

Research trends in horticultural crops in Malawi

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The review looks at the progress in the promotion of horticultural crops through research, as well as the institutions that have been involved in the sector through financial support and the integration of farmers into the research on production of horticulture crops in Malawi, African country. The driving force for research in horticulture in Malawi, is crop diversification and the search for high yielding varieties which are resistant to pest and diseases. The country has one major staple food source, maize and due to the effects of climate change and global warming the country has been hit with erratic rains resulting in poor maize yields and this has been seen the country emphasising its research into root and tuber crops which are believed to do well even with low rainfall. Malawi as a developing country, is at a stage where the main objective for the country's leadership is to feed its people as also evident in the review research endeavours. No or limited research has been initiated in floriculture or ornamental horticulture showing that the country is still at the stage of meeting its basic needs, one of which is food. However, that being said, Malawi has a very narrow economic base which is agricultural and emphasis in horticulture would contribute towards widening the economic base. The review has also shown that as much as the government machinery controls how research is conducted in the country and that the new technologies can only be released by the Agricultural Technology Clearing Committee (ATCC), there is so much dependence upon donors for financial support.

Key words: Breeding, germplasm, horticulture and research.

Malawi is a land locked country which lies on the southern end of the Great Rift Valley between 9°25'S and 17°08'S latitude, and 32°40'E and 35°55'E longitude. It has a total area of 118,480 km², a total land area of 94,079 km² and the remaining 24,401 km² (20%) is covered by mountains (third tallest mountains in Africa) and surface water resources, dominated by lake Malawi and Shire river. It shares boundaries with Tanzania on the north, Zambia on the North West and Mozambique on the South-West, South and South-east (DREA, 1994; EAD, 2002; Kachule and Franzel, 2009).

Malawi is a developing country, its economy is predominantly agricultural and heavily relies on tobacco export. Other major earners of foreign exchange are tea, sugarcane and coffee with cotton and groundnut as the minor export earners. However, increased pressure from the international community to limit dependence on tobacco growing and the decline in world tobacco prices has created heavy burden on the economy of the country (Kubwalo, 2006, Kachule and Franzel, 2009). Horticulture sector has thus great potential to complement the country's traditional cash crops of tobacco, tea and sugarcane in terms of contribution to national economy. Many authors agree on the fact that cultivation of horticultural crops is a potential alternative source of national income as well as income for subsistent farmers (Kainja, 2000, Kubwalo, 2006, Kachule, 2006, 2009, Gotor, 2011,

Daud and Mwenda, 2008). In addition to national economic contribution, horticultural commodities such as fruits and vegetables have the potential to contribute to household nutrition, food security and household income. The fruits and vegetables have, contribution to nutrition, income and national economy but horticulture has received little technical and financial support from the government and the private sector as compared to tobacco, tea and sugar industries (Gotor, 2011; Kachule *et al.*, 1998; Kachule and Franzel, 2009). Availability of disaggregated data for the various components of horticulture is also a problem. Lack of detailed and specific statistics on horticulture makes it difficult to make decisions on specific components of the horticultural sector (Kachule and Franzel, 2009).

Horticulture is currently got attention among the fastest growing sectors in most Sub-Saharan African countries. Compared to traditional field crops, horticultural crops exhibit several advantages that make them attractive to farmers, both commercial and subsistence. Most horticultural crops are labour intensive at each level of production and marketing. Thus, growth of this sector can contribute to the reduction of the rising unemployment. The high prices paid on horticultural crops such as chillies, paprika, macadamia nuts, cut flowers and other spices offer small and large scale commercial producers an opportunity to expand into a highly lucrative export

market thereby making horticulture as one of the major exporter and foreign exchange earner for Malawi (Kachule *et al.*, 1998).

The Ministry of Agriculture and Food Security through its Department of Agricultural Research (DAR) is mandated by government to coordinate research in the country. The department has three research stations, one in each region of the country (Bvumbwe, Kasinthula and Chitedze) where research is conducted on different crops including horticultural crops (Daudi and Mwenda, 2008). The Ministry of Agriculture and Food Security (MoAFS) is responsible for ensuring that all agricultural technologies that are developed in the country are evaluated by the Agricultural Technology Clearing Committee (ATCC) before being released to farmers. The Department of Agricultural Research is mandated to undertake and supervise all the research activities undertaken by private sector. In between the period 2000 and 2005, four tomato varieties, one macadamia variety, four cassava varieties, four sweet potato, one paprika and four yam varieties were released (Saka *et al.*, 2006). Research in horticulture has been in the area of vegetable production techniques, fruit production, tuber and root crops, tree nuts and almost nothing has been done in the area of floriculture. The overriding aim for research in Malawi is crop diversification and to find high yielding varieties that could feed the rising population amidst poor yields from the staple maize, due to erratic rains being experienced due to climate change (Kachule *et al.*, 1998; Ntaurhunga and Moyo, 2013; Benesi, *et al.*, 2013).

Tuber and root crops

Cassava, sweet potato and Irish potato are the major root and tuber crops grown in most parts of the country (Ntaurhunga and Moyo, 2013). There has been an increase in area and production of root and tuber crops over the past few years due to drought which resulted into poor maize harvests hence food insecurity (Kachule *et al.*, 1998). A major constraint in the root and tuber crop development is inadequate supply of sweet potato vines and cassava stalks that could be distributed for multiplication to the small farmers. The major donor agents and some NGOs have embarked on programmes to multiply and distribute cassava cuttings and sweet potato vines. In addition, the Government of Malawi has also put much more emphasis on the production of root and tuber crops in addition to cereals (Kachule *et al.* 1998; Chipungu *et al.*, 2013). In addition, the wood,

textile, milling, confectionery, packaging and explosive (matches) industries are already using cassava as a raw material. This move needs to be supported by increased cassava production and productivity. Therefore there is need to increase cassava production by having high yielding varieties (Benesi *et al.*, 2013; Ntaurhunga and Moyo, 2013). To this effect a Presidential initiative on large scale cassava production for food and agro-processing was launched (Chipungu *et al.*, 2013).

