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The effects of pruning and potassium fertilisation rate in the greenhouse production of Scotch bonnet pepper (*Capsicum chinense* Jacquin)

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Abstract

Two initial studies were conducted to determine the potential for greenhouse production of Scotch bonnet pepper (*Capsicum chinense* Jacq.). When these peppers are grown outdoors in Jamaica, fruit yield declines over time owing to increasing infections with several aphid-vectored viral pathogens. Production of Scotch bonnet peppers in greenhouses with insect-excluding screens covering the side- and end-walls would render the plants virus-free and would extend the harvest season which is limited by damaging rainfall during the wet season. We found in Delaware, USA (39.68° N) that fruit yields from greenhouse-grown plants were far greater than those expected from field-grown plants in Jamaica. Greater fruit number and weight of marketable fruits per plant were achieved from non-pruned plants compared to those from plants pruned to either of two Dutch V systems [plants pruned to two main stems and subsequent laterals pruned to one (V1) or to three (V3) nodes]. These differences were less pronounced when fruit yield was expressed on a per m^{-2} basis since pruned plants were closer together (1.8 plans m^{-2}) than non-pruned plants (1.1 plants m^{-2}). Low-K fertilizer (21N-2.2P-16.6K) compared to high-K fertilizer (15N-2.2P-20.8K) resulted in a 75% early-season and an 8% full-season increase in marketable fruit fresh weight·m^{-2} in non-pruned plants.

Key words: Scotch bonnet pepper, *Capsicum chinense* Jacq., solution fertilization, liquid feed, fertilizer analysis, fertilizer ratio, potassium rate, pruning, Dutch V pruning, Spanish pruning, greenhouse production.

Introduction

The fruit of the Scotch bonnet pepper (*Capsicum chinense* Jacq.) is short and squat with an irregular shape (Fig. 1B) resembling that of a traditional Scottish men's hat also known as a Tam o' Shanter. The fruits ripen from green when immature to varying shades of yellow, orange and red when fully mature. Scotch bonnet pepper is one of the hottest peppers with a "heat" rating of 363,000 to 456,000 Scoville units (Bosland, 1996). The aromatic flavor and high pungency of the fruits is due to a mixture of seven similar alkaloids, capsaicin usually being the most prevalent one. This fruit is used to season traditional Caribbean dishes when used as dried pepper or when made into salsa or sauce.

The Scotch bonnet is a major export crop of the Caribbean islands. In Jamaica in 2009, for instance, 98.3% or 10,387 T of Scotch bonnet pepper was consumed in the local Jamaican market (direct consumption or processing) with only 1.7% or 179 T of the fresh fruit going to the export market (Jamaican Ministry of Agriculture, 2010). The 24 Jamaican exporters indicated they would like to increase exportation of fresh Scotch bonnet peppers if fruit quality was good and the supply was consistent.

The only known literature on the cultivation of Scotch bonnet pepper was published by the Jamaican Ministry of Agriculture and Fisheries (McGlashan, 2001). Typically plants are grown outdoors without irrigation and are harvested during the dry season. Fruit quantity and quality typically decline as the field-grown crop matures owing to lack of adequate water and to increasing severity of viral infections (McGlashan, 2001). Evans and Keil (2009) found that the majority of Scotch bonnet plants in Hanover Parish, Jamaica were infected with Cucumber mosaic Cucumovirus (CMV), tobacco etch Potyvirus (TEV), and potato Y Potyvirus (PVY). These authors reported that as a consequence of viral infection and concomitant reduction in fruit yields over time, Scotch bonnet peppers are being grown using ever-shorter cropping cycles, some now as short as 6 months.

