Immobilization of soil nitrate-N with high-carbon amendments 2020

Richard Smith, Joji Muramoto, and Patricia Love
University of California Cooperative Extension, University of California

Methods

The ability of high-carbon soil amendments to sequester N mineralized from broccolini residue was examined in a greenhouse study conducted from February to April 2020. Materials and rates evaluated were: 1) forest mulch compost at 2.5, 5 and 10 T/A; 2) ground almond shells at 5 T/A; and 3) glycerol at 2.5 T/A. Two control treatments were included: one with and one without broccolini residue, for a total of 7 treatments. The C:N ratio of forest mulch compost was 185 and almond shells was 59 (Table 1). The treatments were evaluated in pots made of 6 inch tall x 6.25 inch in diameter PVC cylinders with 20/20 fiberglass mesh attached to the bottom to prevent soil loss. All pots were filled to a height of 5.5 inches with 4.457 kg of air-dried Chualar loam soil sieved through ¼ inch mesh (see Table 2 for soil analysis; Photo 2). Residue used in the experiement was from mature broccolini plants that were divided into main stalks, petioles, leaf blades and head that were finely chopped (figure 1). The amount of this material that was added to the pots was equivalent to 35 T fresh residue/A which is a typical amount of residue returned to the soil following broccoli harvest (Smith et al. 2016). The residue was 4.68% N and had a C:N ratio of 8.6 (Table 3). The proportion of total fresh weight by plant part add to the pots was: 34.1% leaves, 35.7% petioles, 22.7% stems, and 7.5% heads, following an earlier broccoli residue study (Photo 1). All treatments were replicated four times in a randomized complete block design.

Once residue and amendments were incorporated, the experiment was initiated when all pots were watered with equal amounts of distilled water, resulting in a volumetric water content of 16%. All pots were weighed after the first water was added on February 5th and watered every 2-3 days by adding sufficient water to maintain initial weight and moisture content. The amount of water used was calculated to eliminate leaching from the pots. The experiment was run 10 weeks until April 16. A Meter 5TM sensor was placed in an extra pot to track temperature over the course of the trial. Initially pots were drying too much between irrigations so shade cloth was placed over the pots to slow drying after the 2nd week of the experiment. Soil samples were collected using a ½ inch soil probe at 1, 2, 4, 6, 8 and 10 weeks after first water and extracted in 2M KCl solution to determine NO_3-N and NH_4-N concentrations. Holes from soil sampling were filled with N-free, moist sand to maintain even water content and weight in the pots (Photo 3).

Results: The soil temperatures over the 10 weeks of the experiment ranged from 60 to 71 °F (Figure 1) which was sufficient to allow mineralization of crop residues. The nitrogen in the broccolini residues added the equivalent of 163 ppm N/Kg to the pots. Initial soil nitrate-N levels at the beginning of the experiment on February 5 were 20.1 ppm and increased in all treatments, except for the unamended treatment with no broccolini residue, on subsequent evaluation dates. Seven days after the beginning of the experiment, nitrate- N in the unamended treatments with broccolini residue increased to 119 ppm and treatments that had significantly less mineral nitrogen included: 5 T/A forest mulch compost, 5 T/A almond shells and 2.5 T/A glycerol, as well as the unamended treatment with not broccolini residue. Following that date, the 2.5 T/A glycerol treatment had significantly less mineral nitrogen than all other treatments 14 and 28 days after first water; no other amended treatments reduced mineral nitrogen in the soil over the unamended treatment with broccolini residue.

These results indicate that the beneficial effect of adding high carbon amendments was short lived. This may have been due to the very high levels of nitrate-N that occurred in the soil of this evaluation. The levels of mineral N in the pots varied at the peak ranged from 120 to over 200 ppm N which is many times more than is observed in field soils. It is possible that the the quantity of mineral N overwhelmed the ability of forest mulch compost and almond shells to immobilize N. The glycerol treatment was also overwhelmed after 4 weeks.

Table 1. Amendments rates, analysis and amount added/pot

Material	Rate (T/A)	Moisture %	N %	C %	C:N	N added (mg N/kg)	C added (mg N/kg)
Untreated[1]	---	---	---	---	---	---	---
Untreated[2]	---	---	---	---	---	---	---
Forest mulch	2.5	45.29	0.22	40.8	185	3.08	571
Forest mulch	5	45.29	0.22	40.8	185	6.15	1141
Forest mulch	10	45.29	0.22	40.8	185	12.31	2282
Almond shells	5	10.51	0.69	41.1	59	31.57	1880
Glycerol	2.5	---	---	---	---	---	---

1 – no broccolini residue added

2 – broccolini residue added

Table 2. Soil characteristics

pH	Total N %	Total C %	Total P %	Olsen-P ppm	X-K ppm	OM (LOI) %	Sand %	Silt %	Clay %
7.42	0.064	0.69	0.034	36.7	311	1.38	77	13	10

Table 3. Broccolini residue analysis and amount added/pot

rate (T/A)	moisture %	Total N %	Total C %	C:N	N added mg N/kg	C added mg C/kg
35	90.28	4.68	40.3	8.6	163	1402

Photo 1. Partitioning of mature plants into heads, leaves, petioles, and stems.

Photo 2. Completed pots from one replication on February 5, 2020.

