ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2021; 21(2): 17560-17580 https://doi.org/10.18697/ajfand.97.19905

PRACTICES AND CONSTRAINTS OF TOMATO PRODUCTION AMONG SMALLHOLDER FARMERS IN UGANDA

Ddamulira G[1]*, Isaac O[1], Kiryowa M[1], Akullo R[1], Ajero M[1], Logoose M[1], Otim A[1], Masika F[1], Mundingotto J[3], Matovu M[2] and I Ramathani[1]

Ddamulira Gabriel

*Corresponding author email: ddamuliragab@yahoo.co.uk

[1]National Crops Resources Research Institute, Kampala, Uganda

[2]National Agricultural Research Laboratories, Kampala, Uganda

[3]Kyambogo University Kampala, Kampala, Uganda

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

ABSTRACT

Tomato (*Solanum esculentum*) is one of the most promising vegetables whose production is being intensified in Uganda. However, tomato yields remain low due to several constraints. The study aimed at identifying production and marketing practices, and constraints affecting tomato productivity in major tomato growing areas of Uganda. A survey was conducted in eight major tomato producing districts using a questionnaire to guide interviews for 240 farmers and 16 key informants. The data were analyzed using SPSS software. Results revealed that tomato production in Uganda is dominated by males who grow them on 0.68 acres of land on average. Most tomato farmers (78.4%) use mono cropping system with varieties Asilla F_1 (35.3%), Tengeru97 (21.1%), Rambo (18.1%), Novela F_1 (17.7%) and Riogrande (10.3%) dominating. The choice of tomato varieties used by farmers mainly depend on yield potential, pest and disease tolerance and market preference attributes such as long shelf life. In the study area, tomato is mainly fertilized using foliar fertilizers, followed by Diammonium phosphate and cattle manure. The key pests affecting tomato include caterpillars, thrips, worms and whitefly, while bacterial wilt, blight, leaf spots and viral infections are the major diseases. Majority (95.7%) of farmers use chemical sprays (pesticides and fungicides) and 4.3% of farmers used other control methods. The other methods of pest and disease control included rogueing, hand picking, ash, organic extracts, urine and frequent weeding. Average tomato yield was 4,846.3 kg/acre lower than the potential yield of 6000kg/acre. Thirty five percent of farmers market their tomato individually on-farm, 32.8% sell in rural markets, while 32.2% send to the nearest urban markets. The study revealed intensive chemical use accounting for 20% of the production costs, high seed costs (11%) and drought (10%) as the major production constraints impeding tomato production; and price fluctuations, low prices, high transport costs, post-harvest loss on farm, and poor market access as the major marketing constraints. The research findings will aid in the development of new market-oriented, highly productive tomato varieties with improved access to seed and designing initiatives to address production and marketing constraints, which will eventually enhance tomato production.

Key words: Agricultural inputs, Cropping systems, Marketing, *Solanum esculentum*, vegetable production

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

Tomato (*Solanum esculentum* .L), is among the most widely grown vegetables globally with an estimated annual production of 182 million tons from 4.8 million hectares [1]. The crop is ranked sixth among the most consumed crops worldwide [2]. Africa alone produces 21 million tons from 1.3 million hectares [1]. In East Africa, 1.9 million tons of tomato are produced annually with Tanzania and Kenya leading as producers followed by Uganda [1].

In Uganda, 40,124 tons of tomato are produced from 6,671 hectares. The crop is mainly grown by smallholder farmers who sell the fresh fruits in regional and domestic markets in their localities to generate income [3]. It is also a reliable source of food security and employment for on- and off-farm. As such, it is regarded as an economic crop for rural and peri-urban farmers [4]. In Uganda, tomato is consumed by about 3 million households in their most meals due to their nutrition value [5, 6]. It can be processed and combined in many different dishes and eaten in different ways, such as tinned paste, fresh vegetable, tomato juice, sauce, or soup [7]. Tomato is known for its nutritive value; it is rich in vitamin C and contains lycopene, a very vital antioxidant which prevents cancers [8].

In the last decade, Uganda has experienced an increase in population resulting in an increased demand for food including tomato [9]. Indeed, the increase in regional markets (like South Sudan and Rwanda) is also responsible for increasing demand for tomato at regional level. This has caused a shortage of tomato in the domestic market. However, in the recent past, the short supply in tomato within the domestic market has provided an opportunity for smallholder farmers to engage in tomato farming, which has led to 14.8% increase in production [1]. The increase is attributed to conversion of new areas for tomato production rather than increment in yield per unit area. Hence, tomato yields per unit area remain as low as 4 t ha^{-1} compared to potential yield of 16 t ha^{-1} for the East African region. However, over the last few years tomato production in Uganda has intensified with the introduction of high yielding varieties such as Asilla F_1 and Tengeru97; however, yields continue to be low at 6 t ha^{-1} compared to potential yield of 16 t ha^{-1} for the East African region.

The low tomato yield is mainly attributed to biotic and abiotic factors [10]. Biotic factors of notable economic importance in tomato production comprises of pests and diseases. Bacteria wilt (*Ralstonia solanacearum* Smith), tomato yellow leaf curl virus disease, early and late blight (*Alternaria solani* and *Phytopthora infestans*) are key among the diseases. The infections caused by tomato diseases result in yield losses and jeopardize incomes and livelihoods of growers and other beneficiaries along the crop value chain [11]. On the other hand, key pests known to limit tomato production like invasive leaf miner, mites and thrips also contribute to considerable loss in yield and quality [12]. Additional limitations to tomato production include lack of improved varieties [13], and poor agronomic practices [14].

Although some of biotic and abiotic factors responsible for low tomato production are known anda holistic understanding of current farmer practices in tomato production could aid identification of yield gaps and interventions. Understanding tomato yield

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

gaps through farmer engagement and participation would aid researchers to develop adoptable and effective management options needed by tomato farmers [15]. Similarly, understanding production constraints and opportunities provides a foundation for development of crop interventions that can enhance tomato productivity in a sustainable manner. Therefore, the aim of the study was to understand production practices and constraints at the farm in the major growing areas as a basis for designing an integrated and sustainable tomato productivity enhancement strategy.

MATERIALS AND METHODS

Survey sites

The study was conducted in eight districts from five agro-ecological zones of Uganda. The districts were selected according to their suitability in tomato production and the level of production intensity. The agro-ecological zones and districts include: Lake Victoria Crescent (Wakiso and Mukono), Central woodland savannah (Nakaseke), Western medium-high farmlands (Mbarara and Kasese), south western highlands (Rukiga) and Mount Elgon farmlands (Mbale and Bulambuli). The survey was conducted between April to July 2019, which coincided with the main and the first tomato production season.

Population and sample size

Due to the nature of respondents, three sampling methods were used, namely: purposive, stratified and snowball sampling. Agro-ecological zones, districts and sub counties were selected purposively while the respondent households were selected by snowball sampling [16]. The three-stage stratified sampling was used to cluster tomato farmers into agro-ecological regions, districts and sub counties. Accordingly, eight districts and 16 sub-counties were selected for this study.

