

Title: **Testing Effectiveness of New All Natural Fertilizers/ Additives
on Selected Herbaceous and Woody Plants**

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Abstract

The strong demand for organic and sustainable agriculture has resulted in a number of new organic or all natural fertilizers that supposedly promote plant growth and health, but do these products really work? The goal of this research project was to test four all natural or organic fertilizer products that are produced in Idaho to determine if these products improved plant growth compared to a standard, commercially available fertilizer. Three species of bedding plants (geranium, lantana, and ornamental pepper) and one woody species (mockorange) were planted in 1-gallon containers and arranged on greenhouse benches at the Sixth Street Greenhouse on campus. After an acclimation period of 16 days, four organic or all natural fertilizers were applied to the these species. The applied products tested were Clearwater Fish Fertilizer (from Orofino), Thrive™ (from Boise), Kozgro's All Purpose Organic Plant and Soil Stimulant (from Caldwell), and Chicken Plus™ (from Nampa). These products were compared against Miracle Gro® 24-8-16, the synthetic fertilizer. About 250 milliliters (ml) of fertilizer solution were applied around the base of each plant for each product tested, including Miracle Gro® (control treatment). All plants were treated once every two weeks. The heights of all plants were measured every four weeks. The number of flower heads produced by each geranium plant was also recorded once a week, and the number and dry weight of ornamental peppers produced were also recorded at the end of the experiment. At the end of the study, shoots from all plants were harvested to determine their shoot biomass (dry weight). All four species treated with Miracle-Gro® or Thrive™ produced the most shoot dry weight or plant height (if this parameter was significant). Plants treated with the fish fertilizer were the next largest in size, and plants treated with the Kozgro's product were smallest in size. Plants treated with Chicken Plus™ were excluded from the data analyses, except for geranium plants, since the concentration of this product was too high the first two times the product was applied, which resulted in severe damage to plant roots. Likewise, geranium plants treated with Miracle-Gro® produced the most flower heads per plant. Ornamental pepper plants treated with Miracle-Gro® or Thrive™ produced the most fruits and most fruit dry weights compared to the other treatments. Plants treated with Chicken Plus™ or the Kozgro's product required watering once or twice a week, whereas those receiving the other treatments were often watered every other day or daily during the hottest weather. Under the experimental conditions in this study, the best organic or all natural fertilizer was Thrive™ followed by the fish fertilizer, whereas the Kozgro's product produced the least amount of plant growth for all four species tested in this study.

Materials and Methods

The experiment, testing the effectiveness of four all natural fertilizers or additives on selected plant species, was started in late June 2011. Four plant species were purchased and then planted in Sunshine Mix #2, which lacked a preplant fertilizer charge, on June 29 before being placed in a greenhouse. The four species used in the study included 'Chilly Chili' ornamental pepper, 'Cherry Sunrise' lantana, 'Wilhelm Langguth' geranium (with variegated foliage), and *Philadelphus lewisii* (syringa/ mockorange). The three herbaceous species were growing in 4-inch plastic pots, whereas mockorange plants were grown in 10-inch³ containers (Leach tubes). After 12 days of acclimation, plants were arranged on benches in a randomized complete block design at the Sixth Street Greenhouse Facility at the University of Idaho. Four days later, the plants were fertilized with five different products, which included Miracle-Gro® 24-8-16 (control - synthetic fertilizer) applied at 1 tablespoon per gallon (793 ppm N), Clearwater Fish Fertilizer (fish emulsion product from Orofino) applied at 2 tablespoons per gallon, Thrive™ (Zamzow's product from Boise) applied at 4 ounces per gallon, Kozgro's All Purpose Organic Plant and Soil Stimulant (Caldwell, Idaho) applied at 1.3 ounces per gallon, and Chicken Plus™ (BioFlora Northwest, Nampa, ID) applied at 12.8 ounces per gallon. The all natural fertilizers were applied according to their label rates. Two hundred fifty milliliters (250 ml or about one pint) of diluted fertilizer solution was poured into each pot around the base of the plant for each product. All plants were treated once every two weeks (according to label directions). Plants were watered on an as needed basis from the beginning of the study. As the weather got hotter during the summer, plants receiving the Miracle-Gro®, Thrive™, or fish fertilizer were watered as often as every other day, whereas plants treated with the Kozgro's product or Chicken Plus™ were watered once or maybe twice per week.

