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"Aurora Tropical": Strengthening the Production of Vegetable Seedlings as a Key Strategy in Rural and Urban Horticulture

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ABSTRACT: *The use of good seed and seedling production stage are considered key to the success of horticultural production at rural or urban environment. It really is true, when the horticultural growers say good seedling can represent 50% of production. In Venezuela, the sector called "Campo Lindo" in Quibor Lara state, has become one of the largest tropical area of the world in the production of vegetable seedlings in protected horticulture, with an area greater than 10 hectares which includes about 150 plastic greenhouses (≥500 m^2 each). However, this activity has been presenting some limitations, such as input substrates and soluble fertilizers among others (inappropriate protected structures, pests, neglected research). In this regard, several studies have been developed in partnership with local growers, focused on finding alternative substrates, fertilizers and biostimulants for vegetable seedling production. The results generated from these experiments demonstrate that there are a great variety of local substrates (individual and its mixtures) which are alternative to substrates conventionally used, for example imported peat and local coir dust. The use of mixtures in proportions previously analyzed of relatively inert substrates (peat, coir, sand, bagasse dust) with various composts, vermicomposts, biostimulants and other organic materials locally produced were found to have similar or better performance with respect to conventional substrates. Also, balanced and integrated fertilization plans (organic, mineral, biostimulants) and the use of alternative fertilizers to conventionally used (mineral formulas) generated better results in growth and quality of studied seedlings (tomato and pepper). Complementary, we have been promoting various strategies focused on integrated management of vegetable seedling production (cultivars, pests), the adaptation of new technologies and inputs (big plants, irrigation systems, grafting) and introducing potential alternative horticultural enterprises such as production of sprouts, mini vegetables (lettuce, carrots), new crops, herbs, spices and tropical mushrooms among others.*

Keywords: *evolutionary horticulture,* Capsicum annuum, Lycopersicon esculentum, *vegetable seedlings, sustainable horticulture.*

INTRODUCTION

Constraints faced in the urban and rural production of vegetables can be classified as climatological, technological and others including socio-economic limitations. In the tropics finding a good and appropriate seed and a high quality vegetable seedling has become one of the main key limitations. Actually, after colonization until nowadays the vegetable production sector in the tropics is mainly dependent on imported seed and most other horticultural technologies and commodities, such as the use of peat as a horticultural substrate. Ironically, the tropics contain about the same amount of peatmoss genetic biodiversity as do temperate and boreal regions (Shaw et al., 2003). However, some of these foreign seeds and technologies have been adapted and applied with great success under tropical environments. Regarding on it, a good example is the use of improved seed (hybrids mainly) and the production of vegetable seedlings in trays with soilless substrate under plastic greenhouses (Ramirez-Guerrero *et al.*, 2012).

Tropical vegetables growers have adapted technologies to their local needs and avoid labour-demanding and expensive practices (Stocking, 2006). Tomato and bell pepper are one of the most important

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horticultural crops in Venezuela. The establishment of these vegetable crops is dependent on the production of seedlings in trays, so that the quality of seedlings is crucial to successful commercial production (Preciado *et al.*, 2002). The scope of vegetable seedling production is tremendous owing to suitable tropical climatic conditions prevailing in these marvellous environments, together with the high horticultural and familiar vocation of the local growers (Meza-Figueroa *et al.*, 2012). There is no doubt that the use of good horticultural practices such as a proper substrate and nutrient solution are key factors in achieving the production of vigorous seedlings and subsequently obtaining profitable yields. In this respect, this research will assess growth in tomato and bell pepper seedlings treated with several local substrates (soilless media) and organic and mineral nutrient solutions.

MATERIALS AND METHODS

Two experiments were carried out under semiarid tropical field conditions in polyethylene greenhouses at the university experimental station in Cabudare (10º 2′ N, 60º 16′ W, 510 masl) and experiment 3 was located at a commercial greenhouse in Quibor (10° 2′ N, 69° 56′ W; 670 masl), Lara State of Venezuela. Lara state is a well known national area for vegetable crops, being a pioneer region in Venezuela for producing good quality vegetable transplants in plastic greenhouse (average dimensions of 50 m long x 10 m wide x 4 m high), using trays and imported peat as a media substrate.

