Greenhouse Technology is once again washing the Caribbean. Can we ride the wave this time around?

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Abstract

Yet another attempt is being made in the Caribbean to modernize the agriculture sector through the adoption of technologies that have the potential of increasing the production and productivity of the vegetable sub-sector. The recent re-introduction of Greenhouse Technologies has once again generated heightened interest across the region. As in the past, several drawbacks have impeded full exploitation of the many advantages of this technology.

This paper reviews the status of the sector in Trinidad and Tobago and Jamaica focusing on characterizing the various types of structures being used, crop management practices, the major constraints faced by producers, and the level of training. 16 farmers in Trinidad and Tobago and 22 Greenhouse Vegetable Producers in Jamaica were surveyed using detailed questionnaires. The data were presented as descriptive statistics.

The results showed that the greenhouse vegetable producers rated the lack of information and adequate finance, insufficient technical support followed by heat and humidity as the major constraints to greenhouse vegetable production. These results are compared with information derived from key informants associated with previous attempts at establishing a greenhouse industry and suggestions are made to get the technology right in the shortest period this time around.

Introduction

The use of greenhouses for vegetable production is an attempt to reduce or eliminate the limiting effects of heavy rainfall, high temperatures, and intense solar radiation levels that are typical of tropical countries. Von Zabeltitz (1988) indicated that a plastic covered greenhouse (GH) for humid tropics must provide protection from the rains while having good ventilation efficiency. His design with the necessary ridge vent has been widely adopted with modifications in roof shape and the use of insect screens along the sidewalls, gables, and ridge vent openings. When combined with insect screens, the possibility of reduced pesticide use addresses the issues of food quality, food safety and the increasing regulatory demands.

An undated publication by Republic Bank Ltd., records was a satisfactory attempt at soilless culture in the 1950's at St. Augustine Station in Trinidad by the Ministry of Agriculture. Tomato yields in a 37.5 m by 7.5 m open-sided GH averaged 4.5 kg per plant. This prompted many backyard trials as well as the establishment of a commercial enterprise that eventually folded due to praedial larceny and poor management.

The commercial applications of the nutrient film technique (NFT) especially in England and Holland renewed interest in soilless culture systems at the beginning of the 1980's in Trinidad. Interested growers, funded by the Agricultural Development Bank (ADB), purchased structures ranging from tall, open-sided, multi-span sheds to completely enclosed Quonset-type greenhouses complete with fan and pad cooling systems. While Steiner (1984) suggested the production of only quick growing crops for the NFT system. In a 1987 survey, Bedasie (1991) reported that, there were approximately sixty growers with a total covered area of 4.5 ha. producing tomato and lettuce. Seventy-five percent of the growers were using the

NFT system. He further reported that the failure rate was higher among tomato growers with many of them eventually going out of business.

Such failures can be attributed to many factors. Under humid tropical conditions, the fan and pad cooling systems were ineffective in controlling temperatures inside the enclosed greenhouses used mainly for lettuce production. NFT tomato crops, grown mainly in the open-sided sheds were affected by warm solution temperatures during early growth and never recovered (Dinanath, 1988). While the call for more relevant research and efficient advisory services to support growers was stressed by Steiner (1984), that support was lacking and probably reflected the State's priority towards servicing the larger pool of resource-poor traditional farmers as against the few resource-rich "businessmen-cum-GH growers". Further compounding the issue was the fact that many growers were secretive about their operations, thus giving credence to the term "undercover production".

GH technology was introduced into Jamaica from Honduras in 2004/5 under a USAID funded – Jamaica Business Recovery Programme (JBRP). The Rural Agricultural Development Authority (RADA) of Jamaica, has recommended (RADA, 2003) the combination of antiviral mesh and natural ventilation at altitudes above 500m while at lower elevations, forced ventilation with larger mesh, e.g. shade cloth, were recommended. These measures were necessary for dealing with higher temperatures at lower elevations. The provision of relevant training of extension personnel and the use of foreign consultants supported the efforts of farmers.

