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Challenges in greenhouse crop production by smallholder farmers in Kisii County, Kenya

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Despite the success in greenhouse farming by large scale horticultural farmers in Kenya, smallholder greenhouse farming is beset by many challenges leading to over 30% failure rates. Reasons for the high failure rate are not clearly understood. The objective of this study was to assess the challenges in greenhouse crop production by small-scale farmers in Kisii County, Kenya and provide recommendations for sustained profitability. Data was collected through structured interviews with 138 greenhouse farmers, and analysed using descriptive statistics, t-test and chi-square. Overall, 48.6% of the greenhouses were non-functional, due to pests and diseases, inadequate supply of water, high investment costs, and insufficient knowledge on greenhouse crop farming. Other challenges included lack of market for the produce, and group dynamics challenges. Most of the abandoned greenhouses were owned by institutions (60.5%) and groups (55.6%), and lesser by individuals (38.2%). Number of years of operation significantly influenced functionality of the greenhouses (p=0.04). Greenhouses owned by individuals had significantly higher probability of being functional, than those owned by groups and institutions (p=0.05). Interventions for enhancing contribution of greenhouses to food security of small-scale farmers should include capacity building of farmers on greenhouse crop production, and linking them to appropriate sources of funding.

Key words: Challenges, greenhouse, small-scale farmers, crops, food security, Kenya.

INTRODUCTION

A greenhouse is a structure with walls and roof made of transparent material, such as glass or plastic, in which plants requiring regulated climatic conditions are grown (Smitha et al., 2016). Greenhouse crop farming has the advantage of offering year-round production of crops, crop protection, increased yields, vegetable production in limited land sizes and superior quality product (Wachira et al., 2014; Nordey et al., 2017). In Kenya, greenhouses

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are commonly and successfully used by large-scale horticultural farms (Justus and Yu, 2014), and are gradually being adopted by small-scale farmers to grow vegetables for food security (Omoro et al., 2014; Sanzua et al., 2018; van der Spijk, 2018).

Despite the success in greenhouse farming achieved by large scale horticultural and floricultural farmers for many years, smallholder greenhouse farming is beset by many challenges leading to the abandonment of some of these greenhouses. High failure rate of greenhouses have been reported in Kenya, ranging from 30 to 70% (Sanzua et al., 2018). Reasons for abandonment are postulated to be many challenges such as inappropriate structures, lack of information and skills in crop and greenhouse environment management, poor postharvest handling and marketing issues. However, the exact reasons for the high rate of abandonment of the greenhouses by smallholder farmers are not clearly understood. There is, therefore, a growing interest amongst development agents to identify and address the barriers currently preventing smallholder greenhouse farming for sustainably enhancing the food security for the poor farmers in Africa. The objective of this study was, therefore, to assess the challenges and constraints in greenhouse crop production by small-scale farmers in Kisii County, Kenya. Understanding the bottlenecks faced by farmers will provide insights on sustainable interventions needed for smallholder greenhouse crop production to increase the production and income of farmers.

MATERIALS AND METHODS

Study area

The study was conducted in Kisii County (Table 1), which lies between latitude 0° 40' 38.4" South, and longitude 34° 34' 46° 61" East (Kisii CIDP, 2018). Kisii County exhibits a highland equatorial climate resulting into a bimodal rainfall pattern with an average annual rainfall of 1,500 mm. The long rains are between March and June while the short rains are received from September to November; with the months of January and July being relatively dry. The maximum temperatures in the County range between 21 and 30°C, while the minimum temperatures range between 15 and 20°C. The high and relatively reliable rainfall patterns coupled with moderate temperatures are suitable for growing crops like tea, coffee, maize, beans, bananas, dairy farming and horticultural farming (Kisii CIDP, 2018). The human population is estimated at 1,260,509 (KNBS, 2019). Most people own small parcels of lands, with farm sizes between 0.2 to 2.1 acres (ASDSP, 2014). Greenhouse crop farming, therefore, has potential for enhancing food security in the County due to the small land holdings.

