AGRONOMIC MANAGEMENT OF YELLOW PASSION FRUIT AMONG FARMERS IN MBEERE SUB-COUNTY, KENYA

Peter Mwirigi[*1], Maina Mwangi[1], and Joseph Gweyi-Onyango[1]
[1]Kenyatta University, P.O Box 43844. Nairobi
***Correspondence:** *mwirigip@gmail.com*

Abstract

Yellow passion fruit (*Passiflora edulis var. flavicarpa*) is emerging as an important high value horticultural crop in Kenya since its introduction five years ago. The fruit is gaining wide adoption in Mbeere Sub County due to its apparent adaptation to the hot arid conditions and tolerance to *Fusarium* wilt disease. However, the current production levels of the fruit are low due to poor water and nutrient management, erratic rainfall and poor agronomic practices. A study was conducted to assess the agronomic practices and main constraints among the farmers in Mbeere Sub County. A stratified random sampling procedure was used to collect data from 63 households from a total population of 170,950. Data was collected on household demographics, farm size, farming systems, planting materials, fertilizer use and irrigation types. This was carried out through personal interviews with members in each household responsible for management of passion fruit orchards using structured and semi-structured questionnaires. The results indicate that the majority of the farmers (65%) grow yellow passion as an intercrop with other food crops. Nevertheless, passion contributes to <10% of the proportion of the farm, though this proportion is expected to increase with expansion in production. Major findings indicate that the main source of planting materials were seedlings from KARLO (44%), use of Yaramillar (44%) as the preferred planting fertilizers and irrigation of crops three times per week (49%). In conclusion, yellow passion is a fruit with potential for increased adoption but more detailed studies are needed to clearly identify and understand water and nutrient management.

Key words: Yellow passion fruit, Management constraints, Agronomic practices, Production

Introduction

Yellow passion fruit (*Passiflora edulis var. flavicarpa.)* is native to tropical America and is grown and processed in many countries (Kibet, et al., 2011). The yellow variety has sour and sweet cultivars which are mostly suited for low lands. The variety also thrives well in mid altitudes of up to 1500 m above sea level and lately there has been increased production of the KPF4 variety in semi-arid regions of Embu, Meru, Tharaka Nithi and Kirinyaga counties (HCDA, 2013). The KPF4 was developed by Kenya Agricultural Research and Livestock Organization (KARLO) and is popularly referred to as sweet yellow passion. The strength of the yellow passion is that it is more tolerant to *Fusarium wilt*, a critical disease that has severely reduced purple passion fruit productivity (R.L. Amata, 2011). The disease reduces purple passion yields significantly diminishing its production period from an average of six to two years. It is also tolerant to woodiness virus and brown spot diseases (R.L. Amata, 2011). Moreover, when yellow passion is used as a rootstock in grafting purple passion, it improves the disease tolerance of the purple variety (Wangungu, 2012).

The vulnerability of the purple passion to diseases and its resultant loss of Kenya's market share in the European Union and Middle East prompted KARLO to intensify research on

alternative varieties. Breeding of sweet yellow passion varieties commenced between 1996 and 1997 with the support of USAID and World Bank. Apart from tolerance to diseases, the KARLO breeding programme that took 20 years to establish this new variety was informed by the need for a variety that was drought tolerant and acceptable in both the fresh and processing markets based on size, juice content and sweetness (KARLO, 2014). This has been achieved by combining traits of the sour and purple passion to get the sweet yellow passion varieties: KPF4, KPF11 and KPF12 which were introduced in 2011 (KARLO, 2014). There is greater preference for KPF4 as its yields are of higher juice content and quality. To ensure the varieties were widely disseminated to farmers, KARLO partnered with TechnoServe, a private agribusiness firm to establish a mother block for seed extraction and nurseries. The mother block has also been used for conserving germplasm to facilitate continuous research. The yellow passion is mainly consumed locally and also exported by some Kenya companies (HCDA, 2013). Currently this fruit is widely grown in Mbeere Sub County of Embu County, an initiative promoted by Kenyatta University (KU), KARLO and Kamurugu Agricultural Development Initiatives (KADI), among others.

According to Mongabay (2006), 80% of the total land in Kenya is arid and semi-arid (ASAL) and is characterized by poor households. Such households are unable to meet their most basic needs and have inadequate income, lack of access to productive assets, low productivity, subsistence farming as well as deprivation of social infrastructure and markets (Mariara and Ndeng'e, 2004). Hence this has led to unpredictable income and a major cause of poverty among many rural households (Zeller and Oppen, 2007; Démurger et al., 2009). As a way to mitigate this, there has been an outstanding trend of most smallholder farmers to diversify from low value crops to high value crops (Démurger et al., 2009). Most studies suggest that rural households adjust their agricultural activities in order to exploit new opportunities created by market liberalization (Barrett et al., 2001a; Delgado and Siamwalla, 1997). These adjustments in agriculture have an important impact on income among most rural households (Block and Webb, 2001).

Yellow and purple passion fruits require regular water supply during dry periods, a good management of the numerous diseases and pests that attack and defoliate vines and a commitment to maintain the vines. In addition, proper equipment for spraying of vines, regular disinfection of pruning tools and adequate knowledge in crop nutrition requirements are important (KENGAP, 2011).

