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Secretariat CFCS
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GROWING MEDIA EFFECTS ON SWEET PEPPER (*CAPSICUM ANNUUM L.*) NUTRITION AND YIELD UNDER TIMED FERTIGATION

G. Eudoxie, M. Martin, and L. Carrington. Department of Food Production, University of the West Indies, St. Augustine Campus, Trinidad and Tobago

ABSTRACT: Producers have experienced wide variation in yield and plant performance under tropical greenhouse culture and have attributed this party to choice of growing media. Chemically reactive media interact with nutrients in the fertigation solution and may improve nutrient uptake and plant performance. This hypothesis was tested in a glasshouse trial investigating four physically and chemically different media, including perlite (PL), coconut coir (CC), and combinations of PL with either rice straw compost (RSC) or bagasse based spent mushroom substrate (SMS). Treatments were planted to sweet pepper (Cv. Destra) and fertigated with a modified Hoagland's solution. Total number of fruits per plant and yield were measured over a 3-month production period. Plant tissue samples were taken at the onset of flowering and at the end of the trial stem diameter, along with media pH and EC were measured. Plant height and stem diameter was similar across media, whilst media EC was highest for CC. This correlated with greater number and weight of fruits. Growth parameters were lowest for PL and were indifferent between the two compost treatments. Coconut coir showed high productivity under the tested conditions, but resulted in increased fruit physiological disorders under the present fertigation regime. Completely organic media may not be a suitable growing media choice for tropical production.

Keywords: growing media, sweet pepper, fertigation, nutrient content.

Introduction

Lower yields from extensive cropping systems associated with changing and unpredictable climatic conditions, increased resistance of pests and diseases, the use of newer and stronger pesticides with greater environmental implications has rekindled interest in protected agriculture (PA) systems in the Caribbean. The desire for safer, healthier foods, increase yield per unit area and sustainable production has triggered an increase in the investment and operation of commercial scale PA structures, mainly plastic covered greenhouses. Within these structures the tendency has been to employ control systems to minimize production limitations. As such the majority of growers use soilless media, improved greenhouse varieties, fertigation systems and insect screen mesh. The avoidance of soil implies that the rooting media is free of potential pest and disease, but also implies that the medium in most cases is devoid of inherent fertility. Fertigation in soilless media attempts to maintain a consistent supply of mineral elements within the rootzone at concentrations non-limiting to plant uptake and hence reducing if not cancelling the media influence on plant nutrition. Two important factors among others may affect that reality.

Firstly, the nature of the growing media may affect the chemical equilibrium within the rootzone. Whilst all substrates are selected based on physical criteria for optimising water and oxygen availability, the different substrates could have direct and/ or indirect effects on plant growth and development (Ghehsareh et al., 2011). Substrates can be classified as either organic or inorganic, with further subclasses of inert and chemically active within the

inorganic class. Chemically active media has the potential to alter and change the chemical equilibrium within the media to which roots are exposed with the potential to influence plant growth, development and ultimately yield. Increase vegetative growth and yield has been reported for mixed substrates, combinations of inert and chemically active substrates over solely inert substrates for strawberry (Tehranitar et al., 2007) and tomato (Djedidi et al., 1997; Inden and Torres, 2004). Authors mainly alluded to the increase retentive ability of chemically active substrates for improved performance. Permuzic et al. (1998) went further and showed that organic media produced greater yield of tomato fruit of better quality that inorganic media. Information in the literature suggests that the use of organic media is recommended moderated by some amount of inert substrate.

The second factor for consideration is the composition and supply of the nutrient solution. High frequency fertigation associated with a greater number of fertigation events per day has been reported to increase marketable yield by reducing physiological disorders associated with nutrient uptake and translocation (Silber et al., 2005; Silber et al., 2003). Higher fertigation frequency ensures that the conditions at the root interface mimic that of the fertigation solution, essentially removing any dependence on the retentive abilities of chemically active substrates supplying water and nutrients between fertigation events. Furthermore under this system there is a reduced likelihood that the media will influence the chemical equilibrium of the fertigating solution. Based on the previous statement it was hypothesised that growing media would have no effect on sweet pepper nutrition and yield under high frequency fertigation.

