August 3, 2017

Sustane Water Dispersible Fertilizers for use in Tomato Transplant Production

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Objectives

Experiment 1 (12-0-1)

The objective is to compare performance of tomato transplants fertilized with a once weekly drench in response to Sustane WDF 12-0-1 as compared to another organic alternative nitrogen source, 14-0-0 soluble protein hydrolysate (Ferti Nitro Plus), and a conventional alternative nitrogen source (calcium nitrate, 15.5-0-0). In addition, we wish to determine if 12-0-1 application leads to greater nitrogen use efficiency, i.e. if a lower application rate can be used (150 ppm N vs. 200 ppm N).

Experiment 2 (8-2-4)

The objective is to compare performance of Sustane 8-2-4 WDF to other complete liquid organic fertilizers (Nature's Source 3-1-1, Drammatic ONE 4-4-1) and a conventional fertilizer (Jack's 21-5-20).

Materials & Methods

Plant culture

Both experiments used 4-week old plugs (i.e. seedlings grown in a 128 cell tray) of 'Celebrity' tomatoes grown in a glasshouse at Cornell University. Upon experiment initiation, April 28, 2017, tomato seedlings were transplanted into 4-inch round pots (500 mL volume) containing an organic base substrate. The base substrate was prepared at Cornell and consisted of 75:25 (v:v) peat:perlite along with 8 lbs. per cubic yard Sustane 8-4-4 granular, and adjusted to pH 6.0 with 5 lbs. per cubic yard dolomitic limestone.

Beginning on April 28, 2017 and continuing weekly thereafter, each container was drenched (by hand) with 200 mL liquid fertilizer solution (as described under treatments). A total of 5 weekly drenches were applied. Control plants received tap water only at 200 mL/container. During other days of the week containers were watered by hand (as needed, typically once per day) with tap water only. All plants were grown in a glasshouse at Cornell University with a 72/68 °F day/night temperature set points. No supplemental light was used.

Fertilizer treatments

In both experiments fertilizer materials were prepared manually the day of application. Drenches were executed by manually applying 200 mL solution volume to each container by slowly pouring 100 mL at a time. Fertilizer treatments were as follows:

Experiment 1 (12-0-1)

1. Unfertilized control (plants in base potting mix with no additional fertility)
2. Sustane 12-0-1 WDF @ 150 ppm N
3. Sustane 12-0-1 WDF @ 200 ppm N
4. Ferti Nitro Plus 14-0-0 protein hydrolysate @ 150 ppm N
5. Ferti Nitro Plus 14-0-0 protein hydrolysate @ 200 ppm N
6. Calcium nitrate 15.5-0-0 @ 150 ppm N
7. Calcium nitrate 15.5-0-0 @ 200 ppm N

Experiment 2 (8-2-4)

8. Unfertilized control (base substrate only with no additional fertilizer)
9. Sustane 8-2-4 WDF @ 200 ppm N
10. Nature's Source 3-1-1 @ 200 ppm N
11. Drammatic ONE 4-4-1 @ 200 ppm N
12. Jack's 21-5-20 @ 200 ppm N

Data collection, experimental design and analysis

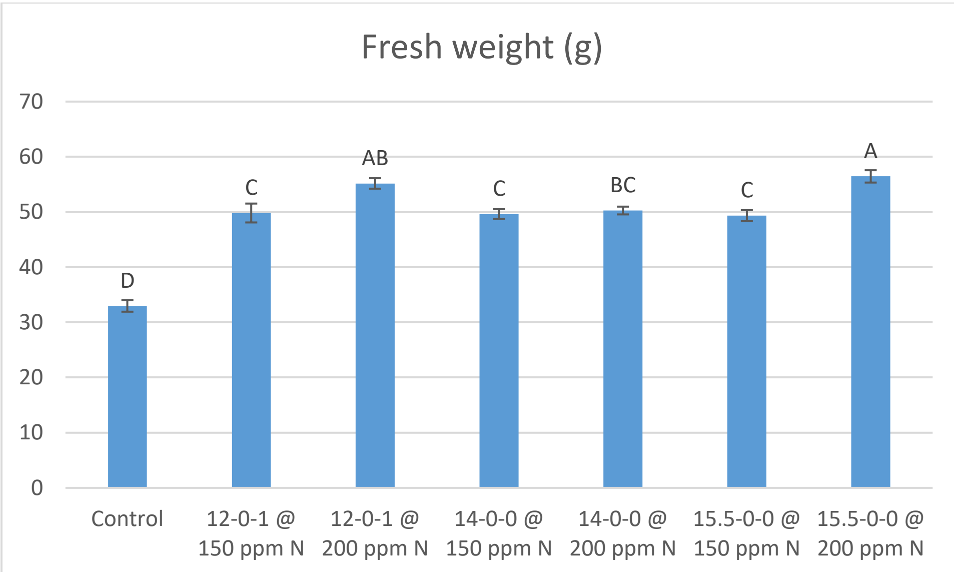
In each experiment there were 8 replicates (1 plant in 1 container) per treatment. Plant location was randomized along one 70 square foot greenhouse bench (therefore plant spacing was 1 plants per 0.73 square feet. Plants received a total of 5 weekly drenches and plants were grown for 5 weeks. After 2.5 weeks from experiment initiation photographs and nondestructive measurements will be taken on: plant height and width, leaf chlorophyll index (SPAD meter), flower number and branch number (these data are included as supplemental material). At 5 weeks (May 31, 2017) photographs and nondestructive measurements (plant height and width, leaf chlorophyll index (SPAD meter), flower number, branch number, and root index) were taken. For experiment 1 plants shoot fresh weight was taken (stem/leaf). Plants were then dried in an oven for 3 days at 158 °F and weighed to determine dry weight. For experiment 2, plants were monitored over a 5 day period to determine effect of fertilizer treatment on wilting and recovery from wilting. At harvest (day 0 in wilt monitoring), plants were fully watered with tap water, and baseline wilt measurements were taken (1=plant fully turgid, 5=nearly all leaves on plants wilted) plants were then held in the same greenhouse and daily wilt index data were taken. At day 4 the majority of plants were quite wilted; therefore after wilt index was recorded plants were fully watered and allowed to recover for 1 day. At day 5 final wilt index (representing recovery from wilt) were recorded. Shoot fresh weight was recorded and as above plants samples were placed in a oven for determination of shoot dry weight.