Research trends in the tuber and root crops

Cassava (*Manihot esculenta* Crantz.) has gained special attention in Malawi as food security crop because of drought in recent years. The wide adaptability of cassava makes it one of the best crops being encouraged by the Government of Malawi in crop diversification for achieving food self-sufficiency and security, as well as sufficient raw materials for the industries (Kachule *et al.* 1998; Benesi *et al.*, 2013). Malawi has thus embarked on a cassava improvement programme which aims at developing varieties with good quality characteristics relevant to the ways in which the crop is produced and utilized in specific areas of the country with high yields, resistant to pests and diseases (Benesi *et al.*, 2013). The Cassava improvement programme has two sources of breeding lines/clones which are genetic recombination from local selected or introduced parents with positive traits that have been identified. Secondly, elite clones from the Consultative Group on International Agricultural Research (CGIAR) centres are introduced in seed or tissue culture form and are evaluated against checks. An International Institute of Tropical Agriculture (IITA) modified breeding scheme is followed in the breeding of new cassava varieties. The trials were implemented at various research stations as well as on-farm trials representing the different agro-ecologies across the country in the 2011-12 (Benesi *et al.*, 2013; Ntaurhunga and Moyo, 2013).

In an effort to improve on productivity, International Institute of Tropical Agriculture (IITA) Malawi, in collaboration with the National Agricultural Research Systems (NARS), conducted research in the 2011-12 crop growing season for the development of cassava varieties in the southern Africa region (Ntaurhunga and Moyo, 2013). A total of 3,196 cassava seedlings from open-pollinated seeds (26 families) were screened at Chitedze Research Station for resistance to major cassava diseases (cassava mosaic

[CMD], cassava brown streak [CBSD] and cassava bacterial blight [CBB]), pests (cassava green mite [CGM] and cassava mealy bug [CM]) and for acceptable root characteristics. One hundred and ninety two (192) plants, 187 white/cream fleshed and 5 yellow fleshed, were selected for further evaluation/multiplication (Mtauruhunga and Moyo, 2013).

Yellow-fleshed cassava can significantly contribute to provision of cheap sources of carotenoids. Several yellow-fleshed clones have been introduced in the past in Southern Africa but most of them taste bitter and watery, making them not suitable for snack and the fresh market. There is need therefore to continue breeding and selecting for sweet yellow fleshed varieties, high in beta carotene and dry matter content. Ntauruhunga and Moyo (2013) evaluated a total of 204 yellow root cassava clones in 2011-12 in a clonal evaluation trial at Chitedze Research Station for root beta carotene content and other agronomic attributes (reaction to diseases and pests, root yield, DM content and taste). 131 clones were selected for further evaluation in 2012-13. Still in 2012 cropping season Ntauruhunga and Moyo (2013) evaluated a total of 88 and 70 cassava genotypes for drought tolerance/resistance at Chitala in the lakeshore area and Ngabu in the Shire Valley under natural conditions. Three improved varieties of cassava (Sagonja [CH92/082], Chiombola [TME 6] and Mpale [NDL90/34]) and one recommended local (Mbundumali) cassava varieties are under evaluation alongside farmers' own local varieties in 2012/13 cropping season in Nkhata Bay (40 sites) and Lilongwe (11 sites) districts in a participatory variety selection approach (PVSA) (Ntauruhunga and Moyo, 2013). IITA Malawi plans to continue with cassava breeding programmes in 2014 with trials in nursery seedling screening for major diseases and pests in cassava. Preliminary trials for the white/cream fleshed clones, the yellow fleshed clones and introducing the 2011 screened clones through the PVS approach and seedling multiplication.

Sweet potato breeding

Crop diversification provides an option to maize in the existing situation of recurrent droughts and erratic rainfall patterns that the country has experienced in recent years. Diversification of crops rather than increased maize production has been proposed to be the

way off this poverty treadmill. Sweet potato (*Ipomoea batatas*) which is grown across the country is one of the alternative and important food security crops. The Department of Agricultural Research Services (DARS), Ministry of Agriculture and Food Security is responsible for sweet potato improvement in the country. Promoting genetic diversity in crops is important as it provides insurance against unforeseeable changes in the environment and to maintain genetic progress. The sweet potato breeding program is therefore mandated to develop varieties that give high and stable yields per unit area and time. In 2010 DARS received an Alliance for a Green Revolution in Africa (AGRA) grant on 'Sweet potato breeding in Malawi. The aim of this project was to develop improved varieties of the required preference and nutritional attributes for increased productivity and contribution to human nutrition. The activities of the project in the three years included population development in a crossing block, adaptation trials and fast track evaluation and participatory selection of genotypes (Chipungu *et al.*, 2013). By 2011, five orange and two white fleshed sweet potato varieties were released for production. DARS received more funding from International Potato Centre (CIP) and IITA/SARRNET to contribute to variety development. CIP also facilitated germplasm exchange and interaction among National Agricultural Research Systems (NARS). Semusa, Mugamba and Salera are some of the varieties that were introduced as clones, evaluated and released in the country with the facilitation of CIP. Sweet potato scientists in the region are networking and therefore exchanging information. A series of sweet potato breeding trials were implemented in the 2012/13 growing season in various on-station and on-farm sites. The first experiment was a seedling nursery where a total of 16,000 true seeds that originated from Bvumbwe Crossing Block and introductions from Mozambique were planted at Bvumbwe Research Station on 1st February 2013. In parallel, orange and white fleshed clonal trials nurseries were planted separately containing selections from 2011-12 seedling nursery at Bvumbwe Research Station. Clones were screened against undesirable below and above ground morphological and organoleptic traits. Entries were also screened for resistance against sweet potato virus and alternaria diseases. At harvest, only 60 clones (26 orange and 34 white) were selected from the seedling nursery (Chipungu *et al.*, 2013).