Sample size and sampling

A sampling frame was developed that gave an indication of where the greenhouses (whether in use or not) were located. This was done in collaboration with the Ministry of Agriculture extension staff in the study site. The list so obtained was enriched further through snow-balling technique, whereby managers of the selected greenhouses were asked to name any other greenhouses they knew of. With approximately 209 greenhouses in Kisii County (Omoro et al., 2014), sample size was determined based on the following equation (Yamane, 1967):

$$n = \frac{N}{1+N(e)^2}$$

where n is the suggested sample size, N is the total number of greenhouses and e is the level of precision, set at 5% for the study. Hence the sample size (n) was set at 138 greenhouses.

Purposive sampling and snowballing technique was used to locate the greenhouses, based on accessibility. Key informants (agricultural extension officers and village elders) assisted in locating the greenhouses. Of the 138 greenhouses, 67 were owned by individual farmers, 20 by farmers groups and 43 by institutions (schools, vocational training centres and religious institutions).

Data collection

Data was collected using a structured questionnaire uploaded on the Open Data Kit (ODK) tool. Enumerators were recruited and trained to map and administer the questionnaires. The data detailed the (i) constraints and challenges in greenhouse farming, (ii) abandoned greenhouses, and (iii) proposed strategies to address the challenges. After detailing the constraints and challenges, the same respondents were asked to suggest probable solutions, based on their experiences.

Data analysis

Quantitative data were analysed using descriptive statistics (frequencies, means, totals and measures of dispersion)-continuous and categorical variables being reported as mean±standard errors and percent, respectively. Chi-square and independent sample t-test were used to compare variables between greenhouses in use and those abandoned, and relationship between abandoned greenhouses and type of ownership. A probability of 5% was considered significant for all statistical analyses. All analyses were done in SPSS (SPSS, 2011). The results are presented in tables, graphs and charts. Qualitative data were summarised into themes. The results are presented under the sub-topics (i) constraints and challenges in greenhouse farming, (ii) abandoned greenhouses, and (iii) proposed strategies to address the challenges.

RESULTS AND DISCUSSION

Constraints and challenges in greenhouse farming

All the respondents reported experiencing constraints in greenhouse crop production. Overall, the main constraints in greenhouse farming were pests and diseases (27.1%), inadequate supply of water (23.1%), high costs of inputs (17.2%) and lack of information on greenhouse farming technology (Table 2).

Pests and diseases

Pests and diseases emerged as the major challenge in

Table 1. Study sites and interviewed respondents in Kisii County, Kenya.

Sub-county	Number of respondents		
	Male	Female	Total
Nyaribari Chache	30	8	38
Bonchari	14	3	17
Bobasi	9	5	14
Kitutu Chache South	6	7	13
Nyamache	7	3	10
Nyaribari Masaba	6	4	10
South Mugirango	6	2	8
Kitutu Chache North	7	1	8
Bomachoge Chache	2	5	7
Gucha	5	1	6
Kenyenya	3	1	4
Bomachoge Borabu	2	1	3
Total	**97**	**41**	**138**

Table 2. Ranked challenges in greenhouse farming, in Kisii County, Kenya.

Constraint	% ranking			
	Individual	Groups	Institutions	All
Pests and diseases	26.3	33.3	24.4	27.1
Inadequate supply of water	22.6	22.2	24.4	23.1
High cost of inputs	19.7	20.4	12.2	17.2
Lack of scientific information on greenhouse farming	9.5	5.6	12.2	9.5
Lack of market for produce	8.7	7.5	2.4	6.6
High investment cost	5.1	1.9	1.2	3.7
Group dynamics challenges	1.5	7.4		2.2
Inability to regulate temperature in the greenhouse			6.1	1.8
Poor quality of construction material	0.7	1.9		0.7
Unavailability of quality planting material	0.7		3.7	1.5
Inability to restrict entry into the greenhouse	0.7		3.7	1.5
Non availability of skilled labour	2.2		2.4	1.9
Lack of irrigation piping material	1.5			0.7
Theft and insecurity			2.4	0.7
Poor soils			1.2	0.4
Soil testing			1.2	0.4
Pump maintenance			1.2	0.4
Maintenance of polythene			1.2	0.4
Destruction by wind	0.7			0.4
Total	100.0	100.0	100.0	100.0