Greenhouse production of Scotch bonnet peppers on Caribbean islands may increase yields over those achieved in the field. Greenhouses with insect screening (≥ 50 openings per 2.5 cm) covering side- and end-walls would exclude the aphids that transmit the viral pathogens. Irrigation/fertigation in the greenhouse would ensure a consistent supply of water and nutrients to the crop for higherfruit yield. Greenhouses would protect plants from damage caused by heavy rainfall during the wet-season (May through December), would prolong the harvest period, would protect plants from excessive solar radiation, and would prevent the escape of pollinators and other beneficial insects.

We know of no reports on greenhouse cultivation of Scotch bonnet pepper, with the bulk of the literature on greenhouse pepper production confined to *C. annuum.* We hypothesize that cultural practices appropriate for *C. annuum* may apply to *C. chinense*. Most of the *C. annuum* cultural literature deals with fertilization, crop pruning and plant population density in the greenhouse.

Hochmuth and Hochmuth (2010) reported that fertilisation recommendations for hydroponically-produced *C. annuum* can be the same as that for tomato (*Lycopersicon esculentum* Mill.). This recommendation requires that concentrations of N, K, Ca, Mg, and S increase with crop ontogeny. By using two analyses of highly water soluble fertilizer, the K concentration can vary as N concentration increased incrementally from 70 mg·L^{-1} at transplanting to first flowering to 150 mg·L^{-1} at crop termination. Greater fruit yields of *C. annuum* have occurred with higher rates of K fertilization (Baghour *et al.*, 2001; Flores *et al.*, 2007; Johnson and Decouteau, 1996; Paz *et al.*, 1996; Paradikovic *et al.*, 2008). As with the N fertilization in hydroponic production, Hochmuth and Hochmuth (2010) recommended incrementally increasing K concentration during pepper plant ontogeny, from 120 mg·L^{-1} at transplanting to first flowering to 200 mg·L^{-1} at crop termination.

Pruning of greenhouse-grown pepper plants reduces the number of stems so that light interception through the canopy would be increased thereby improving fruit set and fruit quality (Portree, 1996). In the Dutch V pruning system for *C. annuum,* one of the two shoots (the smaller one) that develops at each node is removed thereby forming a two-stemmed plant (Jovicich *et al.*, 2004a). Non-pruned plants are said to have the Spanish system of pruning. The Dutch V system increased fruit nodes per plant but decreased incidence of blossom-end rot and fruit set (Jovicich *et al.*, 2004b). These researchers found that the non-pruned plants (Spanish system) gave more extra-large fruit but had no effect on the number or weight of marketable fruit·m^{-2} of floor area. Alonso *et al.* (2012) found that 3-stemmed plants gave greater fruit yields than 2-stemmed pepper plants and Esiyok *et al.* (1994) found that as the severity of pruning increased from non-pruned to 4-, 3- and 2-stems per plant, the number and weight of fruit per plant decreased.

As plants are pruned more severely, the reduction in biomass per plant allows them to be spaced more closely. With any pruning system, therefore, the influence of plant population density (plants·m^{-2}) should be considered. Fruit yield per unit of floor area is the basis upon which costs and profits are calculated. For instance, increasing *C. annuum* plant population density from 1.5 to 3.8 plants·m^{-2} increased the number and weight of both extra-large fruit and marketable fruit despite decreased fruit set and increased blossom-end rot incidence (Jovicich *et al.*, 2004a). Unander *et al.* (1991) likewise found increased fruit yield as pepper population density increased from 3.6 to 7.2 plants·m^{-2}. Such responses would be modified by the level of available photosynthetically-active radiation and on whether supplemental irradiation is used.

In the present studies we determined the effects of fertilizers (low-K or high-K) and two pruning systems (Spanish versus Ductch V) on greenhouse-grown Scotch Bonnet. The second study examined the effects of two severities of Dutch V pruning on fruit yield.