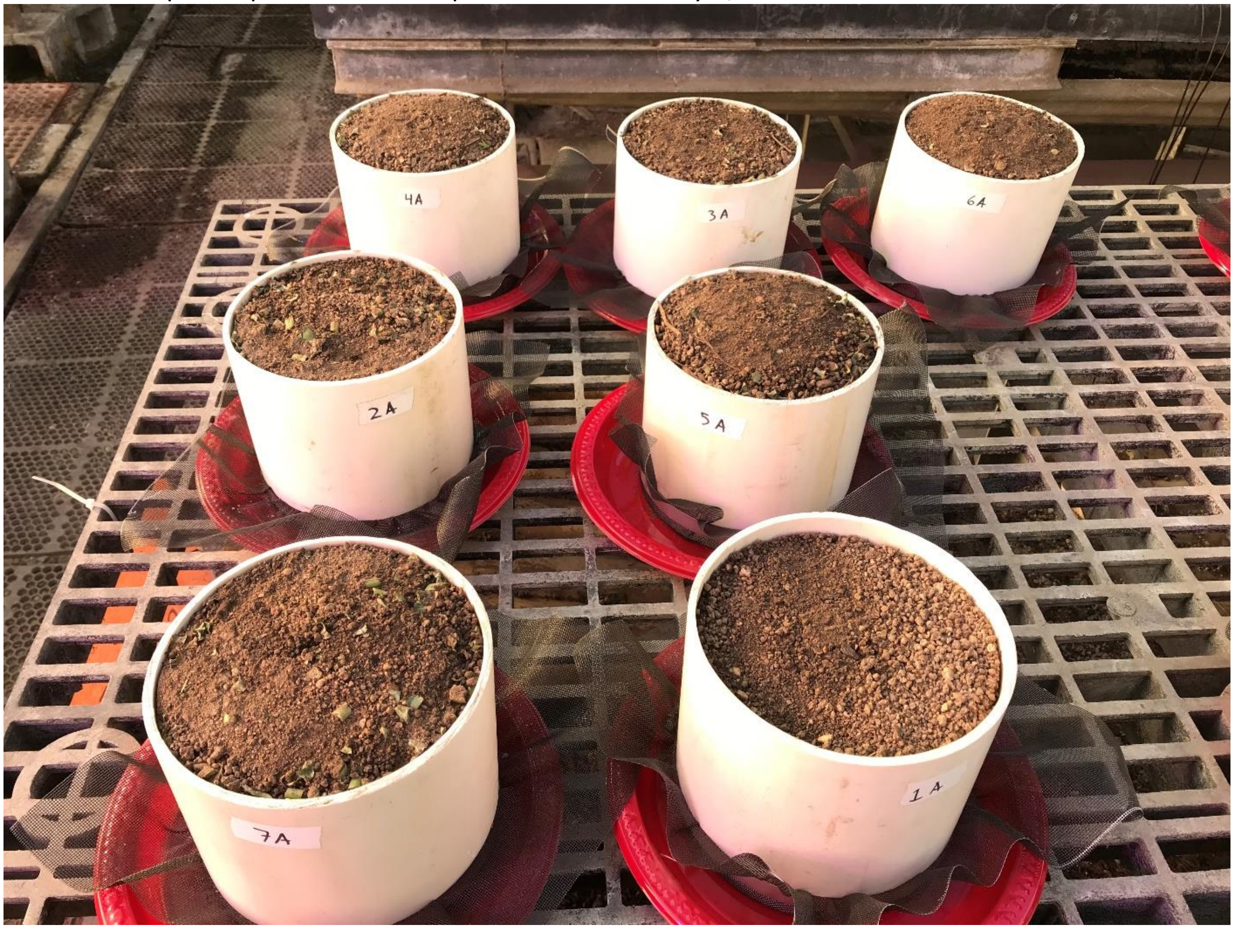

Photo 3. Pot after soil sampling showing backfilling of the sample hole with clean sand

Figure 1. Daily temperatures over the course of the experiment

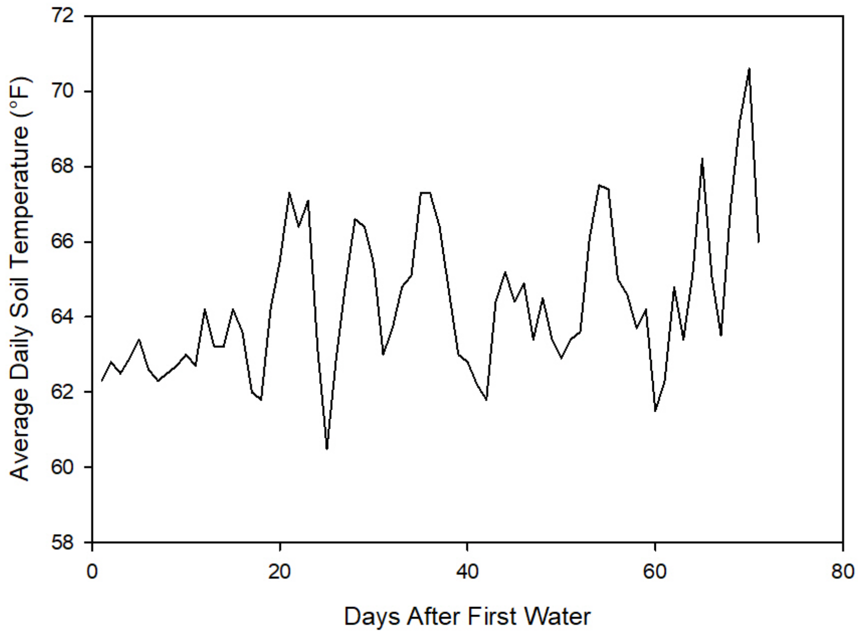

Figure 2. Nitrate-N in the soil in each treatment over the course of the experiment