Some adjustments were made to application rates for three of the fertilizer products. First, the application rate for the Kozgro's product was increased at the producer's request from 1.3 ounces per gallon to 5.2 ounces per gallon. The higher application rate of the Kozgro product was started with the second fertilizer application to the plants. Second, the treatment rate was increased for the fish fertilizer since the producer provided a new formulation (2-2-2 compared to 2-2-0) and asked that a higher application rate of 4 ounces per gallon be used (instead of 2 tablespoons per gallon). Finally, the application rate of Chicken Plus™ was reduced to one-third of the field label rate for reasons described below, and the final application rate was 4.27 ounces of product per gallon. The new application rates for the fish fertilizer and Chicken Plus™ were made after two fertilizer applications (about one month into the experiment).

Two important chemical properties of the potting mix to check during the experiment were pH and electrical conductivity (EC). The pH provided an idea about relative nutrient availability, whereas the EC indicated the amount of salts – and therefore minerals – in the potting mix. Both pH and EC were determined by using the Pour-through extraction method (also called the Virginia Tech. Method). The pH and EC were determined three times during the experiment. These chemical properties were measured on August 9 and 30 as well as September 22, which were after two, four and five, respectively, fertilizer treatments to the plants. The EC data were particularly important since they were used to relate fertilizer applications to the amount of salts remaining in the potting mix as the experiment progressed.

Four replicate plants per treatment and five treatments were included in each of four blocks of plants (4 x 5 x 4) for a total of 80 plants per species used in a randomized complete block design. Each species was considered a separate experiment. Plants were watered with a micro-emitter irrigation system with spray stakes, but hand watering was also used (see the discussion below). Plants were irrigated as needed, with about 250 to 500 ml of water applied at a time. Shoot heights were measured for each plant every four weeks. The number of flower heads produced by geranium plants was recorded once a week. The experiment was ended on October 6th and 7th, 2011. At the end of the study, the number of peppers and their fresh weight were recorded. In addition, shoots from all plants were harvested for determining their shoot biomass (dry weight) by severing shoots at the potting mix surface at the end of the study. Shoots were dried in an oven at 41°C for at least three weeks before their dry weights were determined.

Plant growth (increases in shoot height and final heights) for all for species, mean number of geranium inflorescences produced, mean number and dry weight of ornamental pepper fruits produced, and shoot dry weights were statistically analyzed for treatment significance by one-way analysis of variance procedures. Tests for normality of the data were determined by univariate procedures. Protected Fisher's Least Significant Difference (LSD) test was used at the 5% level to determine significant differences between means.

Results and Discussion

The various fertilizers yielded different results with the four plant species. Differences in plant appearances could be readily seen after two fertilizer treatments (one month into the study). By the end of the study, all plants treated with the Miracle-Gro® or Thrive™ grew the most, as seen in increases in plant heights and shoot dry weight produced (Tables 1, 2, 3, and 4). Plants treated with either of these two products grew well and appeared quite healthy, with the exception of some Thrive™-treated plants (see below). Plants treated with the fish fertilizer generally produced the next highest levels of plant growth followed by plants treated with the Kozgro's product. Plants treated with Chicken Plus™ were damaged by too high of an application rate (the field labeled rate). After one month (two treatments), the application rate used was reduced by two-thirds, but many mockorange, lantana, and ornamental pepper plants were already severely damaged. Therefore, only Chicken Plus™-treated geranium plants were used in statistical analyses for growth comparisons. The growth response of the four plant species to the fertilizer products, including Chicken Plus™, can be seen in Figures 2, 3, 4, and 5. Highlights of the effects of the four organic/all natural fertilizers will be described below.