smallholder greenhouse crop production in the study area. The pests and diseases varied with the type of crop grown in the greenhouse. The main crop grown in greenhouses in the study area was tomato. Major tomato pests included tomato leaf miner, white flies, aphids, cutworms, thrips, spidermite and African bollworms. Major diseases of tomatoes in Kenya are late blight, early blight, bacterial wilt, Fusarium wilt, bacterial spot and powdery mildew, among others. Previous studies in Kenya also identified pests and diseases to be a major challenge in greenhouse crop production by small-scale farmers in Kenya (Anon, 2011). This, however, contrasts studies in other countries which found pests and disease to be the least problem in greenhouse crop production (Senthilkumar et al., 2018).

Generally, pathogens and insects can be established in a greenhouse very fast. Compared to open field cultivation where many environmental factors come into

play, pathogens and insects inside a greenhouse are difficult if not impossible to control. The best strategy is prevention. For greenhouses that are covered with plastic, the use of ultraviolet-absorbing plastics can reduce insect problems (Wambui, 2012). Good management includes the use of resistant varieties and biological pesticides that are used in organic production. However, this study also found that these are expensive for the smallholder farmer.

Inadequate supply of water for irrigation in the greenhouse

Inadequate supply of water for irrigating the greenhouse crops was the second most important challenge for greenhouse crop production. Whereas greenhouse crop production is destined to use less water compared to open field vegetable cultivation (Wambua and Mutua, 2014), farmers in the study region experienced serious water problems in their greenhouse operations. The main source of water used in the greenhouses were borehole (32.3%), harvested rain water (32.3%) and river (27.9%). The farmers did not take the irrigation water for testing for pathogens and chemical contaminants. This could be another source of the soil-borne pathogens such as bacterial wilt and Fusarium wilt (Aloyce et al., 2017; Stewart-Wade, 2011).

High cost of inputs

The high cost of inputs was another challenge faced by farmers. This included the high upfront cost of establishing the greenhouse and the maintenance costs (costs of seeds, fertiliser, water, pesticides, etc.). Greenhouse production is a capital-intensive technology requiring a substantial investment especially during the initial establishment period. Kassamjee (2010) found that price was a significant factor deterring farmers from buying greenhouse kit. Initial capital investment for establishing the greenhouses in the study area was at least US$ 1200, which may be hardly unaffordable by majority of small-scale women farmers whose incomes are low. This led to many farmers making their greenhouses using locally available material such as wood. Whereas use of locally available materials could have resulted in low investment and running costs, it may have compromised on efficient control of operations and performance, as has been reported by previous studies (Baille, 1999; Nordey et al., 2017).

Inadequate knowledge on greenhouse crop production

Most of the farmers also faced the challenge of inadequate knowledge on greenhouse crop production. Farmers lack information on appropriate structures, type of covering materials, agronomic practices, management of greenhouse environment, postharvest handling and marketing aspects. Discussion with farmers revealed that the greenhouses were introduced without farmers being trained on how to manage and run the greenhouses. Hence most of farmers have ended up facing limitation in selecting right materials, and other inputs for greenhouse farming. Therefore, failure of some farmers has discouraged others who are yet to adopt the technology to delay waiting to have a complete awareness of the technology which is yet to be effectively offered. Proper management and the right technical skills are important for successful greenhouse farming (FAO, 2013). Production of crops under greenhouse conditions is highly knowledge and skill intensive. Adequate knowledge enables effective use of the technology. However, farmers in the study find it difficult to get latest information and techniques on crop production under greenhouses. It has been established that extension staff farm visit frequency had a significant effect on performance of greenhouse by smallholder farmers in the region (Omoro et al., 2015). While information from suppliers is useful, it is essential that farmers have unrestricted access to unbiased technical information. Technical support for greenhouse farming and its adoption in the study region remains limited.

