



library@chuka.ac.ke; www.chuka.ac.ke

Improvement of sustainability and profitability of high tunnel tomato production through dissemination of technologies, knowledge and information.

Mbaka, J., Gitonga, J., Gathambiri, C., Mwangi, B.G., Mwangi, M. and Githuka, P.

¹Kenya Agricultural and Livestock Research Organisation, Kandara, P. O. Box 220-01000, Thika

²Ministry of Agriculture, Mwea East Sub-County, Kirinyaga County

³Kenyatta University, P. O. Box 43844-00200, Nairobi

⁴ Kenya National Farmers Federation, Farmers Conference Centre, Thogoto, P. O. Box 43148-00100, Nairobi

Email: jesca.mbaka@kalro.org, jnmbaka@yahoo.com

Citation

Mbaka, J., Gitonga, J., Gathambiri, C., Mwangi, B.G., Mwangi, M. and Githuka, P. (2016) Improvement of sustainability and profitability of high tunnel tomato production through dissemination of technologies, knowledge and information: Isutsa, D.K. and Githae, E.W. 2016. Proceedings of the Chuka University 2nd Annual International Research Conference held in Chuka University, Chuka, Kenya from 28th to 30th October, 2015. 94-102pp.

ABSTRACT

Tomato (*Solanum lycopersicum* L.) is an important income generating crop in high potential rural areas as well as in the peri-urban areas where availability of farming land is a constraint. Production is mainly by smallholder farmers and has been conventionally under open field conditions until recently when production under modified high tunnels, popularly known as ‘greenhouses’, was pioneered by a few farmers and has gained massive adoption in the last decade. The rapid growth in adoption and uptake of the high tunnel innovation has spawned numerous local enterprises that are fabricating and vending tailor-made tunnels for horticultural purposes. However, implementation of the high tunnels is under serious threat by many biotic and abiotic factors. Early adopters abandon the technology while others get into it. A study was conducted in Embu and Kirinyaga Counties to identify the knowledge and technology gaps that threaten sustainability of the innovation. The most serious threats to sustainability of the high tunnel innovation for tomato production were: bacterial wilt caused by *Ralstonia solanacearum*, insect pests such as whiteflies (*Bemisia tabaci*), poor construction and limited knowledge on management. The Farmer Field Schools were used to train farmers on tomato production in the high tunnels. Parameters considered included: establishment of healthy seedlings in germination trays with coco-peat, solarisation and grafting against soilborne pests, pest identification, scouting and management, post-harvest handling and value addition. Production increased by 80% leading to adoption of the technology. Dissemination of the high tunnel production should always be accompanied with training on management.

Keywords: Dissemination, Grafting, Greenhouses, Pests, Sustainability, Tomato

INTRODUCTION

Tomato (*Solanum lycopersicum* L.), over the past decade has gained importance as an income generating crop in high potential rural areas as well as in the peri-urban areas where availability of farming land is a constraint. Tomato was ranked first in the prioritization of vegetable crops value chains in Kenya (KARI, 2011). In 2013, the area under tomato production nationally was estimated at 23.82 thousand hectares producing 494.04 thousand metric tons valued at KES 14.1 Billion (HCDA 2013). The crop is grown in almost all the counties of Kenya and performs best in mid altitude areas at 1150- 1800 meters above sea level (KARI, 2006). To enhance profitability and sustainability of vegetable production enterprises, utilization of agricultural innovations is a necessity. Innovations are seen as extending beyond new technologies to include new skills and ways of organizing along the value chain.

Tomato production is mainly by small holder farmers and has been conventionally under open field conditions until recently when production under modified high tunnels popularly known as ‘greenhouses’ was pioneered by a few farmers and has gained massive adoption in the last decade (Waiganjo et al., 2010). This innovation has to a large extent been driven by the private sector with Amiran Company leading in design, manufacturing and sales of the high tunnels. As an indicator of its success, the high tunnel technology has become a major export product for the main vendor, Amiran Company limited. The rapid growth in adoption and uptake of the high tunnel innovation has spawned numerous local enterprises that are fabricating and vending tailor made tunnels for horticultural purposes.