Insufficient knowledge on good agricultural practices as well as pest and disease management are major challenges in addition to the inaccessibility of pathogen-free planting materials (Mbaka et al., 2006; Kleemann et al., 2010; Wangungu et al., 2010). Farmers are mostly attracted by the high prices of the fruits which leads to investment decision based on partial information; some therefore fail to take note of the challenges faced in growing the crop. Management of the fruit orchards differ from one area to another. This may be influenced by the climate of an area, availability of information, financial ability, infrastructure development, among others (Dirou, 2004).

Passion fruit enterprise has higher returns compared to cabbage, maize, wheat, tomatoes and beans (Kibet, et al., 2011) if production is carried out efficiently especially in the first production year with expected increase in returns during the second and third years of production (Fintrac, 2009). The enterprise can attain a gross margin of Ksh. 629,850 per hectare (US $7,410). Therefore, the enterprise presents a quick avenue to poverty alleviation,

creation of employment and improved food security (Kibet et al., 2011). However, inadequate levels of inputs application (Sibiko, 2012) and weak managerial capacity present a challenge towards attaining production efficiency (Kleemann et al., 2010) among small scale farmers. This present study evaluated the current agronomic management practices for yellow passion and the major constraints facing farmers.

Materials and methods

Study site description

The study was conducted in Mbeere Sub County in December 2014. Mbeere is located in Eastern Kenya and lies between Latitudes 0° 20' and 0°50' South and Longitude 370 16' and 370 56' East. The Sub County slopes in a North West to South East direction. Its altitude ranges from 1200 m above sea level to about 500 m asl on the Tana River basin. The Sub County is served by five permanent rivers namely Tana, Rupingazi, Thuci, Thiba and Ena. The Sub County is covered by three main agro-ecological zones namely: the marginal cotton zone (Lower Midlands, LM 4), the Lower midland livestock-millet zone (Lower Midlands, LM 5) and Lowland livestock millet zone (Lowlands, LM5) (Jaetzold et., al 1986). The soils in the District are variable in structure and texture and are generally low in fertility. There are four main administrative Divisions; Siakago, Evurore, Gachoka and Mwea. The region has four perennial rivers rising from the Mt Kenya highlands and series of seasonal rivers and dry river basins that include Ena, Tana, Thuci and Thiba with only Ena flowing within the District. The district has a bimodal pattern of rainfall with the long rains falling between April and June while the short rains fall between October and December. The short rains are more reliable. The annual rainfall averages range between 640 mm and 1,100 mm with most parts of the district receiving 550 mm of rainfall per year hence making Mbeere a marginal district. The altitudinal variation influences temperatures that range from 15°C and 30°C (Jaetzold et al 1986).

The predominant land use type in Mbeere is agriculture (Livestock keeping, crops production and Agroforestry). The food crops grown are; maize, beans, sorghum, pearl millet, cowpeas, green grams, cowpeas, mangoes, pawpaw, kales, tomatoes grown both for sale and consumption while the cash crops are cotton and millet (Githaiga, 2013).

Sampling and data collection

A house hold level survey covering the five divisions was conducted in December 2014. A stratified sampling procedure was followed to define the sampling units. The area was first stratified in terms of geographical distance to cover the approximate ecological range of yellow passion fruit. Consultation with agricultural officers and key informants knowledgeable with the area enabled accurate identification of the farmers growing passion. Data was collected through personal interviews with members in each household responsible for management of passion orchards using structured and semi-structured questionnaires. Sixty households were sampled representing a proportion of 40% estimated farmers that were growing yellow passion fruits from a total population of 170,950. This number was derived using the following sampling formula (Cochran, 1963):

$$\mathrm{n} = Z^2 \frac{p(1-p)}{\mathrm{e}^2}$$

Where: n-sample size

- Z^2- is the abscissa of the normal curve that cuts off an area at the tails (1–95%)
- p- is the estimated proportion of the population (40%)
- e- is the desired level of precision (0.05)

The data was recorded on general household and farm description, total farm size, proportion

of the land occupied by passion, main crop grown by the farmer, proportion of passion sold (%), source of planting material, average time to germination, time to harvestable maturity, frequency of harvest, watering regimes, fertilizer application, planting materials and main constraints to passion production.

Data analysis

Descriptive statistics were performed using SPSS version 18, with results being presented as tables and figures in percentage form. The variable analysed included farm size, household demographics, farming systems, planting materials used, fertilizers (both planting and top dressing) and irrigation types. A Pearson correlation between the farm size and the proportion under passion was also performed. The analysis used a confidence interval of 95%.

Results and discussion

Farm size

The sizes of the farm under yellow passion cultivation ranged from <1 acre to > 8 acres. Nevertheless, majority of the farmers cultivate small pieces of land ranging 0-2 acres (53%), 22% cultivating 0-4 acres and 12% cultivating pieces of land ranging from 4-8 acres. Few farmers (14%) had slightly over 8 acres. These measurements were estimated by counting the number of steps around the piece of the farm and estimating in acreage or getting the information from the farmer.