Each experiment was arranged in a completely randomized design. There were 8 replicates per treatment. Within each experiment analysis of variance was conducted to determine significant effects of fertilizer treatment on measured parameters. When significant was found, mean separation comparison was conducted using Tukey's honestly significant difference (P=0.05). Results reported below are based on the harvest at 5 weeks. Raw data and the full set of graphs and statistical analysis are available as supplementary material.

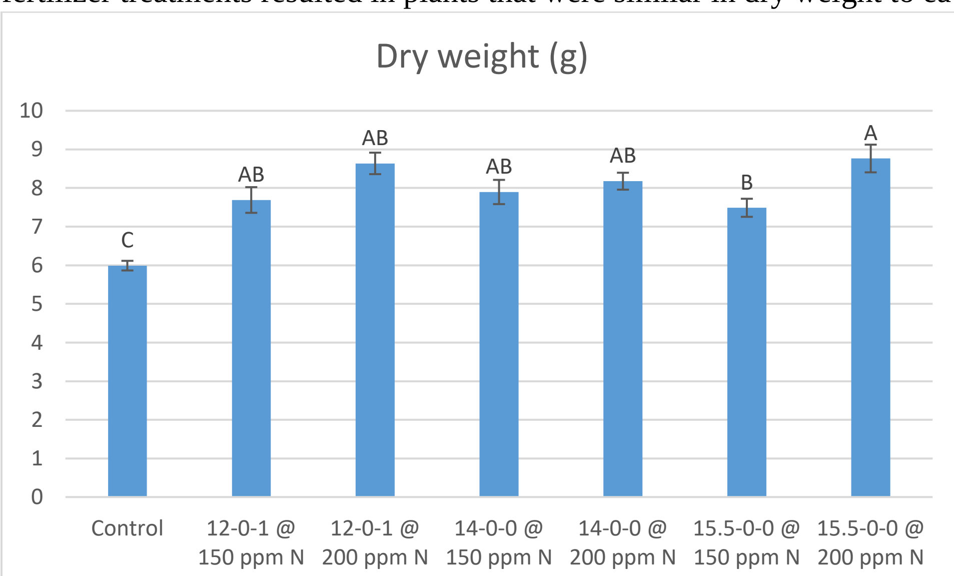
Results Experiment 1 (12-0-1)

Shoot fresh and dry weight

Fresh weight was smallest for control (unfertilized plants) and greatest for plants receiving the 200 ppm N 12-0-1 and 15.5-0-0 treatments. Interestingly, plants that received 150 ppm N from 12-0-1 had the same fresh weight as plants receiving 200 ppm N from 14-0-0.

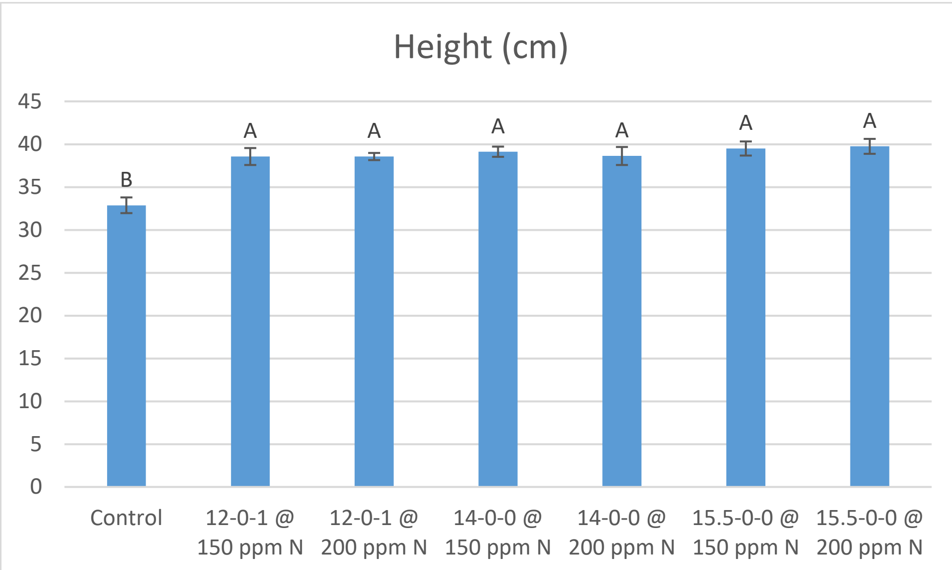


Dry weight was smallest for control (unfertilized plants), followed by 15.5-0-0 at 150 ppm N which was significantly smaller than the 200 ppm N 15.5-0-0 treatment. Otherwise all other fertilizer treatments resulted in plants that were similar in dry weight to each other.