The second set of trials were three preliminary yield trials namely orange, white fleshed clones and introduced varieties from Mozambique implemented at Bvumbwe, Makoka and Chitala Research Stations to evaluate selected materials from 2011-12 clonal trial and the introductions. Trial entries were subjected to preliminary yield and yield components assessment in addition to pests and disease tolerance/resistance and other morphological traits. 36 orange fleshed clones and 20 white fleshed clones were selected. The selected clones will be further evaluated in multi-location Advanced Yield Trials both on stations and on farms (Chipungu et al. 2013).

Cocoyam germplasm evaluation

In Malawi, cocoyams (*Xanthosoma sagittifolium*) are mainly grown in the northern region but the cultivation is very low because so much emphasis was put on maize growing and all the other food crops were neglected. However, with the recurrent droughts in recent years and increase in farm input prices especially fertilizer, the government has no alternative but to look back at indigenous resources. Although cocoyams are not popular there is a lot of germplasm, this was evidenced by the number of accessions that were collected in 2007 during a country wide roots and tubers collection exercise.

Chitete et al. (2013) conducted an on station preliminary evaluation of ten local cocoyam germplasm in 2011-12 with the objective of evaluating the performance of local cocoyam germplasm for yield, and resistance/tolerance to major pests and diseases at a single station, they need to be evaluated in more than two sites depending upon availability of planting materials.

Potato breeding

Potato (*Solanum tuberosum* L) is an important food and cash crop in Malawi. There is great demand for quality potato suitable for different end uses such as crisps, french fries, boiled mashed and even salad products. Despite the favourable climatic conditions that favour the production of Irish potatoes, yields and quality of potato obtained by farmers from locally grown cultivars are relatively low due to poor quality planting materials among other production constraints (Demo et al., 2013). In a series of field trials on station and on farm, under rain-fed conditions Mwenye et al. (2013) evaluated CIP derived potato clones and

varieties introduced from breeding programmes from CIP-Peru, CIP-Kenya, Argentina and Scotland varieties with the aim of identifying high yielding varieties which are also tolerant to major diseases and insect pests that are adaptable to local environmental conditions. Out of the 29 testing clones evaluated, 15 clones recorded higher yields. Mwenye et al. (2013) suggest that there is need for bulking seed tubers for further multi-location evaluation trials.

Mwenye *et al.* (2013) conducted two experiments concurrently at two research stations in the 2012-13 to determine the effect of spacing on tuber yield and size distribution for table potato. The spacing of 60X15cm giving higher yields of <30mm tuber size grades, such sizes are considered non marketable in table and processing sectors, which requires large to medium size potato tuber. However, the spacing of 100X20 cm was optimum for seed potato production since the objective is to maximize yields while limiting tuber development to the smaller sizes (Mwenye *et al.*, 2013).

The low supply and poor quality of potato produced in the country has led to imports of fresh Irish potato and potato crisps from neighbouring countries. In 2006, CIP, in collaboration with DARS, Universal Industries Limited (UIL), Concern Universal (CU), Plan International, Department of Agricultural Extension Services (DAES) and other potato stakeholders, began carrying out activities aimed at improving productivity and farmers' incomes. With funding from the Irish Aid, project partners implemented a Potato phase I project from August 2007 to May 2012, that focused on developing and making available to Malawian farmers improved potato technologies needed for increased crop productivity to improve food security and incomes to farmers.

The Potato Phase II project (2012-2016), currently in its second year (April 2013-March 2014), seeks to reach 45,000 small farmers with improved seed and other potato production technologies, to double productivity among 15,000 direct beneficiaries, and improve their incomes through access to new high yielding improved varieties, and effective market linkages. CIP, DARS and partners aim to provide new potato varieties to farmers. In trying to achieve these objectives two independent experiments were set up each at Bvumbwe Research Station using sandponics and aeroponics facilities. Plant materials for the

experiment were sub cultured for multiplication in the plant tissue culture laboratory for six weeks. The *in-vitro* produced plantlets were then used in sandponics and aeroponics facilities. One potato variety 'Thandizo' is being subjected to five variable nutrients solutions where 40 plantlets were planted per sandponic box. Two potato varieties "Thandizo and Zikomo" are being subjected to two nutrient solution levels in an aeroponics facility and that data collection is in progress in both experiments (Chiipanthenga *et al.*, 2013; Demo *et al.*, 2013).

In Malawi potato production is limited to specific cool areas since potato is particularly vulnerable to high temperatures due to its narrow production "window": it needs mean daily temperatures of 18-20°C and night-time temperatures less than 15°C. However, CIP potato breeding programme has specifically bred for heat and drought tolerance, high yielding, early maturity varieties which are also tolerance to late blight. Chipungu *et al.* (2013) have proposed a research project where 30 heat and drought tolerant potato clones derived from CIP-Peru breeding programme will be evaluated on-station under irrigation from 2013-14 growing season. After two years the promising clones will be tried both on-station and on-farm locations of the different agro-ecological zones under rain fed and irrigated conditions. This will expand potato growing sites to the non traditional growing area under rain fed and irrigation conditions (Chipungu *et al.*, 2013).