Experiment 1. A commercial brand of peat (P: Sogemix VT-M, Canadian Peat) was compared to local alternative substrates (Co: processed coconut coir, B: composted sugarcane bagasse, Rh: ground rice hull) and their binary mixtures. Thirteen different substrates were tested: control P (100%), Co (100%), B (100%), Rh (100%), Co + B (1:3, 1:1, 3:1), Co + Rh (1:3, 1:1, 3:1) and B + Rh (3:1, 2:1, 1:1). Each media was placed in styrofoam trays with 288 cells, each with an individual volume of 19 cm^3. Thirteen treatments and four replications were set out in a randomized complete design. The experimental unit was one tray. Flats were seeded with tomato seeds of the open pollinated cultivar "Rio Grande" (Seminis vegetable seeds, USA). Plants were watered daily as needed and fertilized with macro nutrients four times per week from a commercial 20-20-18 soluble source (Solub, Spanish Fertilizer brand).

Experiment 2. A Canadian peat (P: Pro-Mix PGX) was compared to local alternative substrates (Co: coconut coir, Op: sawdust oil palm stems, Cs: cedar sawdust) and their mixtures. Four substrates were tested: control P (100%), commercial and registered Co (100%, Terraflora 2®), Co + Op (1:1) and Co + Cs (3:7 + 3% perlite). Each media was placed in black plastic trays with 200 cells, each with an individual volume of 13 cm^3. Four treatments and six replications were set out in a randomized complete design. The experimental unit was one tray. Flats were seeded with tomato seeds of the hybrid "Rio Grande" (Seminis vegetable seeds, USA). Irrigation and fertilization were done as in experiment 1.

Experiment 3. Bell pepper seeds (hybrid "Alliance", Harris Moran-USA) were sown by hand in 200-cell plastic trays containing a substrate with a combination of peat and coir (60 and 40% respectively).and then moved straight to the greenhouse. Then, five fertiliser treatments were applied: 1: a conventional solution used by local seedling growers (CS); 2: a biostimulant solution (BS: Viva from Valagro S.p.a, sugarcane molasses, Carbo-Vit from Humus Liquidos-Mexico, Liquid Vermicompost from cattle manure and honey bee); 3: Wye nutrient solution (Wye) (Varley and Burrage, 1981); 4: 50 % Wye diluted with water (dWye); and 5: a control treatment with tap water alone (C). General management of the seedling production was according to the commercial grower, while fertilization plan was the used by Meza-Figueroa *et al.*, (2012).

For all 3 experiments; some physical and chemical properties of substrate treatments and seedling growth parameters were evaluated.

RESULTS AND DISCUSSION

Alternative Substrates Quality

Individual local substrates and its mixtures evaluated in experiments 1 and 2 had desirable physical and chemical characteristics and resemble traditional and imported peat substrates (Table 1). In experiment 1, the individual substrates Rh and B and its mixtures, together with Co + Rh in all proportions and also Co50 + B50 and Co75 + B25 had higher and similar total porosity (TPS) than commercial peat. But Co alone and the mixture Co25 + B75 had lower TPS than the evaluated peat. Regarding air content or airfilled porosity (AFP), Rh and its mixtures with Co and B in all percentages showed the higher values, but all the others substrates had lower values of AFP than peat. Water retention porosity or water holding capacity (WHC) was higher and similar to peat when B and

Table 1
Some physical[x] and chemical[y] properties of commercial peat mixture (P) and alternative local substrates for seedling vegetable production in tropical environments

