6 12.0107 C CARBON

Snake Oil or the next Big Thing?

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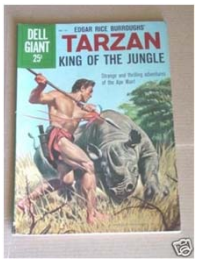
1

This material can be found at:

- Hopkins, B.G. and T.J. Hopkins. 2018. Carbon: the next frontier in fertilization? *Crops & Soils.* 51 (3) 36-38. Available at: https://dl.sciencesocieties.org/publications/cns/articles/51/3/36.

2

Carbon is King



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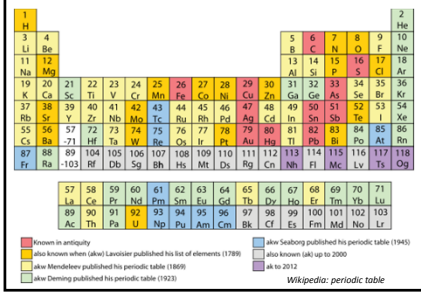
Universe is made of two things: matter and energy. Matter is the chemical elements.



Wikipedia: periodic table

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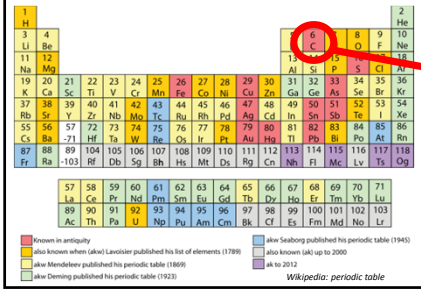
Carbon is atomic number 6. 4th most common in universe.



Wikipedia: periodic table

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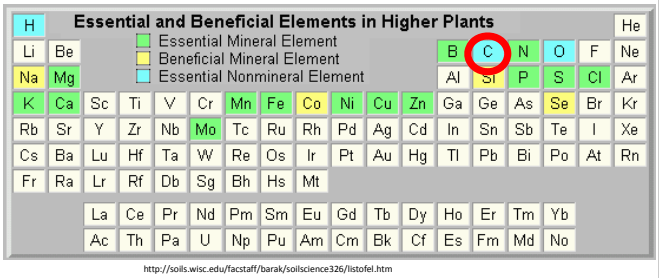
Many chemical elements are essential plant nutrients. Carbon is one of these—as an essential (non-mineral) plant nutrient.



http://soils.wisc.edu/facstaff/barak/soilscience326/listofel.htm

6

Carbon

- Makes up about half of the mass of plants
- It is involved in nearly every plant structure and biochemical process.
- Carbon is DEFINITELY ESSENTIAL!

7

Where do plants get their carbon?

8

Photosynthesis converts the sun's energy to chemical energy to fuel essential plant activities.

$$6CO_2(g) + 6H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 + 6O_2(g)$$

9

$$6CO_2(g) + 6H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 + 6O_2(g)$$

And, it provides the three non-mineral nutrients (carbon, oxygen, and hydrogen) as major building constituents of plant structures and functions.

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Soil Health

"In God We Trust . . .
All Others Must Bring Data"
W. Edwards Deming

U.S. Dept. of Agriculture - NRCS

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Soil Health

- The soil, as a collection pool for carbon, is essential for tempering carbon dioxide concentration in the atmosphere.

U.S. Dept. of Agriculture - NRCS

- Carbon is essential for a healthy, fertile soil.

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Carbon forms in soil

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Carbon is found in
organic (decaying organisms) and
inorganic forms (limestone).

Wikipedia: limestone

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Both forms are found in soils.

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Inorganic Carbon

- Limestone is the most abundant inorganic form of carbon in the soil.
- This mineral is common in arid zone, alkaline soils.
  - These are "calcareous" soils. This limestone is NOT necessarily good for plants.
    - Plugs up soil pores
    - Reduces solubility of some nutrients (P, Zn, Fe, Mn, Cu)
- Limestone is present in acid soils. In fact, we add lime to acid soils to raise the pH.

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Calcareous soil effervescing when a drop of acid is placed on it as the carbonate (CO_3^{2-}) converts to CO_2 gas.

http://gsrpdf.lib.msu.edu/ticpdf.py?file=/article/whitlark-soil-3-4-11.pdf

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But, what about the other kind of carbon?

