# Effects of Biostimulants and Fertilizers on Specialty Bell Pepper


**Pedro E. Cruz-Carballo[1], J. P. Morales-Payan[2], Feiko Ferwerda[2] and Dania Rivera-Ocasio[2]**

[1]Graduate student and [2]Professors, Department of Agro-Environmental Sciences,

College of Agricultural Sciences, University of Puerto Rico, Mayagüez Campus


## ABSTRACT


An experiment was conducted in July-November 2014 in Mayaguez, Puerto Rico, to determine the effects of biostimulants and fertilization on growth, yield, and quality of 'Chocolate Beauty' bell pepper grown in containers in a high tunnel protective structure. The plants were grown in a 3:1 mixture of alluvial soil and sphagnum + perlite mix (Promix® BX), fertilized with either (1) 22.67 kg N-P-K/0.40 ha pre-plant and 45.35 kg N/0.40 ha 10 weeks later using granular urea (=field fertilization recommendation by Ag Experiment Station, UPRM), (2) 22.67 kg N-P-K/0.40 ha pre-plant and 45.35 kg N/0.40 ha divided in 10 applications every 7 days using an urea solution (=greenhouse fertilization), and (3) 22.67 kg N-P-K/0.40 ha from organic 6-6-5-8Ca + 0-0-15-1Ca pre-plant and 45.35 kg N/0.40 ha from organic 6-0-0-8Ca (Bioflora®). Every 14 days the crop leaves were sprayed to run-off with different biostimulant solutions. The biostimulants tried were (1) a blend of amino acids formulated for crops (AA) (Aminoquelant Ca®), at 4 ml/L of water, (2) an extract of the marine alga *Ascophyllum nodosum* formulated for crops (Stimplex®), at 5 ml/L, (3) a mixture of natural ingredients containing brassinosteroids, vitamins, and enzymes (Vitazyme®), at 10 ml/L of water, and (4) water (control). Fruits were harvested at maturity (color turning from green to chocolate), weighted, quantified, and graded into categories according to their diameter and quality. Total fruit number and weight per plant were affected only by fertilizers, with the soluble treatment resulting in more fruits per plant than the other treatments. Marketable fruit number was significantly lower in plants treated with granular fertilizer. There was a significant interaction between biostimulants and fertilizers on total marketable fruit weight and weight of small-sized fruits, with the highest yields resulting from the combination of the alga extract and organic fertilizer. The treatments did not affect the number of non-marketable fruit, but plants treated with granular fertilizer resulted in a larger weight of non-commercial fruits. These results indicate that the yield of this specialty pepper may be regulated with fertilizers and/or combinations of fertilizers and biostimulants.




## INTRODUCTION

Vegetable production in greenhouses or protected structures is a common practice in temperate regions of the world (Jovicich et al., 2005), but the benefits they provide can also be of use in countries with a tropical climate like Puerto Rico. It allows a greater control over many aspects of the agroecosystem through a precise management of irrigation frequency, fertilization rates and pest control. These components can also be adjusted or manipulated according to the specific requirements of the cultivated crop (Jovicich et al., 2007).

In addition to growing crops in protected structures, the application of agricultural biostimulants may bring even further advantages to farmers since these have been proven to improve crop development by better tolerating adverse or stressful conditions and increasing nutrient acquisition (Grabowska et al., 2013). Bell pepper (*Capsicum annuum* L.) production in a protected structure with biostimulant treatments seems to be a promising alternative since these applications can increase the crop's hardiness, making it more tolerant or able to better withstand stressful conditions. It has been reported that agricultural biostimulants can also increase fruit quality and yields, thus increasing the production value without further polluting the environment.

## OBJECTIVES

- Evaluate the effect of foliar biostimulants and fertilization methods on the quality of 'Chocolate Beauty' bell pepper grown under protected structures.
- Determine the effect of foliar biostimulants and fertilization methods on the growth dynamics and productivity of 'Chocolate Beauty' bell peppers (*Capsicum annuum* L.)