Research trends in vegetable production

Exotic vegetables

Vegetable research in Malawi was pioneered by Andrew Spurling, a horticulturist who was based at Bvumbwe Agricultural Research Station in the 1970s. The Department of Agricultural Research, at its Bvumbwe Research Station basically concentrates on exotic vegetables. Cabbage, tomato, brussels sprouts, chinese cabbage, celery, carrot, eggplant, okra, and asparagus are some of the varieties of vegetables that have been released to farmers. The research that was done at Bvumbwe concentrated on variety screening, plant populations, spacing, pests and pathogens, fertilizer use, heat tolerance and storage. The research produced specific recommendations for fertilizer rates, irrigation regimes, time of planting, plant populations, and pesticide formulations for specific varieties (Spurling, 1972; DARS, 1998, Daudi and Mwenda,

2008). However, no work was done in breeding new vegetable varieties. Over time these varieties have fallen behind in yield and resistance to pests and diseases. Recent research has produced new superior tomato varieties (such as Romitel, Rodade and Mbambande). Some high yielding varieties of onions, cabbages and sweet corn have also been released (Saka *et al.*, 2006; Daudi and Mwenda 2008). But according to Chipungu *et al.*, 2013 there is very little research being done in the main line exotic vegetables. On the other hand Lilongwe University of Agriculture and Natural Resources do conduct some research in exotic vegetables through students' final year projects.

Seed production has been a big challenge for the Department of Agricultural Research Services because of financial constraints; as such the country relies on imported seed. The Asian Vegetable Research and Development Centre (AVRDC), the Chinese Agricultural Mission, The JICA project, the Food and Agriculture Organization (FAO) project, International Vegetable Centre have assisted the Department in providing vegetable seed for research and developing vegetable production technologies for small vegetable farmers.

Capsicum / sweet pepper

Chiipanthenga *et al.*, (2013) evaluated nine lines of sweet pepper, (*Capsicum annum L*), eight of which were from AVRDC and one as a check from Malawi, to determine yield performance under Malawi conditions and to isolate sweet pepper lines that could be recommended for use by small farmers. The evaluation was undertaken over three growing seasons 2007-2008, 2011-2012 and 2012-2013 seasons at two research stations and at some selected farmers' fields. Lines 0137-7034, PBC-271, 0137-7048 and 7852-190, outperformed other tested lines in terms of yield, fruit size, days to flowering, and disease resistance and lines 7852-190, 0137-7034 and PBC-271 are more liked by farmers. During the 2007-2008, 2011-2012 and 2012-2013 growing seasons Chiipanthenga *et al.* (2013) also conducted field trials at the four DARS research stations and some selected farmers' fields (on farm) to evaluate the effect of moisture regimes on the yield of chillies / hot pepper (*Capsicum frutescens*). The objectives of these trials were to isolate hot pepper lines that could be recommended for irrigation production and rain-fed production. Five hot pepper lines of ICPN 15 from Taiwan and three irrigation levels were used to evaluate

yield performance of hot pepper lines under irrigation system and rainfall to improve the yield of hot pepper production in Malawi. Chiipanthenga et al. (2013) found that lines 0337-7545, 0337-7065 and 9852-173 outperformed in terms of yield, fruit size, days to flowering, water use efficiency and disease resistance both in rain fed and irrigation. Lines 9955-15 and 0337-7545 were more liked (hot and good flavour) compared to others. Line 9955-15 gave higher yields under rainfall. It was also found that applying water to hot pepper every 5 days (100% ET) was more efficient and economical than applying either at every two (2) days (150% ET) or ten (10) days (50% ET).

Paprika (*Capsicum annum L.*)

As Malawi is looking for alternative crops that would contribute to its economy, paprika is being treated as a strong candidate for diversifying export crops. However, low paprika output in Malawi is attributed, among other factors, to over reliance on rain fed production. Mwamlima et al. (2013) conducted trials at two DARS research stations, Nchenachena and Kasinthula during winter of 2012 and 2013 season to evaluate the performance of released and promising paprika varieties under irrigation. *Seven paprika varieties namely Papri Queen, Papri Royal, Papri Ace, CPS 125, Excel, Brin 3 and Mantenga were used, the results showed that Brin 3 gave the highest yield at both research station.*

Garlic

The local varieties of garlic (*Allium sativum*) grown by the farmers are not well known by the research department. A trial of garlic cultivars that are currently grown in the country was conducted by Chiipanthenga et al. (2013). The trial also evaluated garlic lines for yield, quality and disease resistance. The germplasms were collected at Ntcheu, Dedza, Chikwawa and Thyolo which are the areas where garlic is grown in Malawi. A total number of 18 accessions were collected. These accessions have been multiplied at Kasinthula Research station for characterization (Chiipanthenga et al., 2013).

Spices

Malawi's staple diet is not spicy, as a result there is limited knowledge amongst researchers and farmers on the different types of spices. This coupled with the unavailability of improved seed of most of the

spices, production trends in the country have been on the decline. Today as people travel and mix with other cultures in the world, the influence of spicy food in the country is being observed. Efforts are thus being made to collect and name different varieties of some spices that are found in the country. It was for this reason that Mwamlima (2013) designed a project to collect, evaluate, characterize, multiply and conserve germplasm of major spices that are found in Malawi; some of which are pepper (*Piper nigrum*), ginger (*Zingiber officinale*), turmeric (*Curcuma domestica*), cardamoms (*Ellettaria cardamomum*), cinnamon (*Cinnamomum verum*), annatto (*Bixa orellana*) and lemon grass (*Gymbopogon citratus*).

