



A Survey of the Production Practices of Livingstone Potato (*Plectranthus esculentus*), an Indigenous and Underutilized Vegetable in Zimbabwe

**Gaudencia Tichaidza Kujeke^{1*}, Rose Tafadzwa Masekesa¹, David Icishahayo¹,
Elizabeth Ngadze¹ and Upenyu Mazarura¹**

¹Department of Crop Science, University of Zimbabwe, P.O.Box MP 167, Mt Pleasant, Harare,
Zimbabwe.

Authors' contributions

This work was carried out in collaboration between all authors. Author GTK designed the study, drafted the questionnaire, drafted and proof read the manuscript drafts. Author RTM administered the questionnaire and proof read the manuscript drafts. Author DI managed the statistical analysis and proof read the manuscript drafts. Authors EN and UM supervised the research, proof read the manuscript drafts and managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2015/19612

Editor(s):

(1) Mirza Hasanuzzaman, Department of Agronomy, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh.

Reviewers:

(1) Oondo Juma Alphonse, Maseno University, Kenya.

(2) Klára Kosová, Crop Research Institute, Prague, Czech Republic.

Complete Peer review History: <http://sciencedomain.org/review-history/10612>

Original Research Article

Received 19th June 2015
Accepted 19th July 2015
Published 19th August 2015

ABSTRACT

Aims: The main objectives of the study were to establish the current production practices, constraints, and identity of the different landraces of Livingstone potato (*Plectranthus esculentus*) that are grown in Zimbabwe as well as the potential for improvement of the indigenous traditional vegetable in the small holder-farming sector.

Study Design: A questionnaire based survey was conducted.

Place and Duration of Study: The study was carried out in Makoni, Mutasa and Nyanga Districts (Manicaland Province) and Marondera District (Mashonaland East Province) of Zimbabwe, in April and December 2013.

*Corresponding author: Email: gtmkujeke@gmail.com;

Methodology: A total of 103 respondents from three Districts representing 25% of the population of growers were selected randomly and interviewed.

Results: Livingstone potato is a minor crop mainly grown for sale and food by women (97%). The 12 landraces still being cultivated were *Ndurwe*, *Gombwe/a*, *Chibanda*, *Nziye*, *Sasamwi*, *Musande*, *Chizambezi*, *Nyabewu/Nyabuti*, *Nyatiya*, *Mutsaza*, *Chibhurandaya* and *Tutsenza*. There are no improved varieties and growers retain seed (91.3%) from the previous crops. Production is mainly done on ridges in wetlands, (89.3%) as a sole crop (79.6%). However the current practices have not been evaluated. Production is on the decline and growers attributed this to poor rainfall (30.1%) and poor prices on the market (43.7%). There is evidence of loss of germplasm as indicated by the non-cultivation of some landrace. Results also showed that 97% of the respondents were interested in growing improved varieties from the local germplasm pool and from other countries.

Conclusion: Livingstone potato is a neglected crop as current production practices have not been evaluated to optimize yields. Research on this minor crop needs to be carried out and the landraces available need to be maintained and improved.

Keywords: Livingstone potato; indigenous vegetable; minor crop; landraces.

ABBREVIATION

HRI = Horticulture Research Institute.

1. INTRODUCTION

Traditional and indigenous vegetables play an important role in the economic and social lives of people. Vegetables are an essential component of man's diet and have been shown to offer a significant opportunity for the poorest people to earn a living as producers and/or traders without requiring large capital investments [1]. Livingstone potato, locally known as *Tsenza* in the local Shona language, is one of the edible indigenous tuber crops commonly grown in both the wetland and dry land areas [2] and its cultivation has been known to be commonly, but not exclusively, practiced in the eastern districts of Zimbabwe [3]. The crop has also been found to have medicinal benefits. Some of the ailments known to be cured by Livingstone potato include stomach aches, backaches and problems associated with the female reproductive system [3].