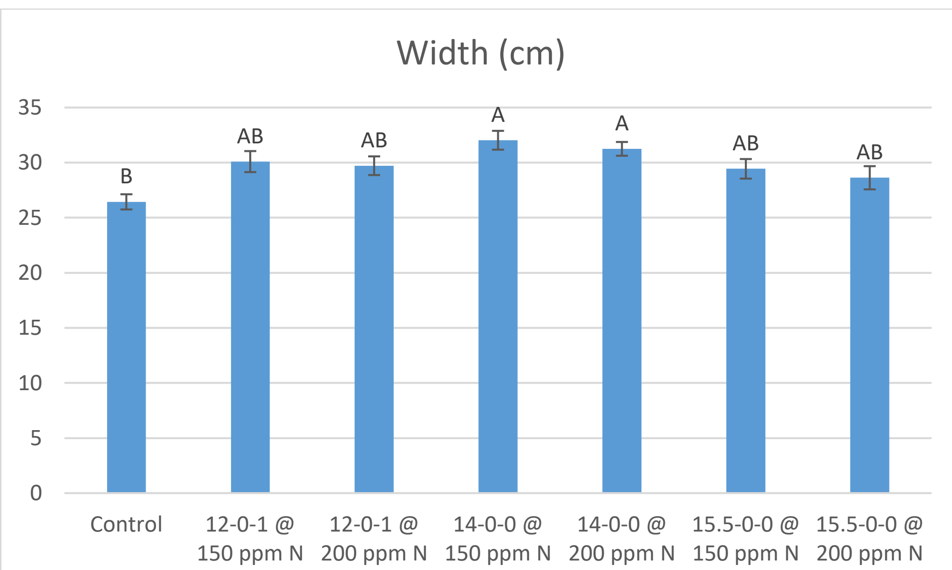


Plant height and width, chlorophyll index

Plant height was smallest for the control plants. For all plants that received fertilizer treatments there was no significant difference in plant height.

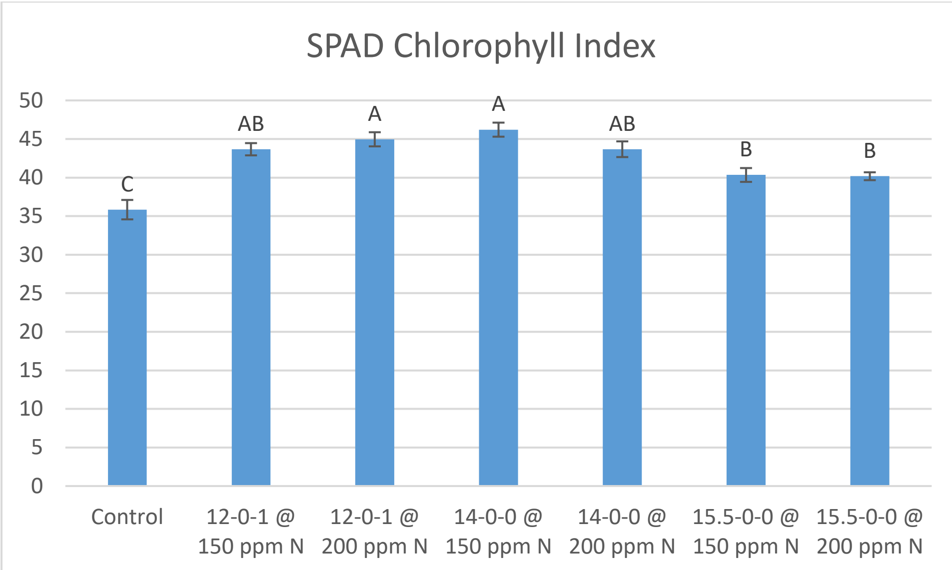


Plant width of the 14-0-0 was about 25% greater than width of control plants. Plant width from all other fertilizer treatments was similar to each other.



Chlorophyll index (as measured on 3 replicate most recently expanded leaves per plant using a Minolta SPAD 502 chlorophyll meter) is a measure of leaf "greenness" and correlates with leaf nitrogen content. Chlorophyll index was lowest for control plants, followed by plants receiving 15.5-0-0. Greatest chlorophyll index was found for plants receiving 200 ppm N from 12-0-1 or

150 ppm N from 14-0-0 and this was statistically similar to plants that had received 150 ppm N from 12-0-1 or 200 ppm N from 14-0-0.