Indigenous vegetables

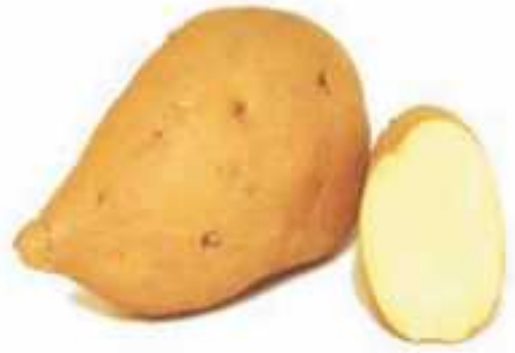
Indigenous vegetables (IVs) in Malawi play a very important role in the local diet of rural and peri-urban communities as they contribute greatly by providing essential nutrients for growth and prevention of nutritional deficiency diseases. Rural families traditionally have made conscious efforts to preserve indigenous vegetables around their homesteads, in crop fields and communal lands as orphan plants. The availability of indigenous vegetables has declined drastically because of excessive cultivation of field crops and habitat change, including deforestation and the perception that indigenous vegetables are inferior to exotic vegetables. This has been exacerbated by a lack of major research and extension efforts to improve their husbandry and promote these species (Mwase 2010; kwapata and Maliro, 1997; Thomo and Kwapata, 1984).

Bunda College, which is now called Lilongwe University of Agriculture and Natural Resources (LUANAR) was a constituent college of the University of Malawi, was mandated to carry out research in indigenous vegetables (Kwapata, M. B. and Maliro, M. F, 1997; Thomo and Kwapata, 1984; Daudi and Mwenda, 2008).

Thomo and Kwapata (1984) conducted a survey of indigenous vegetables in the area around Bunda College. After this survey a project document was prepared and submitted to World Bank for funding under a contract agreement with Ministry of Agriculture. The objective of the project was to conserve the diverse germplasm of indigenous vegetables found in Malawi. The outcome of this research project was a compilation of over 20



Manihot esculenta Crantz (Cassava) Plants, with tubers (inset)



Sweet Potato(White)



Sweet Potato(Yellow)



Capsicum annum L (Paprika)



Cocoyam



Amaranthus lividus (Bonongwe)



Potato Plats



Uapaca kirkiana



Potato tuber

Aeroponics seed potato plants



Ziziphus mauritiana

indigenous vegetables that are found in all climatic zones of Malawi, some of which are *Corchorus trilocularis*, *Cucurbita maxima*, *Cleome gynandra* (*Gynandropsis gynandra*), *Amaranthus lividus*, *Capsicum spp.*, *Bidens pilosa*, *Adenia cissampeloides*, *Hibiscus physaloides*, *Afzelia quanzensis* and 'mukokwa' (Kwapata and Maliro, 1997; Kwapata and Dawa, 2008).

Kwapata and Maliro (1997) implemented a long term research project at Bunda College of Agriculture which was aimed at improving the status of indigenous vegetables in Malawi, and it involved collecting and cataloguing indigenous vegetable germplasm and developing production technologies for adoption by small farmers. Presently local farmers are buying IV seeds produced under this project.

Although research on indigenous vegetables is supposed to be done by Bunda College sometimes due to donor's requirements some research on IVs has been done by DARS. Between 2006 and 2009, Chilanga *et al.* (2008) carried out multilocation trials in a research project which was aimed at selecting superior genotypes and characterizing germplasm on various neglected indigenous vegetable crops where documentation of growth habit, harvesting frequencies and leaf and seed yields was done (Chilanga *et al.*, 2008). Seeds for eight indigenous varieties were obtained from the World Vegetable Centre (AVRDC) and they were evaluated in the different agro-ecological zones of Malawi under irrigation and rainfall regimes.

Mwase, 2010 through the United Nations Development Programme (UNDP), Global Environment facility (GEF) funding, undertook a research project whose main goal was to enhance the contribution of indigenous vegetables to nutrition and socio-economic values and also to enhance conservation of germplasm through increased production of two IVs namely *Amaranthus spp* and *Cleome gynandra*. The purpose of the project was to characterize genetic diversity and to evaluate agronomic practices in order to select superior germplasm of the two indigenous leafy vegetable species. Growth, yield and morphological traits were evaluated in the different agro-ecological zones and amplified fragment length polymorphism (AFLPs) was used to characterise the genetic diversity (Mwase, 2010).

Masturd

During 2010-11, 2011-12 and 2012-13 crop growing seasons Malidadi *et al.* (2013) evaluated new eight Ethiopian mustard (*Brassica cariryata*) lines from The World Vegetable Centre (AVRDC)-Regional Centre for Africa for leaf yield and quality against one check local variety 'Kamganje'. The evaluation was done at Bvumbwe and Kasinthula Research Stations under rain fed and irrigated conditions. The results showed that some of the new Ethiopian lines out-yielded the local variety but the investigator recommends that more evaluations need to be conducted before coming up with conclusive results (Malidadi *et al.*, 2013).

Research trends in fruit production

Cashewnut

The cashew nut (*Anacardium occidentale L*) is an important nut crop that provides food, employment, income and shade. However, the Malawi cashew nut industry is dominated by the estate sector with very little participation by the small farmers. The industry, of which its research is in infancy programme, is in desperate need to reverse the declining trend in cashew production especially for the benefit of small farmers.