Livingstone potato is considered a minor crop globally, in terms of total production and commercial value. The market is reportedly limited, as consumers favour more 'modern' root crops such as yam, cassava and sweet potato [1]. Minor crops like Livingstone potato tend to be displaced by some of the major crops like the Irish potato, causing a potential loss of genetic resources that have been selected over generations by indigenous people, especially women. The role of women as key players in the production of such minor crops has been highlighted and it has been noted that women

possess valuable information about the minor crops they grow [4].

In Zimbabwe, there is very little documented information on the production of this crop besides the common knowledge that it is produced in wetlands by communal farmers [3]. The germplasm currently available on the ground is not known and has not been evaluated. It is therefore important to collect and evaluate the germplasm as a step towards improving the crop whose agronomic practices have not been optimized. In South Africa, in the Northern Transvaal and Eastern Cape, awareness about the crop and the need to conserve the germplasm has been made and better varieties have been reintroduced into communities where the germplasm had disappeared [5]. It is hoped that by preserving and maintaining the germplasm, future collaborations with countries like South Africa (where research has been conducted) can be made to facilitate the exchange of germplasm and knowledge. Production of this crop provides food security, nutritional and medicinal benefits as well as income and as such, its potential should be fully exploited. In addition, production of Livingstone potato on a large scale will ensure conservation of genetic resources for biodiversity, agricultural development and benefit to rural farmers [3].

A study was carried out on Livingstone potato in 2001 by the Horticulture Research Institute in the major producing areas of Zimbabwe and results of the study were published as a short communication in the Plant Genetic Resources Newsletter [3]. To date the germplasm collected during the study has been lost and no research has been done as a follow up to the study

(Muusha. L, Head of HRI, personal communication, 2014). This paper therefore seeks to establish the current agronomic practices and uses of Livingstone potato in Zimbabwe. Results of the study will lay the foundation for research on the crop so as to improve its production and adoption. The specific goals of this study were to identify the different landraces of Livingstone potato that are grown in Zimbabwe, identify production constraints as well as the potential for improvement.

2. MATERIALS AND METHODS

2.1 Description of the Study Areas

The study was carried out in the Makoni, Mutasa and Nyanga Districts of the Manicaland Province as well as in the Marondera District in Mashonaland East Province of Zimbabwe in April and December 2013. Nyanga and parts of

Mutasa lie in Natural Region I of Zimbabwe's agro-ecological zones which is suitable for dairy farming forestry, tea, coffee, fruit, beef and maize production. The region is characterized by rainfall above 1000 mm which occurs in all months of the year [6]. Makoni, Marondera and parts of Mutasa districts lie in Natural Region IIb which is characterized by intensive farming, an annual average rainfall of 850 mm and severe dry spells during the rainy season [5]. Fig. 1 shows the areas where the study was carried out.

2.2 Data Collection and Analysis

A survey was conducted in the stated study areas in April and December 2013. The key informants were the local Agricultural Extension (AGRITEX) officers in each district. The information gathered from each district was used to provide the basis for the selection of the areas



Fig. 1. Map of Zimbabwe showing the study areas
(Adapted from <http://technorevelationcentres.org>)

where Livingstone potato growers were located. There were 103 respondents from three districts (Makoni: 45, Nyanga: 7, Marondera: 51). These represented 25% of the total population of growers from the districts used in the study. The selection of respondents was done randomly using the random numbers technique. A detailed pre-coded questionnaire was designed in order to capture information on current agronomic practices, constraints and uses of Livingstone potato. Enumerators were trained on how to administer the questionnaire which was pretested in Rusape (Makoni District) amongst 10 farmers (these were not included in the actual survey so as to eliminate any bias). The pretesting was done to identify any problems with the questionnaire which could occur for both respondents and enumerators. The questionnaire was corrected prior to the commencement of the survey. Samples of the identified landraces were collected during the survey. The data collected was managed using the Statistical Package for Social Sciences (SPSS) 16 for Windows. Descriptive statistics were used and results were presented using graphs and tables.