In 2007, a collaborative approach in Trinidad between National Agro-Chemicals Limited (NACL), the Agricultural Development Bank (ADB), National Agricultural Marketing and Development Company (NAMDEVCO) and the Business Development Corporation (BDC) produced a financial, marketing, and technical support package for persons interested in GH production. The greenhouses offered came in two sizes, 12 m by 40 m (480 m²) and 12 m by 60 m (720 m²) and enclosed with a 40 – 25 mesh (antiviral). Unlike the Jamaican recommendations, no allowances were made for low altitude conditions where most of the greenhouses were established. It soon became evident that there was a high level of dissatisfaction with the performance of the greenhouses in terms of crop yields and the inability to control temperature and humidity levels. This prompted the call for an urgent Needs Assessment exercise to identify specific production constraints, to identify and prioritize possible solutions and to resolve any pressing issues. A "Shade-house Technology Workshop" was recently held for staff members of the Ministry to acquaint them with the technology. This paper investigates the experiences of those who adopted the technology not only in relation to crop production practices, pest control measures, marketing, and the environmental effects within or under the GH or shade-house structures, but also the information and research support available.

Methodology

A mix methods approached was used: structured interviews of current greenhouse vegetable producers[1] (GHVP); GH visits and personal in-depth interviews with selected key informants associated with previous the GH industry. The structured interviews took the form of a detailed questionnaire, which was prepared in accordance to a rapid assessment survey method (Cernea, 1990). The questionnaire consisted of 52 questions and was designed to capture information on socio-economic factors of the GH vegetable farmers, farm operations, crop protection, marketing, and constraints to GH vegetable production. Field guidelines for answering the questionnaires was discussed and established among the 3 interviewers. A pretest survey (Cannell et al, 1989) was done with 5 GH vegetable farmers to ensure clarity and validity of the first draft questionnaire. Feedback from these 5 GHVP was used to produce the final questionnaire, which was administered to 16 GH vegetable farmers from Trinidad and Tobago and 22 GH vegetable farmers from

[1] GHVP: Greenhouse Vegetable Producers

Manchester, Jamaica. A total of 38 questionnaires were administered. Data were analyzed using Minitab 15 software, and presented as descriptive statistics. Results were reported using modal responses.

Results & Discussion

Characteristics of the Greenhouse Vegetable Producers

Table 1 presents the data on the demographics of the greenhouse vegetable producers. The typical GHVP from Trinidad and Tobago was: a secondary school educated (63%) male (88%) over 41 years old (81%) who purchased one GH (69%) through a loan (69%). He self-owned (69%) and managed (63%) the GH on a full-time basis (44%), had <1 year of GH farming experience (69%) with little or no training in GH production (75%) and > 10years farming experience in open field production (44%). The typical GHVP from Manchester, Jamaica was a college/university educated (64%) male (92%) over 41 years (63%) who purchased >1 GH (68%) without financial assistance (55%). He self owned (41%) and managed (64%) the greenhouses on a full-time basis (77%), had <2 year GH farming experience (55%) with a fair (50%) amount of training and has been involved farming >10 years outside of GH farming (41%).

Design and structures of the greenhouses

Manchester, Jamaica

The main design used was the detached jack-roof (77%) (Table 2). The majority (55%) of greenhouses was aligned in the North/South direction and was fully enclosed (68%) with a UV plastic roof covering (86%) and Antiviral/50 Mesh (41%) side coverings. Some (25%) greenhouses contained hydroponics plus trellis system (25%).

Trinidad and Tobago

The GH designs used varied from dome-shaped, Spanish designs, tropical tunnel types and self-constructed units. The majority (50%) of greenhouses was aligned in the East/West direction was fully enclosed (69%) with antiviral mesh 40:25 (44%) side coverings. Some (44%) greenhouses contained trellising system.