18

Organic carbon in soil is the "organic matter" and is important for plant and soil health.

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Soil organic matter benefits

- Increase
  - Water infiltration into soil (although thatch can have the opposite effect)
  - Permeability of water through soils
  - Water retention in soil
  - Nutrient concentration
  - Nutrient retention
  - Nutrient cycling
  - Oxygen content
  - Soil aggregation
  - Soil structure
  - Biodiversity
  - Buffering

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However, excessive soil organic matter can have a negative impact on drainage on some sports fields

21

So, we should be adding lots of carbon fertilizer.

- Right?
- The answer is "No"

22

A plant's mission in life it to capture, through photosynthesis, the plethora of carbon found in the atmosphere.

$$6CO_2(g) + 6H_2O \xrightarrow{\text{Light Energy}} C_6H_{12}O_6 + 6O_2(g)$$

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As a rule, plants are not carbon deficient.

- Many studies have shown the benefits and detriments of increasing the carbon dioxide (CO_2) in the air. This is essentially fertilizing the air. Which we can do in scientific studies, but not in real world situations.
- But what about adding carbon to the soil as fertilizer?

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Lots of carbon containing products have been shown scientifically to benefit plants.

- Urea fertilizer
- Compost fertilizer
- Organic acids
- Crop residues (grass clippings)

25

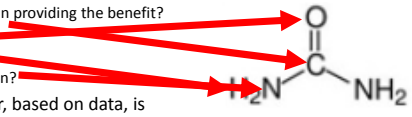
But, plenty of carbon containing materials are detrimental to plants.

- Hydraulic oil
- Gasoline
- Diesel
- Grass Herbicides

26

Is it the carbon that is causing the benefit or detriment or is it the specific molecule?

- Urea fertilizer is a proven valuable tool for plant fertilization
  - But, is it the carbon providing the benefit?
  - (or the oxygen?)
  - (or hydrogen?)
  - Or is it the nitrogen?
- The correct answer, based on data, is nitrogen. Plants aren't deficient of carbon.



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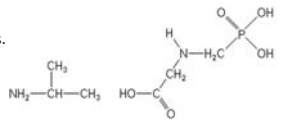
Similar concept for a pesticide.

- Glyphosate (RoundUp®) kills most plants.
- Do plants die because of the carbon?
  - No
  - Rather, it is how the various atoms are arranged in this molecule that kills plants.



Glyphosate-isopropylamine salt

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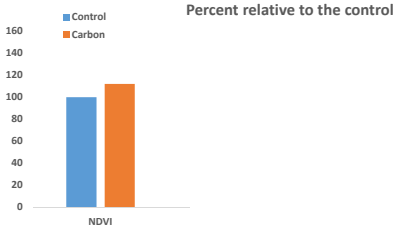
Research study on a "carbon" fertilizer



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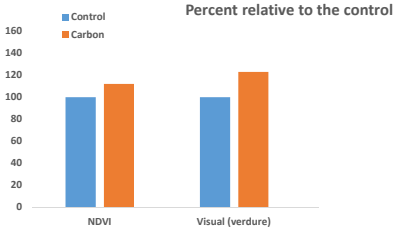
Research study on a "carbon" fertilizer



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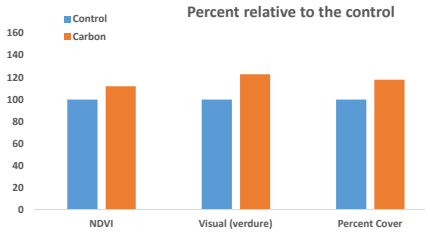

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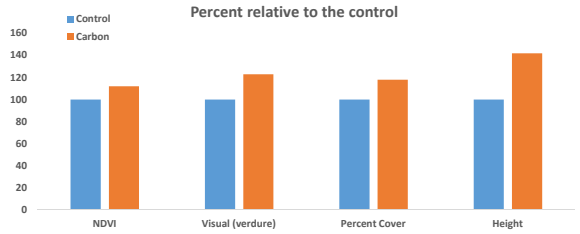

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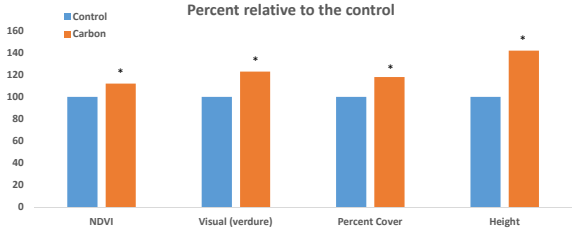
* = statistically significant difference compared to the control



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But, was this a valid evaluation of carbon fertilization?