Despite the disparities in the land sizes, yellow passion was allocated a small proportion of the land with majority of the farmers (50%) growing passion in <10% of their total land while a smaller percentage of farmers (7%) dedicated slightly over 30% of their land to passion farming (Table 1).

Table 1: Farm size and proportion under yellow passion (N=63)

Size of the farm (acres)	Respondents (%)	Std. Error	Proportion under passion (%)	Respondents (%)	Std. Error
>8	13.6	4.4	>30	6.8	3.1
0-2	52.5	6.6	<10	50.8	6.4
0-4	22	5.3	11-20	30.5	5.8
4-8	11.9	4	21-30	11.9	4.2

The sizes of the farms confirm similar findings by John Gichaiga, 2013 in his baseline report on Mbeere North who found out that most of the farmers in Mbeere had land parcels less than 5 acres and a small proportion had >10 acres (John Gichaiga, 2013).

Household demographics

Household sizes varied between one to 11 persons, with a majority size of three persons per household (Table 2). Gender distribution among the respondents was more skewed towards the males (75%) with females (25%) among the farmers. The number of hired workers among the households varied from none to 8 with majority (54%) hiring only one worker at time. Most of the work in the passion orchards was carried out by family members or occasional help from friends and neighbours. The lack of extensive engagement of hired labourers can also be attributed to the low purchasing power among the farmers in Mbeere, a region that is traditionally economically disadvantaged. The yellow passion is also just being commercialized hence the returns are marginal.

Table 2: Household size (N=63)

No of children per household	Respondents Percentage
0	10.2
1	3.4
2	16.9
3	22
4	13.6
5	13.6
6	8.5
7	6.8
8	1.7
10	1.7
11	1.7

Farming systems

Mbeere is largely a low agricultural potential zone (rain-fed conditions), hence crop production is a difficult venture. Food crops such as maize, millet, sorghum, beans, cowpeas, green grams, cassava and bananas are grown mainly for subsistence. In this study, intercropping and mixed farming were the main forms of farming systems in Mbeere. Passion was frequently intercropped with several other crops with maize and Khat/Miraa (34% &31%, respectively) being the most preferred crops. Passion was the preferred crop by 15% of the farmers (Figure 1). Other common crops included watermelon, green grams and tomatoes. The preference for maize was probably due to its short maturity period and use for direct consumption as food by the household while Khat was preferred for its readily available local market and good prices. In addition, previous studies have demonstrated that maize has witnessed a great technological transformation in Kenya compared to other cereals such as sorghum, which were introduced long before maize. This is mainly because of introduction of hybrids and composite varieties (Hassan and Karanja, 1995). Marketing problems and water scarcity have hampered large scale production of passion production and other cash crops especially cotton. In view of the few cash crops grown, most of the food crops, especially green grams, cowpeas and watermelon play the dual role as both food and cash crops, upon sale of surplus in good cropping seasons.

The diversification and preferences in the crops grown could also be due to drought tolerance and disease infestation in other crops as confirmed by a previous study on food security in Mbeere (Githaiga, 2013). Land use also varied within and across agroecological zones as confirmed in a technical report of soil survey and sampling results of Mbeere (Louis, 2002).

There was no significant correlation between the size of the farm and the proportion of yellow passion grown indicating that farmers did not accord any special preference to the passion due to the size of the land (Table 3). This is probably due to the fact that this is a crop being newly commercialized by majority of the farmers hence they have not yet fully adopted it over their traditional crops.

Planting materials

Majority of the farmers used seedlings as the planting material while a few directly sowed the seeds. The source of the planting material varied with majority (44%) sourcing their materials from Kenya Agricultural and Livestock Research Organization in Thika and 33% from their neighbours (Figure 2). Other sources included purchase from agro veterinary shops and local NGO's in the area. The spacing of yellow passion varied among farmers with 3x2 m being the preferred spacing by the farmers. Other spacing distances encountered included 1x2 m, 2x2 m, 3x4 m and 4x2 m. The source of information on spacing varied from farmer to farmer with some reporting to receive advice from local agricultural extension officers, NGO representatives or learning from their neighbours.