In the period between June 2007 and August 2008, Chipojola *et al.* (2009) conducted a study where 40 accessions of cashew collected from 4 populations, were characterized for genetic diversity and relationship using quantitative and qualitative traits. The results revealed similarity values between 35 to 66%. The study showed existence of potential genetic base that could be used to improve production of cashew in Malawi. However, to confirm whether the variation is genetic in nature, there is need to characterize the four populations using molecular markers such as amplified fragment length polymorphism (AFLP) DNA markers, simple sequence repeats (SSRs) or microsatellites. Since there is no cashew breeding programme in Malawi Chipojola *et al.* (2013) evaluated five new cashew hybrids, for adaptability, growth, yield and quality characteristics on station in the 2008/2009 growing season. These cashew hybrids were obtained from Tanzania and data is still being collected and evaluated annually.

Macadamia nuts

In absence of a breeding programme in Malawi, efforts were made to acquire the best clones of known quality from the Macadamia (Macadamia

integrifolia) producing regions. Two studies are in progress to evaluate Macadamia clones for growth, yield and quality characteristics and adaptability to Malawi field conditions. Sixteen new generation clones are in three separate experiments namely clonal trials 3 and 4. The clones under evaluation are: 804, 845, 828, 836, 790, Daddow, 705, 783, 789 in clonal trial 3 and 791, 835, 816, 842, 772, 814, 815 in clonal trial 4. These clones were brought into the country from Hawaii and clones 800 and 246 were used as checks respectively (Nambuzi et al., 2013; Nambuzi and Payne, 2013). Evaluation of several macadamia clones from Hawaii continues for all the agronomic performances in the agro-ecological zones of Malawi since 2001/02 crop season. Testing of the clones continues in trials 3 and 4 only at Bvumbwe Research Station. The objective was to identify promising clones in yield, nut quality and adaptation in the agro ecologies of the country. Trial 4 is also being tested as on farm at Ntchenachena in Rumphidistrict since 2005-06 crop season.

New generation clones have been introduced to the country and are already planted by the estate and small sectors without evaluation. However, macadamia clones highly vary in characteristics such as fruit size, drought tolerance, shell thickness, pest and disease tolerance/resistance, yield and nut quality. Therefore, it is important to generate information of these clones before are planted to large areas. (Nambuzi et al., 2013). A research team in collaboration with the Eastern Produce Estate growers will play a valuable role in identifying promising clones suited to Malawi field conditions in 2014. (Nambuzi and Payne, 2013) Clones 800 (check), 845, 790,789 and 804 performed well in the 2012/13 season and in all consecutive seasons for trial 3 at Bvumbwe. But results on trial 4 as well revealed the existence of promising clones that consistently gave similar performance in all growth parameters for over the previous seasons. However, theft pressure was reported to be an obstacle to discriminate between the test clones as evidenced from some of the known promising clones such as Daddow (DD) and 845 in trial 3. Such pressure as well persisted in trial 4 hence disabling the section to obtain yield data to identify the best clones yield wise under the climatic conditions of the country (Nambuzi et al., 2013; Nambuzi and Payne, 2013).

Mango

Most mango (*Mangifera indica*) cultivars being grown in the country are from outside and were

bred for specific environmental conditions. In the absence of a mango breeding programme in Malawi, efforts are made to acquire new varieties from the mango producing regions. A study is in progress to evaluate mango varieties for growth, yield and quality characteristics and adaptability to Malawi field conditions (Chipojola et al. 2013). Twelve new varieties are being evaluated at Baka, Chitedze and Mkondezi Research Stations. The varieties under evaluation are: Joa, Heidi and Neldica from South Africa; Maya, Apple, Sabina, Chino and Batawi from Kenya; Gin Huan # 1 and Yuwin # 6 from Taiwan; Sensation, Tommy Atkins, Kent, Van Dyke and Keitt from Florida United States of America while Boloma is a local Malawian variety with Tommy Atkins, Kent, Keitt and Boloma used as checks (Chipojola, 2013). The objective of the project was to evaluate new improved mango cultivars for yield and quality.

Research in indigenous fruits

Indigenous fruits are disappearing and as such research on indigenous fruits has accumulated considerably in Sub-Saharan Africa. The role of indigenous fruits is being recognized in the domain of poverty reduction and the difference they make during periods of famine and food scarcity with the threat of extinction due to deforestation (Akinnifesi et al., 2006). Hence, research has been on-going to develop long-term domestication strategies, select priority species, collect germplasm and improve tree genetics. Research into the propagation systems, field management, harvesting and post-harvest technology, economic analysis and marketing is part of this programme. A NUFU-cooperation between Bunda College and the Norwegian Agricultural University as well as the University of Oslo, undertook a project whose objective was to promote the use of indigenous fruit trees in sustainable agricultural production and ensure their conservation. The researchers determined requirements and suitable techniques for the fruits' rapid propagation and acclimatisation in different environments (Mkonda et al., 2002; Grøtan, 2004; Akinnifesi et al., 2007). Following the surveys which were conducted in Malawi and its neighbouring countries *Uapaca kirkiana*, *Parinari curatellifolia*, *Strychnos cocculoides*, *Ziziphus mauritiana* Lam and *Adansonia digitata* were identified as the five most preferred species for domestication by farmers in the region (Mkonda et al., 2002; Grøtan, 2004; Akinnifesi et al., 2007).