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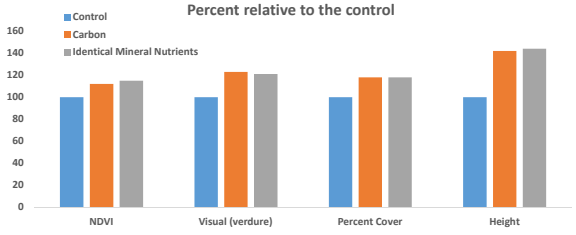
No, let's look at the "rest of the data"



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The "carbon" fertilizer actually contained a wide variety of components.

- In addition to the carbon, also
  - Nitrogen
  - Phosphorus
  - Potassium
  - Sulfur
  - Micronutrients

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Concluding that the measured benefits were the result of carbon is a fallacy because there were multiple differences between the control and the fertilized plots. The only thing that can be concluded is that "fertilizer provided a benefit".

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The analysis of product was

5-2-4-1(N-P_2O_5-K_2O-S)
plus traces of Zn, Mn, Fe, Cu, B, etc.

38

So, we crafted a matching blend so that the only notable difference was the carbon.

- Treatment 1 had nothing applied
  - Negative control
- Treatment 2 has a fertilizer with 5-2-4-1(S) + "carbon"
- Treatment 3 has a fertilizer with 5-2-4-1(S)
  - Positive control

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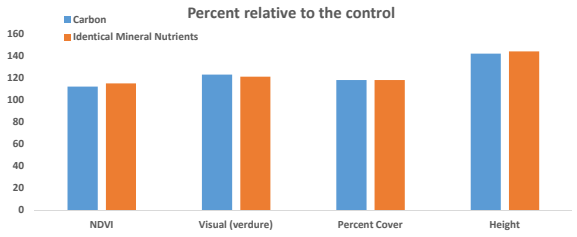
There were no statistical differences between the positive control and the carbon fertilizer.



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We've done 31 of these trials, evaluating various carbon fertilizers, using both a negative and a positive control.

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Carbon fertilization doesn't work

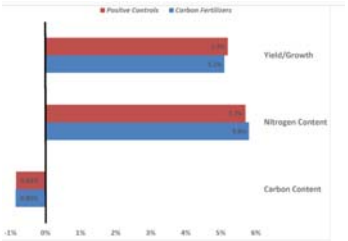
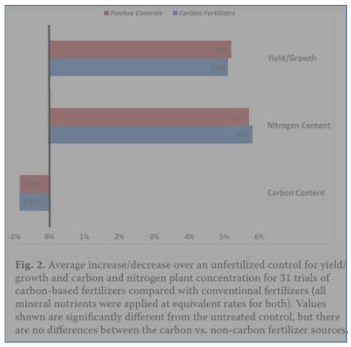


Fig. 2. Average increase/decrease over an unfertilized control for yield/growth and carbon and nitrogen plant concentration for 31 trials of carbon-based fertilizers compared with conventional fertilizers (all mineral nutrients were applied at equivalent rates for both). Values shown are significantly different from the untreated control, but there are no differences between the carbon vs. non-carbon fertilizer sources.

42

In general, we had responses over the negative control (no fertilizer).

As such, data is not shown.



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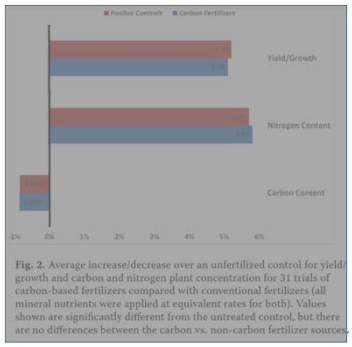
For simplicity, we are just showing the carbon fertilizer (blue bars) compared to the positive control (red bars).



