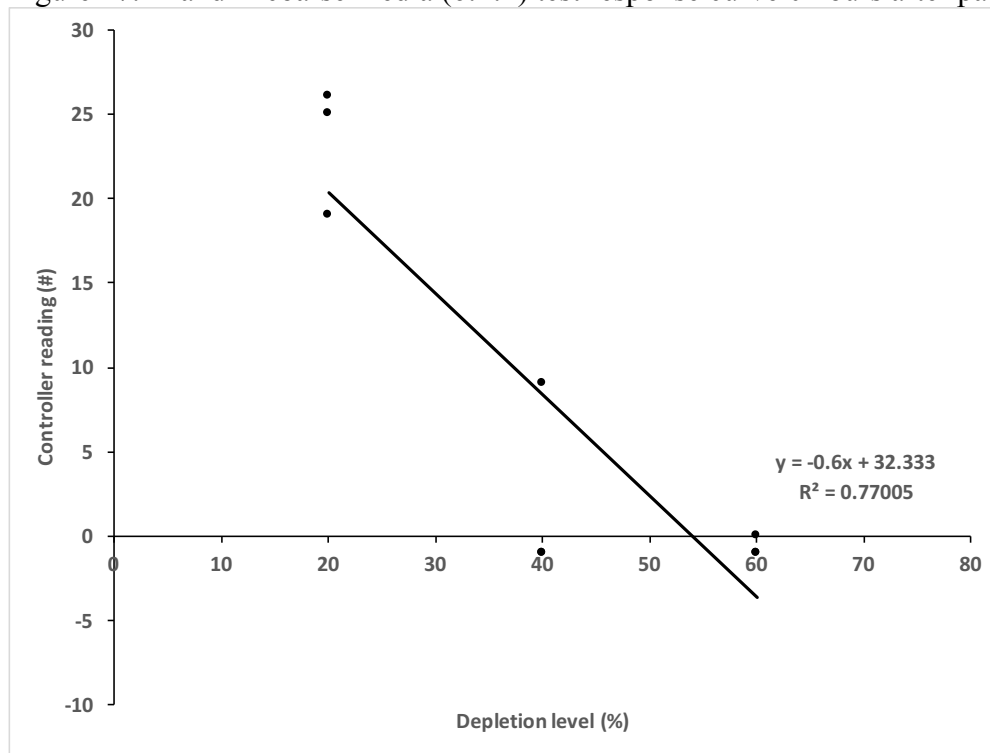


Figure 18. Brand D coarse media (6:2:2) test response curve 24 hours after packing, 0 dS/m water.

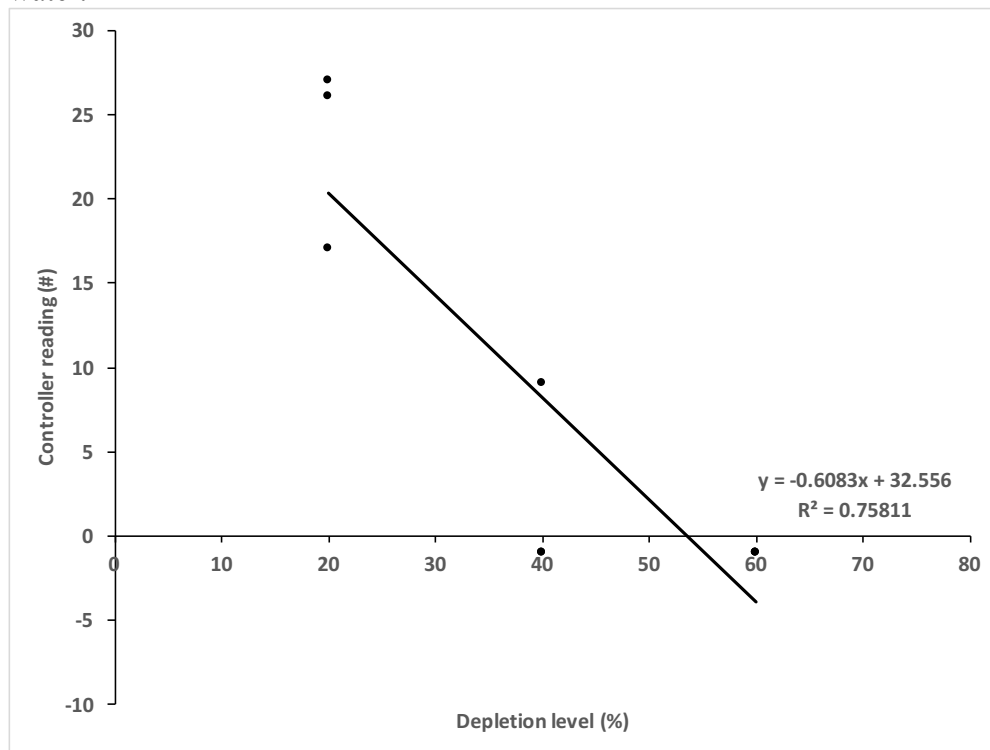


Figure 19. Brand A fine media (1:1:1) test response curve 0 hours after packing, 0 dS/m water.

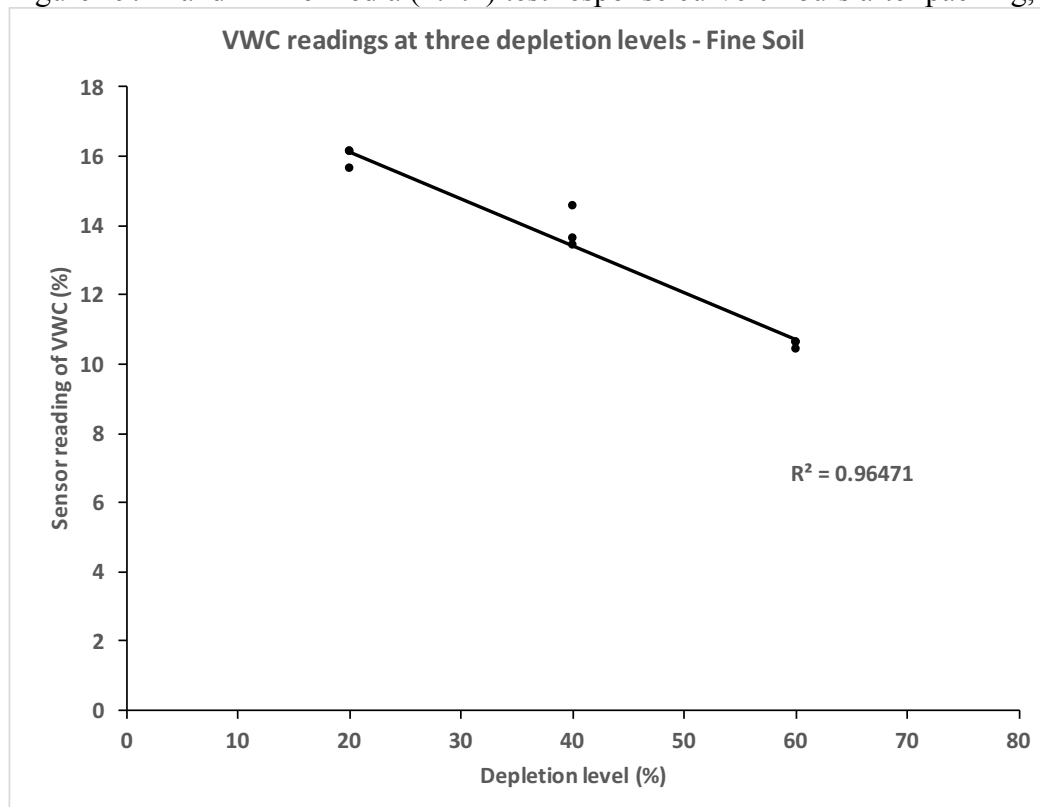


Figure 20. Brand A fine media (1:1:1) test response curve 24 hours after packing, 0 dS/m water.