Materials and methods

Experiment 1 (Pruning and fertilisation): An initial batch of Scotch bonnet pepper seeds was imported from Jamaica under a USDA-APHIS permit. Since, the seed batch contained a wide variation in fruit phenotypes, we grew five generations of plants selecting plants and seeds in each generation for phenotypes exhibiting trueness to leaf shape and fruit colour/shape. Seeds from the fifth generation were broadcasted into peat-lite (RediEarh; Sungro, Agawam, MA., USA) and were fertilised daily with 50 mg N·L^{-1} from 21N-2.2P-16.6K. When seedlings had developed first true leaves they were transplanted singly into a peat-lite (ProMix BX; Premier Tech Horticulture, Riviere du Loup, Canada) contained in 8.9 x 8.9 cm pots until they reached the 5th or 6th true leaf. These plants were transplanted into ProMix BX in 11.4-L black plastic containers in April of 2011.

The two fertilizers selected were 21N-2.2P-16.6K (21N-5P_2O_5-20K_2O, Miracle-Gro Excel Multipurpose Fertilizer; 7.9% ammoniacal N, 12.6% nitrate N, 1.1% urea N) and 15N-2.2P-20.8K (15N-5P_2O_5-25 K_2O, Peat-lite Flowering Crop Special; 4.3% ammoniacal N, 10.7% nitrate N). Both fertilisers were manufactured by Scotts Horticultural Products Company, Marysville Ohio). Stock solutions of these fertilisers were prepared and placed in Model DM11F Dosatron injectors (Clearwater, FL) both of which were adjusted to provide 70 mg N L^{-1} from transplanting until first flowering, then increasing to provide 100, 130 and 160 mg N L^{-1} at 3-week intervals over the 12-week fruit harvesting period (Hochmuth and Hochmuch, 2010). The 15N-2.2P-20.8K has 70% more K per unit of N. Thus, as N increased from 70, 100, 130 to 160 mg N L^{-1}, K concentrations from15N-2.2P-20.8K (high-K fertiliser) increased respectively from 97, 139, 180 to 222 mg K L^{-1}, and from 21N-2.2P and 16.6K (low-K fertiliser) increased, respectively, from 55, 79, 103, to 125 mg K L^{-1}.

Plants were pruned to the Dutch V system in which laterals developing from the two main stems were headed back to three nodes (Dutch V3: Fig. 1A) or plants were not pruned, the Spanish system. Thus, the experiment was a 2 (pruning) X 2 (fertiliser) factorial design with 6 four-plant replications. Each replication had 2 rows of plants spaced 1.2 m apart. Pots were arranged in split block design with fertiliser as main plots and pruning as subplots. Two header pipes (one from each injector) were located between each two rows of a replication with microtubes (spaghetti tubes) leading to the surface of the peat-lite in each pot. Within a row, each pruning system consisted of 4 plants. In-row, plant-to-plant spacing was arbitrarily set at 46 cm for the Dutch V3 plants (1 plant·0.552 m^{-2}; 1.8 plants·m^{-2}) and 76 cm for the Spanish plants (1 plant·0.92 m^{-2}; 1.1 plants·m^{-2}). Data were collected from the middle two plants of the four plants of each fertiliser X pruning treatment to avoid border effects. Solution fertilisations were applied once daily for five minutes throughout the experiment. This frequency was sufficient to keep the growth medium adequately moist and yet provide some effluent from the containers to ensure complete wetting of the growth medium and lack of salt accumulation. Plants were grown in a glass-covered greenhouse from May until September, 2011 in Newark DE (39.68 N, 75.76° W). Plants were supported by plastic twine tied loosely around the stem at the base of the plant and suspended from overhead wires 2.1 m above the greenhouse floor. As plants grew, the twine was periodically wrapped around the stem and vine clips were used for additional support. For Dutch V plants, one twine per leader was required while 4 to 5 twines per plant was required for non-pruned plants. Apical meristems were removed when plants reached the supporting wire 2.1m above the greenhouse floor. Flowers were mechanically agitated between 10:00 and 14:00 daily with an electric toothbrush to promote pollination. Day time and night time temperatures were set at 27 °C and 21°C, respectively. Cooling was achieved with