Data collection

In each sub-county, farmers were randomly selected for interviews from sampling lists obtained from the agricultural office of each district and sub-counties. A total of 240 farmers were interviewed through snowball sampling. In all cases, the agricultural field extension workers guided the research team to tomato farmers in the different areas where the study was conducted. In each district, two sub-counties were selected and in each sub-county, 15 farmers were interviewed and at least one key informant group discussion was conducted. Data collection was carried out using a semi-structured questionnaire administrated by a team of trained research scientists and technicians after pre-testing its validity. The pre-testing was conducted among selected farm households in Mukono district. Farmers were interviewed in their local language (Luganda in Central region), Runyakitara in western region and Lugisu in Eastern region with aid of a translator in districts where interviewers did not understand the local language.

Data analysis

Data collected using questionnaires were captured into a Microsoft Excel spread sheet, cleaned and exported to SPSS version 16 software [17].The data on demography, cropping system, agronomic practices, pest and diseases as well as constraints in

tomato production were analyzed using descriptive statistics. Cross tabulations were employed to compare variable groups, significance of relationships was assessed using Pearson Chi-square tests and associations between nominal independent variables and causative agent were examined using multinomial logistic regression, and goodness of fit tests. On the other hand, qualitative data collected through field observations were summarized and grouped into major themes for analysis.

RESULTS AND DISCUSSION

Demographic information of respondents

The results indicated male dominance in tomato production within the surveyed areas. Majority (84.1%) of the respondents were male with an average household size of 6 persons. The male dominance could be attributed to the fact that tomato production requires capital investment especially in land acquisition and in Uganda, men have more access to land than women. Besides, tomato production is considered a risky venture yet more women are risk averse as compared to men which limits the number of women involved in tomato growing. Among the smallholder farmers involved in tomato production, 38.4% were between 18 to 35 years, 57.3% between 36 to 60 years, while the rest (4.3%) were above 60 years. The relatively low youth participation (38.4%) compared to adults (57.3%) was possibly due to limited or lack of capital for the youth to invest in acquisition of inputs that are required for tomato production. Similarly, the widespread perception among the youth that agriculture is not rewarding also hinders their participation. Furthermore, the limited access to land by the youth with their mentality that benefits from farming take a long time to be realized most often leads them to seek urban employment [18]. In terms of education, levels attained by respondents, 52.2% of the farmers stopped in primary, 29.7% in secondary (Ordinary level), 13.0% in secondary (Advanced level) and 5.1% in tertiary (Diploma and degree level). This indicated that production is mainly done by lowly educated farmers, which could limit the uptake of improved production practices. Earlier studies attribute the low adoption of improved farming practices to low levels of education [19]. The area under tomato production ranged from 0.1 to 3.5 acres with the average acreage of 0.68. This was not different from the average acreage of other crops in Uganda, indicating that tomato is an important crop in the livelihoods of smallholder farmers, which is given a priority during land allocation for crop production.

Cropping system and tomato varieties used by farmers

Most farmers (78.4%) cultivated tomato as a mono-crop, 16.2% as mixed crop and 5.4% as an intercrop. The reason given by farmers practicing mono-cropping was that during tomato growth, specific operations like insecticide and fungicide spraying is done. These operations are obstructed in mixed and intercropped systems because different crops are attacked by different insect pests and diseases, which require different pesticides to manage. This leads to waste in mixed and intercrops when non crop targets are sprayed with chemicals. However, mono-cropping if used for a long time has adverse effect on soil enzyme activities, soil microbial abundance, soil chemical practices and tomato yield [20], hence the need to minimize the use of mono-crop after some time. In all, the cropping systems used in tomato growing, land preparation was done using hand hoe (85.3%), tractors (9.1), herbicide application

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

(4.6%) and ox-plough (1%). Hand hoeing was commonly used probably because most farmers either could not afford to mechanize their operations or with their small holding (0.68 acres), mechanization was not economically viable. The results indicated that most farmers cultivated tomato twice a year, which corresponded to two rain seasons (April to June and September to November) in a year. This means that most tomato growing in the surveyed areas is rain-fed, but a few farmers who could afford irrigation facilities staggered their tomato production throughout, making four seasons a year. Other farmers utilize the wetlands during the dry period to grow tomato as water availability is assured compared to the dryland.

The five tomato varieties mostly grown included: Asilla F_1(35.3%),Tengeru94 (21.1%), Rambo (18.1%), Novela F_1 (17.7%) and Riogrande (10.3%). The high preference of Asilla F_1, Tengeru97, Rambo and Novela F_1 was due to their being hybrids with high yielding potential and long shelf-life. Farmers prefer high yielding tomato varieties (hybrids) which ensure increased production using less land [21]. However, there were other tomato varieties grown on small-scale, which included: Commando, Eden F_1,Ranger F_1, (hybrids) Victoria, VFN Roma, MT 56, Marglobe,"Musununu", Vikima, Omega, Opello and Sifa (open pollinated varieties) among others. The choice of tomato variety to be cultivated was influenced by several factors (Figure 1), though the three high ranking factors were: high yield, pest and disease tolerance and desired market and consumer preference. Market preference is dependent on fruit size, shape (oval) and shelf-life. Traders preferred big size, oval shaped and hard-skinned tomato fruits which are not easily damaged during transit. On the other hand, the consumers preferred tomato with long shelf-life and they are compelled to buy small, medium or big sized tomato as long as they have long shelf-life.

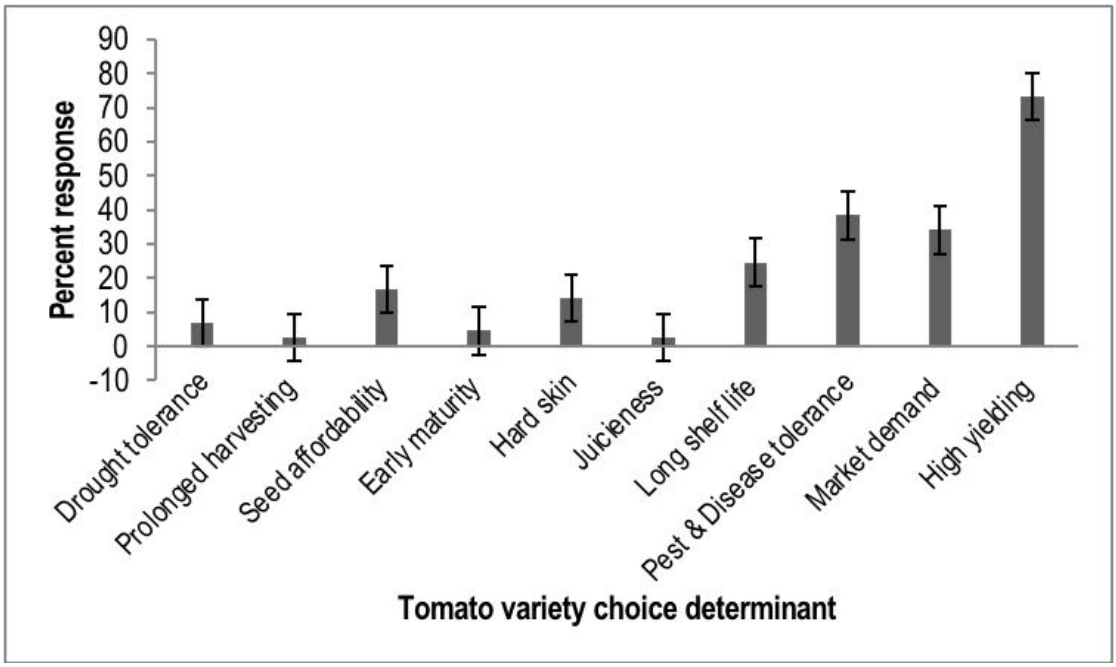

Figure1: Factors influencing the choice of tomato varieties cultivated by farmers