3. RESULTS

3.1 Distribution of Growers and Household Characteristics

Of the 103 respondents who were growers of Livingstone potato, 49% were from Marondera District in Mashonaland East, while 43.3% were from Makoni and 7.7% were from Nyanga Districts of Manicaland province. The AGRITEX officers reported that they were no growers found in the Mutasa District. The average family size was mainly five people. Although the majority (64.4%) of households were headed by males, results from the survey indicated that women were the primary producers (97%) of Livingstone potato and were also largely responsible for the marketing of the crop (92%).

3.2 Seed Source, Selection Criteria and Storage Methods

The majority (91.3%) of the respondents, retained seed from the previous season's crop which is their main source of seed. Most growers (42.7%) had no special criteria for selecting the seed while 32% of the respondents selected their seed based on the size of the retained tuberous roots (Table 1). Livingstone potato growers (46.6%) preferred to store their seed in shallow

holes dug in the field and covered with straw (Table 1).

Responses showed that the majority (51.5%) of Livingstone potato growers have no problems with regards to storage of their planting material, while 19.4% of the respondents indicated some problems with rodents (19.4%) and the occurrence of tuber rots. About 5.8% indicated that both pests and diseases were a problem.

3.3 Common Livingstone Potato Landraces Identified by Respondents

The respondents identified the landraces they knew and grew by common names. These were compared to the list made and coded by the HRI [3]. The new landraces discovered during the survey, were also coded by the University of Zimbabwe (UZ) following the system used by HRI, and added to the list as shown in Table 2. Of the 25 landraces known, only 12 were still being cultivated across the 2 provinces.

3.4 Livingstone Potato Production in the Field

Production of Livingstone potato was mainly done on wetlands (89.3%) especially in Makoni and Marondera districts while a few growers (9.7%) practice dry land cultivation. Some growers in Nyanga District practiced both wetland and dry land cultivation (1.9%). The production in wetlands was mainly done on ridges in Makoni and Marondera Districts while flatbed production was only done in the Nyanga District.

3.5 Planting Times, Spacing, Fertilizer Application and Weeding Frequencies

Most of the growers plant Livingstone potato between the months of July to October (Table 3). The planting is haphazard, (with no defined plant spacing). The farmers indicated that they plant the seed tubers very close to each other as they do for groundnuts (Table 3). There were indications of fertilizer use amongst the majority of the growers and these were mainly organic types: cattle and poultry manure. Of the respondents who used fertilizers, most used organic instead of inorganic fertilizers. A few of the respondents combined organic and inorganic fertilizers (Table 3 and Fig. 2). Almost all of the respondents practiced hoe and hand pulling manual weeding. The majority weeded twice during the production period (Table 3 and Fig. 2).

Table 1. Seed source, selection criteria and storage methods (n = 103) from respondents included in a survey carried out in 3 districts

Practice	Level of practice	Percent respondents
Source of seed	Retained seed from last season's crop	91.3
	Neighbours	7.8
	From the wild	1.0
Selection criteria	No criteria	42.7
	Tuber size	32.0
	Customer's choice	8.0
	Taste of landrace	16.5
Storage method	Treat seed with ash or pesticide and store in a hole	2.9
	Place untreated seed in a hole and cover with straw	47.6
	Retained on ridges or flat beds	17.5
	In a sack at room temperature	21.4
	Spread on the ground at room temperature	10.7

Table 2. Known livingstone potato landraces and landraces identified by the respondents from the respondents included in a survey carried out in Mashonaland East and Manicaland provinces

	Identity no. †	Local name	Production status
1	HRCTzD0001	Ndurwe	Yes
2	HRCTzD0002	Gombwe/a	Yes
3	HRCTzD0003	Chibanda	Yes
4	HRCTzD0004	Muchenagumbo	None
5	HRCTzD0005	Nziye	Yes
6	HRCTzD0006	Sasamwi	Yes
7	HRCTzD0007	Musande	Yes
8	HRCTzD0008	Botswana	None
9	HRCTzD0009	Mungareva	None
10	HRCTzS0010	Rungwe	None
11	HRCTzS0011	Zembeze/ Chizambezi	Yes
12	HRCTzS0012	Mvumvu	None
13	HRCTzN0013	Nyabeyu/ Nyabuti	Yes
14	HRCTzN0014	Nyatiya	Yes
15	HRCTzN0015	Nyakanga	None
16	HRCTzN0016	Honde Valley	None
17	UZTzD0001	Mutsaza	Yes
18	UZTzD0002	Matonongore	None
19	UZTzD0003	Kamvana	None
20	UZTzC0004	Chibhurandaya	Yes
21	UZTzC0005	Nhura	None
22	UZTzC0006	Cheni	None
23	UZTzC0007	Mbangu	None
24	UZTzC0008	Bandwe	None
25	UZTzN0010	Tutsenza	Yes