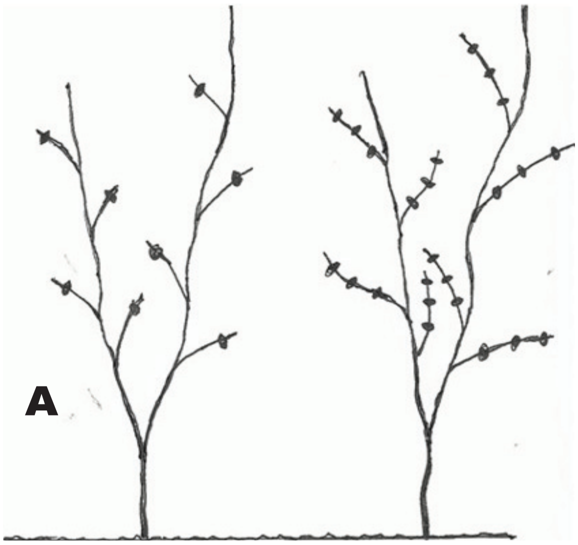

Fig. 1. A. Schematic representation of the Dutch V-pruned plants, either to one node on each lateral (DV1) or three nodes on each lateral (DV3). B. Scotch bonnet fruits. C. A well-grown Scotch bonnet plant in full fruit production in the Dominican Republic.

a combination of ridge ventilation, evaporative cooling, and horizontal air flow fans. Whenever daytime light intensity was ≤ 12 Klux, supplemental lighting from 400 Watt High Pressure Sodium lamps was used.

When sufficient fruit were present to warrant the first harvest, all ripe fruits from the middle two plants of each pruning x fertiliser treatment combination in each row were harvested. Fruits were considered marketable if they were ≥ 3.8 cm diameter, red or orange and free of blemishes. Unmarketable fruit were <3.8 cm diameter when orange or red and showed rot, cracking or blossom-end rot. Harvests were conducted weekly for 12 weeks, with the first 6 weeks being classed as early-season, and all 12 weeks classed as full-season. The number and weight of marketable and non-marketable fruits for the early-season and full-season harvests were subjected to analysis of variance.

Experiment 2 (Pruning only): Materials and methods for this study were identical to those of the first study except that this study was done in the same greenhouse one year later (late March to the end of July, 2012). Only the low-K fertiliser (21N-2.2P-16.6K) was used and a more severe Dutch V pruning system in which laterals on the two main stems were headed back above the first node (Dutch V1, Fig. 1A) was included. Data collection and analysis were identical to those described for the first experiment.

Results and discussion

Experiment 1 (Pruning and fertilisation): When averaged over fertiliser treatments, non-pruned (Spanish) plants produced 760 g fruit·plant^{-1}·week^{-1} (9125 g ÷ 12 weeks) which is equivalent to 707 g·m^{-2}·week^{-1} (8487 g ÷ 12 weeks; Table 1). McGlashen (2001) reported that the expected yield of field-grown Scotch bonnet peppers at 7410 plants· ha^{-1} would be 890 kg·m^{-2}·week^{-1} over 4 to 5 months. This is equivalent to 120 g·plant^{-1}· week^{-1}

Table 1. Marketable fruit yield of greenhouse-grown Scotch bonnet pepper as influenced by pruning system and potassium fertilisation rate

Pruning system[c]	Fertiliser	Marketable fruit yield							
		Per plant				Per m² floor			
		Early-season		Full-season		Early-season		Full-season	
		Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)
Spanish	High K	287 b	2289 b	1201 a	9489 a	267 b	2129 c	1117 a	8148 b
	Low K	472 a	4011 a	1095 a	8761 a	439 a	3730 a	1018 a	8825 a
Dutch V3	High K	96 c	908 c	281 b	2515 b	267 b	2524 bc	781 b	6992 c
	Low K	105 c	1044 c	333 b	3160 b	291 b	2902 b	926 ab	8785 a
<u>*Significance*</u>[e]									
Pruning (P)		***	***	***	***	*	*	**	*
Fertiliser (F)		*	**	ns	ns	*	*	*	*
P X F		*	*	ns	ns	*	*	*	*