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Crop management practices used by tomato farmers

The farmers interviewed used three forms of planting materials; seed (91.8%), seedlings from fellow farmers (6.9%) and volunteer tomato crops from the previous season (1.3%). The results also established that 90.5% of the farmers planted tomato in lines, while 9.5% staggered their planting. This indicated that most farmers adopted line planting practice. But several farmers still used different spacing, notably; (30 x 45), (45 x 45), (60 x 60), (75 x 75), (90 x 90) and (100 x 100) cm, which could not provide them optimum yield except for the (60 x 60) cm, which provides optimum yield under field conditions [22]. Farmers also testified that tomato performs poorly under weed infested gardens, and as a result they always endeavored to keep their fields weed free. Weeding was predominantly characterized by use of hand hoes (96.6%) and application of herbicides (4.4%) which are applied prior to planting. Majority of farmers weeded 3 times, though a few with high-weed densities in their gardens weeded up to 6 times in a season. In relation to mulching, 73.3% of respondents reported mulching their gardens, while 27.3% did not. Mulching was commonly practiced by farmers as a substitute to staking, serving as a safe haven for fruits to lie on before harvesting and also conserve moisture during the dry season.

Irrigation using various methods was a common practice among most of the farmers (80.6%). Tomato farmers applied at least one irrigation method in a given cropping season with a big number using hand watering (63%), water pumps and hose pipes (14%), water canals to divert water into the field (11%), drip irrigation (7%) and sprinkler irrigation (5%). Most farmers used at least one method of irrigation because tomato requires sufficient amount of water for growth as any water deficit occurring during growth, flowering and fruit formation stages reduces yield [23].

Tomato farmers also used a number of fertilizers to boost tomato yields; the results indicated that 90.9% of respondents used fertilizers. Foliar fertilizers (super and rapid grow) were the most applied fertilizers followed by Diammonium phosphate (DAP), cattle manure, urea and NPK. Other fertilizers applied included: goat manure, compost and single super phosphate (SSP) (Figure 2). The high use of foliar fertilizer was due to its rapid response to plant nutrient needs. This was in line with what was reported that foliar applied fertilizer becomes promptly available to tomato plant and their response is instant [24].

Nonetheless, DAP which is a soil-based fertilizer was second to foliar fertilizers. Farmers confirmed that DAP is used for planting as a starter fertilizer which is applied once during the entire cropping cycle. By doing this, labor is saved on fertilizer application when compared to Urea and NPK which are applied in splits requiring twice more labor than cattle manure. Nonetheless, SSP, compost and goat manure are least used because they are not readily available in the study area. But depending on the availability of manure, whether cow or goat, some tomato farmers applied both organic and inorganic fertilizers within the same cycle.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 2 March 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

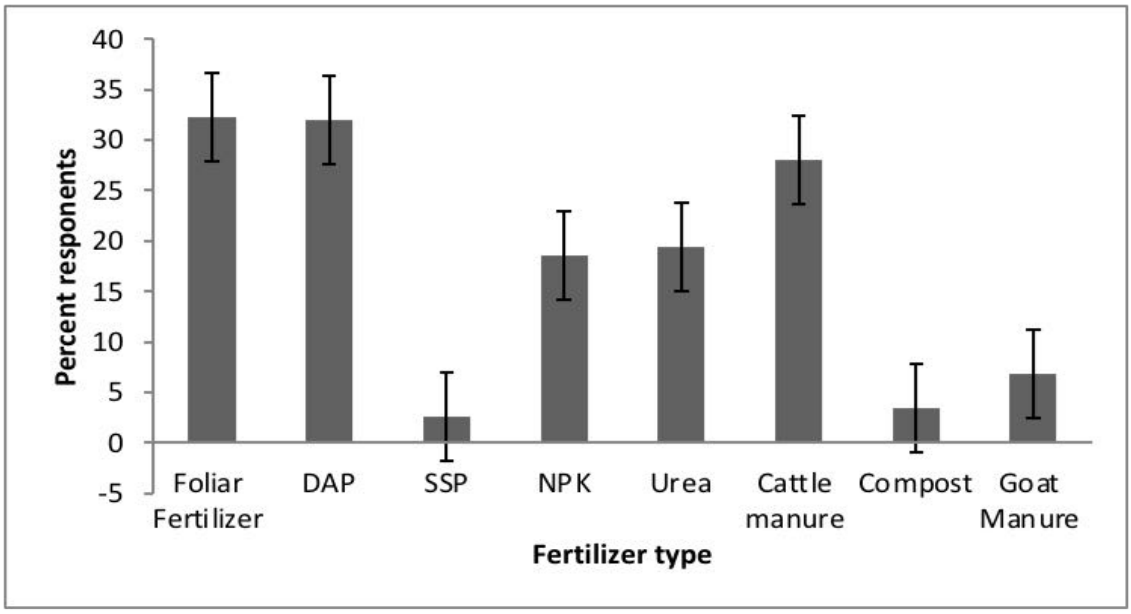

Figure 2: Types of fertilizers used by tomato farmers in the study area

Pests and disease

Farmers reported caterpillars followed by thrips (*Frankliniellspp*), worms and white flies (*Bemisia argentifolii*) as the major pests of tomato (Figure 3). Some of the pests like Aphids (*Aphidoidea spp*) and worms (*Lepidoptera spp*) had been earlier reported as major tomato pests in Uganda [25]. However, the study revealed that caterpillars are emerging as pests of major importance. Indeed, unlike the previous studies, caterpillars were ranked first in tomato growing areas in the current study. The other pests such as moth, spider mites (*Tetrancychus urticae*), leaf hoppers (*Epoasca fabae*), and scales were also mentioned as minor pests. Among the districts sampled, most tomato pests occurred in the central region districts followed by districts in eastern Ugandan, but sampled districts within south western region had low levels of pest infestation. The variation in tomato pest-occurrence in relation to districts in different regions was attributed to differences in weather conditions across the two regions. Tomato pests mostly occur in hotter and cool weather which is typical of central Uganda compared to cool and cold conditions in south western [26].

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 2 March 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