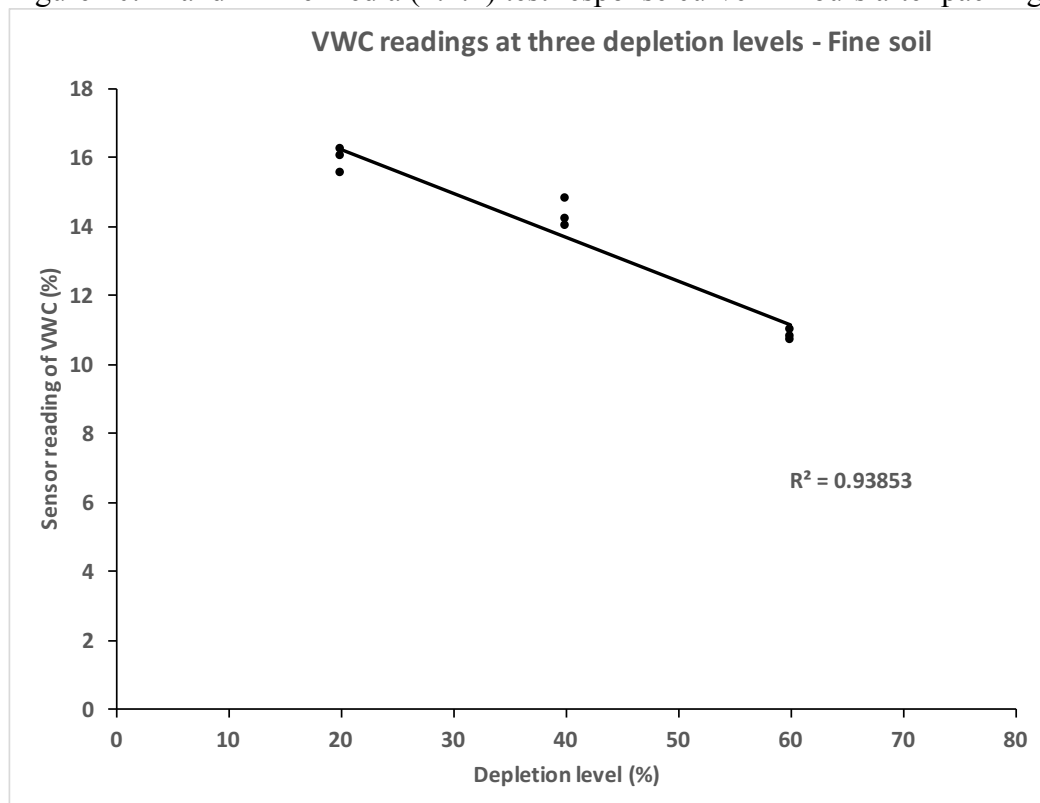


Figure 21. Brand B fine media (1:1:1) test response curve 0 hours after packing, 0 dS/m water.

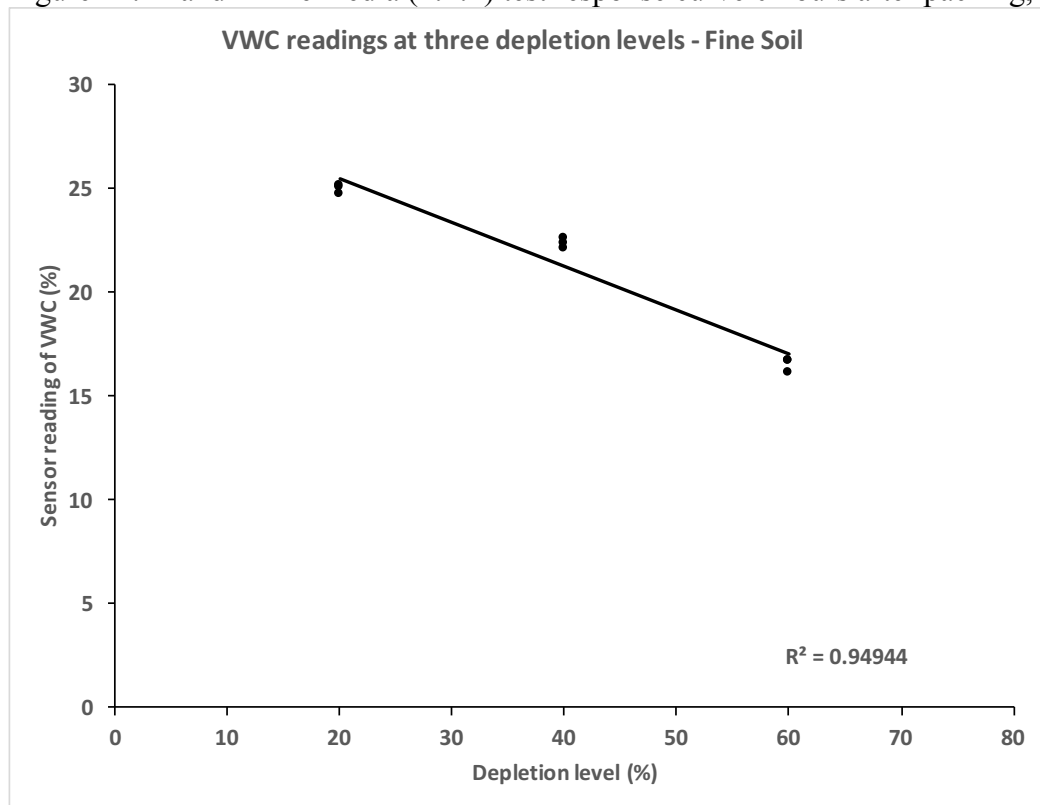


Figure 22. Brand B fine media (1:1:1) test response curve 24 hours after packing, 0 dS/m water.