Methodology

The study was conducted in an open ventilated glasshouse at the University of the West Indies St. Augustine Campus in Trinidad and Tobago (10.5526 °N, 61.3152 °W), from January 11 to May 31, 2013. Mean maximum and minimum temperatures were 33 and 24 °C respectively, at a corresponding relative humidity of 60 and 95 %. Sweet pepper plants (cv. Destra) were transplanted to each of four growing media treatments arranged in a completely randomized layout with five replicates. Growing media was contained in 20 litre plastic buckets perforated at the base and lined internally with a 5 cm layer of 9.5 mm aggregate. Media consisting of perlite (PL), coconut coir (CC), PL plus spent mushroom substrate (SMS) and PL plus rice straw compost (RSC), with the latter two media having a ratio of 3:2 were packed to within 5 cm of the surface. Mix media were thoroughly blended using hand tools prior to filling. All treatments were soaked with water prior to transplanting. A modified Hoagland's solution (N: 206, K: 225, Ca: 200, P: 40, S: 97, Mg: 52, Fe: 2, B: 1, Mn: 1, Zn: 0.25, Cu: 0.25, and Mo: 0.05 mg L^{-1}) was used as the fertigation solution and administered at a high frequency, every two hours for two minutes, delivering 150 ml per event. For the first 40 DAT fertigation duration was restricted to one minute. Fertigation commenced immediately after transplanting. Irrigation was controlled by a zero pressure solar Rain Barrel timer connected to a 140 litre bulk tank, which was refilled when needed.

Mature green fruit were selectively harvested weekly from 57 DAT until the last harvest at 140 DAT. Marketable fruit yield, total and marketable number of fruit and average fruit weight were recorded. Marketable fruit consisted of acceptable fruit free of physiological disorders and with a fresh weight > 100 g. Number of marketable fruit was expressed as a percentage of total number of fruit. Six youngest fully expanded leaves per plant were excised between the 1st and 2nd trusses to determine tissue nutrient content by washing with

distilled water, blotting dry and then oven drying for 72 hours at 65 °C in a convection oven. The dried samples were digested with H_2SO_4-salicylic acid-H_2O_2 formulation (Temminghoff and Houba, 2005) followed by N determination by titration after steam distillation (Bremner, 1996), P determination by ascorbic acid method (Kuo, 1996) and the metals (K, Ca, Mg, Mn, Fe, Cu, and Zn) determined by atomic adsorption spectrometry.

At the end of the trial stem diameter was measured 5 cm from the base using a vernier calliper. Media pH and electrical conductivity (EC) were also measured directly using field probes; IQ 150 pH meter and Field Scout EC 110 meter (Spectrum technologies, Inc.) respectively. These measurements were taken 30 minutes after a fertigation event.

Statistical Analysis

Analysis of variance (ANOVA) was performed to assess the significance of treatment effects. Differences among treatment means were compared using Tukey's multiple range test at the 0.05 probability level. Pearson's correlation coefficient was used to determine relationships among parameters, specifically between tissue nutrient content, yield indices and media characteristics.

Results and Discussion

Statistical analysis revealed that growing media only affected total fruit count out of the four yield variables (Table 1). Notably there was no effect on percent marketable fruit or yield, although the incidence of physiological disorders and other fruit damage was relatively high (> 40%). Total number of fruits was greatest for CC, a trend that was also reflected for media EC. A strong positive correlation ($r = 0.77$) was found between these variables. Timed fertigation events of two hour intervals may have allowed plants to become dependent on the media's nutrient supplying capacity, especially during period of high air temperatures. Coconut coir possessed the greatest retentive capacity and was probably able to supply plant available nutrients longer between events resulting in greater growth and fruit set. Plant stem diameter was greatest for this treatment although the effect was non-significant at $P > 0.05$. All plants grown in this media showed fruit set at nearly every node, however, the greater demand placed on these plants for Ca translocation to fruits resulted in a greater incidence of blossom end rot (BER). Marketable fruit was lowest for CC. While higher media EC was related and can increase fruit count, it affects fruit size and quality (Inden and Torres, 2004).