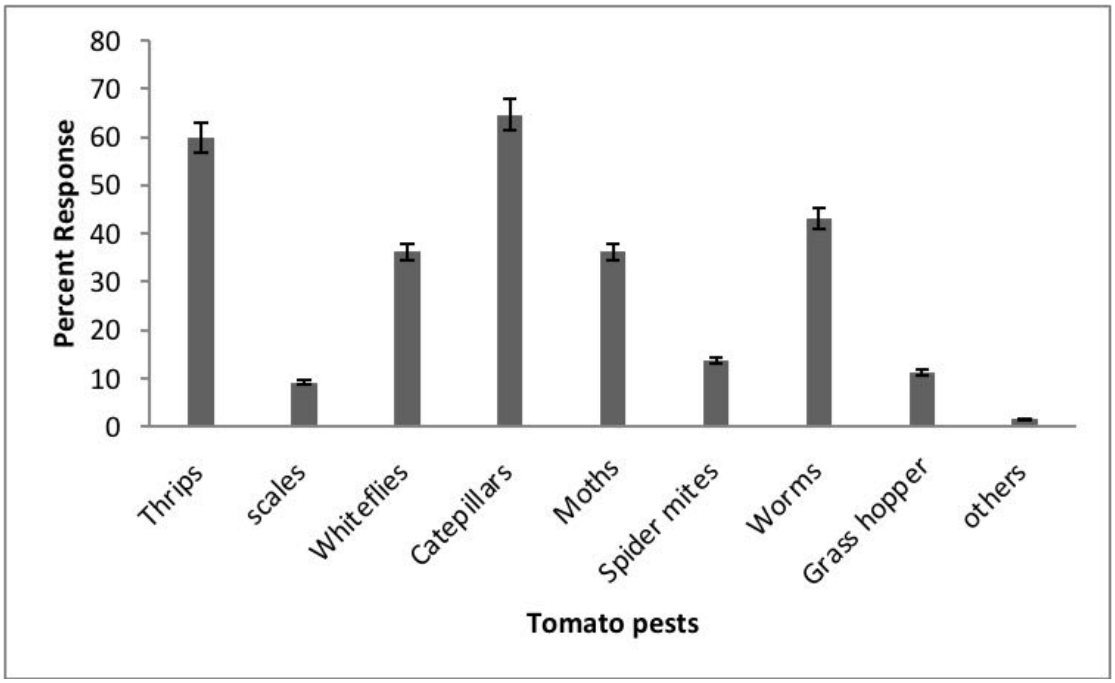

Figure 3: Insect pests that commonly attack tomato in the study area

The major tomato diseases reported were bacterial wilt (*Ralstonia solanacearum*), early blight (*Alternaria linariae*) late blight (*Phytophthora infestans*), tomato leaf spots (*Xanthomonas spp*) and viral diseases (Figure 4). The high bacterial wilt occurrence in the study area was attributed to common use of a mono-crop system with limited crop rotation brought about by land scarcity. Since bacterial wilt is a soil-borne disease, continuous use of same fields leads to pathogen population disease pressure build up, hence escalating the occurrence of the disease in the field [27]. Furthermore, the absence of tomato varieties that are resistant to diseases also contributes to the high occurrence of bacterial wilt, early and late blight diseases mentioned by the respondents.

Other diseases of less economic importance reported included: tomato yellow leaf curl virus, tomato (TYLCV) (8.2%), Anthracnose (2.2%) and some diseases unknown to farmers, which cause burning like symptoms and yellowing of leaves during heavy rains were reported. Although some diseases were not known to farmers, the symptoms described by farmers resembled those of Fusarium wilt (*Fusarium oxysporum*) [26]. However, further tests are needed to confirm the disease.

In terms of disease occurrence across the study areas, tomato blights were highest among farmers in the central region. This is because late and early blight of tomato are escalated by hot and humid conditions, which often occur in central Uganda as compared to other regions [26]. On the other hand, cases of tomato late blight were low in south-west and western region due to cold conditions which do not favor the causative agents of blight.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

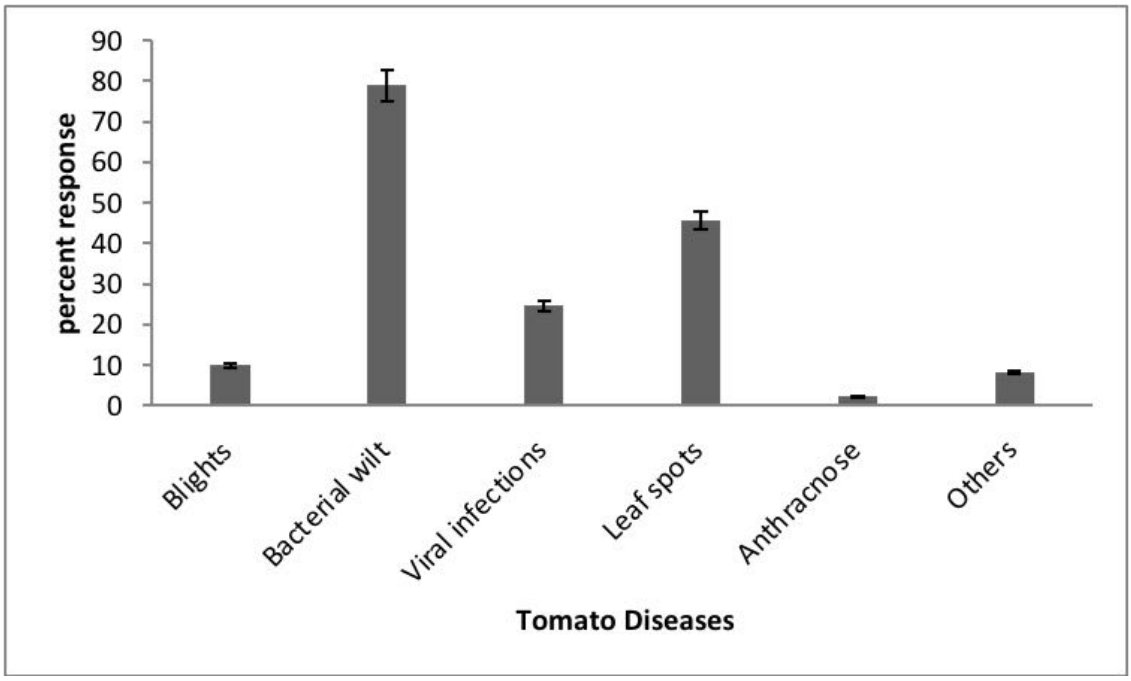

Figure 4: Diseases that commonly attack tomato in the study areas

Pests and disease management

The farmers interviewed reported that several methods are used to control pests and diseases in tomato. Majority (95.7%) of them used chemical sprays (pesticides and fungicides) to manage tomato pests and disease. Most farmers perceive the use of chemicals as the most effective method to control pests as compared to other methods, namely, the use of organic concoctions as well as cultural practices: crop rotation, rouging, wider spacing and others. As such, there is need to create awareness on other possible methods, that can be used to control pests and disease such as the use of the egg york mixture that was found to be effective at managing tomato pests [28]. Adoption of an integrated pest management approach is important since relying on chemicals may lead to development of pest resistance over time, accumulation of chemical residues in the fruits and environmentally hazardous. Other pest and disease control measures used on small-scale were: rouging(12.1%), hand picking (9.9%), organic concoctions (2.6%), ash (6.0%), urine (2.6%) and frequent weeding. However, these are not often used in combination with the chemicals which render them less effective when used in isolation. The use of pheromone traps (0.4%) to control tomato pests was generally very low and unpopular among most farmers. This is probably due to the fact that the use of pheromones was recently introduced during the outbreak of invasive life miner (*Tuta absoluta*) to scout and monitor pest population in tomato fields. As such it is more of a monitoring tool rather than control, hence the reason as to why it is still less popular. The study revealed that farmers applied a range of pesticides and fungicides and in combination. Some of the pesticides used include: Dudu Cypermethrine, Ridomil, Dudu phenos, Rocket, while fungicides such as Agrozeb, Dimethoate, Greenzeb, Diathane M45, Indofil were used. The effectiveness of a practice of combining pesticides and fungicides, which farmers reported needs to be investigated since the two are known to have antagonistic effects when mixed together.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

The mixing of fungicides and insecticides could be the reason for the high frequency in spraying reported by farmers. Majority of farmers sprayed weekly (62.1%) and bi-weekly (3%), respectively while 20.7% and 3% of farmers sprayed two and three times a week especially during the rainy season. Spraying three times per week is beyond what is recommended, an indication that chemicals are either wasted or not effective on the target pests and diseases. Farmers mixed on average 32.7ml of pesticides per 20 liters of water and 112.8g of fungicide per 20 liters of water with the minimum and maximum application rate of 5ml and 200ml per 20 liters of water respectively for insecticide and 2-500g per 20 liters of water for fungicides. None of the farmers mentioned that the mixtures or dilutions they use were following the recommendations by the manufacturer, which means that injudicious use of pesticides is common.