## METHODOLOGY

The experiment was conducted under a high tunnel protected structure of the Alzamora Experiment Station in the University of Puerto Rico at Mayagüez campus. 'Chocolate Beauty' bell pepper seeds were planted in germination trays (Fig 1.) and were uniformly selected to transplant one seedling for each 5-gallon container at the 4-5 true leaf stage. The medium used in each container was a 3:1 mixture of alluvial soil and sphagnum + perlite mix (Promix® BX).

**Fig.1. Establishing the experiment. a.** Germination trays used for seedlings measured 52.7 x 26.7cm (L x W) and had 72 cells of 6.35cm deep. **b.** Seedling transplant from the germination trays to the 5-gallon containers filled with the 3:1 mixture. **c.** Panoramic view of the experiment from the inside of the high tunnel protected structure. **d.** Outside view of the high tunnel protected structure which measured 4.57 x 9.1m (L x W).

The containers were placed on raised beds that measured 12.2m x 1.5m x 0.8m (L x W x H) at a distance of 43 cm between each plant and 76 cm between each row of 4 plants. A completely randomized design was implemented with 12 treatments in a 3 x 4 factorial arrangement with 10 repetitions each. Fertilizers were divided into pre-plant and post-transplant applications. A synthetic 10-10-10 granular fertilizer was incorporated to the soil as a pre-plant application for the granular and solubilized urea fertilization methods at a rate of 22.67kg N-P-K/0.40ha.

The same rate was used for the organic fertilization method but using Bioflora pellets (6-6-5-8Ca) and Bioflora liquid fertilizer (0-0-15-1Ca) as a pre-plant application.

| Treatment | Biostimulant Dosage* (ml/L) | Biostimulant | Pre-plant Fertilization incorporated to the soil (22.67kg N-P-K / 0.40ha) | Post-transplant Nitrogen Fertilization (45.35kg N / 0.40ha) |
|---|---|---|---|---|
| 1 | 4 ml | Aminoquelant-Ca | Bioflora pellets (6-6-5-8Ca) + Bioflora solution (0-0-15-1Ca) | Bioflora solution (6-0-0-8Ca) |
| 2 | 4 ml | Aminoquelant-Ca | Synthetic granular fertilizer (10-10-10) | Granular Urea (46-0-0) |
| 3 | 4 ml | Aminoquelant-Ca | Synthetic granular fertilizer (10-10-10) | Urea solution (46-0-0) |
| 4 | 5 ml | Stimplex | Bioflora pellets (6-6-5-8Ca) + Bioflora solution (0-0-15-1Ca) | Bioflora solution (6-0-0-8Ca) |
| 5 | 5 ml | Stimplex | Synthetic granular fertilizer (10-10-10) | Granular Urea (46-0-0) |
| 6 | 5 ml | Stimplex | Synthetic granular fertilizer (10-10-10) | Urea solution (46-0-0) |
| 7 | 10 ml | Vitazyme | Bioflora pellets (6-6-5-8Ca) + Bioflora solution (0-0-15-1Ca) | Bioflora solution (6-0-0-8Ca) |
| 8 | 10 ml | Vitazyme | Synthetic granular fertilizer (10-10-10) | Granular Urea (46-0-0) |
| 9 | 10 ml | Vitazyme | Synthetic granular fertilizer (10-10-10) | Urea solution (46-0-0) |
| 10 | N/A | Control | Bioflora pellets (6-6-5-8Ca) + Bioflora solution (0-0-15-1Ca) | Bioflora solution (6-0-0-8Ca) |
| 11 | N/A | Control | Synthetic granular fertilizer (10-10-10) | Granular Urea (46-0-0) |
| 12 | N/A | Control | Synthetic granular fertilizer (10-10-10) | Urea solution (46-0-0) |

*Dosage recommended by the biostimulant's manufacturer

**Fig. 2. Treatment descriptions and details. a.** Pre-plant fertilizers were manually incorporated to the soil using a hand shovel. **b.** Bioflora 6-0-0-8Ca liquid fertilizer applied as a solution every 7 days for 10 weeks to provide post-transplant Nitrogen throughout the crop cycle. **c.** Bioflora 0-0-15-1Ca liquid fertilizer applied as a solution to supplement the missing Potassium in the pre-plant Bioflora 6-6-5-8Ca fertilizer. **d.** Biostimulant solutions were manually applied to stems and foliage until run-off every 14 days using a hand sprayer. **e.** Treatments consisted of a combination of two factors: foliar biostimulants and fertilization methods.