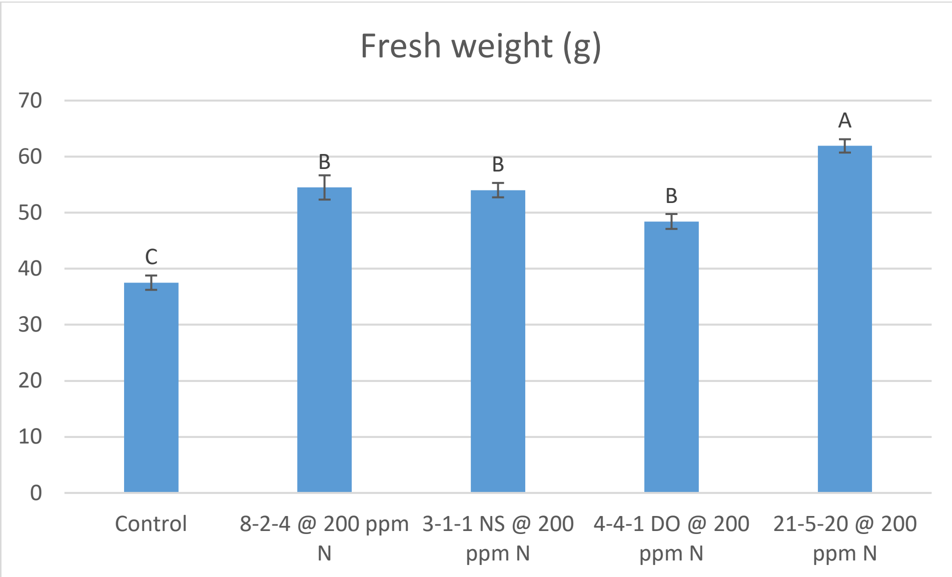
Branch number, flower number, and root index

For experiment 1, fertilizer treatment had no statistically significant effects on branch number, flower number, or root index (see supplemental material).

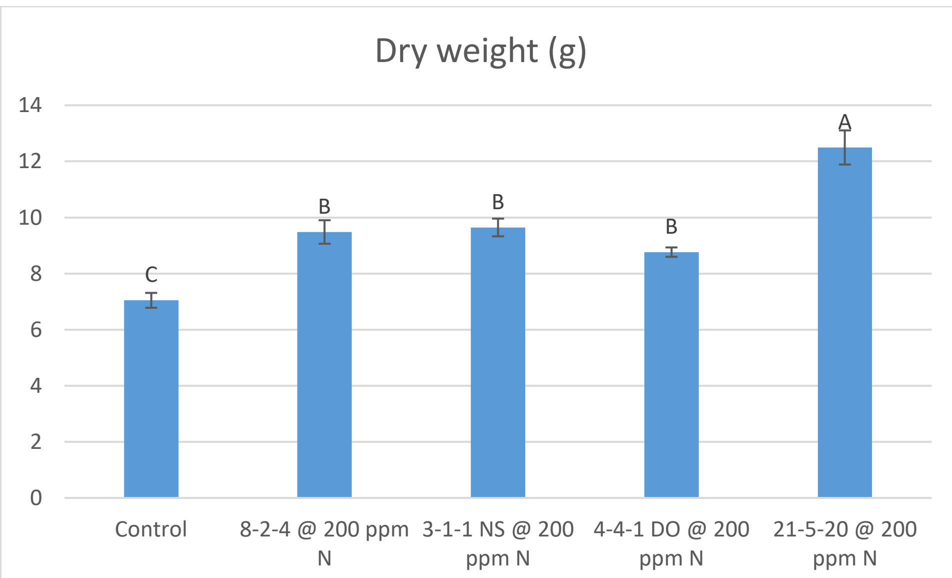
Results Experiment 2 (8-2-4)

Shoot fresh and dry weight

Fresh weight was greatest for the conventional liquid fertilizer (21-5-20) followed by all three organic fertilizers (8-2-4, 3-1-1, and 4-4-1) which all had similar fresh weight. While 8-2-4 and 3-1-1 had a slightly greater fresh weight than 4-4-1, this was not statistically significant. Lowest fresh weight was for control (unfertilized plants).

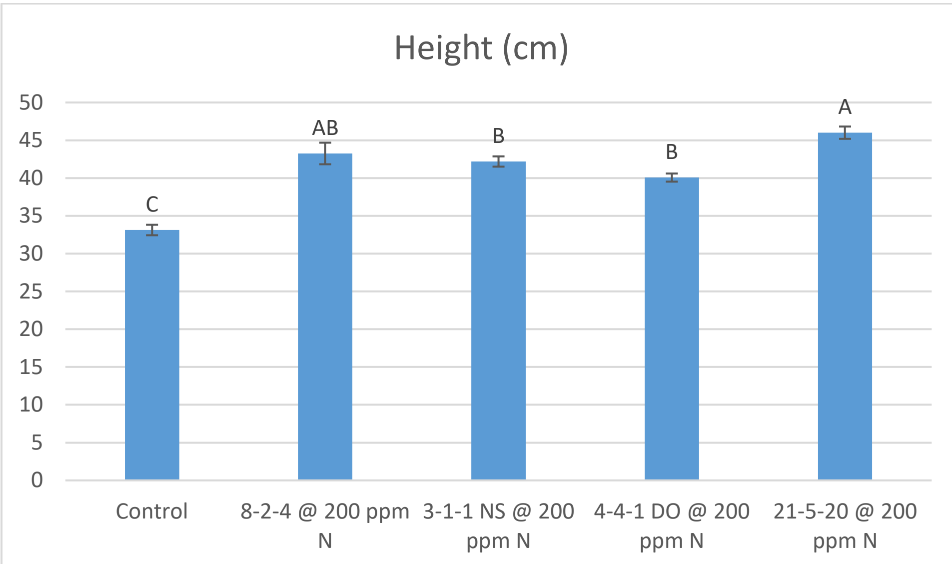


Dry weight followed the same trends as fresh weight with 21-5-20 plants having the largest dry weight, followed by all organic fertilizers which had similar fresh weight to each other. Control plants had the smallest fresh weight. Again there was a slight (but not statistically significant) increase in dry weight for plants receiving 8-2-4 or 3-1-1 instead of 4-4-1.