Research trends in floriculture

Cut flower production

The cut flower industry could assist Malawian economy to wean itself off tobacco. However, the unavailability of quality seeds, the lack of finance, skills shortages, stringent food and safety regulations in the developed countries and high international standards on both quality and production poses serious challenges to the development of the industry in Malawi. The Malawian cut flower industry has its roots in a horticultural pilot project which was set up by the government in 1988. Lingadzi Farm which was the largest and the first to be set up was followed by Maravi Flowers. Lingadzi Farm closed in the year 2000 due to high freight costs and was closely followed by the opening of Zikomo Flowers. Presently cut flower production in Malawi is done by private commercial farms and it is thus not supported by government and no research is undertaken in that area so far. However, LUANAR has started conducting research in floriculture through students' final year research projects. The cut flower producing plants that are grown in Malawi are roses, carnations, chrysanthemums, gladioli and gerberas. Asparagus, nephrolepis ferns, phitonia and statice (*Limonium* sp.) are some of the greeneries grown in these commercial nurseries for flower arrangement.

Landscaping plant production

Landscaping is an integral part of infrastructure development in Malawi and government through the Department of Buildings ensures that there is a landscape architects input in all its projects. The plants that are used for landscaping are from horticulture nurseries which are privately owned. Most of the government owned ornamental plants nurseries are not maintained any more due lack of financial support. Tropex farm in Mangochi district Four Seasons and Evergreen Nurseries in Lilongwe are privately owned nurseries which stock ornamental plants. City councils, especially Blantyre, Lilongwe and Mzuzu and the municipality Zomba produce ornamental crops mainly for landscaping within the cities and for the domestic market. Potted plants, shrubs and herbaceous plants, palm trees and grasses are the plants that are sold to interested individuals for residential landscaping. There is no research being undertaken in this area by government (Kainja, 2000). However, there are many small nursery owners who display ornamental plants by

roadsides for sell mainly in the cities and district headquarters. There is need for research to support these small business ventures.

REFERENCES

- Acquaah, G. 2008. *Horticulture Principles and Practices*. (4th ed). Pearson Prentice Hall. Upper Saddle River, New Jersey, Columbus, Ohio.
- Akinnifesi, F.K., Ajayi, O.C., Sileshi, G., Kadzere, I. and Akinnifesi, I. 2007. Domesticating and commercializing indigenous fruit and nut tree crops for food security and income generation in sub-saharan africa.
- Akinnifesi, F. K., Kwesiga, F., Mhango, J., Chilanga, T., Mkonda, A., Kadu, C. A. C., Kadzere, I., Mithofer, D., Saka, J. D. K., Sileshi, G., Ramadhan, T. And Dhliwayo, P. 2006. Towards the development of miombo fruit trees as commercial tree crops in Southern Africa. <http://www.worldagroforestry.org/downloads/publications/PDFs/ja06015.pdf>
- Akinnifesi, F.K., Kwesiga, F.R., Mhango, J., Mkonda, A., Chilanga, T. and Swai, R. (2004a) Domesticating priority miombo indigenous fruit trees as a promising livelihood option for small farmers in southern Africa. *Acta Hort.* 632:15-30.
- Benesi, I. R. M., Chilungo, S., Mtonga, A. P. and Chipungu, F. P. 2013. *Cassava Breeding Ann. Report*, 2013.
- Chilanga, T. G., Malidadi, C and Kumwenda, R. 2008. *Horticulture Commodity Group, Annual Report 2008*, pp 64-65. Ministry of Agriculture and Food Security, Lilongwe, Malawi.
- Chilanga, TG; Malidadi, C and Kumwanda, R. 2008. Promotion of neglected indigenous vegetables crops for nutrition and health in Southern and Eastern Africa Phase 11 (ProNIVA 11). accessed on 28th October, 2013 <http://www.cabi.org/gara/FullTextPDF/2008/20083323850.pdf>
- Chiipanthenga, M., Mwamulima, L., Malidadi, C., Chipungu, F. P. and Soko, M. 2013. Evaluation of sweet pepper lines for adaptation, yield under malawi conditions. *Horticulture Commodity Group 2013 Ann. Prog. Report*. Lilongwe, Malawi.