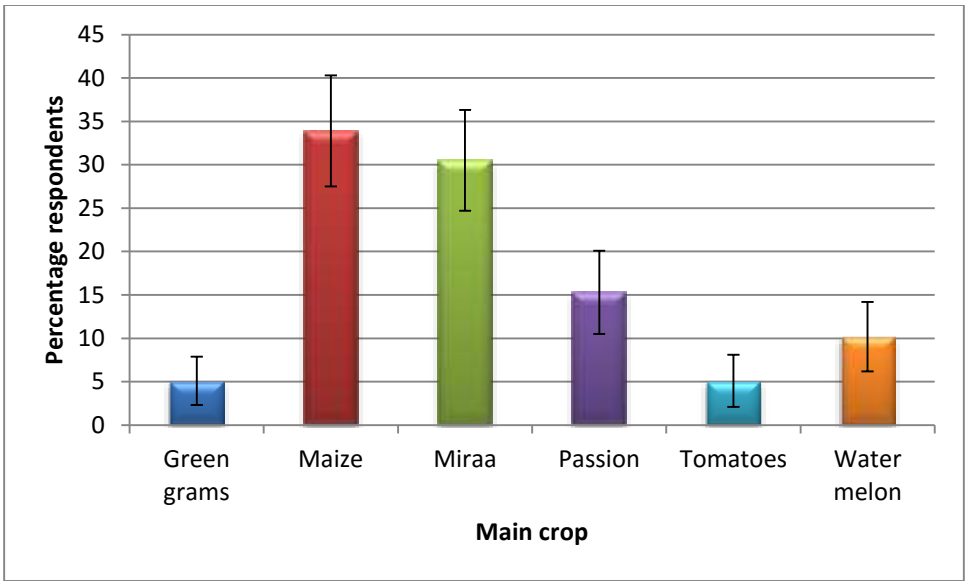

Figure 1: Intercropping of passion with other crops (N=63)

Table 3: Pearson correlation for size of the farm and the proportion of farm under passion

		Size of the farm	Proportion of farm under passion (%)
Size of the farm	Pearson Correlation	1	0.121
	Sig. (2-tailed)		0.362
	N	59	59
Proportion under passion (%)	Pearson Correlation	0.121	1
	Sig. (2-tailed)	0.362	
	N	59	59

Planting and top dressing fertilizers

Majority (44%) of the farmers used Yaramillar winner® (15%N: 9%P: 20K), a NPK (Nitrogen Phosphorus and Potassium) brand recommended by one of the private buyers of passion in the region. This was always used in combination with farmyard manure. In addition, some farmers used manure only (27%) while others used DAP (Diammonium Phosphate) (20%). Other fertilizers used by farmers for planting included top dressing fertilizers Nitrabor®, (25.6 % CaO, 15.4 % Nitrogen, 14.1 % Nitrate, 1.3 % Ammonium and 0.3 % Boron) and TSP (Triple Super Phosphate) (Figure 3). The use of these top dressing fertilizers for planting can be probably attributed to ignorance or the readily availability of the particular fertilizer. The common rate (44%) of application among the farmers was 100g/plant of Yaramillar winner fertilizer. Other farmers used different rates per plant. The method of measuring the fertilizer differed with some using their hand palms, teaspoon, empty tin cans, debes and spades. These applications of varying rates of fertilizers are likely to lead either to low or excessive uptake of nutrients leading to reduction in the yield of passion. Other studies on nutrient uptake have demonstrated a higher uptake of nutrients by fruits than that of cereal crops in most farming systems. To replenish the removal and to supply sufficient amount of nutrients at each stage of crop growth, adequate rates are needed in any fertilizer application

programme of these crops (Kemmler and Tandon, 1988).

Top dressing fertilizers commonly used by the farmers included Nitrabor®, CAN (Calcium Ammonium Nitrate), Easygrow®, farm yard manure, NPK (Nitrogen Phosphorus and Potassium) and MOP (Muriate of Potash) with majority (41%) of the farmers preferring Nitrabor (Table 4). The rates of application varied from 25g to 100g/plant with most farmers (44%) applying 100g/plant.

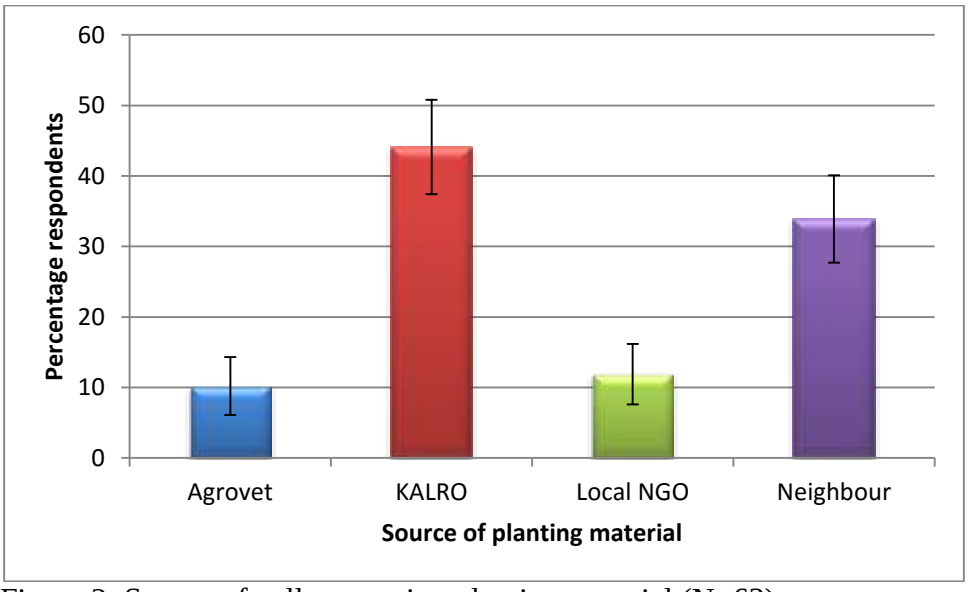

Figure 2: Source of yellow passion planting material (N=63)

