Response of 'First Lady' Marigolds to Plant Extract Fertilizers, Granular Organic Fertilizers, and Biochar

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In recent years I've have written articles about my work with organic fertilizers as alternatives to traditional water-soluble chemical fertilizers (Cox, 2010; Cox and Eaton, 2011; Cox, 2013; Eaton, et al., 2013). Not surprisingly, because of their differences in the makeup, success in growing acceptable greenhouse crops has been variable. However, one thing does seem clear: organic fertilizer combinations work better than relying on one type alone.

I've worked with several types of soluble organic fertilizers manufactured from extracts of sugar beets and a granular fertilizer made from poultry waste materials. Results were reported in the June 2013 issue of *Floral Notes* (Cox, 2013).

Recently a type of charcoal called "biochar" has caught the attention of soil scientists, farmers, and the environmental community. Biochar may be useful for soil improvement, increasing nutrient retention, and slowing global climate change. Some suggest that biochar in potting media would reduce nutrient leaching, but there hasn't been any research evaluating biochar for use in potting media. If biochar could be used along with organic fertilizers it might prove to be a simple and low cost way of reducing nutrient leaching. In this project biochar was used with several organic fertilizers to determine what effects the treatments might have on growth and nitrogen leaching in potted crops. The project was supported by grants from New England Floriculture, Inc., Massachusetts Flower Growers' Association, and the New England Florist Credit Endowment.

What is biochar?

Biochar is a type of charcoal made from burning organic matter with a minimum of oxygen. Less refined than standard charcoal, biochar is made from agricultural wastes, food processing wastes, and tree trimmings. The biochar used in this study was made by the Ideal Compost Co. of Peterborough, NH from spruce and fir tree trimmings. The burning process effectively ties up ("sequesters") the carbon in a highly stable, complex structure preventing its release as CO_2 to the atmosphere as it would during normal burning or natural decomposition. Environmentalists believe that biochar might be one way of reducing atmospheric CO_2 thus slowing global change. Biochar is not a fertilizer, but nutrient retention is one of its valuable properties.

How the plants were grown

'First Lady'marigold plugs were potted on 30 January 2013 in 4½-inch pots of Fafard 3B soilless mix. Prior to planting, biochar was incorporated in the mix at a level of 20% by volume. Pots were suspended through the lids of larger containers to collect the leachate for ammonium (NH_4-N) and nitrate (NO_3-N) analysis at 10 day intervals as the plants grew.

Plants were fertilized with 250 ppm N from Plantex (20-2-20) chemical fertilizer or Espartan (2.7-3.03-2.6) plant extract fertilizer (fermented sugar beet molasses). In another treatment, Sustane (8-4-4) granular fertilizer (aerobically composted turkey litter, hydrolyzed feather meal, and potassium sulfate) was incorporated in the growing mix of one-half the pots in each fertilizer treatment prior to planting at a rate of 7.6 gm/pot (0.27 oz./pot). Also, Espartan was applied in combination with Sustane. In this treatment Espartan was applied at every other watering. The same amount of nitrogen (N) was supplied by all fertilizer treatments. In the combination treatments one-half of the N was supplied Espartan and the other half by Sustane. Plants in all treatments were irrigated with the same amount of fertilizer solution or plain water during the experiment.

Plant height and first flower diameter were measured and the plants were harvested for shoot dry weight determination 4 April, 60 days after transplanting.

Results

Plant appearance and growth. In general, plants in all treatments were normal in appearance. Plants fertilized with Espartan were darker green and the leaves had a slightly wilted appearance, however the leaf chlorosis exhibited by seed geraniums in an earlier experiment (Cox, 2013) did not occur on marigolds.

The tallest plants with the greatest dry weight were those fertilized with Plantex while those plants fertilized with Espartan were the shortest and had the least dry weight (Table 1). The Sustane treatments and Espartan alone had the smallest flowers. Combining Espartan and Sustane produced larger plants than Espartan alone. Overall Biochar had no effects on the growth parameters measured in this study (Table 2).

Table 1. Growth of 'First Lady' marigold as affected by different types of fertilizers.

Fertilizer	Plant hgt. (cm)	Flower dia. (cm)	Dry wt. (gm)
Plantex 20-2-20	25.1a	8.5a	16.8a
Plantex + biochar	25.1a	8.4a	16.5a
Sustane 9-4-4	22.9b	7.9b	13.4bc
Sustane + biochar	23.8b	7.6b	13.8bc
Espartan 2.7-3.0-2.6	21.0c	7.5b	10.5e
Espartan + biochar	21.6c	8.2a	11.5de
Espartan + Sustane	22.4b	8.2a	12.7cd
Espartan + Sustane + biochar	23.5b	8.4a	14.4b

Table 2. Growth of 'First Lady' marigold as affected by biochar in the growing medium.