- Chiipanthenga, M., Fandika, I. R., Soko, M., Makoko, K. and Chipungu, F. P. 2013. Effect of moisture regimes on yield of hot pepper lines. Horticulture Commodity Group 2013 *Ann. Prog. Report*. Lilongwe, Malawi.
- Chiipanthenga, M., Pungulani, R., Mwamulima, L. Malidadi, C. and Chipungu, F. 2013. Garlic Germplasm Collection, Characterization and Evaluation. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Chipojola, F. M., Mwase, W. F., Kwapata, M. B., Bokosi, J. M., Njoloma J. and Maliro, M. F. 2009. Morphological characterization of cashew (*Anacardium occidentale* L.) in four populations in Malawi. *African J. Biotech.* 8:5173-81.
- Chipojola, F. M., Nambuzi, S., Soko, M. M. M., Jonga, M. and Joshua, B. 2013. Evaluation of Introduced cashew nut (*Anacardium occidentale* L) varieties for growth, yield, quality and adaptation at Chitala in Malawi. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Chipojola, F. P., Mphaya, S. C. J., Nambuzi, S., Moyo, Gondwe, E. and Kachigamba D. 2013. Evaluation of new improved mango varieties for yield and quality. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Chipungu, F. P., Chipojola, F. M., Malidadi C. and Masamba, K. 2013. Horticulture Commodity Group 2013 *Ann. Prog. Report*. Lilongwe, Malawi.
- Chitete, M. J., Pankomera, P., Chipungu, F. P., Moyo, C. C. and Chiipanthenga. 2013. Preliminary evaluation of local cocoyam germplasm for 2011-12 Season. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Daudi, A. T. and Mwenda, A. R. E. 2008. The role of the DARS in vegetable research and development in Malawi. AVRDC Pub. No. 08-705. pp. 116
- Demo, P., Chipungu, F., Nyekanyeka, T., Kapalasa, E., Mwenye, O., Chiipanthenga, M., Benesi, I., Masamba, K. and Kumar, N. 2013. Improving Food Security through Enhanced Potato Productivity, Technology Development and Supply Chain in Malawi. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Demo, P., Mwenye, O. J., Pankomera, P. and Chimwala, L. 2008b. Investigation of appropriate fertilizer levels for potato production using different planting spacing in major growing areas of Malawi. *CIP-DARS Research Collaborative 2008/2009 Prog. Report*. Lilongwe, Malawi.
- DREA (Department of Research and Environmental Affairs) 1994. *National Environmental Action Plan*. Volume 1: The Action Plan. DREA: Malawi Govt.
- EAD (Environmental Affairs Department) 2002. *Initial National Communication of Malawi on United Nations Framework Convention on Climate Change* (UNFCCC). EAD: Malawi Govt.
- Gotor, E. 2011. Integrated Agricultural Research in Malawi. *Bioversity International*. CGIAR.
- Grøtan, T. 2004. *Fruits in the Hunger Season*. Global Knowledge No. 1.
- Kachule, R. N. Nakhumwa, T. O. and Tchale, H 1998. *Promotion of Horticulture: National Horticulture Development Strategy for Malawi*. Volume 1.
- Kachule R and Franzel S. 2009. The status of fruit production, processing and marketing in Malawi. *Working Paper 87*. Nairobi: World Agroforestry Centre.
- Kubwalo, M. 2006. Factors affecting the development of non-traditional export: a case study of the cut flower industry in Malawi. *Research Project Submitted for M Com Degree*. University of the Western Cape.
- Kainja, S. 2000. Forestry outlook study for Malawi. In *Forestry Outlook Studies in Africa* (FOSA) Food and Agriculture Organization (FAO) Country Report June 2001.
- Kwapata, M. B. and Maliro, M. F. 1997. Indigenous vegetables in Malawi: germplasm collecting and improvement of production practices. In Guarino, L., 1997. *Traditional African Vegetables*.

- Kwapata, M. B. and Dawa, G. 2008. The role of the University of Malawi in vegetable Research. *Vegetable Research and Development in Malawi, Review and Planning Workshop Proc.*, Sept. 23-24, 2003
- Malidadi, C., Kumwenda, R. C., Chilanga, T. G. and Soko, M. M. 2013. Evaluation of ethiopian mustard (*Brassica carinata*) lines for yields, and consumer qualities in Malawi. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Mkonda, A., Akinnifesi, F. K., Maghembe, A., Swai, R., Kadzere, I., Kwesiga, F. R., Saka J., Lungu, S. and Mhango, J. 2002. Towards domestication of 'Wild Orange' *Strychnos cocculoides* in Southern Africa, a synthesis of Research and Development efforts. <http://www.worldagroforestry.org>
- Mwamlima, L. H. 2013. Spices germplasm collection, conservation and evaluation. Horticulture Commodity Group 2013 *Ann. Prog. Report*. Lilongwe, Malawi.
- Mwamlima, L. H., Malidadi, C. and Chiipanthenga, M. 2013. Evaluation of the performance of released and promising paprika varieties under irrigation. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Mwenye, O. J., Demo, P., Chipungu, F. P., Masamba, K., Mbewe, W., Chiipanthenga, M., Benesi, and Chimwala, L. 2013. Potato (*Solanum tuberosum* L.) Breeding Progress Report FOR 2012/2013. In Chipungu, F. P., Chipojola, F. M., Malidadi C. and Masamba, K. 2013. Horticulture Commodity Group 2013. *Ann. Prog. Report*. Department of Agricultural Research Services (DARS). Lilongwe, Malawi.
- Mwenye, O. J., Chiipanthenga, M., Demo, P., Chimwala, L., Benesi, I. and Chipungu, F. P. 2013. The effect of plant spacing on table and seed potato production. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Nambuzi, S., Chipojola, F. M., Simbi-Banda, H. and Munyenye, Z. 2013. Macadamia variety evaluation trials (3 and 4) for growth, yield, nut quality and adaptation under Malawi field conditions. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Nambuzi, S. and Payne, C. 2013. Macadamia variety evaluation trial for agronomic performance, yield and response to pests and diseases under Malawi field conditions. Horticulture Commodity Group 2013, *Ann. Prog. Report*. Lilongwe, Malawi.
- Saka, A. R., Mtukuso, A. P., Mbale, B. J. and Phiri, I. M. G 2008. The role of research-extension-farmer linkages in vegetable production and development in Malawi. *Vegetable Research and Development in Malawi, Review and Planning Workshop Proc.* Sept. 23-24, 2003, Lilongwe, Malawi.
- Saka, A.R., A.P. Mtukuso, A. P., Daudi, A. T., Banda, M.H.P. and Phiri, I.M.G. 2006. Agricultural Technologies Released by the Ministry of Agriculture and Food Security- 2000-2005. DARS, Lilongwe Malawi.
- Spurling AT. 1972. *A Handbook of Vegetable Production in Malawi*.
- Thomo, M.A. and Kwapata, M.B. 1984. A survey of indigenous fruits and vegetables in villages around Bunda College of Agriculture. Bunda Coll. *Agric. Res. Bull.* **12**:135-67.