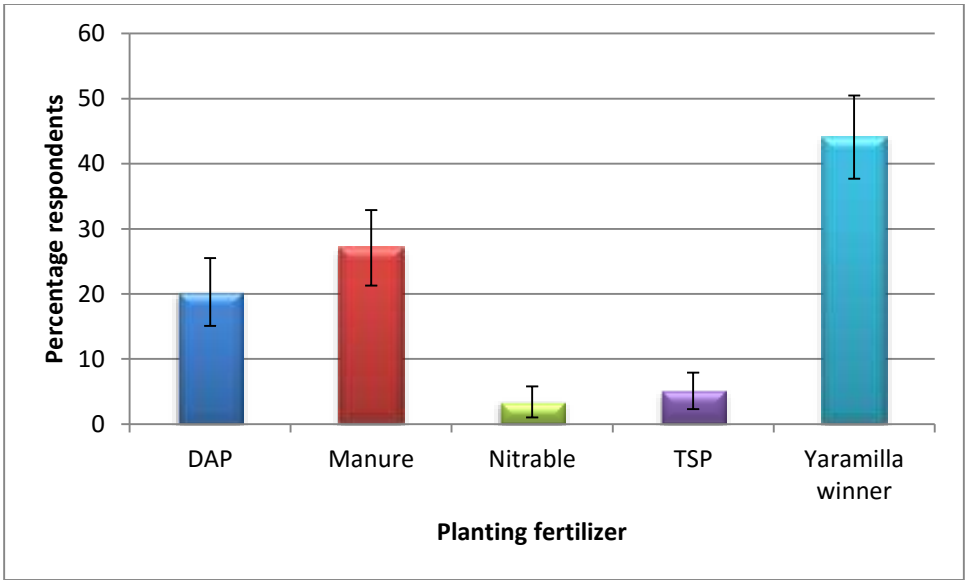

Figure 3: Type of planting fertilizer used in yellow passion fruit farming (N=63)

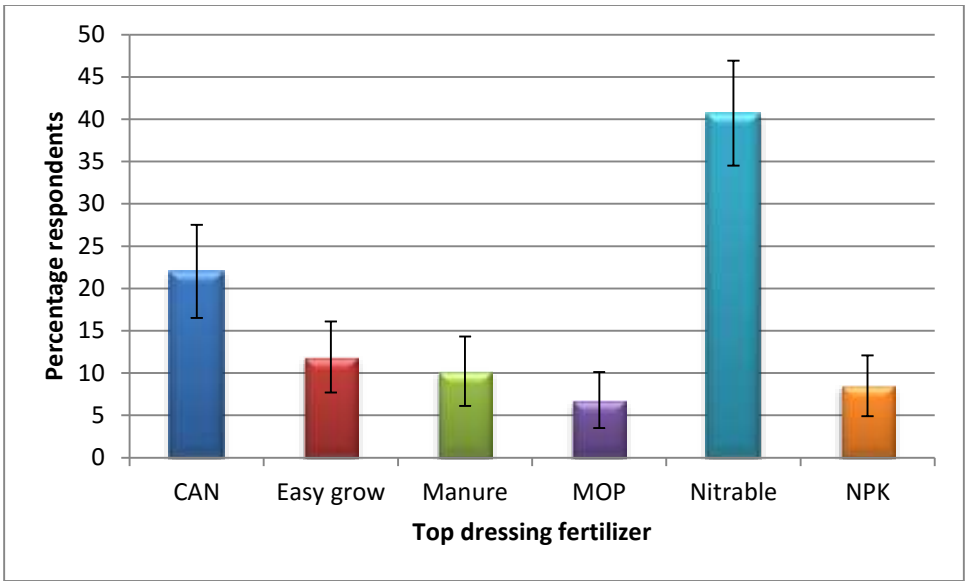

Figure 4*:* Type of top dressing fertilizer used in yellow passion fruit farming (N=63). CAN = calcium ammonium nitrate; MOP = Muriate of Potash; NPK = nitrogen, phosphorous and potassium.

Table 4: Rates of application of different fertilizers applied in yellow passion fruit farming in Mbeere (N=63)

Fertilizer type	Rate/plant	Percentage
Planting fertilizer		
Manure	0.5 debe	3.4
Manure	1 debe	3.4
Manure	1 spade	5.2
Manure	20kg	1.9
Manure	2kg	1.6
Yaramillar winner	100g	44.1
DAP	10g	1.8
DAP	1kg	1.6
DAP	200g	1.5
DAP	20g	3.5
DAP	25g	3.4
DAP	40g	1.7
DAP	50g	23.7
Top dressing		
Nitrabor	100g	54.3
MOP	40g	6.8
TSP	500g	1.6
NPK	50g	37.3

Where DAP =Diammonium Phosphate, MOP = Muriate of Potash, TSP = Tripple Super Phosphate and NPK = Nitrogen Phosphate and Potassium

Soil fertility has been declining in the semi-arid regions of Eastern Kenya including Mbeere District (Kihanda and Warren, 1998). Other studies have shown that soil fertility decline is the biophysical root cause of decreasing per capita production (Warren, et al., 1996). To reverse soil fertility decline, effective management strategies need to be explored at the levels of adding nutrients to the production system, reducing losses of nutrients already available in the system, optimizing nutrient cycling and increasing the efficiency of nutrient uptake (Hilhorst and Muchena, 2000). The decline in fertility is attributed to farmers' limited knowledge base in integrated nutrient management. This is further exacerbated by inappropriate and, sometimes, untimely response to constraints posed by socio-economic and biophysical pressures within which soil fertility management takes place.