Tissue macronutrient concentration of P and Mg was significantly higher in CC compared to PL (Table 2). Mixtures of PL with compost apparently modified the effects of the single inert media, resulting in non-significant effects compared to the single organic media. The inclusion of organic substrates increased P content in the luxury zone, although all treatments had concentrations above optimal. This is important as P has been shown to have a linear relationship with dry matter accumulation and yield in sweet pepper (Silber et al., 2005). A similar significant relationship is reported herein between tissue P content and total fruit number ($r = 0.57$). At 40 mg P L^{-1} P uptake was enhanced under the high fertigation frequency. Xu et al. (2004) explained that frequent fertigation improves nutrient uptake by continuous replenishment of nutrients in the depletion zone in the root media and also enhances transport of dissolved nutrients by mass flow, because of the higher time-averaged water content in the media. The latter is probably more pronounced in organic

media, with greater water retention. Tissue Mg concentration was the only variable significantly related to fruit yield (r = 0.72).

Interestingly, although media treatments affected tissue content of five essential nutrients only three of these (P, Mg and Fe) were significantly related to total fruit number. Further, those three nutrients were all within the sufficiency range identified for sweet peppers at that growth stage (Jones et al., 1991). This implies that plants were still responding to external supply of these nutrients with implications for improved fertigation practices. Using PL to reflect the concentration of micronutrients exposed to roots from the fertigation solution, inclusion of organic substrates or total replacement either increased or decreased Fe, Mn and Zn tissue concentration. Iron and Zn concentrations were greater in leaves from P+SMS treatments, which is most likely related to inherent concentrations of these nutrients from feedstock material used during composting. The greater content of Mn seen in P+RSC plants may be related to the lower pH of this treatment. A significant negative correlation (r = -0.45) was observed between tissue Mn content and media pH. Of greater importance than the treatment effect was that Mn and Zn contents across media were in the deficiency range. Concentrations of these nutrients were similar to other studies (Silber et al., 2005; Jovicich et al., 2007) and hence the lower concentrations may be associated with chemical conditions at the root interface limiting nutrient uptake, namely pH. Sonneveld and Voogt (1997) reported that lower solution pH to 5.6 strongly suppressed chlorosis associated with micronutrient deficiency in Gerbera. They further indicated that the effect of pH on micronutrient absorption was substantial. Increasing the concentration of micronutrients in the fertigation solution at higher pH (>6.0) may increase uptake.

Conclusion

Growing media treatments resulted in minimal effects on sweet pepper yield attributes. Total fruit number was highest in CC media associated with a higher EC and greater concentrations of tissue macronutrients. Marketable fruit, total yield and average fruit weight was not significantly affected by media type. Chemical conditions of the media affected nutrient uptake mainly for micronutrients, this effect was further compounded by the activity of the organic substrate. Variation in macronutrient tissue concentration had little practical implication since all values were either within or above the sufficiency range. Sweet pepper tissue nutrient content was related to chemical activity of the media and this should be considered as it may affect fruit quality.

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Table 1. Variance ratios of measured variables affected by treatment.

Variate	Ratio
Total Fruit	8.03**
Marketable Fruit	0.81
Total Yield	2.08
Average Fruit Weight	1.8
N	0.64
P	4.28*
K	2.72
Ca	1.39
Mg	3.78*
Fe	10.98***
Zn	23.64***
Cu	2.99
Mn	13.37***
Stem Diameter	1.17
pH	1.06
EC	62.46***

*, **, *** represent significance at P < 0.05, P < 0.01 or P < 0.001, respectively

Table 2. Total number of fruit and tissue nutrient content affected by growing media.

Media	Total Fruit	P	Mg	Fe	Zn	Mn	EC
		← % →		← mg kg^{-1} →			$\mu S\ cm^{-1}$
P	12.8b	0.644c	0.504b	38.2b	6.17c	15.59b	105c
CC	20.6a	0.74a	0.663a	28.2c	10.63b	15.45b	1355a
P+SMS	15.4b	0.675bc	0.567ab	48.7a	13.5a	10.29c	620b
P+RSC	13.6b	0.712ab	0.538b	36b	9.55b	22.57a	403b

Values followed by different lowercase letter within a column are significantly at P < 0.05, least squares means analysis.