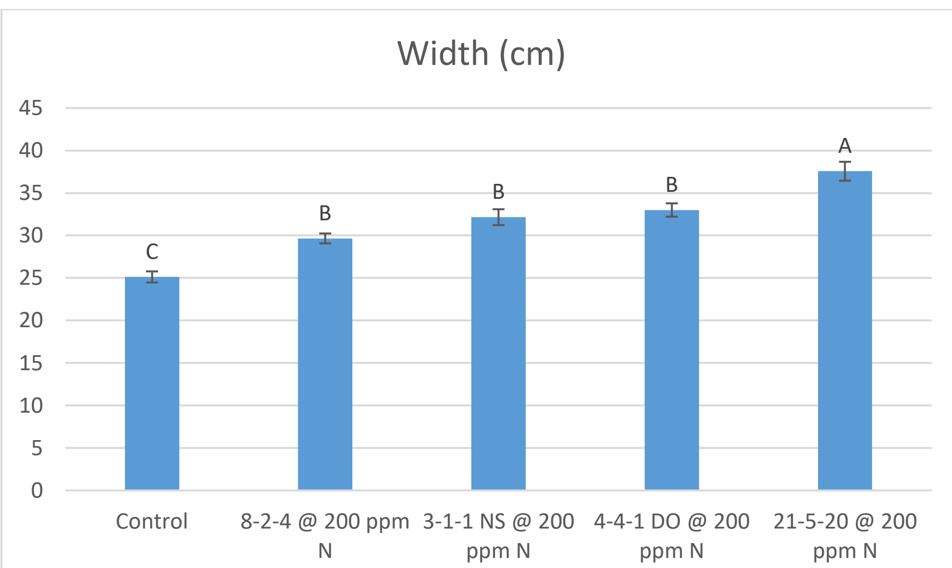


Plant height and width, chlorophyll index

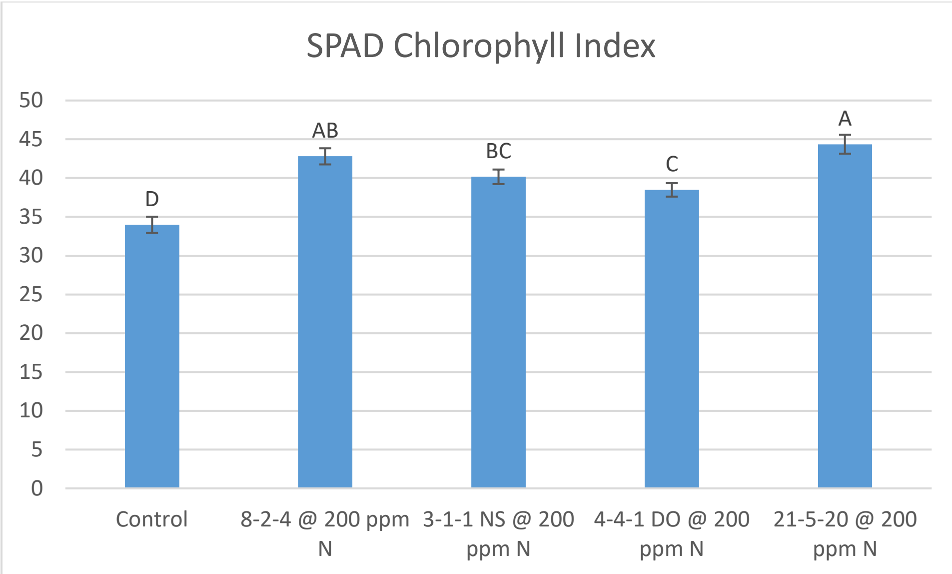
Plant height was greatest for 21-5-20 plants and this was similar to plants receiving 8-2-4. Plants receiving 3-1-1 or 4-4-1 were a bit shorter than 21-5-20 treatment plants. Control plants were the shortest.



Plant width was greatest for the 21-5-20 treatment, followed by all three organic fertilizer materials (which did not differ from each other), and smallest for control (unfertilized plants)



Chlorophyll index was was greatest for 21-5-20 plants and this was similar to plants receiving 8-2-4. Plants receiving 3-1-1 or 4-4-1 had a lower chlorophyll index than 21-5-20 treatment plants. Control plants had the lowest chlorophyll index.