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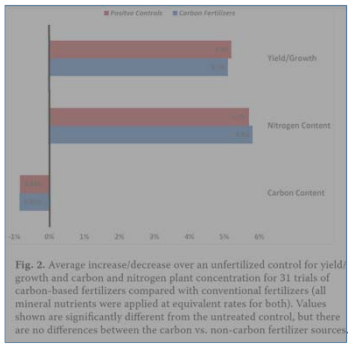
Remember, the positive control has the same nutrients as the carbon fertilizer, with the exception of carbon.



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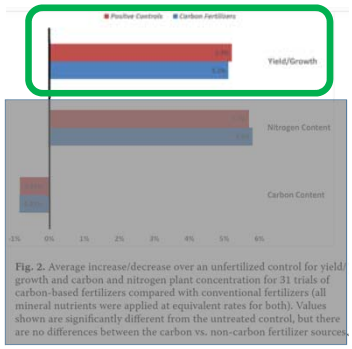
No differences in yield or growth due to carbon



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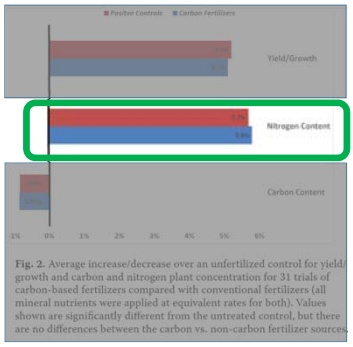
No differences in nitrogen (N) concentration in plants



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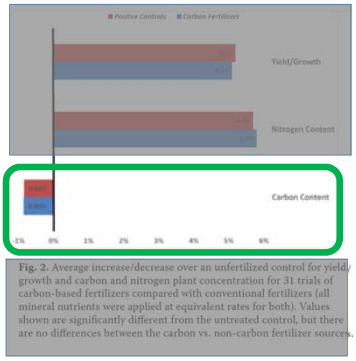
No differences in carbon concentration in plants.



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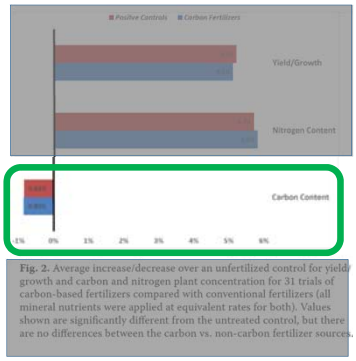
In fact, carbon concentration decreased (because the plants were more succulent and less fibrous due to N fertilization).



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Another study with a so-called carbon fertilizer . . . This one worked!

- New sod
- Soil test phosphorus levels were medium-low

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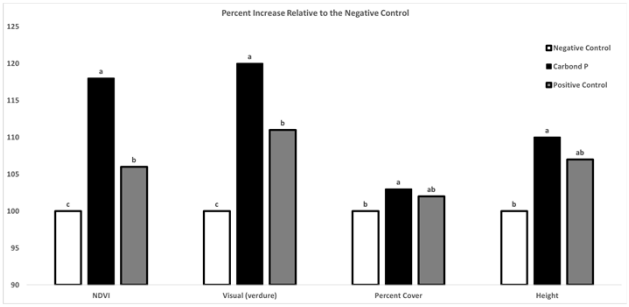

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Why?

- The carbon containing compound (organic acid) was bonded to phosphorus (P), which increased its solubility and uptake.
- So, it was a P response (not carbon).

52

Conclusions

- Carbon is essential for plant and soil health.
- Some carbon products can be beneficial to plants if managed correctly (urea, organic acids, etc.).
- Others are not.
- But carbon fertilization itself isn't beneficial.

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How do we manage carbon?

- In general, it is good to add crop residues to help build healthy soils. (This includes grass clippings, as long as they don't smother the turfgrass)
- Use all best management practices for proper nutrient, water, soil, crop, and pest management.
- Use scientifically proven products as appropriate, including carbon based ones, such as:
  - Urea fertilizer
  - Compost fertilizer
  - Hormones
  - Organic acids as a means of enhancing nutrient solubility

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