Growing media **Experiment 1**	*Total Porosity (%)*	*Airfilled Porosity (%)*	*Water retention Porosity (%)*	*pH*	*Electrical conductivity ($dS\ m^{-1}$)*
P100[z]	66.07cd*	5.00g	61.06ab	6.56abcd	0.62cde
Co100	62.88e	4.36gh	58.52c	6.32d	1.49a
B100	66.97bc	3.77gh	63.19a	6.75a	0.41fg
Rh100	71.60a	39.46a	32.13h	6.68ab	0.45defg
Co25 + B75	64.48de	2.46h	62.02ab	6.39d	0.64cd
Co50 + B50	65.10cd	3.36gh	61.73ab	6.42cd	0.65cd
Co75 + B25	65.13cd	4.36gh	60.77b	6.50abcd	1.09b
Co25 + Rh75	68.81b	27.93b	40.88g	6.65abc	0.75c
Co50 + Rh50	66.25cd	19.83cd	46.41f	6.57abcd	0.99b
Co75 + Rh25	66.94bc	13.95e	52.98d	6.45bcd	1.43a
B25 + Rh75	67.00bc	21.97c	45.03f	6.32d	0.56cdef
B50 + Rh50	68.43b	17.99d	50.44e	6.33d	0.42efg
B75 + Rh25	66.91bc	8.42f	58.49c	6.46bcd	0.32g
Experiment 2					
P100	85.10	13.16	71.94	6.60	0.16
Co®100	92.79	26.26	66.53	6.49	0.11
Co50 + Op50	91.10	27.17	63.94	6.59	0.14
Co30 + Cs70	93.35	16.16	77.19	6.75	0.13

*Within a column, values followed by different letters differ significantly at the 0.05 probability level. [x]Physical characteristics measured by Dilger (1998) methodologies. [y]Chemical characteristics measured with standard methodologies cited by Hao et al.. (2005). [z]Terms represent the percentage of volume distribution. P: Commercial peat; Sogemix VT-M (Experiment 1) and Pro-Mix PGX (Experiment 2), Co: processed coconut coir, B: composted sugarcane bagasse, Rh: ground rice hull, Co®: Commercial coconut coir (Terraflora 2 from Floritec, Venezuela), Op: sawdust oil palm stems and Cs: cedar sawdust.

its mixtures with Co were used. As the very good water holding capacity of the soils is not suitable for container cultures, because of its low air volume at low tensions; water and air content become the most important physical parameters of substrates. Water must be available in the substrate at the lowest possible energy status, but at the same time sufficient air is necessary in the root zone. A substrate can never contain too much water, but can be deficient in air (Gruda and Schnitzler, 2004).

All the evaluated substrates showed a slightly similar pH than peat with values between 6 to 7. However, the salinity of alternative substrates, expressed as the electric conductivity (EC) of the saturated media extract, varied greatly among treatments. Coconut coir alone, Co75 + B25, Co50 + Rh50 and Co25 + Rh75 had significantly higher EC than peat. Other samples reported similar or lower figures than peat. Initial and crucially, seed germination and seedling emergence are significantly delayed by substrates with high EC. According to Oberpaur *et al.,* (2010), salinity is present due to the presence of intrinsic high concentrations of salts in substrates or an excessive contribution of mineral nutrients from fertilization, irrigation water, in regard to the amounts absorbed by the plant and losses by lixiviation. Nevertheless, the excess of the soluble salts could be easily and effectively leached from the material under customary irrigation regimes (Abad *et al.,* 2002).

Seedling Growth

The data in table 2 indicate that all tested substrates showed a significant effect on tomato seedling height (SH), number of leaves (NL) and stem diameter (SD). However, SH and SD were not affected by any substrate mixture in experiment 2. The control treatment P (Peat mixture alone) and combinations of Co25 + B75 and B75 + Rh25 do provide a greater seedling height. Regarding this important growth parameter and according to the similar WHC of the mixture Co25 + B75 to peat and the lowest EC of the combination B75 + Rh25 (Table 1), it may be inferred that these combinations could be the best in meeting this variable optimal demand as peat substrates generally do. In experiment 3, bell pepper seedlings fertilized with the Wye solution showed the greatest height, followed by those treated with CS and dWye solutions.