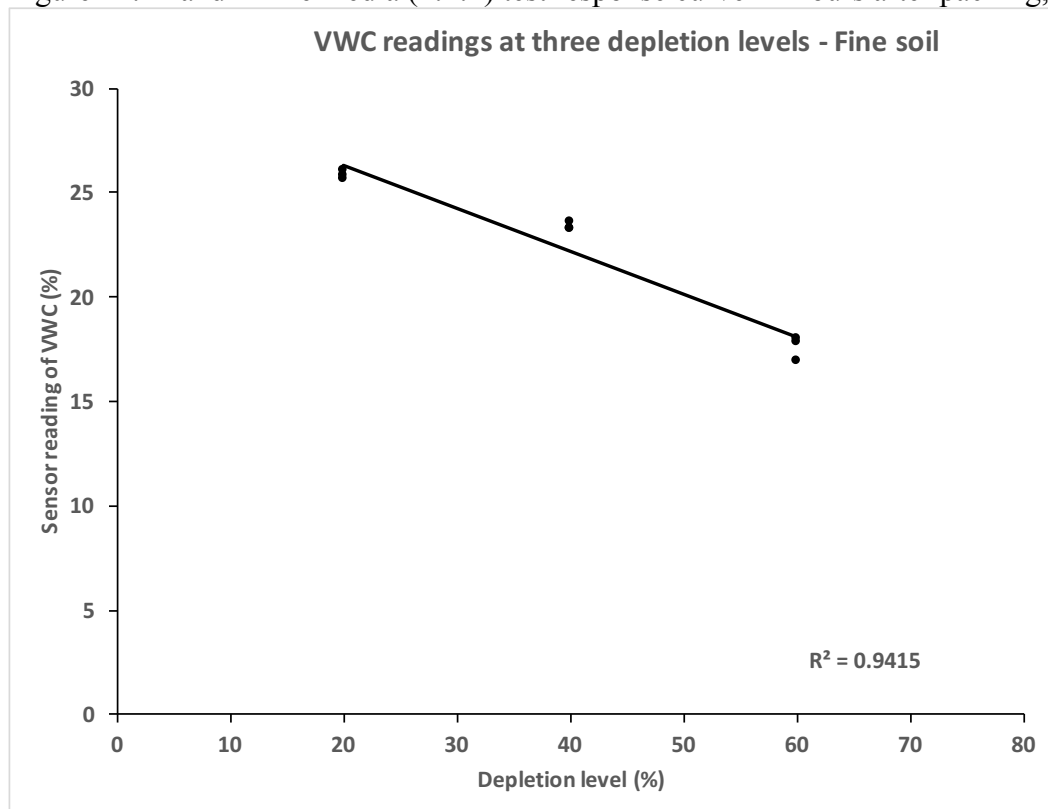


Figure 23. Brand C fine media (1:1:1) test response curve 24 hours after packing, 0 dS/m water.

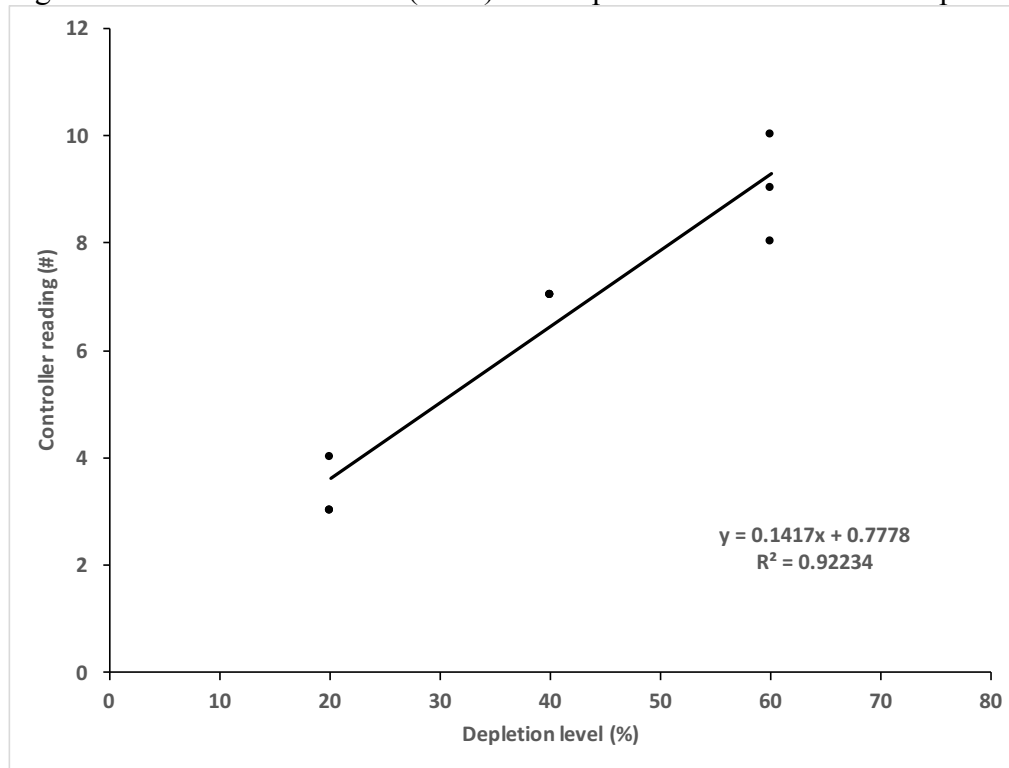


Figure 24. Brand D fine media (1:1:1) test response curve 0 hours after packing, 0 dS/m water.

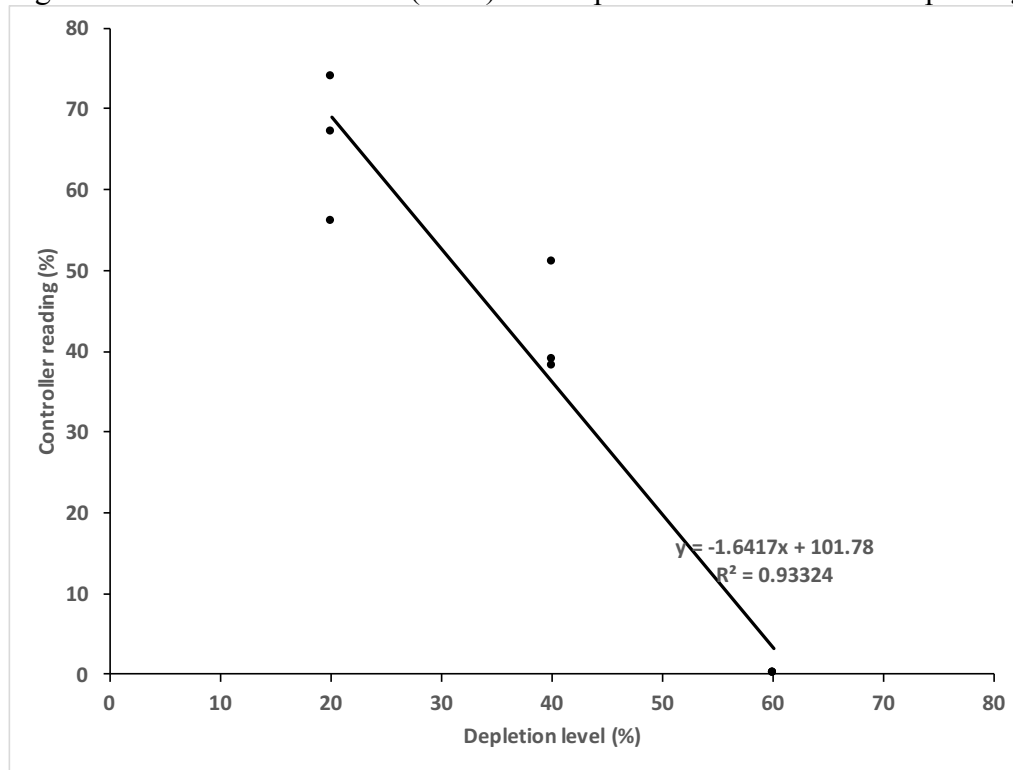


Figure 25. Brand D fine media (1:1:1) test response curve 24 hours after packing, 0 dS/m water.

