Foods 2025 Conference
The 6th International Electronic Conference on Foods
28–30 October 2025 | Online
MDPI

Bell Pepper (*Capsicum annuum*) Production in Protected Environments in the Dominican Republic: Optimization of Fertigation and Substrate

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INTRODUCTION & AIM

In 2022, global vegetable production exceeded 1.2 billion tons, with bell pepper accounting for 37 million tons. This crop is essential due to its versatility and nutritional value.

In the Dominican Republic, greenhouse vegetable production has grown over the past 23 years, exceeding 10 million m². Specifically, bell pepper production increased from 9,122 to 32,000 tons over two decades.

However, there is limited documented information on the influence of various management factors (fertigation and type of substrate, among others) on fruit yield and nutritional quality.

Objective: To evaluate the effect of fertigation programs, substrate types, and their interaction on bell pepper yield, under greenhouse conditions.

MATERIALS & METHODS

- **FACTORS IN THE STUDY**: Three fertigation programs and three substrate types were evaluated in a 3×3 factorial experiment, conducted under a completely randomized split-plot design.

- **DESCRIPTION OF THE FACTORS AND LEVELS UNDER STUDY:**
  - **Fertigation programs (P)** evaluated in greenhouse bell pepper cultivation (mg/kg).
    - **P1)** N: 90-100; P: 30-40, K: 163-192, Ca: 96-111, Mg: 36-42, S: 65-78, CE: 1.2-1.4, Micronutrients: 35;
    - **P2)** N: 110-130, P: 35-45, K: 217-242, Ca: 125-143, Mg: 48-54, S: 85-100, CE: 1.6-1.8, Micronutrients: 45:
    - **P3)** N: 145-170, P:40-50, K: 258-300, Ca: 150-175, Mg: 57-66, S: 105-120, CE: 1.9-2.2, Micronutrients: 55.
  - **Substrate factor**: coconut fiber (CF), a substrate based on charcoal and rice husk (BRH) and a 50% mixture of both materials (BRH + CF 1:1).
- **EXPERIMENTAL DESIGN**: A completely randomized split-plot design was used, with fertigation programs assigned to main plots and substrates to subplots, with four replications. Each experimental unit consisted of 3 m-long beds. A total of 185 plants were grown, with five plants evaluated per useful area.
- **MEASURED VARIABLES**: Substrates: bulk density, moisture retention. Fertigation programs: electrical conductivity and pH. Crop: plant height, stem diameter, chlorophyll content, leaf moisture, fruit number, fruit weight, and fruit °Brix.
- **STATISTICAL ANALYSIS**: Analysis of variance (ANOVA), DGC multiple range test, and multivariate analyses (PCA and manovar). Data were processed in Excel, and statistical analyses were performed with InfoStat.

RESULTS & DISCUSSION

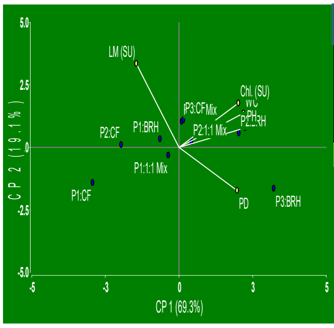

Figure 1. PCA of fertigation programs and substrates on pepper growth

Table 1. MANOVA of fertigation programs and growth variables in pepper

Prueba Hotelling Alfa=0.05
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FP	PH	PD	WC	Chl. (SU)	LM (SU)	n			
P3	95.48	1.15	51.27	56.57	29.10	72	A		
P2	93.88	1.10	50.93	55.80	28.95	72		B	
P1	86.86	1.08	48.24	54.68	28.98	72			C

Table 2. MANOVA of substrate types and growth variables in pepper.

Prueba Hotelling Alfa=0.05
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Sustrat.	PH	PD	WC	Chl. (SU)	LM (SU)	n		
CF	80.11	1.07	47.52	55.15	29.07	72	A	
BRH	103.16	1.15	52.04	56.16	28.96	72		B
1:1 Mix	92.95	1.11	50.89	55.74	29.01	72		B

Medias con una letra común no son significativamente diferentes (p > 0.05)

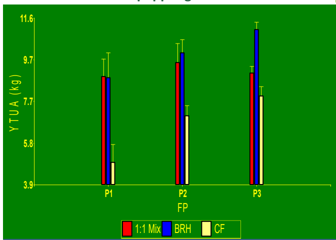

Figure 2. Effects of fertigation and substrate on pepper yield

Table 3. DGC test of fertigation and substrates on pepper yield.

Test:DGC Alfa=0.05 PCALT=2.2593
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FP	Sustrat.	Medias	n	E.E.			
P1	CF	4.90	4	0.73	A		
P2	CF	7.08	4	0.73		B	
P3	CF	8.00	4	0.73		B	
P1	BRH	8.85	4	0.73		B	
P1	1 1 Mix	8.90	4	0.73		B	
P3	1 1 Mix	9.08	4	0.73		B	
P2	1 1 Mix	9.55	4	0.73		B	
P2	BRH	10.00	4	0.73		B	
P3	BRH	11.10	4	0.73			C

Medias con una letra común no son significativamente diferentes (p > 0.05)

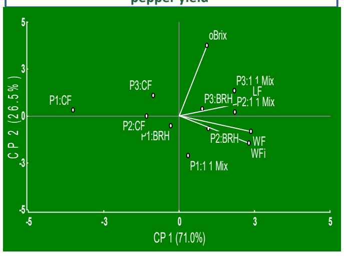

Figure 3. PCA of fertigation and substrates on *pepper* fruit quality.

In the PCA, components 1 and 2 explained 88% of the variability in plant height (PH), stem diameter (DP), canopy width (WC), leaf water content (LW), and chlorophyll (Chl.). Fertigation programs 2 and 3 with rice husk biochar showed greater effects on these variables (Figure 1).

No interaction between factors was observed. Among programs, P3 outperformed P2, and P2 outperformed P1 (Table 1). Regarding substrates, rice husk biochar (BRH) and the 1:1 mix surpassed coconut fiber, with the latter two being statistically similar (Table 2).

Regarding yield (Table 3), fertigation program three with rice husk biochar (P3 BRH) achieved the highest value, while the combination of P1 with coconut fiber (P1 CF) showed the lowest. The 1:1 mix had an intermediate effect among the three programs evaluated.

For the individual effects by program, in P1 coconut fiber (CF) had the lowest yield, while BRH and the 1:1 mix were similar. In P2, the same trend was observed, although CF showed improved performance. In P3, all three substrates differed, with BRH being the most effective and CF the least.

CONCLUSION

Fertigation program **P3 + burned rice husk (BRH)** maximized physiological traits and yield. Fertigation response: **P3 > P2 > P1**. Substrates **BRH** and **BRH + CF (1:1)** outperformed **coconut fiber (CF)** alone. PCA confirmed that evaluated factors explained most of the variability, supporting statistical results.

FUTURE WORK / REFERENCES

To test other BRH/CF ratios or include local substrate materials. To optimize irrigation volume and frequency for each substrate. To conduct advanced physiological assessments: nutrient content, photosynthesis, transpiration, water use efficiency, and drainage to understand BRH superiority. To scale-up validation in commercial greenhouse conditions to estimate economic impact. To assess long-term sustainability: substrate health, agricultural waste recycling, and cost reduction. To implement automated monitoring of nutrients and water to isolate effects. To explore multifactorial nutrient models. To develop and adapt a fertigation app for local conditions.

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