Tomato seedlings rising in growing media composed of all combinations of Co + B (mainly Co25 + B75), peats and B75 + Rh25 and those bell pepper

Table 2
Some growth quality parameters of tomato and bell pepper seedlings following treatment with different growing medias and organic and mineral nutrient solutions at 30 and 35 days after sowing (dds) for tomato (Experiment 1 and 2) and pepper respectively

Experiment 1 *Growing media*	*Height* *(cm)*	*Leaves* *Number*	*Stem Diameter* *(mm)*
P100[x]	18.19a*	3.5ab	2.35[a]
Co100	15.07c	3.4b	2.33[a]
B100	11.08g	2.8e	2.02de
Rh100	10.10h	3.0de	1.84f
Co25 + B75	18.19a	3.7a	2.28ab
Co50 + B50	16.74b	3.4b	2.11c
Co75 + B25	16.85b	3.4b	2.24b
Co25 + Rh75	12.62f	3.3bc	2.00de
Co50 + Rh50	13.86de	3.1cd	2.00de
Co75 + Rh25	14.62cd	3.3b	2.07cd
B25 + Rh75	13.17ef	3.0de	1.95e
B50 + Rh50	16.18b	3.3bc	2.14c
B75 + Rh25	18.52a	3.4b	2.25b
Experiment 2			
Growing media			
P100	20.00	3.72a	2.50
Co®100	19.00	3.37b	2.43
Co50 + Op50	19.00	3.58ab	2.40
Co30 + Cs70	20.00	3.35b	2.57
Experiment 3			
Nutrient Solution			
C	15.92c	5.75b	3.32b
Wye	19.52a	7.00a	3.82a
dWye	17.91abc	7.08a	3.55ab
CS	18.94ab	7.08a	3.53ab
BS	16.83bc	6.50ab	3.41b

*Within a column, values followed by different letters differ significantly at the 0.05 probability level. [x]Terms represent the percentage of volume distribution. P: Commercial peat; Sogemix VT-M (Experiment 1) and Pro-Mix PGX (Experiment 2), Co: processed coconut coir, B: composted sugarcane bagasse, Rh: ground rice hull, Co®: Commercial coconut coir (Terraflora 2 from Floritec, Venezuela), Op: sawdust oil palm stems and Cs: cedar sawdust. C: control tap water. Wye: Wye solution. dWye: diluted Wye. CS: Conventional local grower solution (Solub®). BS: Biostimulants solution.

Figure 1: Tomato and bell pepper seedlings raised in different growing media in polyhouse

seedlings fertilized with mineral and organic fertilizers gave the best results, producing healthy seedlings with more number of leaves. Based on stem diameter, peat and Co followed by the mixture of Co25 + B75 generated largest values, showing Rh the lowest value. In general, transplant growers base transplant growth on three major parameters: leaf area, stem diameter and root development (Arenas *et al.*, 2002). Furthermore, transplant growers often judge plant quality by their ability to control height (Vavrina *et al.*, 1996) and to reach a greater stem diameter. In experiment 3, bell pepper seedlings fertilized with Wye solution showed the highest SD. Alternative solutions (Wye and diluted Wye) are very advantageous compared with conventional grower solution; they are more concentrated and balance forms of nutrients, which can be transported much more efficiently and readily than CS (Ramirez-Guerrero *et al.*, 2012).

CONCLUSIONS

Keeping in mind the conservation of our priceless and very sensitive tropical biodiversity, we must start seriously to explore all the numerous local products and alternative substrates in the tropics, such as the immense variety of good local products from municipal, industrial and agricultural wastes. Therefore, looking for its enrichment, strengthening and integration with amendments and conditioners (compost, biostimulants, biochar, gypsum, lime, and many other both organic and mineral ones).

The use of a good, proper, local or adapted substrate and nutrient solution are key factors in achieving the production of vigorous seedlings and subsequently obtaining profitable yields, either urban or rural tropical horticulture.

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