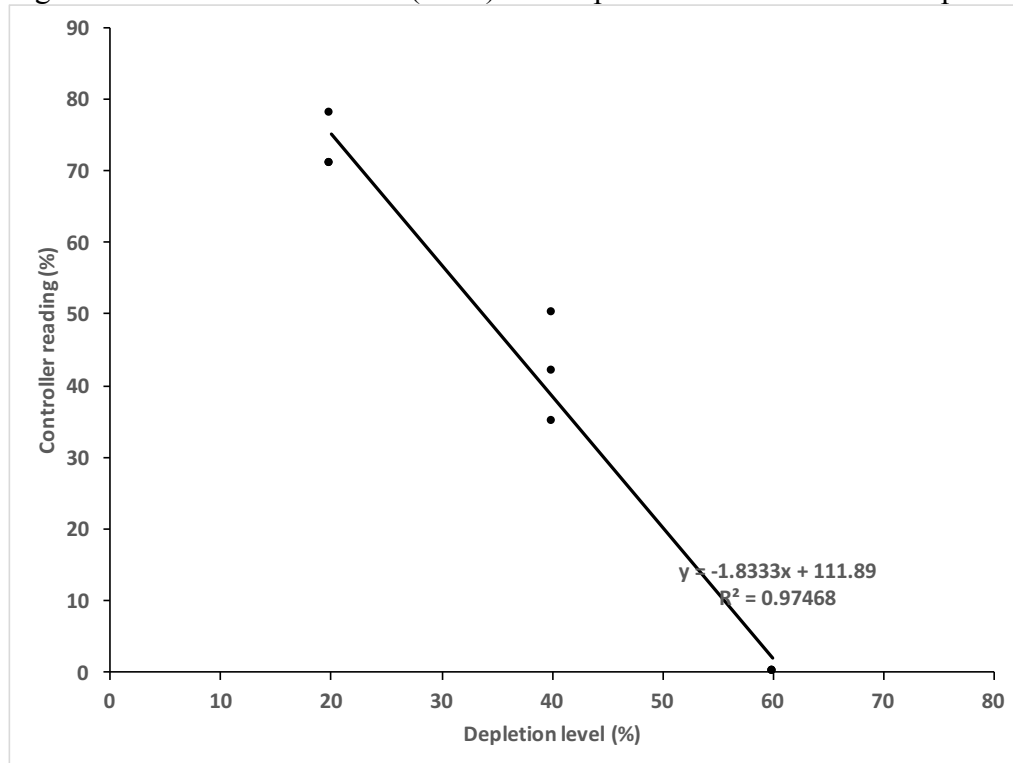


Figure 26. Brand A coarse media (6:2:2) test response curve 0 hours after packing, 3 dS/m water.

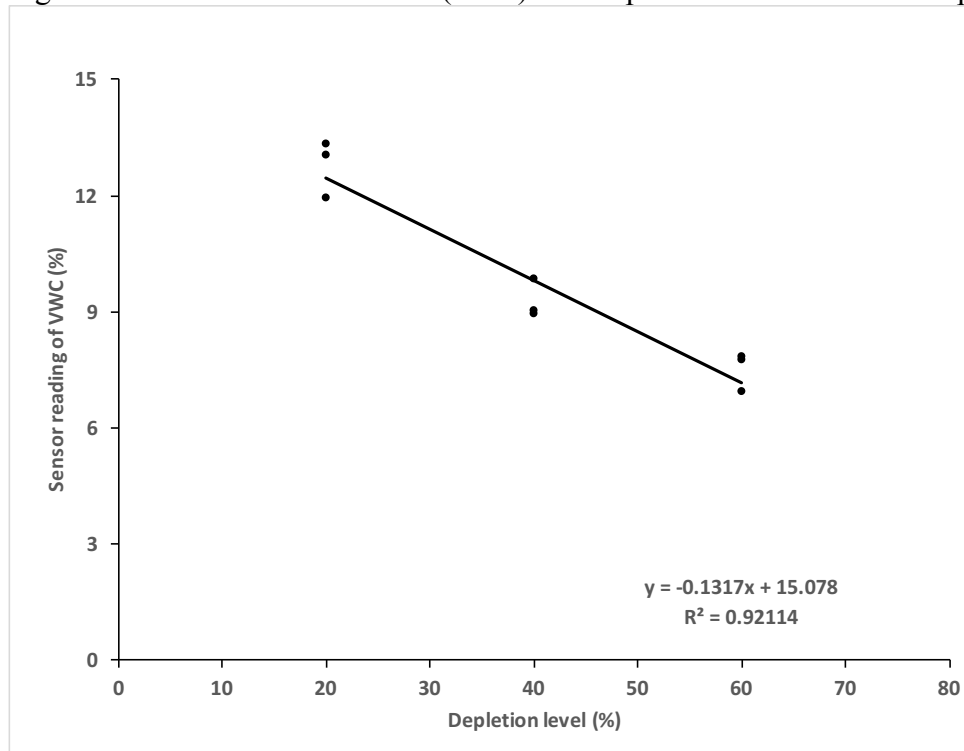


Figure 27. Brand A coarse media (6:2:2) test response curve 24 hours after packing, 3 dS/m water.

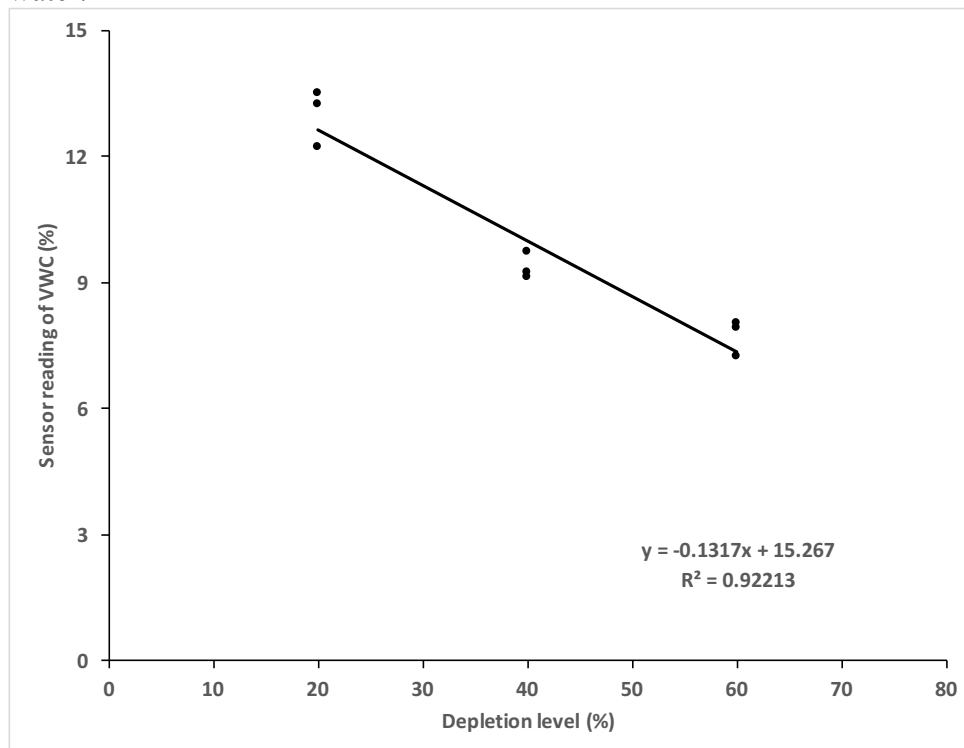




Figure 28. Brand B coarse media (6:2:2) test response curve 0 hours after packing, 3 dS/m water.