Table 1 Modal responses to inquiries into socio-economic factors

	Location	
Line of inquiry	Trinidad and Tobago	Manchester, Jamaica
Highest Educational level	Secondary (63%)	College/university (64%)
Sex	Male (88%)	Male (92%)
Age group	>41 years old (81%)	>41 years old (63%)
Number of greenhouses owned	1(69%)	>1 (68%)
Means by which greenhouse was purchased	Loan (69%)	Without financial assistance (55%)
Type of greenhouse ownership status	Self owned (69%)	Self owned (41%)
Time dedicated to the greenhouse operation	Full time (44%)	Full time (77%)
Experience in greenhouse farming	<1 year (69%)	<2years (55%)
Amount of greenhouse training received	Little or no training (75%)	Fair (50%)
Experience in farming outside of greenhouse farming	> 10years (44%)	>41years (41%)

Table 2 Modal responses to inquiries into the design and structures of the greenhouses

	Location	
Line of inquiry	Trinidad and Tobago	Manchester, Jamaica
Greenhouse design	Varied	Detached jackroof (77%)
Greenhouse alignment	East/West (69%)	North/South (55%)
Greenhouse enclosure	Fully enclosed (69%)	Fully enclosed (68%)
Roof covering material	UV plastic (85%)	UV plastic (86%)
Side covering material	Antiviral mesh/ 40:25 (44%)	Antiviral/50 mesh (41%)
Structures in the greenhouse	Trellis (44%)	Hydroponics and trellis system (25%)

Operation

Manchester, Jamaica

Some (60%) of GHVP owned a total farm area of > 2ha on which greenhouses covering a land area of 790m^2 (38%) was situated (Table 3). GHVP (45%) used a hydroponics production system for growing vegetables and 55% of them received assistance from their family members, for <25% of the time (58%) to run the GH operation.

Within the last year, most (90%) of the GHVP used their total GH area to produce either a crop of tomato or sweet pepper. Seedlings were either bought or produced (45%) and the soil was the main (45%) growth media used to produce the crops. Seventy seven percent of the GHVP used machinery in their greenhouses. Thirty percent of GHVP used water from wells to irrigate their crops using a drip irrigation system (90%) that was manually (59%) operated. The most commonly used method of fertilizer was fertigation (33%), however, the fertilizers and rates of application used varied depending on the crop planted and the GHVP.

Trinidad and Tobago

In most (75%) cases the GHVP from Trinidad and Tobago owned a total farm area ranging from 0.5 – 2ha on which a GH (38%) covering a land area of 480m^2 (12m by 40m) was situated (Table 3). The GHVP (69%) used a traditional production system for growing vegetables and 63% of the GHVP received assistance from their family members, for > 25% of the time (44%) to run the GH operation.

Within the last year, most (44%) of the GHPV used their total GH area to produce a crop of tomato. The tomato variety most (19 %) grown was heat master at a spacing of 0.3m X 0.3m (19%). Seedlings were normally (69%) bought and the soil was the main (50%) growth medium used to produce the crops. Sixty three percent of the GHVP used a small rotary tiller to prepare the planting area and 75% irrigated with water from WASA using a drip irrigation system (94%) that was manually (75%) operated. The fertilizers used, rates, and method of application varied among the GHVP. Most (81%) of the GHVP had an organized recording system in the form of a diary (38%).

Crop Protection

The main insect pest problem in Trinidad and Tobago was white flies (14%), compared to mites (55%) in Manchester, Jamaica (Table 4). It is notable that 14% of the GHVP from Trinidad and Tobago reported no pest problems.

Most (75%) GHVP from Trinidad and Tobago had a footbath at the entrance of the GH, however, only used it sometimes (25%). Some (50%) GHVP from Manchester, Jamaica had a footbath at the entrance of their greenhouses (Table 4).