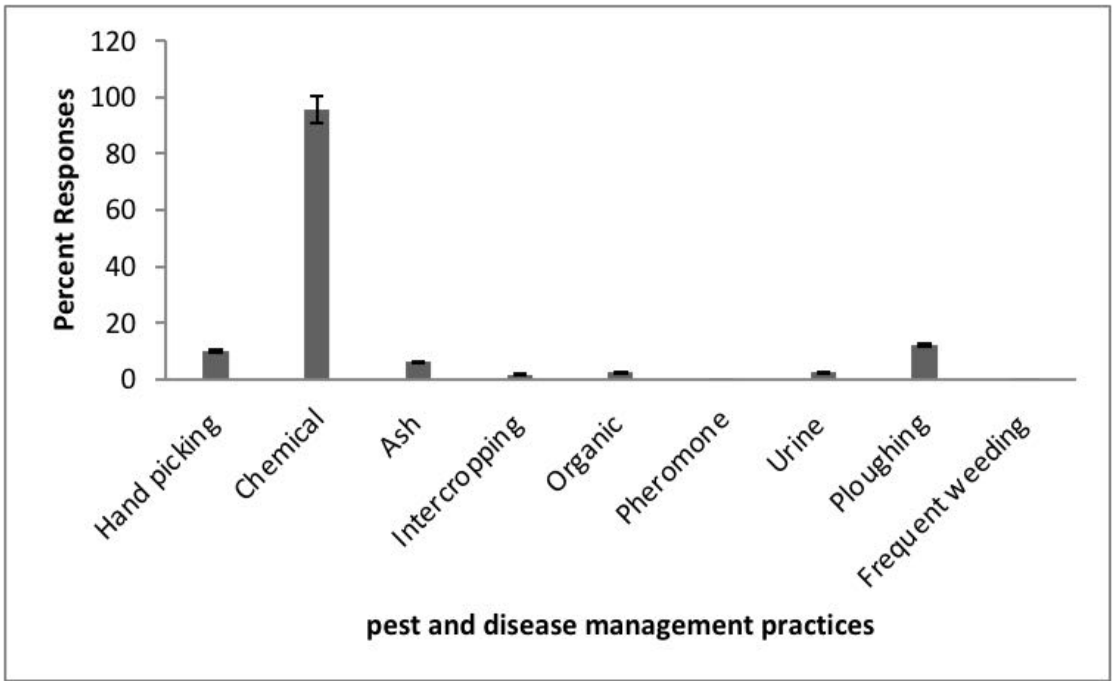

Figure 5: Methods used to control pests and diseases in the study area

Tomato productivity

The smallholder tomato farmers interviewed cultivated between 0.1 - 3.5 acres with an average land holding of 0.68 acres allocated for tomato production (Table 6). The average yield per 0.68 acres of tomato was 3.2 tonnes, translating into 4.9 ton/acre. In terms of tonnes/hectare, farmers obtained 12 t ha^{-1}. This yield was far below the expected yield potential of 16 t ha^{-1} under good agronomic management and weather conditions in East Africa [29]. There is need, therefore, for technical capacity building and support to farmers to adopt improved agronomic practices in order to attain the potential yield.

Production costs

The findings from this study revealed five major tomato production costs namely: pest and disease management, cost of seed, land preparation, purchasing and application of fertilizers and staking of plants (Figure 6). The highest production costs were mainly

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

input costs (insecticides and fungicides, seeds and fertilizers) followed by labor related activities (land preparation, weeding and staking). The high cost of inputs in tomato production was partly due to their being imported, thus attracting high transportation and distribution costs which increase their market prices. These results, therefore, imply that the most cost effective way to reduce tomato production costs is by developing low cost pest and disease management packages and strengthening tomato seed systems to reduce reliance on expensive imported seed. Similarly, some of these seeds are from breeding systems, which may not have similar environmental conditions like Uganda, hence poor adaptability in Uganda translating to poor yields. On the other hand, the high production costs related to labor were due to continued use of manual labor which takes much more time and resources. There is need to develop low cost-effective, methods of land preparation and staking tomato to cut down tomato production costs. This could be achieved through development of reusable tomato stakes that are possibly made out of plastics as well as use of plastic mulch that minimizes the labor of weeding and also conserves soil moisture.

.

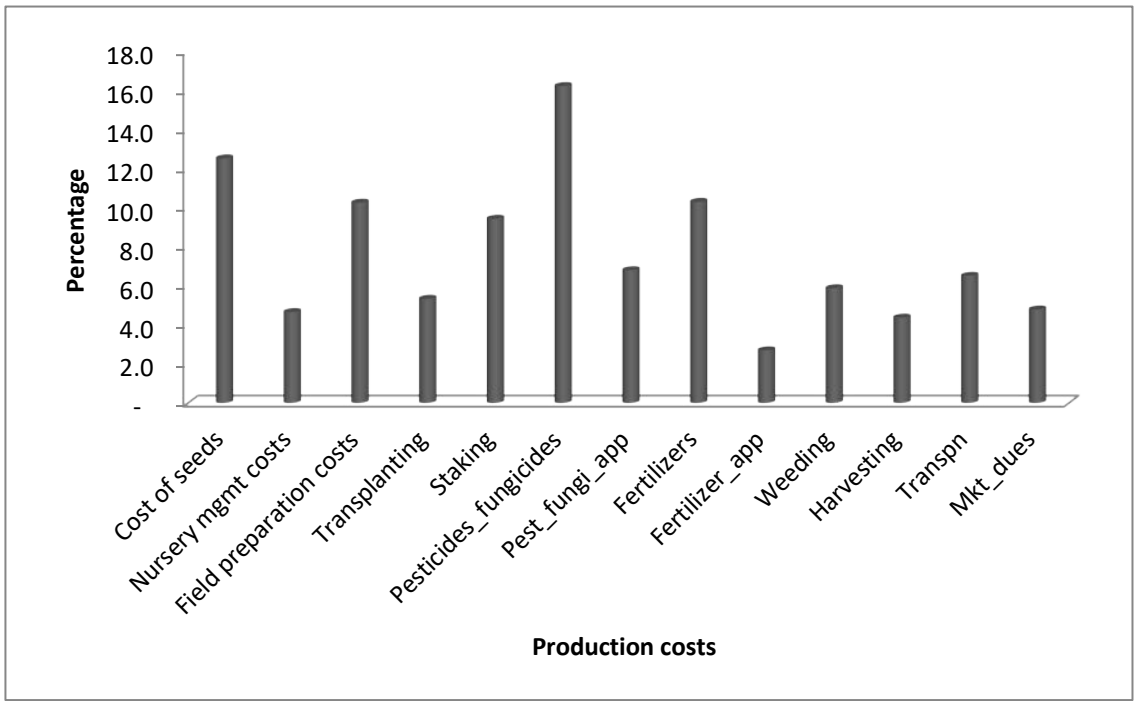

Figure 6: Farmer tomato production costs

Based on the study findings, it costs a farmer USD 309.0 to establish and manage an average of 0.68 acres of land for tomato; this translates to production costs of USD 454.4 per acre. Therefore, with the average market price of USD 0.59/Kg, with minimum and maximum market price of USD 0.054 and USD 1.12/Kg, respectively (Table 6), farmers earned on average, a gross income of USD 1946.1 per acre. However, the gross income was lower than what was earlier reported possibly due to variation in prices across years and seasons [26]. This variation in price was clearly exhibited by the market price reported by farmers which ranged from USD 0.054 to 1.12.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Postharvest handling and marketing