Plants fertilized with Thrive™ grew about as well as those fertilized with Miracle-Gro® (control fertilizer). By the end of the study, however, a few of the Thrive™ treated plants of the all four species had a little leaf margin necrosis on some leaves (Figure 1), which was probably due to increases in salt concentrations in the potting mix. At the end of the study, the electrical conductivity (EC) of the potting mix for the various species averaged 4.2 dS·m⁻¹ (4.2 mmhos·cm⁻¹) for Thrive™-treated plants (data not shown). Overall, however, all four species treated with Thrive™ grew quite well, as indicated by shoot dry weight production and increases in plant heights. Geranium plants treated with Thrive™ produced similar final plant heights to those treated with Miracle-Gro®, but produced the highest amount of shoot dry weight, and second



Figure 1. Marginal leaf necrosis (dead brown areas) on some ‘Wilhelm Langguth’ geranium leaves on plants treated with Thrive™ fertilizer. This damage appeared during the last three weeks of the study and was probably due to too high a salt concentration in the potting mix.

highest amount of average change in plant heights and total number of flower inflorescences compared to the other three organic/natural fertilizer treatments (Table 1). Ornamental pepper plants treated with Thrive™ produced similar amounts of shoot dry weights, total numbers of fruit and fruit dry weights per plant compared to Miracle-Gro®-treated plants (Table 2). Mean final height and mean change in plant heights were also similar for plants receiving these two treatments. The next best fertilizer treatment for lantana was the fish fertilizer, but these growth parameters for fish fertilizer-treated plants were about 20%, 45%, 41%, and 38% lower for shoot dry weight, change in plant height, number of fruit produced per plant and fruit dry weight per plant, respectively, than for Thrive™-treated plants. Lantana plants treated with Thrive™ produced the second highest shoot dry weights and final plant heights but had similar mean change in plant heights compared to plants receiving Miracle-Gro® (Table 3). Lantana plants receiving fish fertilizer produced similar amounts of shoot dry weights and grew to similar heights as Thrive-treated plants (Table 3). Mockorange plants treated with Thrive™ produced the second highest shoot dry weights compared to plants treated with Miracle-Gro® (Table 4), and the shoot dry weights of the former plants were at least 16% less than those of Miracle-Gro®-treated plants. Plants treated with Thrive or Miracle-Gro® grew to similar heights and had similar mean changes in plant heights.

The product formulation for Clearwater Fish Fertilizer changed early in the study. One month into the experiment, all plants treated with this product seemed to have some type of

Table 1: Effect of five fertilizer treatments on mean shoot dry weight, mean final height, mean change in height and mean total number of flower inflorescences produced per plant on geranium plants after 12 weeks (end of the experiment).

| Fertilizer treatment | Shoot dry weight (g) | Final shoot height (cm) | Change in shoot height (cm) | Total flower heads per plant |
|----------------------|----------------------|-------------------------|-----------------------------|------------------------------|
| Miracle-Gro® | 37.9 b* | 29.5 a | 9.6 a | 43.1 a |
| Thrive™ | 41.7 a | 27.9 ab | 7.5 bc | 37.3 b |
| Kozgro | 22.5 c | 25.8 b | 5.5 c | 24.3 d |
| Fish Emulsion | 35.3 b | 28.9 ab | 8.8 ab | 32.5 c |
| Chicken Plus™ | 15.5 d | 22.2 c | 2.0 d | 24.9 d |

*Different letters within a column indicate significant differences between means as determined by Fisher's Protected LSD test at $p \leq 0.05$ level ($n = 16$).

nutrient deficiency (refer to the Midterm report). Just before the third fertilizer treatment, however, the producer called and asked us to use the new product formulation at a higher