Unavailability of quality planting material

This related mainly to certified seeds and seedlings, and the right seeds for greenhouse crop farming. Other challenges faced by farmers related to procurement of nutrients and chemicals. Agro-dealers do not stock these locally. Most agro-dealers in the region stock supplies which are used in open field agriculture and not greenhouses. Seeds, seedlings and greenhouse inputs had to be sourced from certified nurseries in Nairobi, over 400 km away. This took quite some time, at least over one month. Lack of planting material was cited as one of the factors hindering adoption of greenhouses by smallholder farmers in Kenya (van der Spijk, 2018).

Abandoned greenhouses

These challenges led to some of the greenhouses being abandoned. Overall, 48.6% of the greenhouses had been abandoned because of the challenges. This finding corroborate the finding of Sanzua et al. (2018) who reported high failure rate of smallholder greenhouses in Kenya, ranging from 30 to 70%. Most of the abandoned greenhouses in the present study were owned by institutions (60.5%) and groups (55.6%), and lesser by individuals (38.2%) (Table 3). Number of years of

Table 3. Characteristics of functioning and abandoned greenhouses in Kisii County, Kenya.

Continuous variables		Functioning Greenhouses (n=71)*	Abandoned greenhouses (n=67)	*p*-value	*t*-value
		Mean±SE**	Mean±SE		
Years of operating the greenhouse		3.2±0.3	4.2±0.4	0.04	-2.03
Number of greenhouses owned		1.2±0.1	1.1±0.1	0.35	0.94
Categorical variables	**Category**	**%**	**%**	***p*-value**	**χ^2-value**
Gender of respondent	Male	74.6	65.7	0.25	1.33
	Female	25.4	34.3		
Ownership of greenhouse	Individual	61.8	38.2	0.05	5.87
	Group	44.4	55.6		
	Institution	39.5	60.5		
Membership to production or marketing group	Yes	21.4	15.4	0.54	0.38
	No	78.6	84.6		

*n=number of respondents per site; **SE = standard error of the mean.

operating the greenhouse significantly influenced the functionality of the greenhouses (p=0.04), with greenhouses established earlier having more likelihood of being functional. This could be due to the fact that farmers with more experience seem to have more knowledge and are better placed to cushion themselves against any adverse effects (Ozor and Nnaji, 2020). Type of greenhouse ownership also had a significant effect (p=0.05) on the functionality of the greenhouses, with greenhouses owned by individuals having higher probability of being functional (Table 3). This could be due to the fact that the risk was high for individuals who, therefore, were keen in managing their greenhouses as opposed to groups and institutions who could be engaged in wrangles due to group dynamics, thereby negatively affecting the performance of the greenhouses.

Proposed strategies to address the challenges in smallholder greenhouse farming

Pests and diseases

For pests and diseases, the main method suggested by farmers (55.5%) was use of chemicals (Table 4). This implies that pesticide use could by high in greenhouses. Whereas this study did not evaluate pesticide residues in greenhouse crops, previous studies detected pesticide residues in greenhouse crops consumed in the country (Kinyunzu 2015; Nguetti, 2019). Pesticide use in greenhouses is expected to be lower than open field cultivation, as greenhouses are constructed to grow crops in a protected growing environment (Nordey et al., 2017; van der Spijk, 2018). The fact that farmers encountered this challenge is an indication that knowledge needed in greenhouse farming is not adequate, as has been reported in this paper among the challenges experienced. Other suggested methods for dealing with pests and diseases included soil treatment using steam and water, and appropriate training on greenhouse management. Soil sterilisation using steam and water has been effective in killing soil-borne pathogens and nematode pests (Loenen et al., 2003; Luvisi et al., 2008).