Table 3 Modal responses to inquires into the operation of the greenhouses

Line of inquiry	Location	
	Trinidad and Tobago	Manchester, Jamaica
Total farm size	0.5 – 2ha (75%)	> 2ha (60%)
Average size of greenhouse	480m^2 (38%)	790m^2 (38%)
Type of Crop Production system used	Traditional[2] (69%)	Hydroponics (45%)
Family assisted labour	Yes (63%)	Yes (55%)
Frequency of family assistance	> 25% of the time (44%)	<25% of the time (58%)
Vegetable crop most frequently grown in your greenhouse for the past year	Tomato (44%)	Tomato (90%) Sweet pepper (90%)
Tomato variety grown	Heat master (19%)	NR[3]
Tomato plant spacing	0.3m X 0.3m	NR
Means by which seedling were acquired	Bought (69%)	Bought (45%) Produced (45%)
Plant media used to grow vegetable crops	Soil (50%)	Soil (45%)
Use of machinery in the greenhouse	Yes (63%)	Yes (77%)
Machine used	Rotary tiller (63%)	NR
Source of water used for irrigation	Water and Sewage Authority (75%)	Wells (30%)
Type of irrigation system used	Drip irrigation (94%)	Drip irrigation (90%)
Type of drip irrigation system used	Manually operated (75%)	Manually operated (59%)
Method of fertilization	Varied	Fertigation (33%)
Fertilisers used	Varied	Varied
Application rate of fertilisers	Varied	Varied
Operated an organised record keeping system	Yes (81%)	NR
Type of recording system	Diary (38%)	NR

2 Traditional: vegetable crop grown in the greenhouse in the soil, on beds without the use of fertigation, a hydroponics system, grow-box system

3 NR: not reported

Table 4 Modal responses to inquiries into crop protection

Line of inquiry	Location	
	Trinidad and Tobago	Manchester, Jamaica
Main insect pest	White flies (14%) No insect pest (14%)	Mites (55%)
Presence of a footbath at the entrance of the greenhouse	Yes (75%)	Yes (50%)
Use frequency of footbath	Sometimes (25%)	NR
Main disease problem	Fungal (24%)	Fungal (81%)
Main weed problem	*Cyperus rotundus* (31%)	No major weed problem (100%)
Main pest control method used	Chemical (31%)	NR
Frequency of main control method used	Once a week (29%)	NR

Fungal diseases were identified as the main disease problems in Manchester, Jamaica (81%) and Trinidad and Tobago (24%). Fourteen percent of the farmers from Trinidad and Tobago reported no disease problems. Nut sedge (*Cyprus spp*.) was reported as the main weed problem in Trinidad and Tobago whereas GHVP from Manchester, Jamaica reported that they had no weed problems.

The use of synthetic chemicals was the main method used to pest and disease problems in Trinidad and Tobago (31%) (Table 4). In Trinidad and Tobago, 29% of the GHVP used synthetic chemicals as often as once a week during the life cycle of the crop to control insect pests to a level below economic threshold.

Marketing

GHVP (31%) from Trinidad and Tobago sold their produce to either the wholesale or the retail market (Table 5). Whereas, GHVP from Manchester, Jamaica used a combination of different marketing avenues including farm gate, wholesale and retail markets, supermarket, and hotel (Table 5). None of the GHVP exported vegetables produced in their greenhouses. In both countries, harvested produce was graded upon request (56%) and mainly (56%) transported to the markets in crates. The GHVP (%) from Trinidad and Tobago were generally satisfied with the prices they received for vegetables. In Trinidad and Tobago, 38% of the GHVP reported tomato as the highest income earner while 31% of the GHVP from Manchester, Jamaica rated sweet pepper as the highest income earner.

Table 5 Modal responses for inquiries into marketing of vegetable crop produced in the greenhouse

	Location	
Line of inquiry	Trinidad and Tobago	Manchester, Jamaica
Market avenues	Wholesale market (31%) Market (31%)	Used a combination of the marketing avenues
Grading of produce	Yes, upon request (56%)	Yes, upon request (56%)
Type of container used to transport vegetables	Crates (56%)	Crates (56%)
Satisfaction with prices of vegetables	Yes (50%)	NR
Vegetable bringing the highest income	Tomato (38%)	Sweet pepper (31%)

Technical information, Perception and Constraints

GHVP (69%) from Trinidad and Tobago received most of their technical information from the Agro-shops while most (59%) of the GHVP from Manchester, Jamaica received most of their technical information from the internet (Table 6). In Trinidad and Tobago, 56% of the GHVP said that they never received technical information from the Ministry of Agriculture, Land and Marine Resources (MALMR) or extension officers, agricultural type development banks, or Universities (Table 6).