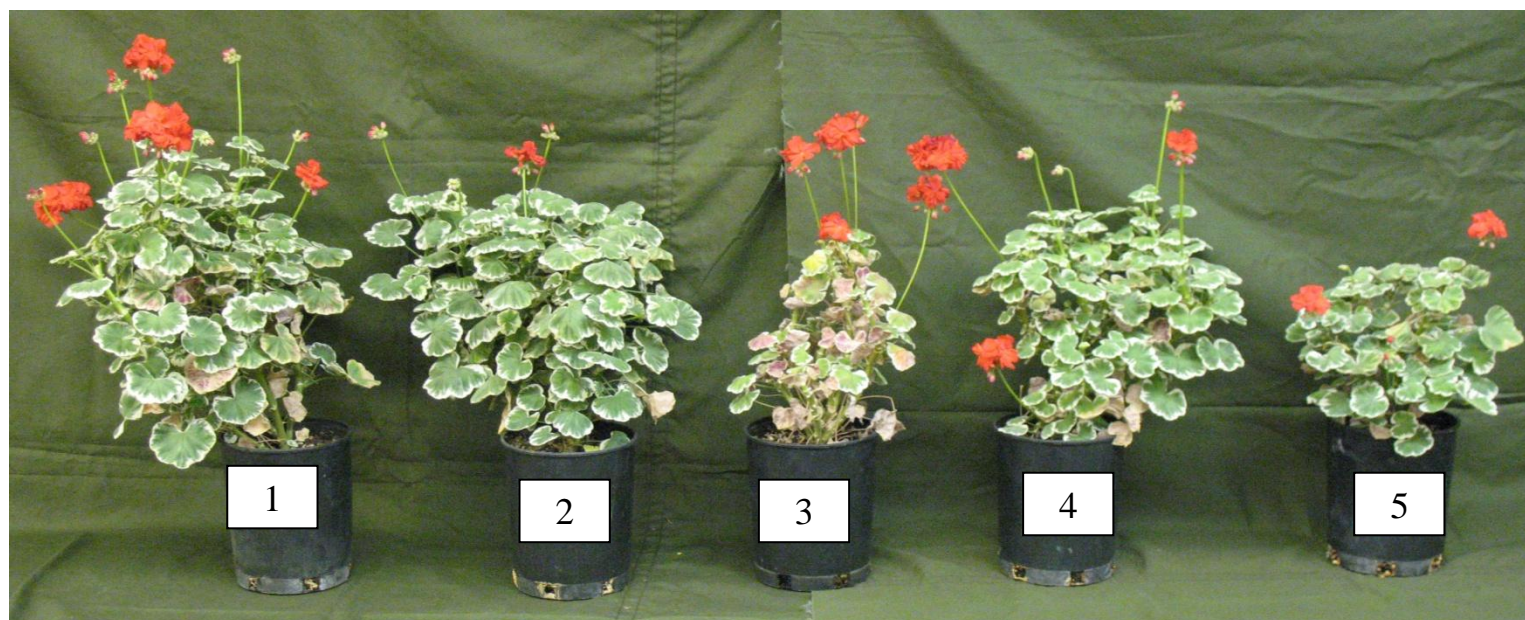


Figure 2. Appearance of 'Wilhelm Langguth' geranium plants after being fertilized with (1) Miracle-Gro®, (2) Thrive™, (3) Kozgro's All Purpose Organic Plant and Soil Stimulant, (4) Clearwater Fish Fertilizer, or (5) Chicken Plus™ for 12 weeks. This study was completed in a greenhouse, and plants were fertilized once every 2 weeks.

concentration. We complied with this request. As the new product 2-2-2 (compared to the old product of 2-2-0) was used on the plants, we could see all four species of plants were growing better and that nutrient deficiency symptoms seemed to be absent by the end of the study (compare fish fertilizer-treated plants to those treated with Miracle-Gro® or Thrive™ in Figures 2, 3, 4 and 5). Therefore, changing to the new formulation used at a higher rate allowed us to complete the study with the most up-to-date product used at its recommended rate.

Table 2: Effect of five fertilizer treatments on mean shoot dry weight, mean final height, mean change in height, mean total number of fruits produced per plant, and mean fruit dry weight per plant of ‘Chilly Chili’ ornamental pepper plants after 12 weeks (end of the experiment).

| Fertilizer treatment | Shoot dry weight (g) | Final shoot height (cm) | Change in shoot height. (cm) | Total number of fruit produced per plant | Fruit dry weight per plant (g) |
|----------------------|----------------------|-------------------------|------------------------------|--|--------------------------------|
| Miracle-Gro® | 10.6 a* | 20.1 a | 2.4 a | 82.8 a | 13.4 a |
| Thrive™ | 10.4 a | 19.0 ab | 2.2 ab | 82.9 a | 12.3 a |
| Kozgro | 6.2 c | 18.2 b | 1.6 abc | 28.5 c | 4.5 c |
| Fish Emulsion | 8.3 b | 18.5 b | 1.2 c | 48.9 b | 7.6 b |
| Chicken Plus™§ | 9.9 | 18.7 | 2.3 | 33.9 | 4.5 |

*Different letters within a column indicate significant differences between means as determined by Fisher’s Protected LSD test at $p \leq 0.05$ level ($n = 16$).