In Mbeere, it has been reported that the quantities of nutrients being removed from the soil, through crop uptake, leaching and erosion exceed the amount of nutrients returned to the soil through natural processes such as atmospheric deposition and biological nitrogen fixation or through additions of inorganic and organic fertilizers. Nitrogen is being depleted at the rate of 26 to 46 kg ha-1 yr-1 (Gitari et al., 1999; Kihanda and Gichuru, 1999). Other authors working in semi-arid areas (Karyotis et al., 2005) of Kenya have also shown that current farm management practices result in nitrogen depletion at the rate of 53 to 56 kg ha-1 yr-1, implying that 60-80% of farm income is based on nutrient mining (De Jager et al., 1999). In general, the soils in Mbeere are reported to have low organic matter, nitrogen and phosphorus contents except for localized areas.

Balanced fertilizer application must be based on the concept of integrated nutrient management for a crop/cropping system, as this is the only viable strategy advocating accelerated and enhanced use of fertilizers with matching adoption of organic manure and biofertilisers so that productivity is maintained.

Irrigation

Mbeere being a semi-arid zone presents great challenges in water availability especially for irrigation. Majority of the farmers (44%) irrigated their passion fruits on a daily basis per week while 34% irrigated 2 days per week. Other irrigation frequencies included 3 days and 4 days per week (Figure 5). These were the few farmers who could afford to pay for irrigation water. A significant proportion of the farmers depended on rain fed and this led to reduced production of the passion fruit as this is a crop with heavy water demands. The method of irrigation varied from using buckets, flooding by pumping from rivers and streams and the use of overhead sprinklers. The common rates of application were 10, 20 and 40 liters with majority of the farmers (46%) applying 20lts per plant (Figure 5). Water in Mbeere is also slightly saline with high pH content. This has a significant effect on the yield and growth of passion. Studies on pH content have indicated that plants growing in a high pH substrate are subject to nutrient imbalances as a result of changes in nutrient availability as pH increases in the substrate. This effect may be related to the mainly low availability of micronutrients related to vegetative growth, such as Copper which has an important role in photosynthesis, respiration, fixation and reduction of nitrogen (Cácio et al, 2013). This could be one of the factors contributing to flower abortion and shrivelled fruits that are becoming common amongst farmers.

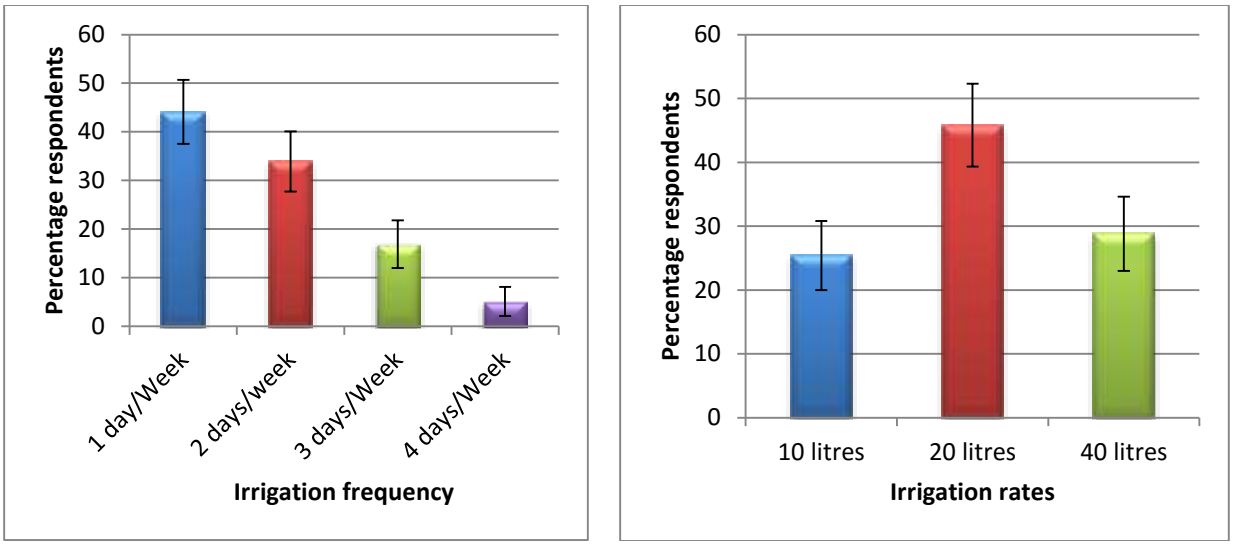

Figure 5*:* Irrigation frequency and rates per yellow passion plant in Mbeere *(*N=63)

However, passion fruit productivity can be improved by tapping the five rivers in the region (Tana, Thuci, Thiba, Ena and Rupingazi) which all have great potential for irrigation. These rivers, together with the limited seasonal streams, earthdams and springs in the district provide irrigation potential for small-scale group based horticultural gravity schemes, group based horticultural pump-fed schemes, group-based food schemes and individual small holder schemes (Gachimbi et al., 2007). Other significant water resources in the district are dams, which serve to generate hydroelectric power. These dams include Kiambere, Gitaru, Kamburu, Kindaruma and Masinga, all of which are situated along the Tana River.