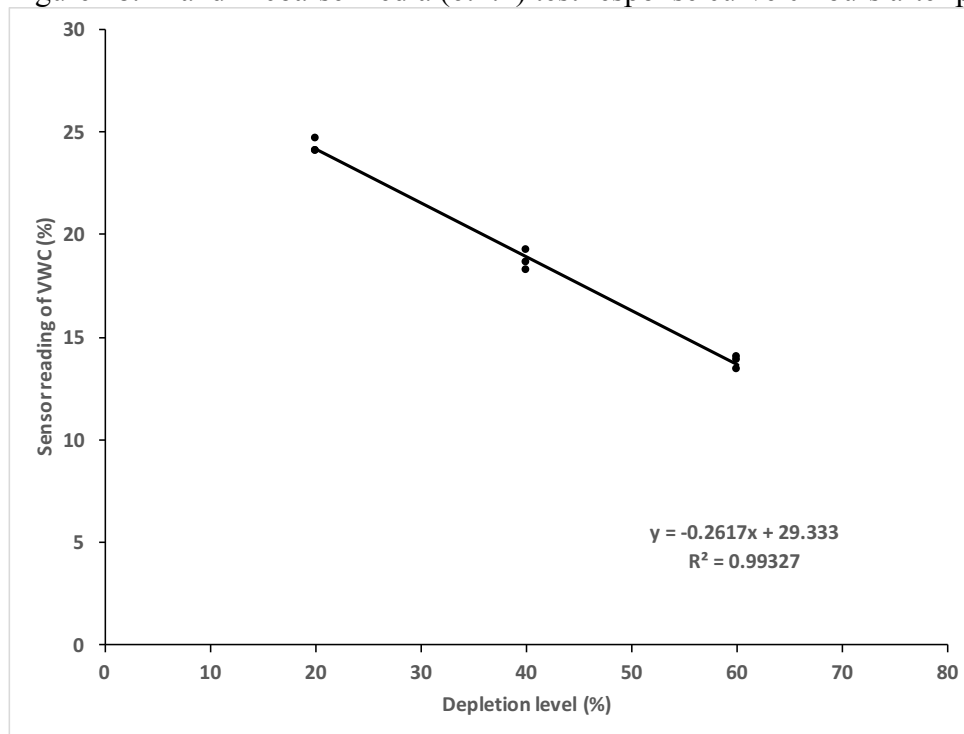


Figure 29. Brand B coarse media (6:2:2) test response curve 24 hours after packing, 3 dS/m water.

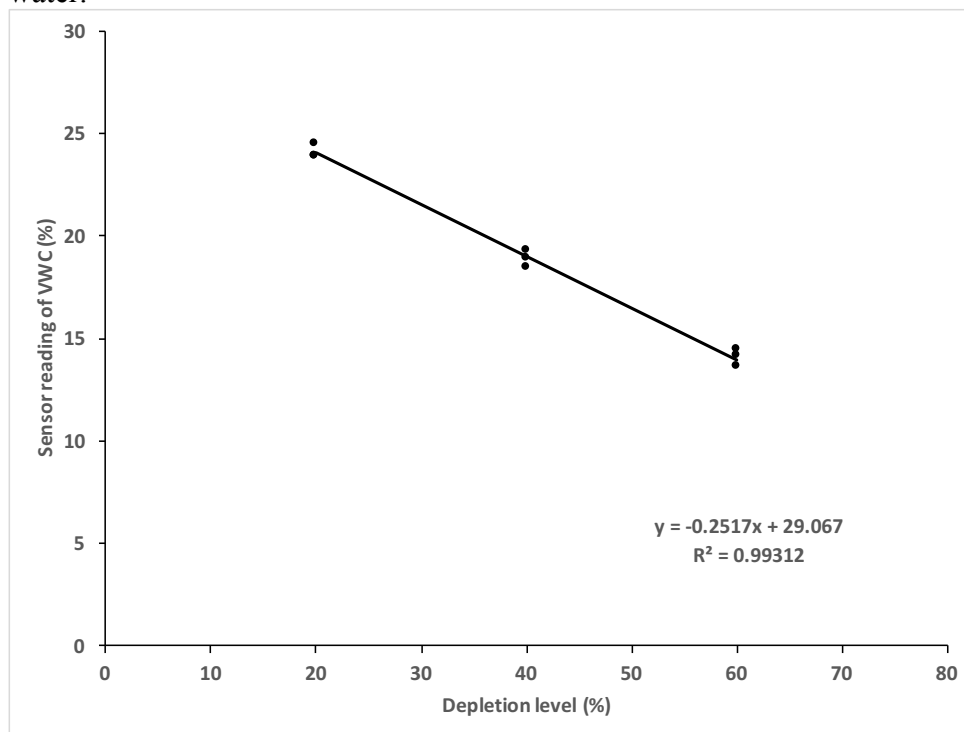


Figure 30. Brand C coarse media (6:2:2) test response curve 24 hours after packing, 3 dS/m water.

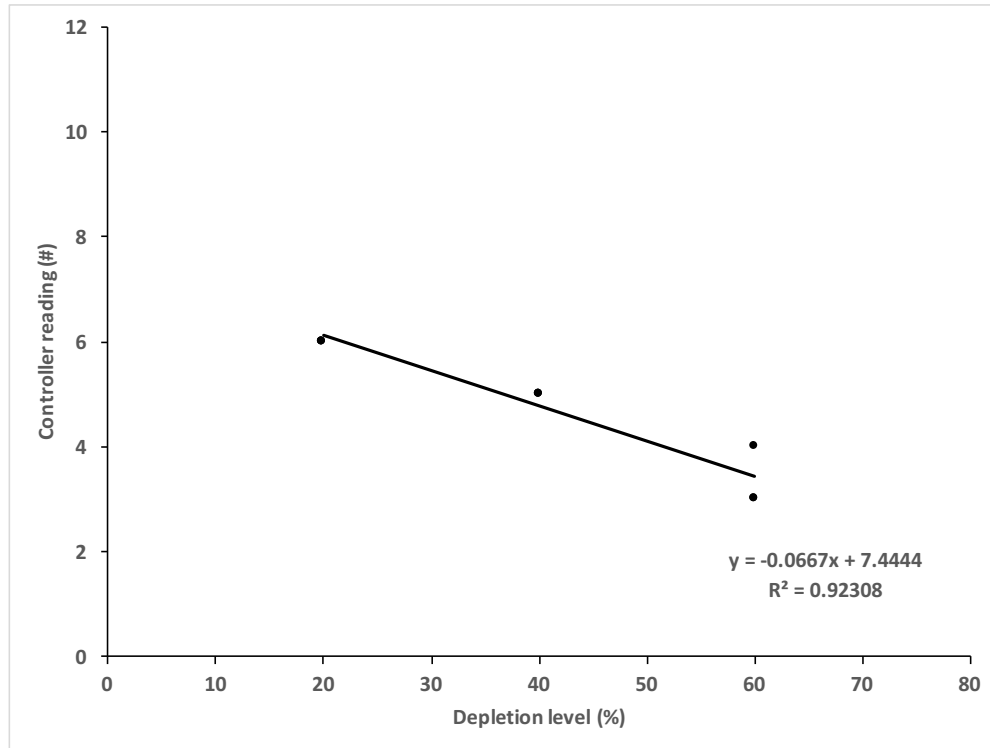


Figure 31. Brand D coarse media (6:2:2) test response curve 0 hours after packing, 3 dS/m water.