§Means for Chicken Plus™-treated plants were based on the 7 surviving plants and were excluded from statistical analyses.

The second best organic/all natural fertilizer to use on the plants was the Clearwater Fish Fertilizer based on plant growth of all four species. Fish fertilizer-treated geranium plants produced similar amounts of shoot dry weight, grew to similar final heights, and had similar mean changes in heights compared to plants treated with Miracle-Gro® (Table 1). Fish fertilizer-treated plants also produced almost 25% fewer flower inflorescences than Miracle-Gro®-treated plants. Although fish fertilizer induced a good growth response by ornamental pepper plants, mean shoot dry weights, final plant heights, changes in shoot heights, number of fruits produced per plant, and fruit dry weight per plant were at least 21%, 8%, 50%, 41%, and 43% lower, respectively than those growth parameters for Miracle-Gro®-treated pepper plants (Table 2). Although fish fertilizer-treated lantana plants produced similar shoot dry weights and final shoot heights as Thrive™-treated plants (Table 3), the fish fertilizer-treated plants produced 25% less shoot dry weights, 8% lower final shoot heights, and 43% lower change in shoot heights compared to Miracle-Gro®-treated plants. Mockorange plants treated

with fish fertilizer produced at least 40% less shoot dry weights and 35% fewer numbers of shoots than Miracle-Gro®-treated plants, but shoot heights of plants treated with these fertilizers were similar (Table 4).



Figure 3. Appearance of ‘Chilly Chili’ ornamental pepper plants after being fertilized with (1) Miracle-Gro®, (2) Thrive™, (3) Kozgro’s All Purpose Organic Plant and Soil Stimulant, (4) Clearwater Fish Fertilizer, or (5) Chicken Plus™ for 12 weeks. This study was completed in a greenhouse, and plants were fertilized once every 2 weeks.

Table 3: Effect of five fertilizer treatments on mean shoot dry weight, mean final shoot height, and mean change in shoot height for ‘Cherry Sunrise’ lantana plants after 12 weeks (end of the experiment).

| Fertilizer treatment | Shoot dry weight (g) | Final shoot height (cm) | Change in shoot height (cm) |
|----------------------|----------------------|-------------------------|-----------------------------|
| Miracle-Gro® | 25.6 a* | 21.3 a | 5.3 a |
| Thrive™ | 20.2 b | 19.5 b | 4.5 a |
| Kozgro | 12.3 c | 17.6 c | 1.4 c |
| Fish Emulsion | 19.0 b | 19.6 b | 3.0 b |
| Chicken Plus™§ | 8.3 | 12.2 | 2.1 |

*Different letters within a column indicate significant differences between means as determined by Fisher’s Protected LSD test at $p \leq 0.05$ level ($n = 16$).

§Means for Chicken Plus™-treated plants were based on the 9 surviving plants for shoot dry weight, 3 surviving plants for heights, and were excluded from statistical analyses.

All four species of plants treated with Kozgro's All Purpose Organic Plant and Soil Stimulant grew the least compared to plants treated with Miracle-Gro®, Thrive™ or fish fertilizer. Regardless of species, plants fertilized with the Kozgro's product produced 40 to 76% less shoot dry weights and grew 9 to 17% shorter (Tables 1, 2, 3, and 4). Mean height changes of only geranium and lantana plants treated with the Kozgro's product (Tables 1 and 3) were lower than those treated with MiracleGro by 42% and 73%, respectively. Use of the Kozgro's product resulted in 43% fewer geranium flower inflorescences (Table 1), 65% less ornamental pepper fruits (Table 2), and 41% fewer mockorange shoots (Table 4). In general, all plants treated with the Kozgro's product seemed to have a nutrient deficiency (Figures 1, 2, 3, and 4). I talked with a sales representative from the Kozgro Organics, Inc., and the representative said that the All Purpose Organic Plant and Soil Stimulant was designed more as a supplemental fertilizer to be used in field production rather than greenhouse pot production. The representative further explained that the product helped the microbes in the soil to flourish and that the effect of the ingredients might be different for soilless potting mixes. The sales representative wondered if we overwatered the plants (see the discussion in the next paragraph). To determine if we had overwatered Kozgro's product-treated plants, we removed plants from all treatments from their pots at the end of the study and visually inspected the roots. Roots on all plants, including the Kozgro's-treated plants appeared to be quite healthy. The only roots that appeared to have damage were those treated with Chicken Plus™.