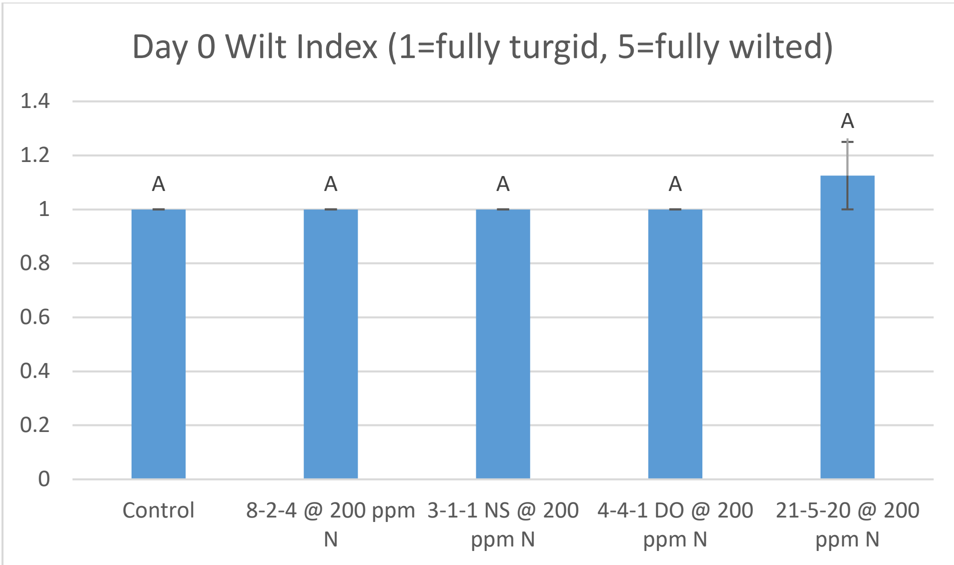


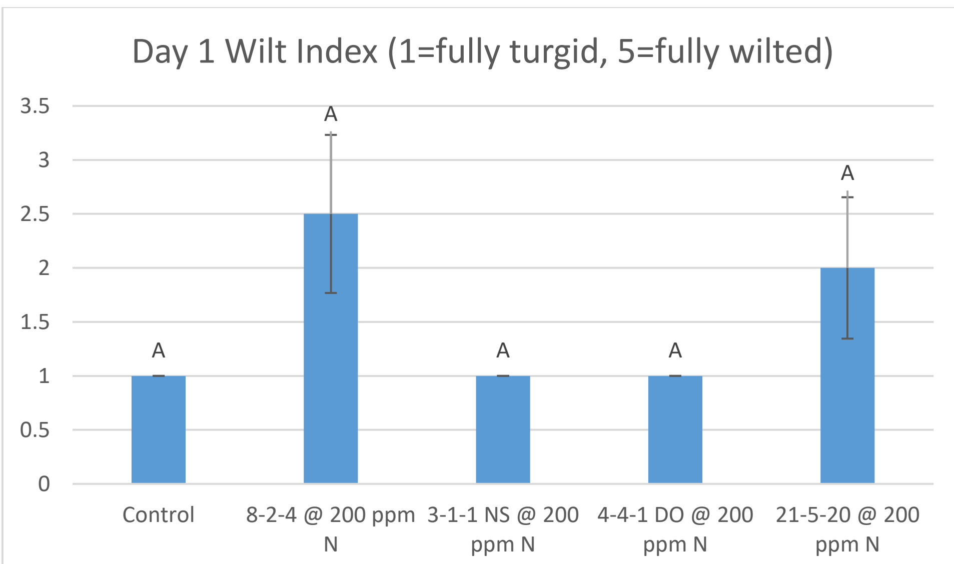
Branch number, flower number, and root index

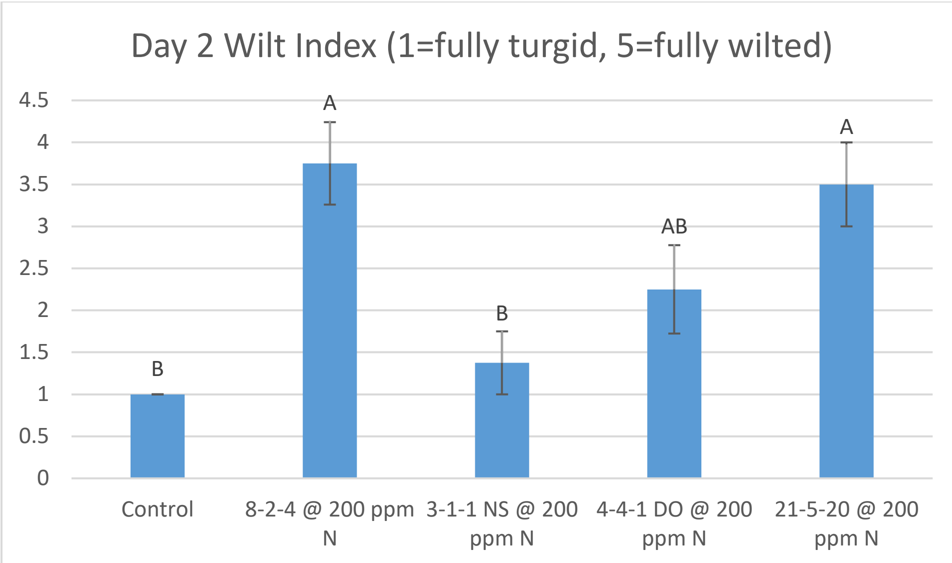
For experiment 1, fertilizer treatment had no statistically significant effects on branch number, flower number, or root index (see supplemental material).