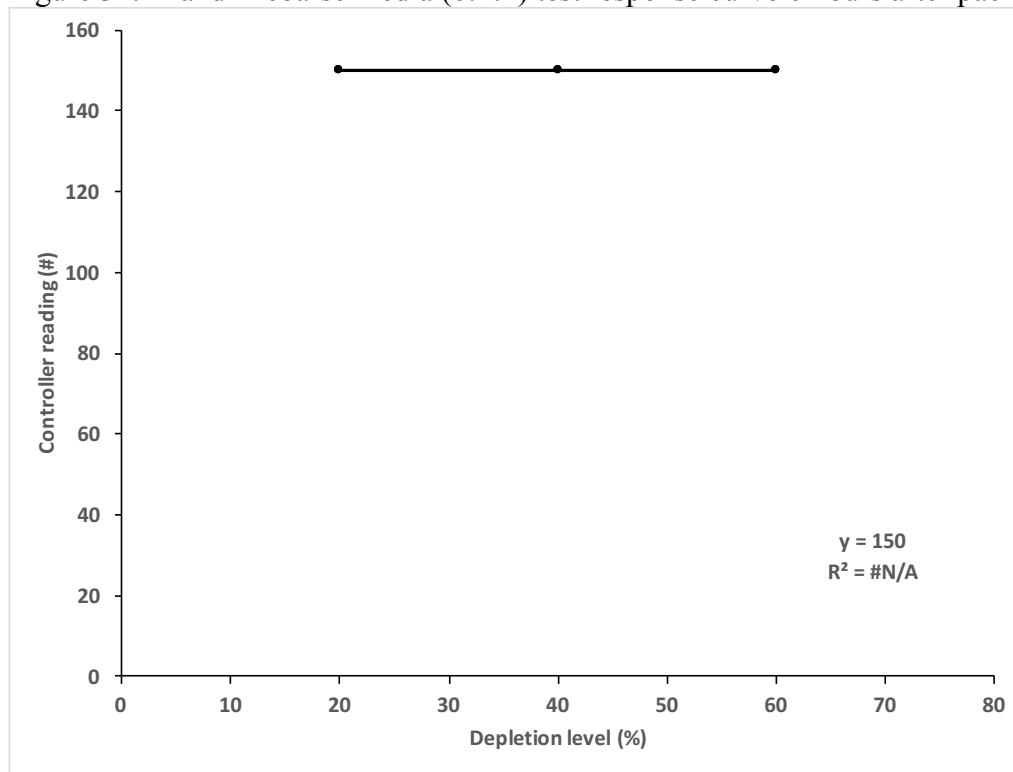


Figure 32. Brand D coarse media (6:2:2) test response curve 24 hours after packing, 3 dS/m water.

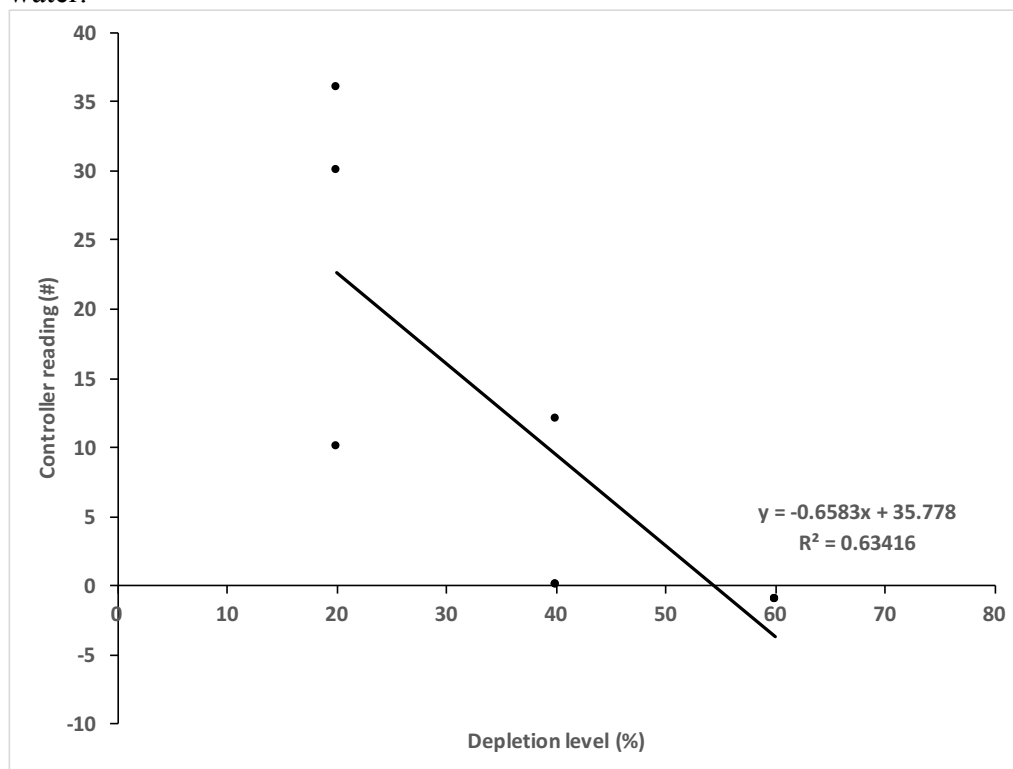


Figure 33. Brand A fine media (1:1:1) test response curve 0 hours after packing, 3 dS/m water.