The post-transplant fertilization methods varied in ways of applying a total of 45.35kg N / 0.40 ha required for the crop cycle. The total N was divided into 10 applications for both, the organic fertilization and the solubilized urea. (1/10th of the total N was applied as a solution every 7 days for 10 weeks.) For the granular urea method, the total post-transplant N was applied fully and incorporated to the soil 70 days after transplant (70 DAT). Biostimulant treatment solutions were diluted to manufacturer's recommendation and were sprayed to run-off on leaves (Fig. 2.) every 14 days for 10 weeks. Every 7 DAT plant height was measured and leaves were counted. At flowering stage, buds and flowers were also counted. SPAD values were measured in recently expanded leaves and, in addition, beneficial insects, pests and their respective damage to plants and fruits were observed and logged throughout the crop cycle (Fig 3). Fruits were handpicked at maturity with at least 50% of the color developed. They were counted at harvest and their weight, length, diameter, wall thickness and percentage of soluble solids was measured from each fruit. Fruits were classified as marketable or nonmarketable and graded into categories depending on their diameter (Jovicich et al., 2003), quality, and damage caused either by pests or physiological disorders. Once every pepper fruit was harvested from the plant, the fresh stems and leaves were collected and weighted. The 5-gallon pots were emptied and sieved through a 1.27cm mesh in order to expose and collect the whole root. Roots were carefully rinsed of dirt and debris, excess water was wringed out, and the fresh weight was registered. Dry weight was also registered by placing the fresh stems, leaves, roots and peppers in a drying oven at 65°C for 72 hours (Fig 4).

**Fig. 3. Pests, damages and data acquisition. a.** The Minolta® SPAD-502 Chlorophyll Meter measures the relative chlorophyll concentration using light transmitted through the leaf at wavelengths of 650 nm and 940 nm. **b.** The tobacco hornworm (*Manduca sexta*) at larval stage was found feeding throughout the crop cycle and was manually removed from the experiment. **c, d.** Pests caused significant damage to pepper fruits and turns the produce unmarketable. **e.** Mites caused significant damage to pepper plants by feeding on foliage, thus reducing photosynthetic capacity and leaving pepper fruits directly exposed to sunlight, causing sun scalding and turning the produce unmarketable. **e.** Fruit height (polar diameter) was measured in mm using a plastic caliper, the peduncle was not included in this measurement. **f.** Fruit width was measured and fruits were classified into categories according to their equatorial diameter. **g.** Wall thickness of fruits was measured by cutting the fruit in half and averaging the wall thickness of the lobules.

**Fig. 4. Collecting shoots & roots and selecting, classifying, and grading pepper fruits. a.** Each pepper fruit was inspected and harvested at maturity with at least 50% of the chocolate color developed. **b.** Harvested peppers before being classified into categories according to their equatorial diameter (extra-large ≥ 8.38cm; large, 7.62 to 8.13cm; medium, 6.35 to 7.37cm; and small, 5.59 to 6.10cm). **c.** Stems and leaves were clipped, placed in a paper bag, and immediately weighted to obtain their fresh weight. **d.** After clipping the stems and leaves, the 5-gallon pots were emptied on a sieve to separate the roots from the growing medium. **e.** Growing medium was sieved through a 1.27cm mesh to expose the whole root system without causing any significant damage. **f.** After sieving the growing medium, roots were rinsed with tap water until most of the debris was eliminated. **g.** Clean roots were then wringed of excess water before the fresh weight was taken. **h.** Stems, leaves, roots and fruits were placed in a drying oven at 65°C for 72 hours and dry weight was registered.