Biochar	Plant hgt. (cm)	Flower dia. (cm)	Dry wt. (gm)
No	22.9	8.0	13.4
Yes	23.5	8.1	14.0
Significance	ns	ns	ns

Water use and nitrogen leaching. Since the same volume of fertilizer solution and water was applied to each treatment the total leachate volume is an indicator of water use by the plants in each treatment (Table 3). Leachate volume was lowest with Plantex and the combination of Espartan + Sustane with biochar. This result is a reflection of the fact that plants had greater dry weight than plants in the other treatments. Presumably more water was absorbed by these plants and less was available for leaching.

Fertilizer treatment had a great effect on N leaching. The least amount of total N (NH_4-N + NO_3-N) leached occurred with Plantex. The largest amount of total N leaching occurred with Espartan alone with or without biochar followed by the Espartan + Sustane combination with or without biochar. NO_3-N leaching was greatest Plantex while NH_4-N leaching was greatest with Espartan with or without biochar.

Overall, biochar significantly reduced NO_3-N leaching by 35%. However, adding biochar to the growing mix had no effect on leachate volume, total N leached, or NH_4-N leached.

Table 3. Water use and nitrogen leaching by 'First Lady' marigold treated with different types of fertilizer.

Fertilizer treatment	Total leachate vol. (ml)	NH_4-N (mg/pot)	NO_3-N (mg/pot)	Total N (mg/pot)
Plantex 20-2-20	600.4c	8.6d	90.5a	99.2d
Plantex + biochar	548.1c	7.3d	38.4cd	45.9e
Sustane 9-4-4	1317.7a	67.7c	44.6c	112.3cd
Sustane + biochar	1123.1b	58.8c	28.4d	87.2d
Espartan 2.7-3.0-2.6	1400.3a	177.9ab	60.9b	264.5a
Espartan + biochar	1393.9a	217.1a	54.5bc	271.7a
Espartan + Sustane	1070.4b	91.2bc	57.5b	148.6b
Espartan + Sustane + biochar	745.3c	81.8c	46.4c	128.1bc

Table 4. Water use and nitrogen leaching by 'First lady' marigold as affected by biochar in the growth medium.

Biochar	Total leachate vol. (ml)	NH_4-N (mg/pot)	NO_3-N (mg/pot)	Total N (mg/pot)
No	1097.2	86.4	63.4	156.2
Yes	952.6	91.3	41.0	133.2
Significance	ns	ns	**	ns

Conclusions: What does it all mean?

Plant growth, flowering, and dry weight were similar for all treatments, but clearly the largest plants resulted from Plantex. The Espartan plants were darker green than plants treated with other fertilizers and had a slightly wilted appearance. In my opinion, this is probably due too much ammonium which is a characteristic of fish emulsion and plant extract fertilizers. This “ammonium toxicity” is supported by the large amount of NH_4-N in the leachate of Espartan plants. For this reason it’s best to use Espartan or any other soluble organic fertilizer be rich in NH_4-N with another fertilizer like Sustane which has a slower nutrient release rate. No chlorosis occurred on the marigolds unlike the seed geraniums in the earlier study (Cox, 2013).

Biochar reduced NO_3-N leaching by 35%, but did not affect growth parameters, leachate volume or N leaching. From my point of view the reduction in NO_3-N leaching is quite important, but I’ve done experiments similar to this one with biochar and the effects on NO_3-N leaching have been very inconsistent with reductions ranging from <5 to 40%. I think this inconsistency is mainly due to plant growth rate as it is affected by daylength and greenhouse temperature. Rapidly growing plants under increasing daylength and greenhouse temperature of the spring probably take up NO_3-N fast enough to limit NO_3-N leaching and the effect of biochar on leaching isn't as apparent compared to slower growing plants in the late fall and winter period. Since biochar doesn't seem to have any other positive effects on the growth of plants, I can't recommend it at this time for containerized greenhouse crops. Biochar isn't free since it takes heat energy to make it and it's probably the most dusty material I've ever used in the greenhouse. If you plan to try biochar you need at least a dust mask and you should do mixing outdoors or in a well-ventilated environment where nothing can be hurt by fine particulates.

References

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