The underutilization of the water resources in the district is largely due to inability of the local farmers to acquire enough cash capital input. This situation is not any different from many parts of sub-Saharan Africa where it is reported that there is generally low levels of adoption of modern technologies (such as irrigation) for land intensification (Badiane and Delgado, 1995). FAO (1986) has further reported that the contribution of irrigation to food supply in sub-Saharan Africa is limited at regional scale despite the emerging large scale, centralized technology driven schemes and that the performance of these schemes has been disappointing with low returns to investment. They suffer from various administrative, financial and technical constraints characterized by salinization and degradation of the watersheds as a result of siltation and other problems like outbursts of weed growth, limited skilled personnel and capital needed to maintain equipment.

Conclusion

Yellow passion fruit is highly suitable for small-scale farmers due to its high nutritional content, market value and short maturity period. However, its production in Mbeere is constrained by water scarcity, technical knowhow on crop cultivation, relatively higher capital investments and poor market prices. The key recommendation of this project will include developing suitable agro-technologies, for example optimum utilization of the available water, improvement in the agronomic practices and enhancing participatory dissemination of market information to the farming community will go a long way in popularizing the crop.

Additional key recommendation could be identification of superior agronomic practices and refinement in techniques involving accurate diagnosis of nutritional disorders and a

clear understanding of the correct fertilizer and irrigation regimes will lead to improved yield of the yellow passion in Mbeere region. The heavy capital investment in passion can then be compensated by improved productivity which will translate to higher incomes. Prolonging the longevity of productive life, from the present average life of three to four years of passion is desirable. While doing so, high density planting in modern greenhouses that are climate controlled could be a possibility in the future, in order to match with frontline passion fruit growing countries. A concerted effort on the other hand is much needed in creating awareness, developing market linkages and setting up of processing units, post-harvest management and creation of proper infrastructure and logistics for the management of the entire yellow passion value chain. It would be important to also carry out detailed studies on yellow passion adoption and management in other regions of the country to accurately identify the challenges and potential of the crop countrywide.

Acknowledgement

The authors wish to acknowledge Kenya Agricultural Productivity and Agribusiness Project for the financial support in carrying out this work, participation of the farmers in Mbeere in the study and to Kenyatta University for providing the technical guidance.

References

Badiane, O. Delgado, C.L., (1995). A 2020 Vision for Food, Agriculture and the Environment in Sub-Saharan Africa. Food, Agriculture and the Environment. Discussion paper 4. International Food Policy Research Institute. Washington, DC.

Barrett, C., Bezuneh, M. and Abdillahi, A. (2001). "Income Diversification, Poverty Traps and Policy Shocks in Cote D'ivoire and Kenya". Food Policy, 26, pp. 367–384.

Block, S. and Webb, P. (2001). "The Dynamics of Livelihood Diversification in Post-Famine Ethiopia". Food Policy, 26 , pp. 333–350.

Cácio Luiz Boechat, Aretusa Martins Teixeira, Alexandre Sylvio Vieira Da Costa, Mar-Cela Rebouças Bomfim. (2013). Initial Growth of Yellow Passion Fruit Seedlings in Substrate Composed Of Pulp Mill Sludge and Cattle Manure. Journal of Revista Caatinga. ISSN:0100-316X. Universidade Federal Rural do Semi-Árido, Brasil.

Cochran WG. Sampling Techniques. 2nd ed. (1963). NewYork: John Wiley and Sons, Inc., 1963.

De Jager, A., Onduru, D.D., Wijk, M. S., Vlaming, J. and G.N. Gachini. (1999). Assessing Potentials of Low External Input Farm Technologies with the Nutrient Monitoring Approach: A case study in Kenya. Agricultural Systems 69: 99-118.

Delgado, C. L. and Siamwalla, A. (1997). "Rural Economy and Farm Income Diversification in Developing Countries". MSSD Discussion Paper, No. 20.

Démurger, S., Gurgand, M., Li, S. and Yue, X. (2009). "Migrants as Second-Class Workers in Urban China? A decomposition Analysis". Journal of Comparative Economics, in press, doi:10.1016/j.jce.2009.04.008.

Dirou, J. (2004). Passion Fruit Growing: What You Need To Know. Retrieved from http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0009/119691/passionfruit-growing.pdf.

FAO, (1986). African agriculture: The next 25 years. Annex 4, Irrigation and water control. FAO, Rome.

Fintrac. (2009). USAID-KHDP Kenya Horticultural Development Program October 2003 – 2009. Nairobi: USAID-Kenya.