Inadequate supply of water

The main strategies for addressing the challenge of inadequate supply of water included rain water harvesting and storage in tanks, collecting water from the river, and drilling boreholes (Table 5).

High cost of inputs

The main strategies for addressing high cost of inputs included acquiring inputs on credit, making savings, government subsidising inputs and getting donations from government and NGOs (Table 6).

Lack of sufficient information on greenhouse farming

The main strategies for addressing the challenge of insufficient information on greenhouse farming were appropriate training of farmers on greenhouse crop production, seeking advice from extension officers and experienced farmers (Figure 1). Knowledge on greenhouse crop production can be transferred to farmers through training of extension agents and farmers. There should also be increased extension services to

Table 4. Suggested solutions (in ranked order) for addressing pests and disease challenge in greenhouse farming in Kisii County, Kenya.

Solution	Rank (Percentage)
Spraying chemicals	55.5
Soil treatment using steam and water	12.1
Appropriate training on greenhouse management	7.4
Seek help from extension officers	5.6
No way to cope / no steps taken	3.8
Borrow from friends and relatives	2.8
Soil testing	1.9
Make savings	1.9
Plant certified sees	0.9
Contribute money to buy pesticides	0.9
Plant tolerant varieties	0.9
Crop rotation	0.9
Working in the greenhouse by self (taking time in the greenhouse)	0.9
Using new techniques to improve, e.g. using black polythene for planting	0.9
Leaving the greenhouse without crop for 2 years	0.9
Planting crops at the right time	0.9
Use insect traps	0.9
Plant onions around the greenhouse	0.9
Total	**100.0**

Table 5. Suggested solutions (in ranked order) for the challenge of inadequate water supply in greenhouse farming in Kisii County, Kenya.

Solution	Rank (Percent)
Harvest rain water and store in tanks	26.1
Collect water from the river	25.2
Drilling borehole	23.4
Buy water	4.5
Use available water supply sparingly	4.5
Piped water from municipal	4.5
Government to subsides inputs	2.7
Make savings	2.7
No way to cope / no steps taken	1.8
Fencing	0.9
Seek help from extension officers / specialists	0.9
Spraying	0.9
Shifted the greenhouse from its original location	0.9
Manual application of water using buckets	0.9
Total	**100.0**

greenhouse farmers, as it has been found that frequency of extension staff visit had a significant effect on performance of greenhouses in the region (Omoro et al., 2015).

For the challenge of lack of market, suggested solutions included carrying out market research, marketing the produce to far distance, and targeting production to coincide with the time when prices are high. For the high cost of establishing greenhouse structures, suggested strategies included government subsidy on greenhouse inputs, donation of greenhouses by development agents, acquiring inputs on credit and constructing greenhouses using cheaper locally available materials. As earlier pointed in this paper, use of locally available materials

Table 6. Suggested solutions (in ranked order) for addressing the challenge of high cost of inputs in greenhouse farming in Kisii County, Kenya.

Solution	Rank (Percentage)
Acquire inputs on credit	22.8
Make savings	17.5
Government to subsidise inputs	12.3
Donation from Government and NGOs	12.3
Use manure	7.0
Contribute money to buy pesticides	5.3
No way to cope / no steps taken	3.5
Working in the greenhouse by self (taking time in the greenhouse)	3.5
Seek help from extension officers / contact specialists, technicians	1.8
Go for cheaper inputs	1.8
Developing wooden structure	1.8
Set funds aside for greenhouse management from Institution kitty	1.8
Cooperation from group members	1.8
Improvising the natural one	1.8
Use ITK	1.8
Own manufacture of planting bags	1.8
Support from spouse business	1.8
Total	**100.0**