Some (50%) of the GHVP from Trinidad and Tobago disagreed that GH farming is only suitable for temperate countries whilst 50% from GHVP Manchester, Jamaica strongly disagreed. The majority (73%) of GHVP from Manchester, Jamaica and only 38% from Trinidad and Tobago strongly agreed that better use could be made of the land by using GH farming (Table 6). GHVP (36%) from Manchester, Jamaica and 50% of the GHVP from Trinidad and Tobago agreed that GH farming will take the drudgery out of agriculture. Only 44% of the GHVP from Trinidad and Tobago agreed that GH farming can attract youth into agriculture whilst 59% of the GHVP from Manchester, Jamaica strongly agreed.

Only 36% of GHVP from Manchester, Jamaica and 44% of the GHVP from Trinidad and Tobago agreed that consumers will readily accept GH produce more readily over produce from traditional farming system. 44% of the GHVP from Trinidad and Tobago and 32 % of the GHVP from Manchester, Jamaica disagreed that all the necessary support is available for GH producers. Lack of adequate finance (50%) was identified as one of the major constraints facing GHPV in Manchester, Jamaica whereas lack of technical

information and technical support (56%) were the major constraints facing GHVP from Trinidad and Tobago. Other major constraints identified by the GHVP from Trinidad and Tobago were excess heat and high humidity (31%).

Table 6 Mode responses for inquiries into the source of technical information, perception, and constraints to greenhouse vegetable production

	Location	
Line of inquiry	Trinidad and Tobago	Manchester, Jamaica
Source of technical information	Agro-shops (69%)	Internet (59%)
Received information from the MALMR, extension officers, agricultural type development banks or Universities.	Never (50%)	Never (50%)
Greenhouse farming is only suitable for temperate countries	Disagree (50%)	Strongly disagree (50%)
Greenhouse farming makes better use of land	Strongly agree (38%)	Strongly agree (73%)
Greenhouse farming will take the drudgery out of agriculture	Agree (50%)	Agree (36%)
Greenhouse farming can attract youth into agriculture	Agree (44%)	Agree (59%)
Consumers will readily accept greenhouse vegetable more readily over vegetable produce from traditional farming system	Agree (44%)	Agree (36%)
All the necessary support is available for greenhouse producers	Disagree (44%)	Disagree (32%)
Major constraints facing GHPV	Lack of technical information (56%) Lack of technical support (56%) Excess heat and humidity (31%)	Lack of adequate finance (50%)
Constraints to greenhouse farming can be easily overcome	Agree (44%)	Agree (36%)
There is a bright future for greenhouse farming	Strongly agree (38%)	Strongly agree (68%)
Likely-hood to continue using greenhouse systems and technology	Very Likely (38%)	Very likely (86%)

Although, only 36% of the GHVP from Manchester, Jamaica and 44% from Trinidad and Tobago agreed that the constraints to GH farming can be easily overcome; 68% from Manchester, Jamaica and 38% from Trinidad and Tobago strongly agreed that there is a bright future for GH farming. Eighty-six percent from Manchester, Jamaica and 38% from Trinidad and Tobago reported that it is very likely that they will continue using the GH systems and technologies.

Discussion

Manchester, Jamaica is located at longitude 77°38'W, latitude 17°51'N and is 626m above sea level and further away from the equator while almost all the GHVP in Trinidad and Tobago, the southern-most (10°50′N 61°55′W) island in the Caribbean, operate at less than 100m above sea level. This means that growers in Trinidad will experience higher temperatures, due to elevation and latitudinal position, than their Jamaican counterparts in Manchester. Trinidadian GHVP (31%) did indicate that the heat and the humidity

were constraints to their operations. The incidence of fungal diseases was a bigger problem in Jamaica than in Trinidad it also gives an indication of the cooler, humid conditions compared to Trinidad.