The study established that tomato production is being mainly undertaken by farmers who are working individually with only 37.1% working in groups. Among the farmers in social groups, majority (74%) are members of farmers' groups, 20% members of a Village Saving and Loan Association (VSLA) and 6% are members of farmers' cooperatives. Most of the farmers (88%) sell their produce individually with only 12% selling through groups. Tomato farmers use mainly five materials for collecting and transporting tomato to the markets, namely: wooden boxes (64.7%), plastic basins (23.3%), and woven baskets (18%). Wooden boxes were mostly used by transporters from the field to the market due to their convenience with minimal tomato damage during transportation. However, plastic basins and woven baskets were mostly used during harvesting in the field because they are easy to carry and retain the freshness of the tomato while harvesting.

Tomato fruits were sold in four main forms: as ripe fresh fruit (72.8%), mature green (18.4%), mixed green and ripe fresh fruits (7.5%) and others (1.2%). The ripe fruits were most harvested for ready markets (rural and urban markets), while the mature green were mainly for regional markets, especially Kenya and South Sudan, where tomato spends some time in long transit. The study revealed that farmers mostly sold tomato on-farm (35.0%), through rural markets (32.8%) and the nearest urban markets (32.2%). Farmers also confirmed that although urban markets offer better prices than on-farm, most farmers continue to sell their tomato on-farm to avoid transport costs to the market and the exorbitant market dues charged in urban markets. The better prices in the urban markets were further revealed by the willingness of middle-men to move and transact business with farmers' rights on farm. In addition, a small percentage of tomatoes were sold through entities such as supermarkets, local processors, road-side sellers and exporters to regional markets. The results further revealed that except for the high tomato price fluctuation, demand and market for tomato was readily available.

Constraints faced by farmers in production and marketing of tomato

A diverse range of constraints impede tomato production in Uganda. Farmers reported high pest and disease burden (20%), high input (11%), high seed costs (10%) and seasonal variability (9%) as the major production constraints affecting tomato in the country (Figure 7). The high pest and disease incidence and severity were due to favorable warm conditions for pathogen sporulation and insect pests mating. Most farmers associated high tomato disease incidence to high (peak) rainfall. The high disease incidence was also attributed to use of susceptible tomato varieties, such asTengeru97 and Moneymaker which were more susceptible than Riogrande, Novella $F_1$and Rambo. There was generally a higher concentration of disease burden in the central region than the rest of regions with bacterial wilt being reported in all the eight districts though at varying magnitude of severity and incidence.

The high input costs of improved seed, fertilizers, pesticides and fungicides dictate the number of farmers that can afford them. In the study areas, the cost of inputs was high (Figure 7), partially due to market liberalization and trade policies that increase input prices relative to commodity prices, a common occurrence in the Ugandan economy. This deniesfarmers the opportunity to use improved and quality inputs. Poverty and

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

cash constraints amidst poor credit markets also limit farmers' purchase of inputs claiming that they are expensive [30]. Further, the liberalization policies allow the private sector to import most inputs used in tomato production, which increases their distribution costs and thusthe final input costs.

Among the inputs, the farmers interviewed emphasized the high cost of seed. This was attributed to the fact that most of the seed companies are interested in hybrids, which are high yielding. The production and distribution costs of imported hybrids are high compared to open pollinated varieties whose production costs and yields are low, hence their prices are low as compared to hybrids. The importation of hybrids has been mainly due to lack of breeding programs to develop tomato hybrids locally. However, availability of high cost seed leads to smallholder farmers' preference fortraditional varieties as an alternative to expensive variety, which contributes to low productivity of tomato [31,32].

Poor soil fertility was also ranked high among the major tomato production constraints by farmers interviewed (Figure 7). The decline in the fertility was partly attributed to the fact that in the study areas, mono-cropping coupled with continuous cultivation with or without external inputs was commonly used. In such a system, inherent soil nutrients are bound to be lost through nutrient mining (nutrients removed through harvesting crops, erosion and leaching) leading to decline in soil fertility. Also due to small land holding (0.68 acres) in the study areas, farmers no longer practice bush fallowing and hence, limited replenishment of depleted nutrients. This concurs with observations where declining or no fallow period in the tropics and subtropical environments was identified as the major cause of soil fertility decline [33].

Drought significantly affected tomato production in the study area. Drought reduces tomato yield and quality [34]. The low tomato production in the study areas was partly due to drought experienced during off-season farming since there are limited rainfall and low levels of irrigation which affect nearly all crops. Since most tomato growing in Uganda is rain-fed, most losses due to drought start at vegetative stage through the reproductive stage as farmers plant their crop towards the end of the rain season to avoid incidences of early and late blight. They range from hidden losses due to small sized fruits, sun scotches, reduced shape and juice content which all lead to poor quality tomato. Similarly, drought is estimated to cause about 50% reduction in yield of tomato [35]

Other tomato production constraints reported include: high labor costs, weed infestation and management, excessive rains, poor varieties, limited production information, vermin, adulterated agro-chemicals and hail stones among others (Figure 7). These, to a less extent, affect tomato but over time farmers have developed copping mechanism to reduce their effects.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 21 No. 2 March 2021
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