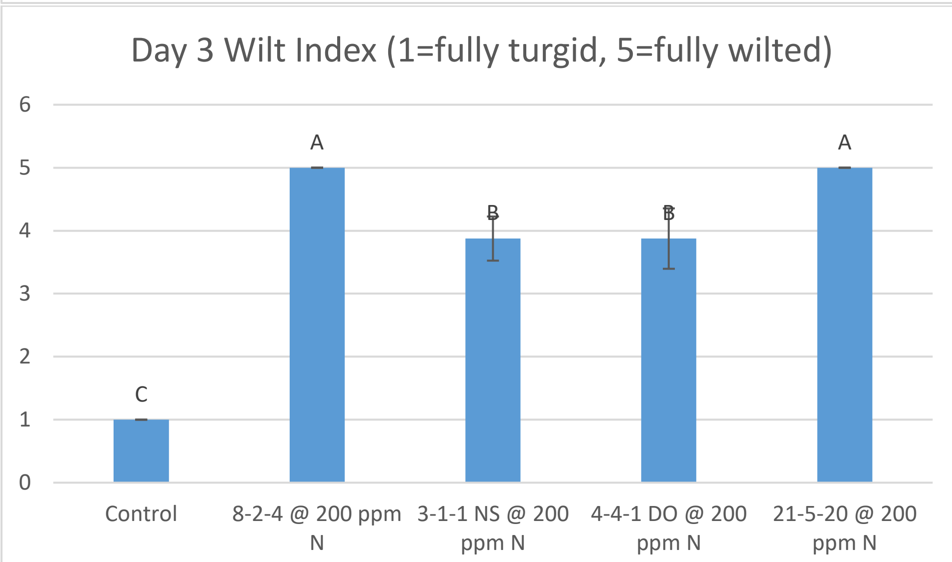
Wilt index

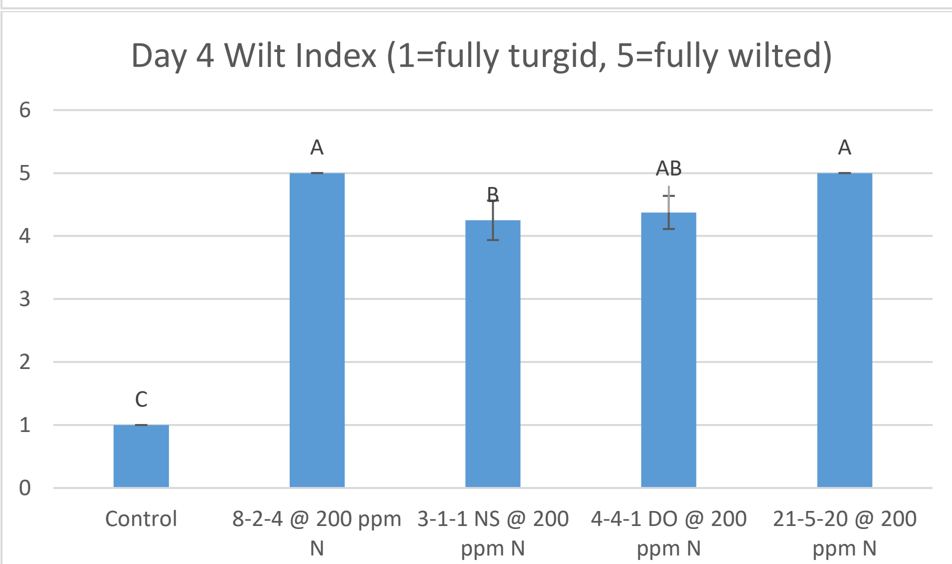
Initially at day 0 (following a complete watering) plants from all fertilizer treatments were fully turgid. After 1 day without watering, plants in 8-2-4 and 21-5-20 exhibited a greater degree of wilting (increased wilt index) but this was not statistically significant as compared to the other treatments. By Day 2, the 21-5-20 and 8-2-4 treated plants did exhibit greater wilting than control or 3-1-1 treated plants. By Day 3, control plants had wilted the least, followed by 3-1-1 and 4-4-1 treated plants, with 21-5-20 and 8-2-4 plants exhibiting the greatest wilting. At day 4 control plants exhibited the least wilting followed by 3-1-1, followed by all other fertilizer treatments. Plants were then rewatered and monitored for recovery from wilt 24 hours later. At day 5, there was some recovery from wilt (decreased wilt index) for all the fertilizer treatments however all fertilizer treatments still showed a large degree of wilt with slightly less wilting in the 3-1-1 treatment. Control plants wilted very little during the 5 day period, this is most likely related to their overall smaller size. Within fertilizer treated plants, 21-5-20 and 8-2-4 plants exhibited the greatest degree of wilt, probably due to their larger size and therefore larger transpiration of water from their leaf surfaces. It is also interesting to note that 3-1-1 treated plants, while similar in size to 8-2-4 plants, exhibited less wilting. The cause is unknown.