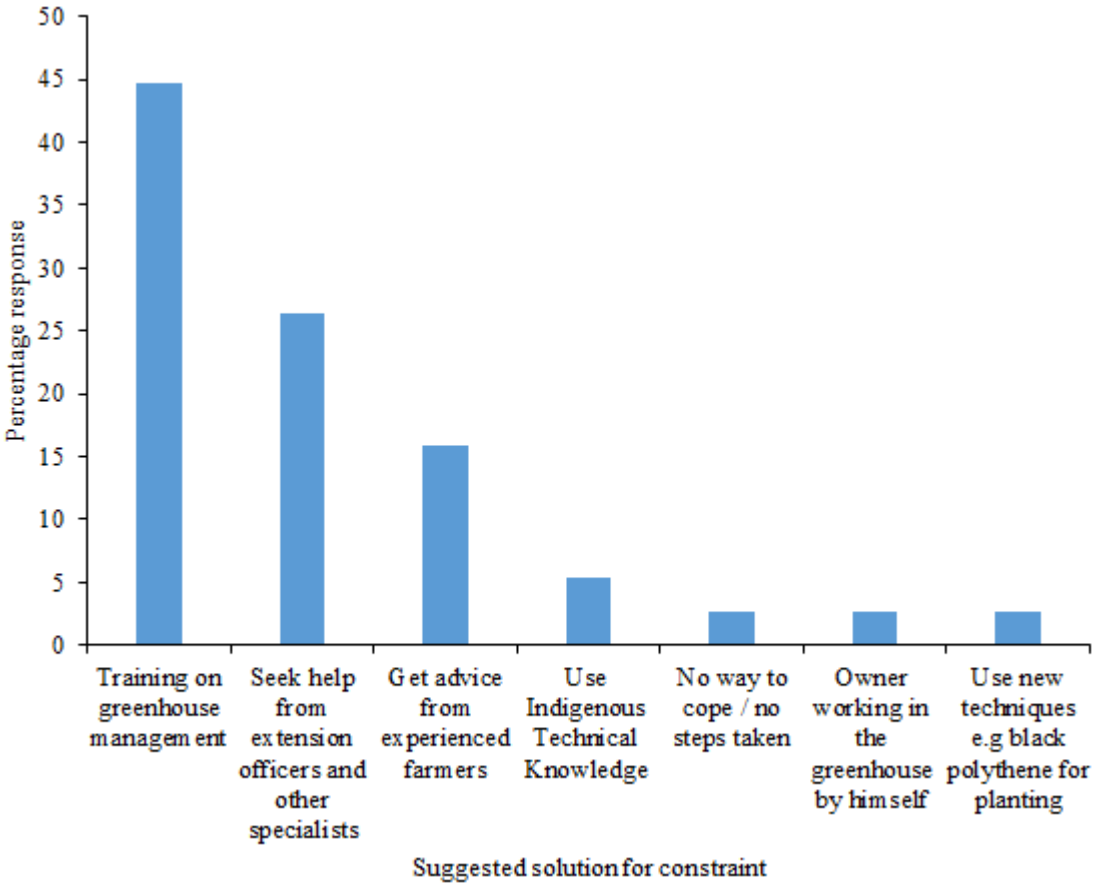

Figure 1. Suggested solutions for addressing the challenge of lack of information on greenhouse crop farming in Kisii County, Kenya.

could have resulted in low investment and running costs, but also compromised on efficiency of the greenhouses, as has been reported by previous studies (Baille, 1999; Nordey et al., 2017).

Conclusions

This study has shown that smallholder greenhouse farmers face several challenges and constraints, which prevent the farmers from realising full benefits from the technology. The main constraints include pests and diseases, inadequate supply of water, high initial costs for establishing and operating the greenhouses, and insufficient knowledge on greenhouse crop farming. Primary interventions for revitalising smallholder greenhouse farming include linking farmers to appropriate sources of funding to acquire the funds to construct and operate the greenhouses, and capacity building of farmers on greenhouse crop farming. Such trainings should ensure that the workers involved in greenhouse activities are invited, and not necessarily the owners of the greenhouses. This is important to ensure the knowledge gained is applied to improve the greenhouse production. There should be follow-up extension visits to farmers. There is also need to organise study tours for farmers to successful areas, especially large-scale horticultural farmers.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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