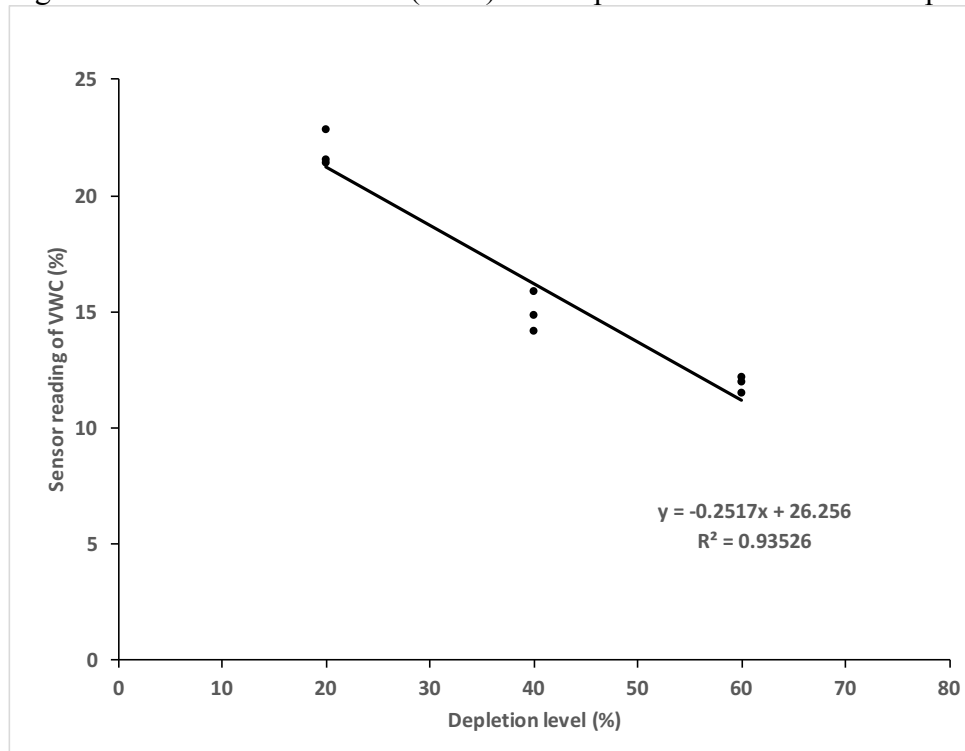


Figure 34. Brand A fine media (1:1:1) test response curve 24 hours after packing, 3 dS/m water.

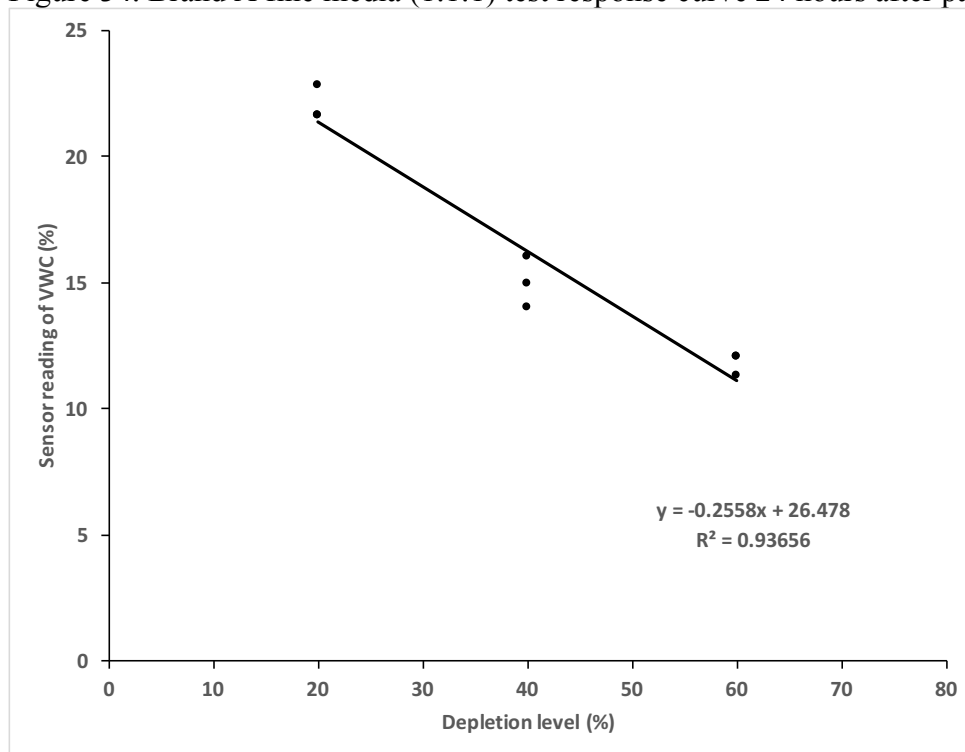


Figure 35. Brand B fine media (1:1:1) test response curve 0 hours after packing, 3 dS/m water.

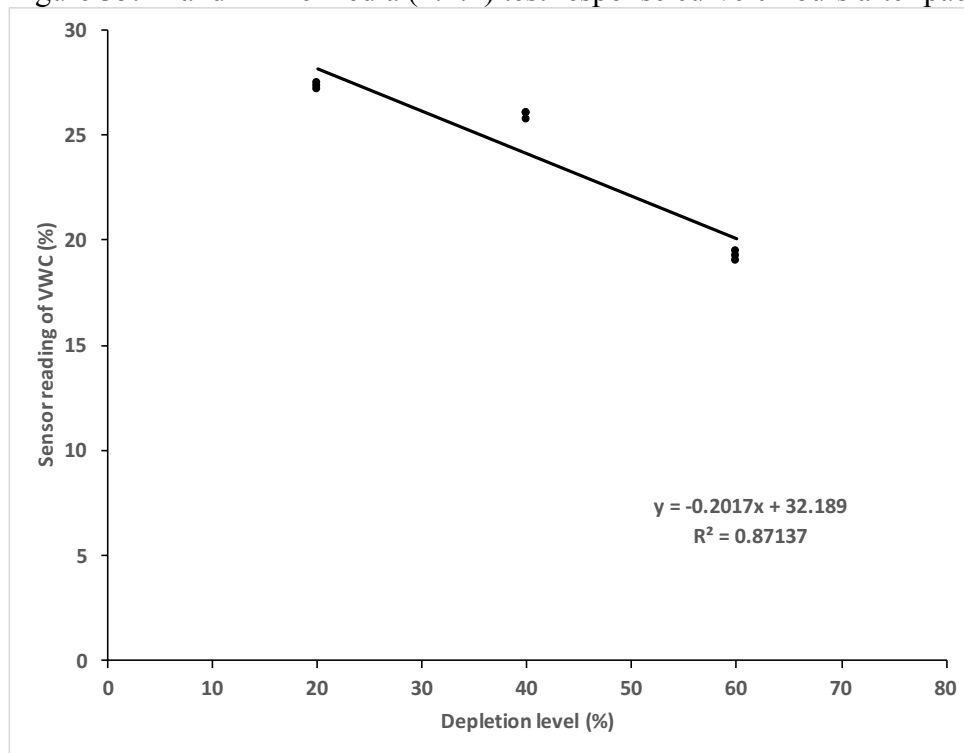


Figure 36. Brand B fine media (1:1:1) test response curve 24 hours after packing, 3 dS/m water.