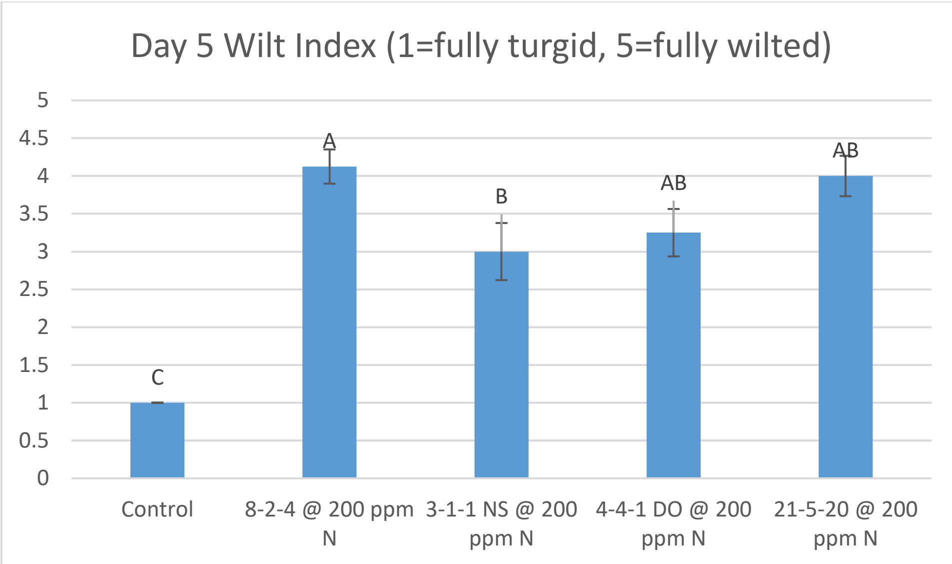

Day 0 Wilt Index (1=fully turgid, 5=fully wilted)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
A
A
A
A
A
Control
8-2-4 @ 200 ppm N
3-1-1 NS @ 200 ppm N
4-4-1 DO @ 200 ppm N
21-5-20 @ 200 ppm N


Day 1 Wilt Index (1=fully turgid, 5=fully wilted)
3.5
3
2.5
2
1.5
1
0.5
0
A
A
A
A
A
Control
8-2-4 @ 200 ppm N
3-1-1 NS @ 200 ppm N
4-4-1 DO @ 200 ppm N
21-5-20 @ 200 ppm N


Day 2 Wilt Index (1=fully turgid, 5=fully wilted)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
B
A
B
AB
A
Control
8-2-4 @ 200 ppm N
3-1-1 NS @ 200 ppm N
4-4-1 DO @ 200 ppm N
21-5-20 @ 200 ppm N


Day 3 Wilt Index (1=fully turgid, 5=fully wilted)
6
5
4
3
2
1
0
C
A
B
B
A
Control
8-2-4 @ 200 ppm N
3-1-1 NS @ 200 ppm N
4-4-1 DO @ 200 ppm N
21-5-20 @ 200 ppm N


Day 4 Wilt Index (1=fully turgid, 5=fully wilted)
6
5
4
3
2
1
0
C
A
B
AB
A
Control
8-2-4 @ 200 ppm N
3-1-1 NS @ 200 ppm N
4-4-1 DO @ 200 ppm N
21-5-20 @ 200 ppm N



Conclusions Experiment 1 (12-0-1)

Plants that received 12-0-1 had equal or greater performance of all measured parameters as compared to their counterparts that received 14-0-0 (organic) or the conventional 15.5-0-0. Therefore, 12-0-1 can serve as an excellent substitute for either of these liquid applied fertilizer materials. In addition plants receiving 12-0-1 at 150 ppm N performed as well as 14-0-0 or 15.5-0-0 plants that received 200 ppm N suggesting that 12-0-1 may have enhanced nitrogen use efficiency with the ability to use at 25% lower application rate. One caveat is that within each fertilizer type typically only subtle differences were found between 150 and 200 ppm N treatments and this may also be due to the fact that plants had background fertility (8 lbs per cubic yard of Sustane 8-4-4 granular added to their potting mix). We found that the combination of Sustatne 8-4-4 granular added to a potting mix plus a once weekly drench of 12-0-1 at either 150 or 200 ppm N is a good fertility program for use in organic tomato transplant production under the conditions of our experiment.

Conclusions Experiment 2 (8-2-4)

Tomato plants that received weekly drenches with conventional liquid fertilizer (21-5-20) were slightly larger (in measured parameters) than plants that received the organic fertilizer treatments. Within the organic fertilizers examined (8-2-4, 3-1-1, and 4-4-1) there were no statistically significant differences in plant size from each other, and all treatments were equally effective in promoting plant growth as compared to control (unfertilized plants). Plants receiving organic fertilizer or conventional fertilizer would be considered commercially marketable whereas unfertilized plants were smaller and with yellower leaves. There were some subtle (but non significant) benefits in terms of growth parameters for either 8-2-4 or 3-1-1 as compared with 4-4-1. Regarding plant wilting, treatments that resulted in larger plants typically resulted in earlier wilting. Overall, under the environmental conditions of our experiment plants receiving Sustane 8-2-4 WDF as an organic fertilizer treatment performed just as well as Nature's Source 3-1-1 or Drammatic ONE 4-4-1 when applied as a once weekly drench at 200 ppm N.