## RESULTS

The computer program Infostat was used to find statistical differences ($p > 0.05$) between the different factors. This experiment was analyzed as a factorial treatment structure in a completely randomized design with two factors: Factor A (Fertilizer) and Factor B (Biostimulant). Fertilizer factor had 3 levels: granular urea, solubilized urea, and organic fertilization. Biostimulant factor had 4 levels: Aminoquelant-Ca, Stimplex, Vitazyme and the Control (water). No significant interaction ($p > 0.05$) was observed between Factors A and B for the total fruit number and total fruit weight per plant. Both factors were interpreted separately and only Factor A (Fertilizer) had a significant effect on both of these parameters (Fig 5).

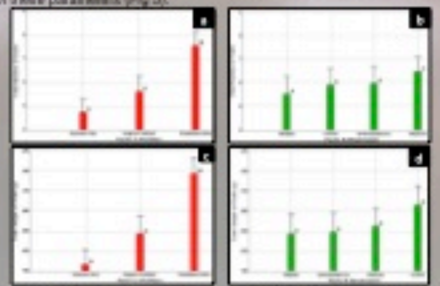

**Fig. 5. Effects of fertilizers and biostimulants on total fruit number and total fruit weight per plant. a.** Solubilized urea fertilization proved to be the most effective at producing a significantly higher number of fruits per plant. **b.** Biostimulant treatments did not cause any significant effect on total number of fruits per plant. **c.** Total weight of fruits per plant was significantly higher by fertilizing with solubilized urea, thus, producing the heaviest fruits. **d.** Biostimulant treatments did not have any effect on the total weight of fruits. Means with the same letter are not significantly different ($p > 0.05$).

From the total number of fruits per plant, a total marketable number of fruits was determined based on peppers with an equatorial diameter of 5.58cm or more and that were also free of pest damage, diseases (e.g. anthracnose) or physiological disorders (e.g. blossom end rot). Fertilizer treatments had a significant effect on the total number of marketable fruits (Fig. 6) but no significant effects of biostimulants were observed.

**Fig. 6. Total number of marketable fruits per plant. a.** Plants treated with the granular urea fertilizer produced a significantly less amount of marketable fruits per plant when compared to the organic or solubilized urea fertilizations. **b.** Biostimulant treatments did not have a significant effect on the total number of marketable fruits produced. Means with the same letter are not significantly different ($p > 0.05$).

There was a significant interaction between biostimulants and fertilizers on total marketable fruit weight and weight of small-sized fruits, with the highest yields resulting from the combination of the alga extract and organic fertilizer (Fig. 7). None of the treatments had any effect on the number of non-marketable fruits, but plants treated with granular fertilizer resulted in a larger weight of non-commercial fruits (Fig. 8).

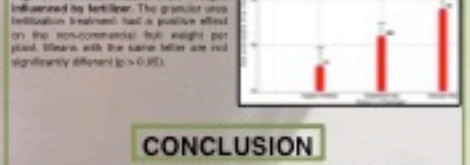

**Fig. 7. Total marketable fruit weight & Small-sized fruit weight per plant. a.** A significant interaction was observed for the total marketable fruit weight in which the combination of organic fertilizer and alga extract biostimulant produced the heaviest marketable fruits. **b.** Another interaction was observed on the weight of small-sized fruits in which the highest yields were produced by the same combination of organic fertilizer and Stimplex. Means with the same letter are not significantly different ($p > 0.05$).

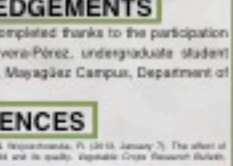

**Fig. 8. Non-marketable fruit weight influenced by fertilizer.** The granular urea fertilization treatment had a positive effect on the non-commercial fruit weight per plant. Means with the same letter are not significantly different ($p > 0.05$).

## CONCLUSION

These results indicate that the yield of this specialty pepper may be regulated with fertilizer applications and/or combinations of fertilizers and foliar biostimulants.

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