Early-season = sum of first 6 weekly harvests.
Full-season = early season + sum of further 6 weekly harvests.
Spanish = no pruning, 1.1 plants·m^{-2}; Dutch V3 = pruned to two leaders then to 3 nodes on each subsequent lateral shoot, 1.8 plants·m^{-2}.
Low-K = 21N-2.2P-16.6K; High-K = 15N-2.2P-20.8K. At the same N concentration, high-K fertilizer delivers 76 % more K than low-K fertilizer.
ns, *, **, *** = Not significant or significant at $P \leq 0.05$, 0.01 or 0.001

Table 2. Shoot fresh and dry weights of greenhouse-grown Scotch bonnet pepper after the final fruit harvest as influenced by pruning system and potassium fertilisation rate

Pruning system	Fertiliser	Shoot fresh weight (g)		Shoot dry weight (g)	
		Per plant	Per m^2 floor	Per plant	Per m^2 floor
Spanish	High-K	4204 a	3910 b	816 a	759 b
	Low-K	3816 b	3549 c	775 a	721 b
Dutch V3	High-K	2184 c	6072 a	339 b	942 a
	Low-K	1516 d	4214 b	364 b	1012 a
Significance					
Pruning (P)		***	*	**	**
Fertiliser (F)		**	*	ns	ns
P X F		ns	ns	ns	ns

Spanish = no pruning, 1.1 plants·m^{-2}; Dutch V3 = pruned to two leaders then to 3 nodes on each subsequent lateral shoot, 1.8 plants·m^{-2}

Low-K = 21N-2.2P-16.6K; High K = 15N-2.2P-20.8K. At the same N concentration, high-K fertilisr delivers 76 % more K than low-K fertiliser.

ns, *, **, *** = Not significant or significant at $P \leq 0.05$, 0.01 or 0.001

or 89 g·m^{-2}· $week^{-1}$. Thus, our greenhouse yields were 6.3-times greater per plant and 7.9-times greater per m^2 than those expected from field-grown plants in Jamaica. These greater yields in the greenhouse than in the field may be attributed at least partially to the absence of viral infection and to the adequate supply of water and nutrients to plants.

Non-pruned (Spanish) plants had greater marketable fruit yields per plant than plants pruned to the Dutch V3 system (Table 1). Pruning system had a less pronounced effect on fruit yields per m^2 compared to fruit yields per plant. Jovicich *et al.* (2004a) found that regardless of the pruning system (Spanish vs Dutch V), marketable fruit yield per m^2 of *C. annuum* increased as plant density increased from 1.5 to 3.8 plants per m^2; however, yields per plant generally decreased. In our study, the higher plant population density of Dutch V3-pruned plants (1.8 plants·m^{-2}) compared to the non-pruned (Spanish) plants (1.1 plants·m^{-2}) largely compensated for the lower fruit yields per plant since differences in fruit yields per m^2 between the two systems was greatly diminished or non-existent (full-season fruit number and weight). It is unknown whether higher yields per m^2 could have resulted in our study by using the population density of 1.8 plants·m^{-2} as compared to our 3.8 plants per m^2 in Florida (Jovicich *et al.*, 2004a), However less canopy interception of photo-synthetically active radiation at our greater latitude is expected. The higher plant population density is possible with plant pruning which requires significantly more labor. Jovicich *et al.* (2004a) noted that non-pruned plants required a total labor time of 3.3 min.·m^{-1} of row while Dutch V plans required 14.1 min.·m^{-1} of row, the former system thus representing a 75% saving in labour.