Gender roles in the tomato value chain are apparently disaggregated with men undertaking most of the manual activities while women carry out operations that require precision. In the marketing segment of the chain, transportation and wholesale operations are dominated by the youth (mainly young men) while retailing operations are done by both men and women (Ndungu et al., 2004). The shift to the highly specialized commercially lucrative high tunnel production system has the potential to attract more highly trained youth to horticultural farming since the innovation is perceived to be smart, modern and a cutting edge technology. Development and aggressive implementation of a targeted marketing campaign by the main innovation vendor (Amiran), and pursuit of strategic linkages with microfinance institutions targeting women and youth, and partnering with relevant government ministries and NGOs has contributed to enhance uptake and adoption of this technology. The high tunnel production system saves space which is advantageous in the context of dwindling arable farm sizes. It is also less labour intensive

and would be favorable to the increasing category of senior citizens who can be gainfully active in farming after retirement from formal employment especially in the urban and peri-urban settlements.

Unfortunately, the great promise of success that is possible through implementation of the high tunnel and other agricultural innovations is under serious threat by pests and diseases. By far, the single most serious threat to utilization of the high tunnel innovation for tomato production is bacterial wilt caused by *Ralstonia solanacearum* (Coutinho, 2005; Loreti et al., 2007). Under open field production conditions, areas with high rainfall are unsuitable for tomato production due to prevalence of fungal diseases such as late blight (*Phytophthora infestans*) and early blight caused by *Alternaria solani* (Jones et al., 1991). These diseases are no constraint under high tunnels because the environment is controlled to an extent. In addition, even under open field conditions, fungal diseases have been effectively controlled by use of fungicides, while bacterial wilt relies on crop rotation and use of plant resistance. Whiteflies (*Bemisia tabaci*) are a serious pest but these are effectively excluded by insect proof mesh (Waiganjo et al., 2010).

Crop rotation is rendered ineffective due to diminishing land sizes and the long survival of the bacteria wilt pathogen in water, plant debris and soil (McCarter, 1991). Soil sterilization whether using chemical or organic fumigants or by use of the solar energy in a process referred to as solarization offers effective control. However this is not sustainable due to possible re-introduction of the pathogen during farm operations. Plant resistance remains one of the effective options of bacteria wilt management but this is limited by lack of resistant varieties with the other traits with high market demand. Efforts are now in early stages to explore opportunities for using grafted seedlings mainly by grafting superior cultivars on wilt resistant rootstocks (King et al., 2008). Activities to improve the sustainability and profitability of the high tunnel tomato production were undertaken between 2012 and 2014 in Embu and Kirinyaga Counties. This paper describes how the baseline was established, what constraints were identified, what interventions were undertaken, the impact thereof and suggestions for future work.

METHODOLOGY

Knowledge and technology gaps were identified through structured interviews with individual farmers or farmer groups and visits to 40 high tunnels in Embu and Kirinyaga Counties. This was done by a multidisciplinary team (pathologist, entomologist, food scientist, social economist and agronomist) from KALRO, KU, KENFAP and MOA. The identified gaps were addressed through dissemination of technologies, knowledge and information through farmer training (Farmer Field Schools-FFS).

FINDINGS

The major constraints identified were:

1. Poor construction of high tunnels (Fig. 1a and b)

Due to the popularity of the innovation, some farmers rushed to have high tunnels constructed with poor material and the structures ended up collapsing during the rains. Most of the farmers did not perceive the essence of adopting the innovation. Most claimed to have read in the internet, introduced by the vendors and heard of the high tunnel production system from neighbors and friends. At the time of the survey, none of the farmers was utilizing the structures profitably and some had abandoned them despite the capital expenditure of between KES 250,000 and 800,000 to establish them (Fig 2a and b).

2. Pests and diseases

Bacterial wilt was identified as the most binding constraint to the success of high tunnel tomato production in the project areas. Although most of the farmers knew of the disease, very few knew its epidemiology and mode of spread. The main mode of spread was identified as irrigation water from rivers, infected seedlings, farm equipment and workers' and visitors' shoes. Infection occurred at all crop growth stages (Fig 3a and b). Whiteflies (*Bemisia tabaci*) and aphids (*Frankliniella occidentalis*) were the major arthropod pests.