Gachimbi, L.N., Kamoni, P.T., Wanjogu, S.N,, Macharia P.N and Gicheru, P.T. (2007). Land Use Practices in Mbeere District: Biophysical and Socio Economic

Challenges, Copping Strategies and Opportunities: A Baseline Survey Report. Kenya Agricultural Livestock and Research Organization. Nairobi. Kenya.

Gitari, J.N. Matiri, F.M., Kariuki, I.W., Muriithi, C.W., Gachanja, S.P., (1999). Nutrient and Cash flow monitoring in farming systems on the Eastern Slopes of Mount Kenya. Nutrient Disequilibria in Agroecosystems, pp 211-227.

Hilhorst, T. and Muchena, F.M (Eds.) (2000). Nutrients on the move-Soil fertility dynamics in African farming systems. International Institute for Environment and Development (IIED), London, UK.

Horticultural Crop Development Authority (HCDA). National Horticulture Validated Report. 2013.

http://slmkenya.org/sites/default/files/mbeere_north_baseline_survey.pdf. Accessed on 18th May 2016.

Jaetzold, R., Schmidt, H., Hornetz, B. and Shisanya, C. (2006). Farm Management Handbook of Kenya: Vol. II Subchapter C1. Ministry of Agriculture, Government of Kenya. Nairobi, Kenya.

John Gichaiga. (2013). Mainstreaming Sustainable Land Management in Agropastoral Production Systems in Kenya. Mbeere North Baseline Survey Report. UNDP SLM Project. Ministry of Livestock.

Karyotis, T., D. Onduru C. Noulas, L.N. Gachimbi and F.N. Muchena. (2005). Nutrients, trace elements and Net N mineralization in Acid Soils. Soil Sc. Plant Nutr. 51 (5): 645-648.

Kemmler, G. and Tandon, H.L.S., (1998). Potassium deficiency and its correction in horticultural crops, Int. Potash Inst., Berne and FDCO, New Delhi, p. 23.

KENGAP. (2011). The Passion Fruit Farming Handbook. Nairobi: KENGAP Publishing Ltd.

Kenya Agricultural Research Institute (2014). KARI Sweet Yellow Passion that withstand critical diseases that ravaged Purple passion. Hortfresh journal. Tech Era Communications. Nairobi. Kenya.

Kibet, N. (2011). The Role of Incentives and Drivers in Crop Trade-Off: Evidence from Passion Fruit Uptake in Uasin-Gishu District, Kenya. MSc. thesis in Agricultural Economics of Egerton University, Kenya.

Kihanda, F.M. and Warren, G.P. (Eds.), (1998). Maintenance of soil fertility and organic matter in dryland areas. Department of Soil Science, The University of Reading, occasional publication Number 3. Proceedings of a workshop held in Embu, Kenya, Nov 27-28, 1997.

Kleemann, G., Chege, P. and Krain, E. (2010). Growing Value: Achievements in Value Chain Promotion for Passion Fruit Value Chain in Kenya. Nairobi: PSDA.

Louis N. Gachimbi (2002). Technical Reports of Soil Survey and Sampling Results: Embu-Mbeere District, Kenya. LUCID working paper series Number 9. Nairobi, Kenya. International Livestock Research Institute.

Mariara J. K. and Ndeng'e G. K. (2004). Measuring and Monitoring Poverty: The Case of Kenya.

Mbaka, J., Waiganjo, M., Chege, B., Ndungu, B., Njuguna, J., Wanderi, S., Njoroge, J. and Arim, M. (2006). A Survey of the Major Passion Fruit Diseases in Kenya. 10th KARI biennial scientific conference. Volume 1/Kenya.

R.L. Amata, M.J. Otipa, M. Waiganjo, L.A. Wasilwa, J. Kinoti, S. Kyamanywa, M. Erbaug (2011). Management Strategies for Fungal Diseases in Passion Fruit Production Systems in Kenya. ISHS Acta Horticulturae 911. DOI: 10.17660/ActaHortic.2011.911.20.

Sibiko, K. (2012). Determinants of Common Bean Productivity and Efficiency: A Case of Smallholder Farmers in Eastern Uganda. MSc Thesis, Egerton University.

Wangungu, C. (2012). Etiology, Epidemiology and Management of Dieback Disease of Passion Fruit (*Passiflora spp*) in Central and

Eastern Regions, Kenya. Unpublished MSc Thesis, Kenyatta University.

Wangungu, C., Maina, M., Mbaka, J., Kori, N. and Gathu, R. (2010). Biotic constraints to passion fruit production in central and eastern provinces of Kenya. Second RUFORUM Biennial Meeting. Entebbe, Uganda.

Warren, G.P., Muthamia, J. and Irungu, J.W., (1996). Soil Fertility Improvements under Manuring in Semi-Arid Lower Embu and Tharaka-Nithi. In: Fungoh, P.O and Mbadi, G.C.O., Focus on Agricultural Research for sustainable development in a changing Economic Environment. Proceedings of the 5th KARI Scientific Conference, 14th -16th October 1996. KARI, pp 151-163.

Zeller, H. and Oppen, M. V. (2007). "Socio-Economic Impact of Upland Rice Production on Rural Livelihoods–The Case of Three Nigerian States". Conference proceedings on International Agricultural Research for Development. Gut Kröchlendorf.