One of the characteristics of greenhouses for humid tropical climates is that it should have good ventilation efficiency (Von Zabeltitz, 1988) but the installation of insect screens will reduce the ventilation rate as it imparts resistance to air flow. The use of anti-aphid screens in vent openings was found to cause a 33% reduction in GH ventilation rate (N**.** Kasoulas, et al., 2006). GH designs therefore become critical, and in Trinidad and Tobago, designs ranged more widely from dome-shaped, Spanish designs, tropical tunnel types and self-constructed units. Failure to recognize the parameters of location and designs, as they influence crop yields, temperature and humidity levels can lead to varied opinions with respect to performance, adoption or complete rejection of the technology.

In Jamaica, more GHVP are using hydroponics while in both countries; they have opted for crops that attract the best prices, namely sweet pepper and tomato. Hydroponics is more precise with respect to fertilization. Sweet pepper and tomato are tall crops that require considerable amount of handling in terms of pruning (removal of suckers) and providing overhead support. This allows for more optimum use of both the vertical as well as the horizontal space in the GH. It is also very demanding in terms of labour. One of the most striking features between Jamaica and Trinidad however, is that 77% of GHVP in Jamaica operated on a full time basis as against 44% in Trinidad. This is because the majority of GHVP in Jamaica have more than one GH, which they acquired without financial assistance. These situations would explain why 50% of the Jamaican GHVP have availed themselves to some form of training and making use of the internet notwithstanding their field experience. It also indicates that the Jamaican GHVP has probably recognized that the best person to work in a GH is the GHVP him/herself. The frequency of family assistance slightly favours the Jamaican GHVP. Such a comparison begs the question as to whether or not the GHVP from Trinidad and Tobago are still approaching GH production merely as a hobby, depending mainly on advice from the agro-shops, and more importantly, hoping that outstanding loans may be written off as a bad investment. While it cannot be confirmed that this was the intention during the last wave in the '80's, this was the eventual outcome.

Seventy five percent of the GHVP in Trinidad have received no training. The extension officers have not been of much help either. A survey did not reveal any agronomic package provided or formal training programs conducted or planned by the promoting agencies (ADB, NAMDEVCO, NACL, and BDC). Recently, the Extension, Training and Information Services Division of the MALMR in Trinidad, conducted a 3-day workshop on "Shade-house Technology" as part of its staff training program. Staff members of ADB and NAMDEVCO were also invited. Unless the Trinidadian GHVP are exposed to appropriate courses and training materials, they may not be able to fulfill their financial obligations to those who were quick to get their signatures on the dotted line.

Jamaican GHVP (73%) are of the view that better land utilization is possible with the adoption of GH technology when compared to Trinidad and Tobago GHVP (38%). It means that they have recognized the advantages of GH crop production. It also addresses a national issue of the reducing availability of arable lands in small island states. The survey shows that in most other categories, there are close similarities. The majority of GHVP are educated; they see an avenue for the young people to get involved. The Jamaicans were more optimistic about the future of the GH industry and were more likely to continue than their Trinidad counterparts.

GH is a knowledge intensive activity. However, GH producers reported very little training in production using this type of system (Trinidad-75%; Jamaica-50%). This is cause for concern as they are very inexperienced in GHVP (1.5% years) and about half of the producers in both countries (50%) reported never getting very little information from government extension service, development banks or the University. All these factors constitute key ingredients for failure and are similar to the previous wave of greenhouses in the 1980's. Clearly, this area of education and Extension must be urgently addressed if

success is to be achieved this time around. Technical support is rated as a bigger concern than excessive heat and humidity in GH by Trinidad producers and highlights the importance of information for this next generation of producers.

Conclusion

The results of this investigation tend to show that the experiences of this present wave of GH producers as well as the constraints being faced are similar to what occurred in the 1980'S, and this could spell trouble for the industry. GHVP in Manchester, Jamaica appeared to have had a better experience in the reintroduction of GH technology than their counterparts from Trinidad and Tobago. This is reflected in their more favourable attitude to the industry. The crucial elements that are influencing their attitudes need to be investigated to be able to assist their counterparts in the region. However, there is available both in Trinidad and Jamaica, a higher level of technical expertise and experience and this is a significant advantage if this human resource is well connected with the industry. Education, training, and research must be engaged almost immediately if we are to successfully ride this wave of GH production in the region.

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