While shoot fresh and dry weights per plant were greater for non-pruned plants, these weights per m^2 were similar to or greater for the Dutch V3-pruned plants (Table 2). Assuming a positive relationship between shoot weight and leaf area, the higher population density of the Dutch V3 plants (1.8 plants·m^{-2}) generally resulted in higher leaf area per m^2 than found in non-pruned (Spanish) plants (1.1 plants·m^{-2}). Thus, there would be more leaf area per flower node in the pruned plants than in non-pruned plants resulting in more photosynthate per fruit and therefore greater weight per fruit (9.70 vs 8.24 g early-season and 9.22 vs 7.95 g full-season). The lower early- and full-season fruit number per plant of pruned plants can be attributed to removal of flower nodes per plant by pruning. However, non-pruned plants had similar or slightly greater fruit numbers per m^2 as pruned plants indicating that flower abscission/fruit abortion was greater in non-pruned plants. Contrary to this result, Marcelis *et al.* (2004) found that lower leaf area per plant resulted in greater flower abscission or flower abortion in *C. annuum*. However, non-pruned plants had more flowers per plant than pruned plants, and it is known that the presence of developing fruits can inhibit subsequent set and growth of young fruit (Stephenson *et al.*, 1988). These authors also reported that this inhibition of fruit set may be caused by competition for available assimilates, by dominance due to the production of plant growth regulators from the developing fruit or a combination of competition and dominance. Such a decrease in percentage fruit set in non-pruned plants compared to pruned plants may be associated with reduced pollination because locating the flowers to agitate them was more difficult owing to the greater shoot biomass. Marcelis and Hofman-Eijer (1997) found that fruit size and set in *C. annuum* were positively correlated with seed number per fruit and thus to adequate pollination, although only a relatively low number of seeds per fruit (50-100) which is 20-30% of maximum seed number was sufficient for maximal fruit set.

The low-K fertiliser resulted in a greater number and weight of marketable fruit per plant and per m^2 than the high-K fertiliser in non-pruned (Spanish) plants only during the early-season harvests (Table 1). Early- and full-season fruit weight per m^2 was greater with low-K than with high-K fertiliser. For plants pruned to the Dutch V3 system, fertiliser had no effect on per plant fruit yields but the low-K fertiliser increased the full-season fruit weight per m^2. Our results are in contrast with others (Baghour *et al.*,

Table 3. Marketable fruit yield of greenhouse-grown Scotch bonnet pepper as influenced by pruning system

Pruning system	Marketable fruit yield per plant				Marketable fruit yield m^{-2} floor			
	Early-season		Full-season		Early-season		Full-season	
	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)	Number	Weight (g)
Spanish	190 a	1220 a	713 a	4818 a	177 a	1135 a	663 a	4481 a
Dutch V3	35 b	313 b	107 b	900 b	97 b	870 b	297 b	2502 b
Dutch V1	38 b	285 b	137 b	1078 b	106 b	792 b	381 b	2997 b
Significance	***	***	***	***	**	*	**	*

Early-season = sum of first 6 weekly harvests.

Full-season = early season + sum of further 6 weekly harvests.

[c]Spanish = no pruning, 1.1 plants·m^{-2}; Dutch V1 and V3 = pruned to two leaders then to 1 node or 3 nodes on each subsequent lateral shoot, respectively, 1.8 plants·m^{-2}.

*, **, *** = Significant at $P \leq 0.05$, 0.01 or 0.001, respectively.

Table 4. Shoot fresh and dry weights of greenhouse-grown Scotch bonnet pepper after the final fruit harvest as influenced by pruning system.