Fig. 1.a: Wrong material for construction



Fig. 1.b: Improper entrance



Fig. 2 a: Abandoned structure used for drying maize



Fig. 2b: A totally abandoned high tunnel



Fig. 3a: Bacterial wilt at fruit stage



Fig. 3b: Bacterial wilt at harvesting stage

3. Intervention

Capacity building of farmers on high tunnel vegetable production was conducted through in house trainings and farmer field schools. The in house training were power point presentations on: The essence of high tunnel production; identification and management of pests and diseases in high tunnels; Agronomic practices in high tunnel tomato production; principles of high tunnel as an integrated management (IPM) tool in vegetable production, record keeping and post-harvest handling. Practical training was done using the farmer field school (FFS) model and dubbed “walking with the farmer from land preparation to harvesting”. Eight farmers from the two counties were selected for training as trainers. The course content included the following:

a) Factors to be considered when establishing a high tunnel

The trainees were taken through the essence of adopting the technology as:

- To economize on land-there should be maximum yields of high quality per unit area
- Efficient use of irrigation water –the drip system makes irrigation precise and avoids losses
- Production all the year round- the farmer can sell all year round hence maximizes on profit when conventional growers are off season
- Reduced incidence of pests and diseases-the double exclusion door, the insect proof netting and the foot bath should be included to keep away insects and disease soil borne pathogens (Fig. 4).
- Roll-up and ventilation to be used for temperature regulation and reduction of fungal diseases
- Farmers who had already constructed high tunnel were advised to make modifications, those who were intending to have them were connected to vendors who would construct the right ones for them.



Fig. 4: A properly set high tunnel with double exclusion door, foot bath, insect proof net and roll ups

b) Solarization

Solarization was considered the most effective and environmentally method to reduce bacterial wilt pathogen, nematodes, arthropod pest populations and weed seeds in the high tunnels. This was done together with the farmers for ease of adoption. Soil was well tilled, beds prepared, watered and covered with a 500 gauge transparent polythene sheet for eight weeks (Fig. 5 a and b). Solarization was considered effective when no weeds were observed under the polythene sheet in the eight weeks period.



Fig. 5a: Land preparation



Fig. 5b: Solarization

c) Establishment of pathogen free seedlings

The danger of introducing bacterial wilt and nematodes through seedlings raised on soil media was emphasised to the farmers. They were then trained on raising seedlings in germination trays with coconut waste (Fig 6) or sterilized soil in nursery beds. The trays and the coconut waste are available from agro-vet dealers countrywide.



Fig6: Establishing seedlings in germination trays with cocopit

d) Transplanting

The seedlings in nursery beds or germination trays are watered thoroughly prior to transplanting. Transplanting was done using a trowel or a panga. When moving plants from the nursery bed, it was ensured that their roots were protected with a ball of soil - this lessens transplanting shock. Transplanting was best done in the evening when the weather was cool. Transplanting was done directly into well watered prepared holes (Fig.7). Spacing ranged from 60x45 cm (single stem training), or 60x60 cm (double stem training).



Fig. 7: Farmers being trained on transplanting

e) Nutrient management

The general principle was to apply phosphate fertilizer as basal dressing for root development. For this, Diammonium phosphate (DAP) or Triple superphosphate (TSP) was used at the rate of 150 kg/ha (10 g/hole). After transplanting, either Urea or Calcium ammonium nitrate (CAN) was used for leaf establishment. Urea was applied 2-3 weeks or CAN one month after transplanting. Both are applied at the rate of 200 kg/ha (12g/plant). At the onset of flowering, top dressing with NPK (17-17-17) at 200 kg/ha (12g/plant) for the supply of N, P and especially K needed for flowering was done. The NPK top dress was repeated after the first harvest. To correct micro-nutrient deficiencies, foliar feeds were applied at least once a month. Calcium fertilizer was incorporated into the nutritional program because inadequate calcium could lead to blossom end rot disorder.

THE IMPACT

With the adoption of the disseminated technologies, knowledge and information, there was rekindled hope in the high tunnel innovation adoption among the farmers. Bacterial wilt was reduced by 60-80% (Fig. 8) where there was initial inoculum and was excluded in high tunnels that had none earlier. Yields

increased from near zero to an average annual production 10 to 12.5 metric tons translating to an income of KES 400,000 to 600,000 in a standard 8 by 15 meter high tunnel.



Fig 8: a) Well managed vegetative crop



Fig: 8b) Crop at early harvesting

One of the people we trained in Embu County was a young man, has since become a successful high tunnel vegetable farmer, a trainer and a vendor of the structures. After ‘walking’ with him from land preparation to harvesting, he felt confident to not only train others but also venture into fabrication of the high tunnels to make them affordable. In his own 8 by 15 m high tunnel after the training, he made a profit of KES 846,000 between June 2013 and April 2014.