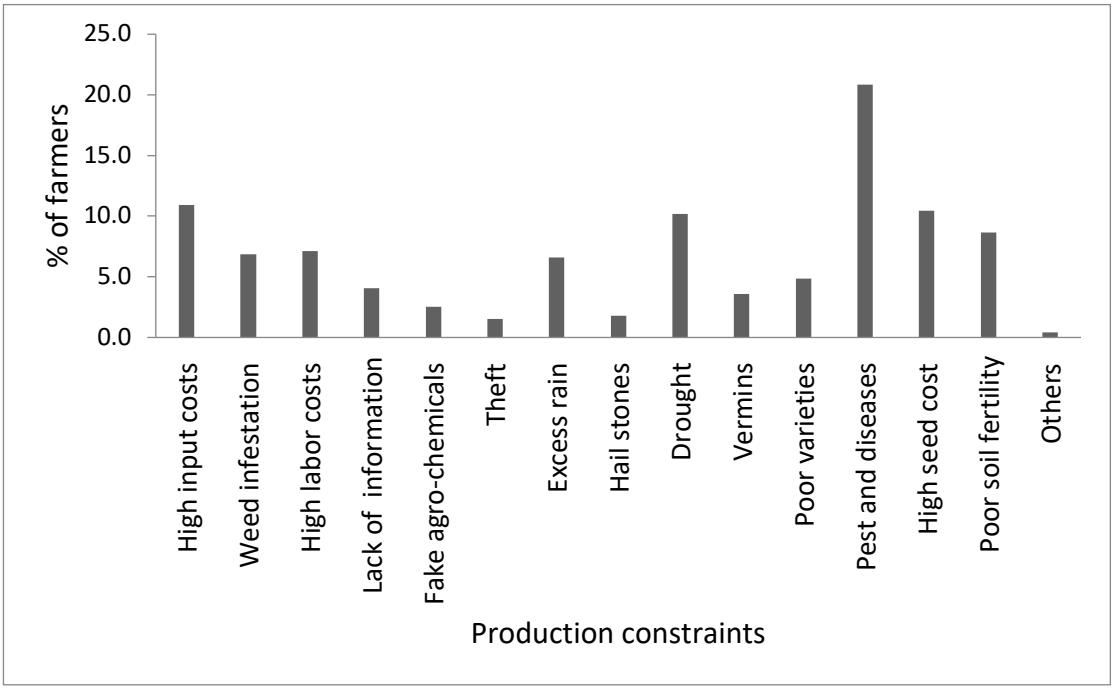

Figure 7: Tomato production constraints in Uganda

Marketing constraints

The four major market constraints affecting tomato farmers in Uganda include: price fluctuations, low prices, high transport costs and poor market access (Figure 8). The market price results revealed that tomato market prices highly fluctuate, sometimes with market prices dropping as low as USD 0.054 during bumper harvests and rising to USD 1.12 per kilogram during off-seasons (periods of scarcity). A research on marketing of tomato in the Upper East Region of Ghana also attests to the problem of price fluctuation and low price as market constraints [36]. Similarly, marketing tomato is also constraint by low prices offered to farmers, particularly during peak production periods, when prices are often too low for farmers to break even. This is mainly attributed to high tomato supply in the market. On the other hand, the low prices can be partly explained by the individual marketing approach commonly used by farmers (Figure 8). The individual marketing denies farmers bargaining power, which gives middlemen a chance to offer low prices. The high transport costs associated with poor road network is a constraint to marketing, since most of the tomato production zones are in rural areas with poor road network which increases the distribution costs. The high transport costs also deny farmers access to markets yet farmers have limited market information as indicated by farmers' response, which spelled out that 65% lacked access to market information. Additional market constraints of economic importance reported by farmers include: non standardized scales (13.4%), exploitation by middlemen (14.2%) and poor road networks. Additionally, middlemen are reported to purchase tomato using extra-large boxes, hence exploiting farmers.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

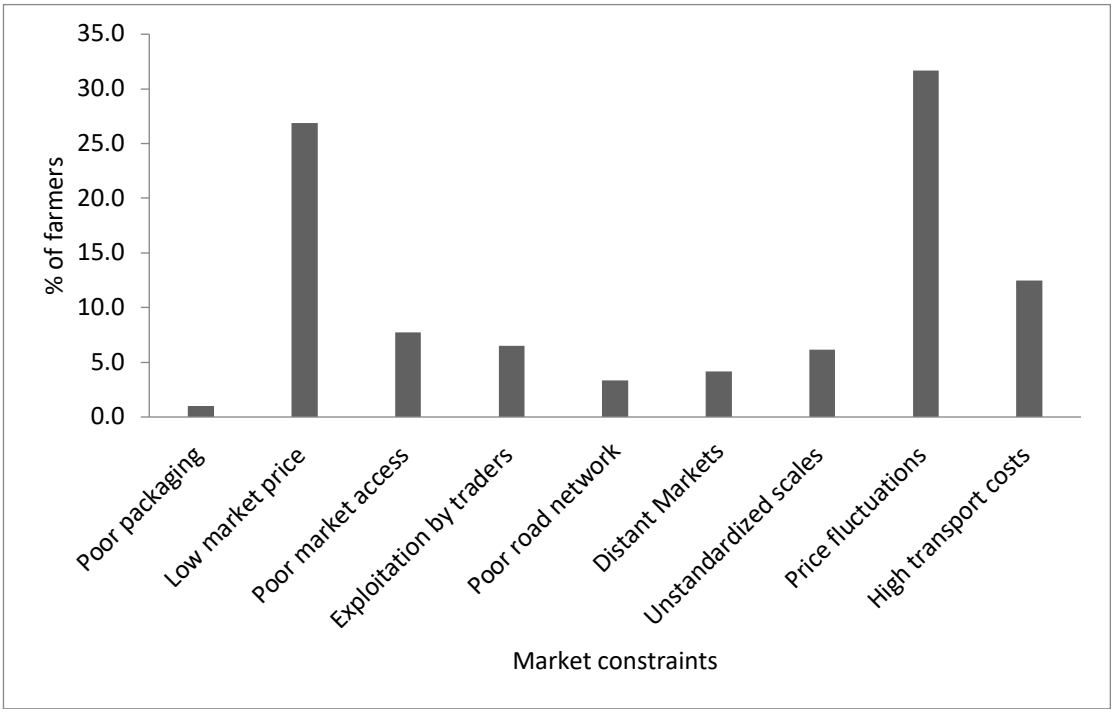

Figure 8: Tomato market constraints in Uganda

CONCLUSION

There is male dominance and limited women and youth participation in tomato production in Uganda. Majority of tomato farmers cultivate 0.68 acres of land on average. The key drivers of the varieties farmers choose to grow include: high yields, pest and disease resistance and the cost of seed. Commonly used tomato varieties include: Asilla F_1, Rambo, Novela F_1 and Riogrande, which are high yielding but costly in terms of seed. However, despite Tengeru97 being susceptible to pests and diseases it is often used because its seed is cheap. The key production constraints in the study area included pests and diseases, high costs of inputs and seed, drought, and decline in soil fertility while high price fluctuations and low prices were the main market challenges. The major pests reported by farmers were: caterpillars, thrips, white flies and insect worms, while the diseases of major concern were tomato bacterial wilt, blight, leaf spot and viral disease. The pests and diseases were managed through indiscriminate use of synthetic insecticide and fungicides with a few sporadic uses of cultural methods. Lastly, tomato production was no doubt a profitable venture earning farmers a gross revenue of USD 1,430.9 per acre.

Based on the findings of the current study, deliberate efforts should be made to increase women and youth participation in tomato production. The government can support this by increasing access to physical and human capital and rebranding agriculture to make it appealing to the youth. Tomato breeding programs should develop high yielding and disease resistant tomato varieties that are affordable to farmers. Innovations in developing effective integrated low-cost pest and disease

management options to reduce on pest and disease management, cost in tomato production should be supported.

ACKNOWLEDGEMENTS

This research was supported by National Agriculture Research Organization (NARO) Competitive Grant Scheme (CGS) with funding from Government of Uganda. The authors are grateful to National Crops Resources Research Institute implementing the research activities and the farmers for their valuable time during the survey.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 21 No. 2 March 2021 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Table 1: Farmers' tomato productivity and average price

Parameters	N	Minimum	Maximum	Mean
Land planted (acres)	226	0.1	3.5	0.680
Yield (Kgs)	222	144.0	12120.0	3298.5
Market Price(USD/Kg)	222	0.054	1.126	0.590
Valid N (listwise)	217			

REFERENCES

1. **Food and Agriculture Organization of the United Nations.** FAOSTAT Statistical Database FAO Publications, Rome, Italy. 2017; 5-8.

2. **Ntonifor NN, Nsobinenyui DN, Fokam EB and LA Fontem** Developing an Integrated Management Approach for the Fruit Fly Dacus punctatifrons on Tomatoes. *American Journal of Experimental Agriculture*.2013; **3**: 470-481.