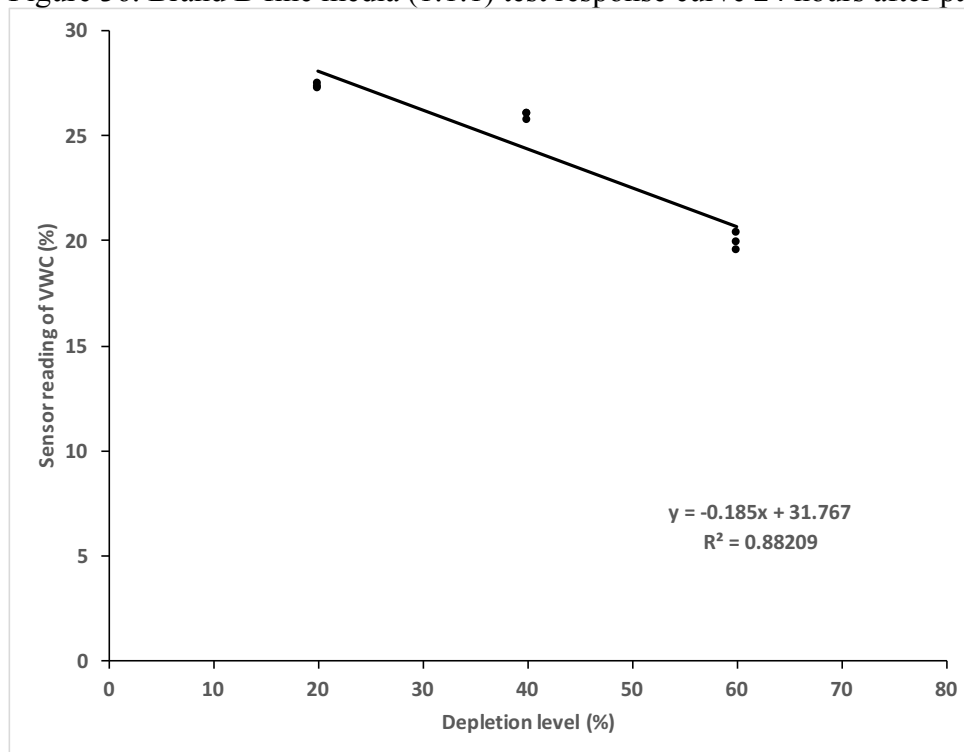


Figure 37. Brand C fine media (1:1:1) test response curve 24 hours after packing, 3 dS/m water.

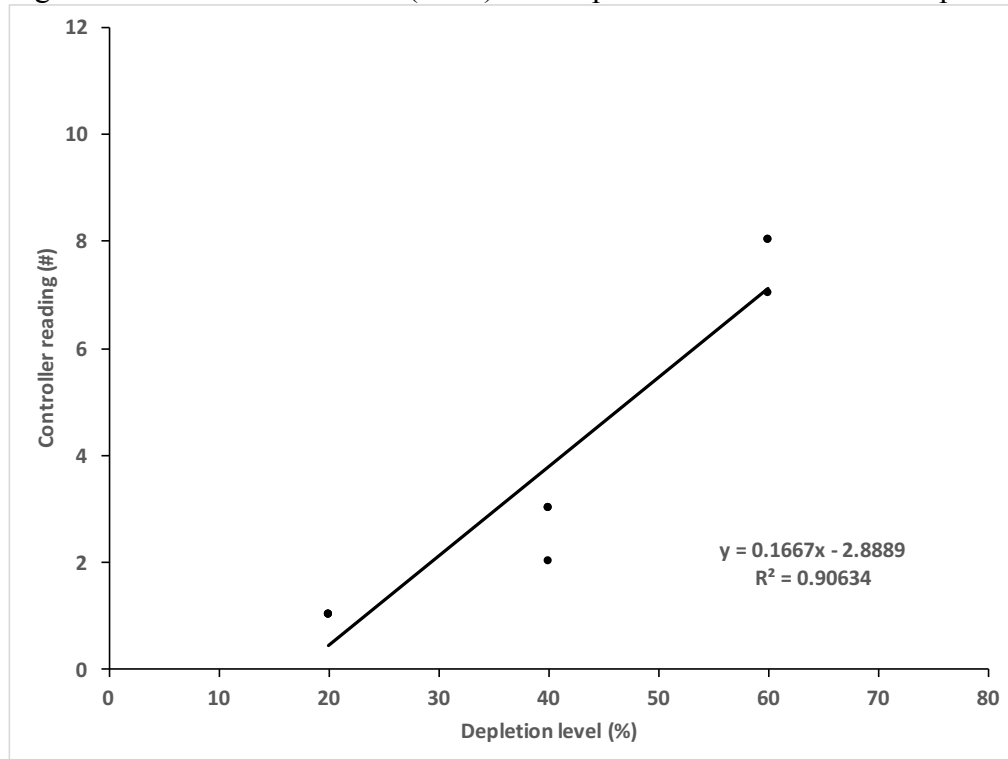


Figure 38. Brand D fine media (1:1:1) test response curve 0 hours after packing, 3 dS/m water.

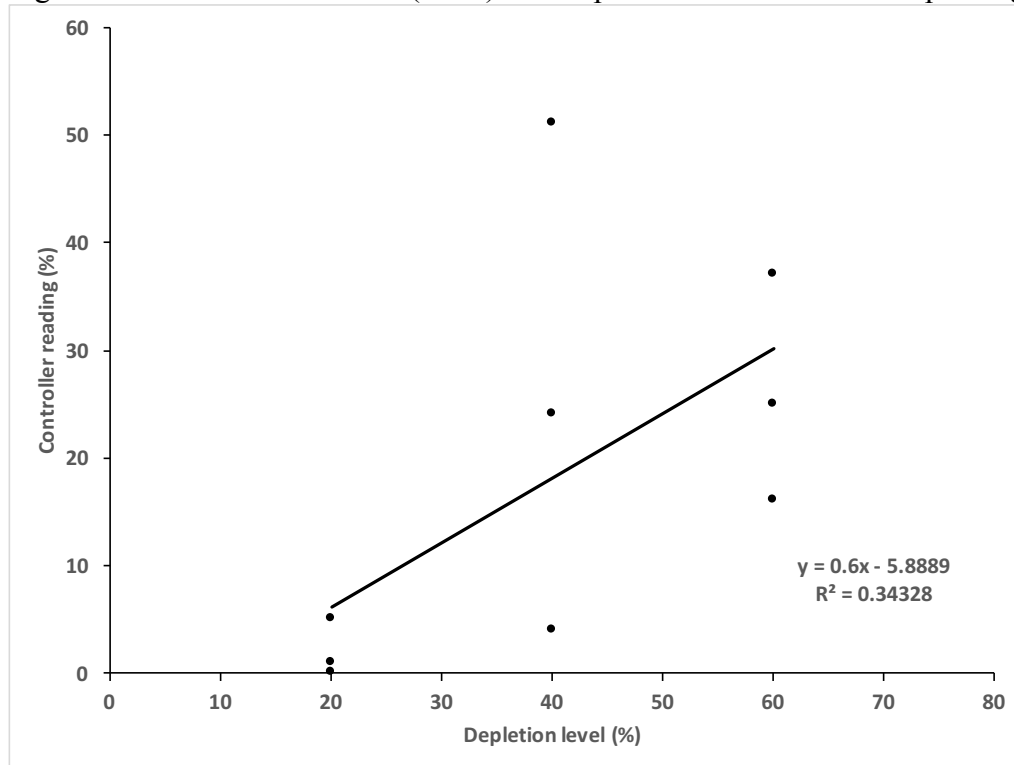


Figure 39. Brand D fine media (1:1:1) test response curve 24 hours after packing, 3 dS/m water.