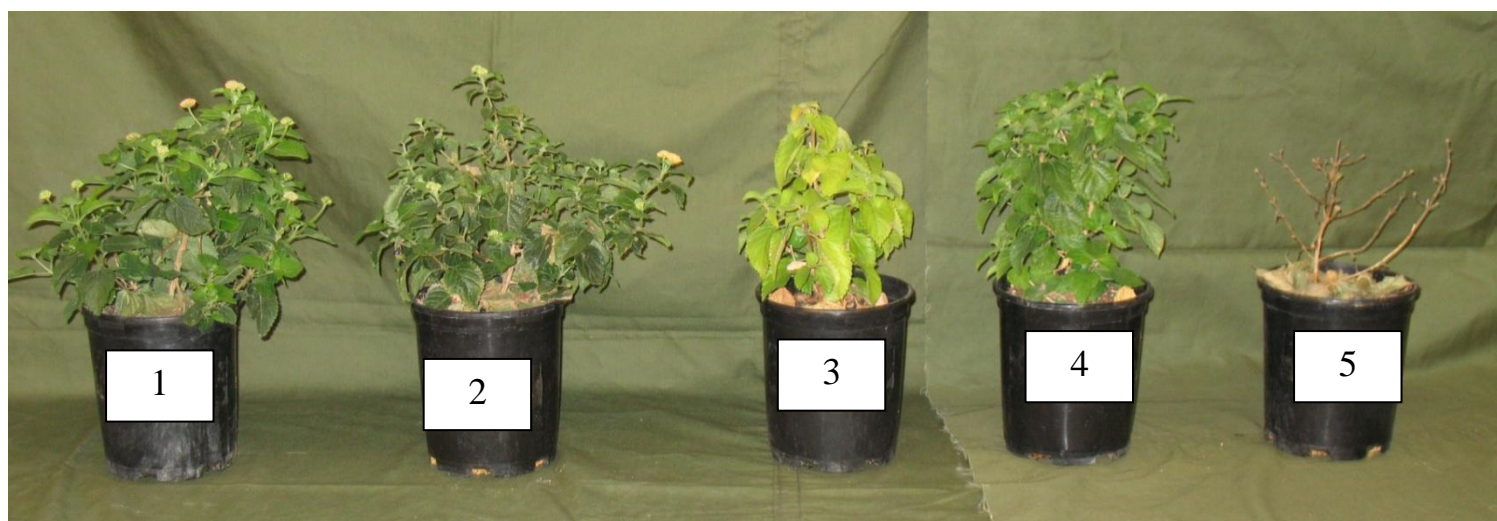


Figure 4. Appearance of 'Cherry Sunrise' lantana plants after being fertilized with (1) Miracle-Gro®, (2) Thrive™, (3) Kozgro's All Purpose Organic Plant and Soil Stimulant, (4) Clearwater Fish Fertilizer, or (5) Chicken Plus™ for 12 weeks. This study was completed in a greenhouse, and plants were fertilized once every 2 weeks.

One other interesting aspect of this study was the amount of water needed for growing the plants. All species treated with Miracle-Gro®, Thrive™, or fish fertilizer usually need to be watered every other day or daily in the hottest weather, whereas those plants treated with the Kozgro's product or Chicken Plus™ needed to be watered once a week or about every third day during the hottest weather. I am unsure of the reason for this difference in watering

requirements. The Kozgro's product may have supported algal and microbial (mainly fungus and bacterial) growth in the peat-based potting mix. I would speculate that algae or microbes could have caused pore space in the mix to become smaller so that the peat moss mix held more water than when other fertilizers were used. According to the Kozgro's sales representative, the humic acid in their product made more humus in the potting mix; with more putative humus present, the mix could hold more water. Because the high concentration of Chicken Plus™ killed or damaged roots on a number of plants, perhaps the root balls on these injured plants stayed moist for long periods of time due to less water uptake by damaged roots.