Meanwhile in August 2013, we wrote an article that was published online by <http://www.farmbizafrika.co.ke> covering the work done by KARI-Thika on high tunnel tomato production. This gave him visibility and farmers started contacting him from many corners of the country and neighboring countries. His structures can remain intact for 5 years. Unlike other vendors he also gives technical backstopping for his clients and liaises with KALRO, Kandara Crop Protection Section when faced with a pest problem unique to him. This has led to increased yields and quality of tomatoes (Fig 9).



Fig. 9: High yielding tomatoes in two different high tunnels

In this way the ‘ripple’ effect of the knowledge imparted by KALRO Kandara staff has reached more people and more regions (Table 1) and contributed to the sustainability and profitability of the high tunnel innovation.

Table 1: Construction of demanded high tunnels by County (August 2014 to March 2015)

S/no	County	Size of high tunnel	Number of Units	Earning from construction (KES)
1	Embu	8 × 30 m	3	240,000
2	Isiolo	8 × 30 m	2	160,000
3	Kajiado	8 × 30 m	1	80,000
4	Nyeri	8 × 17 m	1	40,000
5	Kitui	8 × 30 m	1	80,000
6	Kiambu	8 × 15 m	3	120,000
7	Nairobi	8 × 20 m	1	40,000
8	Machakos	8 × 20 m	1	50,000
9	Muranga	8 × 20 m	1	50,000
10	Tharaka Nithi	8 × 30 m	1	80,000
11	Tororo, Uganda	8 × 15 m	1	40,000
	Total		16	980,000

CONCLUSION

At the start of this activity, the team was wondering if the high tunnel innovation was worth investing in. However from experiences gained from the work undertaken, it is concluded that in the dwindling of arable land sizes, limited irrigation water, increased urbanization and food and income scarcity, the innovation is the way to go. However massive capacity building of farmers through training should be embraced. The venture is only successful if a farmer involved is ready to acquire the skills and practice them because if one does not put them into practice then he stands to lose as there will be no increased yields. This is mostly common with people who do not want to practice farming on their own and depend a lot on workers and yet workers sometimes are not passionate about what they are doing. The innovation has a big potential to attract the youth to agriculture as it is looked at as a smart cutting edge technology.

RECOMMENDATION

The KALRO, Kandara team that worked in Embu and Kirinyaga and made the reported impact would appeal to any willing donors to fund a replication of the same to other counties. A recent visit on another program by some members of the team to Western and Rift Valley regions established similar problems with the ‘greenhouse’ innovation. While the county Governments in those areas are busy investing in the structures, the vendors are not able to give effective technical backstopping. There is need for synergy in collaboration to make the innovation sustainable and profitable.

ACKNOWLEDGEMENTS

The authors appreciate NACOSTI for funding, KALRO, Kandara for logistical support and farmers for being receptive.

REFERENCES

- Coutinho, T. A. 2005. Introduction and prospectus on the survival of *R. solanacearum*. Pages 29-38 in: Bacterial wilt disease and the *Ralstonia solanacearum* species complex. Allen, C., Prior, P., and Hayward, A. C., eds. APS press, St. Paul, M. N.
- HCDA. 2013. Horticultural Crops Development Authority, Validated Report 2013.
- Jones, J. B., Jones, J. P., Stall, R. E., Zitter, T. A. 1991. Compendium of Tomato Diseases. APS Press, Minnesota, USA.
- KARI. 2006. Kenya Agricultural Research Institute 2006, Annual Report
- KARI. 2011. Vegetable Crops Sub-Sector Analysis Workshop Report
- King, S. R., Davis, A. R., Liu, W. G., and Levi, A. 2008. Grafting for disease resistance. HortScience. Pg 1673-1676
- Loreti, S., Kiori, L.M., de Simon, D., Falchiz, G., Galetti, A., Schiaffino, A. and Ena, S. 2007. Bacterial wilt caused by *Ralstonia solanacearum* in Italy. New Disease Reports 15: 44

McCarter, S. M. 1991. Bacterial wilt. Pages 28-29 in: Compendium of tomato diseases. Jones, J. B., Jones, J. P., Stall, R. E., and Zitter, T.A., (eds). APS Press Publisher: St. Paul, M. N.

Waiganjo, M.M. Mbaka, J.N., Gathambiri, C.W., Gitonga, J, Kleinhenz, M. and Gikaara D. 2010. Survey of tomato pests and diseases in Kirinyaga district, in IPM-CRSP Annual Report, 2010