3. **Ddamulira G, Idd R, Namazzi S, Kalali F, Mundingotto and M Maphosa** Nitrogen and Potassium Fertilizers Increase Cherry Tomato Height and Yield. *Journal of Agricultural Science*. 2019; **13**: 9752-9760.

4. **Sanga A and C Mgimba** An Analysis of Constraints That Affect Smallholder Farmers in the Marketing of Tomatoes in Mbeya Urban and Peri-Urban, Tanzania. *Imperial Journal of Interdisciplinary Research*.2016; **3**:603-608.

5. **Nick C and DJH Silva** Melhoramento detomate. In: Nick C, Bore´m A (Eds) Melhoramento de hortalic¸as. UFV, Vic¸osa, 2016;**13**: 396-431.

6. **Ssekyewa C** Incidence, distribution and characteristics of major tomato leaf curl and mosaic virus diseases in Uganda. Ghent University, Belgium, PhD Diss. 2016; 2-6.

7. **Tandi TE, Wook CJ, Shendeh TT, Eko EA and CO Afoh** Small-scale tomato cultivators' perception on pesticides usage and practices in Buea Cameroon. *Health.* 2014; **6**: 2945-2958.

8. **Beckles DM** Factors affecting the post-harvest sugar content of tomato *Solanum lycopersicum* L. *Fruit Post Harvest Biol Technol*.2012; **63**: 129-140.

9. **Uganda Bureau of Standards UBOS.** Statistical Abstract Report. 2018;159-162.

10. **Ochilo WN, Gideon N, Nyamasyo N, Kilalo D Otieno W, Otipa M, Chege F, Karanja T, Eunice E and K Lingeera** Characteristics and production constraints of smallholder tomato production in Kenya. *Scientific African*.2018; **2**: 2468-2276.

11. **Salih EE, Hanadi EA and M Mohammad** Value Chain Analysis for Tomato Production and Marketing in Khartoum State, Sudan. *Current Investigations in Agriculture and Current Research.* 2018;**5**: 2637-4676.

12. **Pratt CF, Constantine KL and ST Murphy** Economic impacts of invasive alien species on African smallholder livelihoods. *Global Food Security*. 2017;**14**: 31-37.

13. **Kasenge V, Akemo MC, Taylor DB, Kyamanywa S, Adipala E and B Mugonola** Economics of fresh market tomato production by peri urban farmers in Wakiso District. *African Crop Science Journal*. 2002; **6**: 301–306.

14. **Anastacia O, Masinde A, Kwambai TK and NH Wambani** Evaluation of tomato *(Lycopersicon esculentum* L.) variety tolerance to foliar diseases at Kenya Agricultural Research Institute Centre-Kitale in North West Kenya. *Afr. J. Plant Sci.* 2011; **5**:676–681.

15. **Tefera T** Farmers' perceptions of sorghum stem-borer and farm management practices in eastern Ethiopia. *International Journal of pest management*. 2004; **50:34**-40.

16. **Biernacki P and D Waldorf** Snowball sampling: Problems and techniques of chain referral sampling. *Sociological Methods & Research*.198; **10**: 141-163

17. **Statistical Package for Social Scientists SPSS** Inc. Released-SPSS for Windows, version 16.0, SPSS Chicago. 2007.

18. **Mbah EN** Effects of rural-urban youth migration on farm families in Benue state, Nigeria, *International Journal of Agricultural Research, Innovation and Technology*. 2016; **6**: 14-20.

19. **Asfaw S, Shiferaw B, Simtowe F and L Lipper** Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy*.2012;**37**:283-295.

20. **Hongdan FU, Guoxian Z, Fan Zhang Z, Zhouping S, Guoming G and L Tianlai** Effects of Continuous Tomato Monoculture on Soil Microbial Properties and Enzyme Activities in a Solar Greenhouse. *Sustainability*. 2017; **9**: 317.

21. **Odame H, Musyoka P and J Kere** Kenya: maize, tomato, and dairy, Agribus. Innovation Systems in Africa. The World Bank, Washington D, C. 2009; **89**: 91-132.

22. **Papadopoulos AP and DP Ormnond** Plant spacing effects on yield of the green house tomato. *Can.J.Plant Sci*. 1990; **70**:565-573.

23. **Kuşcu H, Turhan A and AO Demir** The response of processing tomato to deficit irrigation at various phenological stages in a sub-humid environment. *Agricultural Water Management*. 2014; **133**: 92–103.

24. **Naz RMM, Muhammad S, Hamid A and F Bibi** Effect of boron on the flowering and fruiting of tomato. *Sarhad Journal of Agriculture*. 2012; **28**: 37-40.

25. **AkemnMC, Kyamanywa S, Luther G, Ssekyewa C, Erbaugh JM and H Warren** Developing IPM systems for tomato in central and eastern Uganda. IPMCRSP sixth Annu. Rpt. 2000; **6**:117-121.

26. **Ramathani I, Ddamulira G, Naluyimba R, Shim H and D Nampanya** Tomato production. A field guide for Agronomy, Soil fertility and disease and pest management. National Agricultural Research Organization. Uganda publications. Entebbe. 2018; 16-24.

27. **Bharathi PVL, Warwick E, Ravishankar M, Devender P and B Sreeram** Bacterial Wilt Management in Tomato Training course guide. The World Vegetable Centre. 2015; 2-4.

28. **Ramathani I, Semalulu O, Ddamulira G and S Hongsik** Efficacy of Conventional, Immune-Botanical and Egg Yolk Mixture on the Management of Diseases and Insect Pests of Tomato *Solanum lycopersicum* L. in Uganda. *Adv Crop Sci Tech.* 2018; **6**: 388.

29. **SNV.** Smallholder Horticultural production and business trainers' manual. 2016; 65-67.

30. **Ibeawuchi II, Obiefuna JC, Ofor MO, Ihem EE, Nwosu FO, Nkwocha VI and IO Ezeibekwe** Constraints of resource poor farmers and causes of low crop productivity in a changing environment. *Researcher*. 2009; **1**:48-57.

31. **Kassie M, Jaleta B, Shiferaw F, Mmbando F and M Mekuria** Adoption of interrelated sustainable agricultural practices in smallholder systems: evidence from rural Tanzania. *Technol. Forecasting Social Change*. 2013; **80**: 525–540.

32. **Bezu S and S Holden** Are rural youth in Ethiopia abandoning agriculture? *World Dev*. 2014; **64**: 259–272.

33. **Barret CB** Towards improved natural resource management in African agriculture. In: C.B. Barret, F. Place F and A.A. Aboud AA(Eds). Natural resources management in African agriculture. Understanding and improving current practices, Wallingford, UK, CAB International. 2002; 287-296.

34. **Pervez AM, Ayub GM, Shahid MA and HA Khan** Effect of drought stress on growth, yield and seed quality of tomato (*Lycopersicon esculentum* L.). *Pakistan Journal of Agricultural Sciences*.2009; **46**:174-178.

35. **Cantore V, Lechkar O, Karabulut E, Sellami MH, Albrizio R and F Boari** Combined effect of deficit irrigation and strobilurin application on yield, fruit quality and water use efficiency of "cherry" tomato (*Solanum lycopersicum* L.). *Agric. Water Manage*. 2016; **167:53**–61.

36. **Robinson E and KL Shashi** The Case of Tomato in Ghana: Marketing. Working Paper #20. Accra, Ghana: International Food Program. 2010; 7-8.