Table 4. Effect of five fertilizer treatments on mean shoot dry weight, mean final shoot height, mean change in shoot height and mean number of shoots produced by mockorange plants after 12 weeks (end of the experiment).

| Fertilizer treatment | Shoot dry weight (g) | Final shoot height (cm) | Change in shoot height (cm) | Number of shoots produced per plant |
|----------------------|----------------------|-------------------------|-----------------------------|-------------------------------------|
| Miracle-Gro® | 22.5 a* | 36.1 | 10.0 | 10.6 a |
| Thrive™ | 18.8 b | 36.7 | 10.7 | 11.0 a |
| Kozgro | 5.4 d | 29.4 | 5.6 | 6.2 b |
| Fish Emulsion | 13.4 c | 48.9 | 18.1 | 6.8 b |
| Chicken Plus™§ | 7.6 | 29.8 | 4.7 | 4.3 |

*Different letters within a column indicate significant differences between means as determined by Fisher's Protected LSD test at $p \leq 0.05$ level ($n = 16$).

§Means for Chicken Plus™-treated plants were based on the 3 surviving plants and were excluded from statistical analyses.

Most plants treated with the Chicken Plus™ product were damaged because of the high concentration rate that was used. This rate was recommended as the amount to use by the company for field production. The other products used in this study were also applied at the labeled rate for field application. Unfortunately, most ornamental pepper, lantana, and mockorange plants eventually (over two months) succumbed to the root damaged caused by the first month of high salt concentration in the potting mix. Although geranium plants were injured by the high concentrations of Chicken Plus™, all plants survived, indicating this particular cultivar tolerated very high salt concentrations in its root zone. Even though a number of ornamental pepper, lantana, and mockorange plants eventually died from the initial high salt stress, those that recovered were starting to grow again in the last couple weeks of the experiment, making a case for trying to test Chicken Plus™ once more a future experiment.