Pruning	Shoot fresh weight (g)		Shoot dry weight (g)	
system	Per plant	Per m^2 floor	Per plant	Per m^2 floor
Spanish	1925 a	1790 c	463 a	431 c
Dutch V3	1812 a	5037 a	437 a	1215 a
Dutch V1	1415 b	3934 b	299 b	831 b
Significance	*	***	*	**

Spanish = no pruning, 1.1 plants·m^{-2}; Dutch V1 and V3 = pruned to two leaders then to 1 node or 3 nodes on each subsequent lateral shoot, respectively, 1.8 plants·m-^{2}.
*, **, *** = Significant at $P \leq 0.05$, 0.01 or 0.001, respectively.

2001; Flores *et al.*, 2007; Johnson and Decouteau, 1996; Paz *et al.*, 1996; Paradikovic *et al.*, 2008) who found that higher rates of K fertilisation increased fruit yields of *C. annuum.* Flores *et al.* (2007) noted that increasing rate of K fertilisation increased shoot biomass at the expense of fruit number and weight per plant in *C. annuum*, a general response we noted with full-season fruit number and weight per m^2.

We observed a higher incidence of non-marketable fruit, primarily due to blossom-end rot with high-K fertiliser than with low-K fertiliser (data not shown). Rubio *et al.* (2009) likewise found that blossom-end rot incidence was greater with high K or low Ca fertilisation of *C. annuum* and attributed this to a lower Ca concentration in the distal end of the fruit, a condition known to increase this physiological disorder (Pill and Lambeth, 1977). While shoot fresh weight per plant was greater with high-K fertiliser than with low-K fertiliser, shoot dry weight per plant was unaffected by K rate (Table 2) suggesting higher succulence of the high-K-fertilised plants. Assuming greater plant uptake of K with high-K fertiliser, the consequent lowering of plant solute potential by K may increase plant water uptake and succulence.

Experiment 2 (Pruning only): In this experiment only one fertiliser (low-K, 21N-2.2P -16.6K) and an additional Dutch V pruning system was used. Since the combination of Dutch V3 pruning and low-K fertiliser had produced similar fruit number and weight as non-pruned (Spanish) plants (Table 1), we hypothesized that lowering the flower load per plant by heading back the laterals to one node on the two main stems (Dutch V1) may increase fruit yield by increasing the ratio of leaf area per flower/fruit compared to that of Dutch V3 plants.

Compared to Dutch-pruned plants, non-pruned (Spanish) plants had greater fruit number and weight both for the early- and full-season either on a per plant or on a per m^2 basis (Table 3). The lower overall fruit numbers and weights of this experiment compared to those of the first experiment were possibly related to the earlier timing (March-July, 2012) of this experiment than of the first one (May-Sept, 2011) and its relative effects on light intensity and temperature. The similarity of fruit numbers and weights resulting from the two Dutch V systems revealed that either the Dutch V1 system resulted in greater flower/fruit set than the Dutch V3 system, or that the Dutch V3 system resulted in greater flower abscission or fruit abortion than the Dutch V1 system. Increasing the population density of the Dutch V1 plants beyond that of this experiment (1.8 plants·m^{-1}) may have increased fruit yields of these more severely pruned plants. Unander *et al.* (1991), for instance, reported increasing *C. annuum* fruit yield as population density increased from 3.6 to 7.2·plants m^{-2}.

From the results of these two initial studies we conclude that fruit yield of Scotch bonnet pepper can be many times more in the greenhouse than can be expected in the field. Using the low-K fertiliser (21N-2.2P-16.6K) compared to the high-K fertiliser (15N-2.2P-20.8K) increased full-season fruit weight per m^2 by an average 16.3%. We found fruit weight per m^2 of floor area generally greater in non-pruned (Spanish) plants than in pruned (Dutch V1 or V3) plants, without the greater labor time involved associated with pruning. We suggest that further work should be conducted in the Caribbean region in greenhouses whose side- and end-walls are covered with insect screen to exclude aphid vectors of viral pathogens and to contain insect pollinators. We suggest that the effects of varying plant population density (in-row or between-row spacing) of non-pruned plants provided with low-K fertiliser may be studied.

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