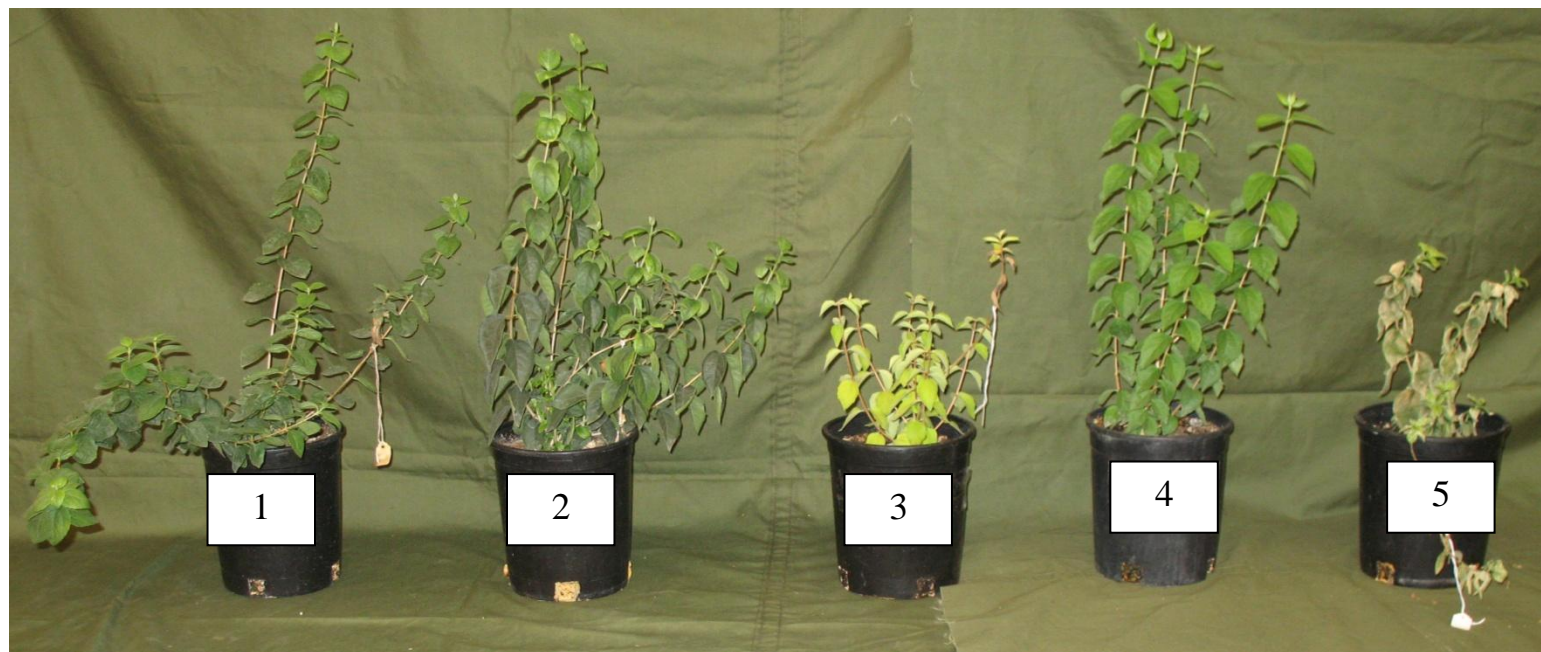


Figure 5. Appearance of mockorange plants after being fertilized with (1) Miracle-Gro®, (2) Thrive™, (3) Kozgro's All Purpose Organic Plant and Soil Stimulant, (4) Clearwater Fish Fertilizer, or (5) Chicken Plus™ for 12 weeks. This study was completed in a greenhouse, and plants were fertilized once every 2 weeks.

Significance to the Nursery Industry

This study showed that at least two of the organic or all natural fertilizers tested were reasonably good products. Thrive™ fertilizer was a good product to use on the four plant species grown in this study since geranium plants treated with this product produced 9% more shoot dry weight, and ornamental pepper plants produced as much shoot growth and fruits as plants treated with Miracle-Gro® (control fertilizer). Even though Thrive™-treated lantana and mockorange plants produced 21% and 17% less shoot dry weight, respectively, than plants treated with Miracle-Gro®, the former plants grew well and would have been commercially salable. Plants treated with Clearwater Fish Fertilizer grew well, but produced less growth than those fertilized with Miracle-Gro®. The reduced growth was probably due, in part, to starting the experiment with the old product formulation. The plants definitely grew better after at least 6 weeks of treatment with the new fish fertilizer formulation applied at the higher rate. All plants treated with Kozgro's All Purpose Organic Plant and Soil Stimulant grew poorly under our experimental conditions. The plants seemed to suffer from one or more nutrient deficiencies since they were often short and had yellow colored foliage. A sales representative for the company said that this particular product should be used as a supplement to a fertilizer regime used on field grown plants. A positive aspect about the Kozgro's product was that it did improve the water-holding capacity of the potting mix (Sunshine Mix #2) used in the experiment. We are unable say how effective Chicken Plus™ was on promoting growth of the four plant species used

in this study since the high concentration of product applied twice at the beginning of the experiment severely damaged roots on ornamental pepper, lantana, and mockorange plants. A new study using Chicken Plus™ at the proper application rate (probably about one-fourth to one-third of the field application rate) is needed to test the effects of this product on herbaceous and woody plants grown in containers.

This study was aimed at providing information for garden centers, homeowners and potentially production nurseries and greenhouses. The experiment showed that Thrive™ and Clearwater Fish Fertilizer promoted plant growth but often somewhat less growth than that produced by plants receiving the synthetic fertilizer (Miracle-Gro®). Nonetheless, either of these two fertilizers, which are considered all natural products, could be used for maintaining plants in a managed landscape either in soil or containers. For homeowners, landscape maintenance contractors, and nursery or greenhouse growers, these two products would be relatively good alternatives to synthetic fertilizers since all plants treated with either of these two products looked quite healthy by the end of the study. Salt levels in the potting mix would need to be monitored over time, however, since it could build up in the root zone (as was seen with Thrive™). Overall, the four products were safe to use on the four plant species tested and safe for workers applying the products.