† HRCTzD0001 to HRCTzD0009 were collected from the Makoni District, HRCTzS0010 to HRCTzS0012 were collected from Seke and the rest were collected in Nyanga [3]. UZTzD001-UZTz0003 were identified in Makoni District, UZTzC004 to UZTz0008 were identified in Chihota, Marondera District and UZTzN0010 was identified in Nyanga District

Table 3. Planting times, spacing, fertilizer application and weed control practices carried out by farmers expressed as a percentage of the total respondents (n=103)

Cultural practice	Level	Percent respondents
Planting time	July to August	46.6
	September-October	51.5
	November onwards	1.9
Planting spaces used	Haphazard	100.0
Use of fertilizer ameliorates	Use fertilizers	55.4
	Do not use fertilizers	44.7
Method of weed control	None	1.0
	Manual (hoeing or hand pulling)	99.0
Frequency of weeding	None	4.0
	Once	32.0
	2 times	44.7
	3 times	17.5
	4 times	1.0

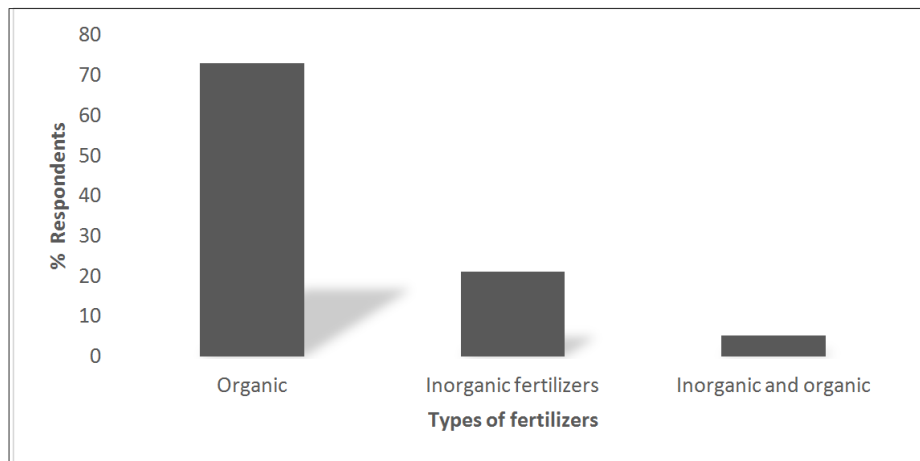


Fig. 2. Types of fertilizers used in Livingstone potato production expressed as a percentage (n=57)

3.6 Cropping Systems Used in Livingstone Potato Production

Livingstone potato is mainly produced as a sole crop (79.6%) in all districts although 20.4% of the respondents practiced intercropping. These were mainly found in the Marondera District and they intercropped Livingstone potato with okra and pumpkin and to a lesser extent, sweet potato (Fig. 3).

3.7 Criteria for Selecting Landraces Used in Production

The respondents used various criteria to select the landraces they preferred to grow and most of the farmers considered the taste, quality and yield potential. Seed availability was also considered as a factor (Table 4).

3.8 Harvest Times and Harvest Indices Used in Livingstone Potato Production

The majority of the growers (80%) harvested the crop from April to June and used various indicators to determine the harvest time. These included mainly the senescence of leaves (39.8%) and flowers (35.9%).

3.9 Problems Associated with the Production of Livingstone Potato in the Field

Poor rainfall causing a decline in wetlands was identified as one of the problems linked to the production of Livingstone potato (Table 5). Rats and moles were the prevalent pest problem and to a smaller extent caterpillars. Notable diseases

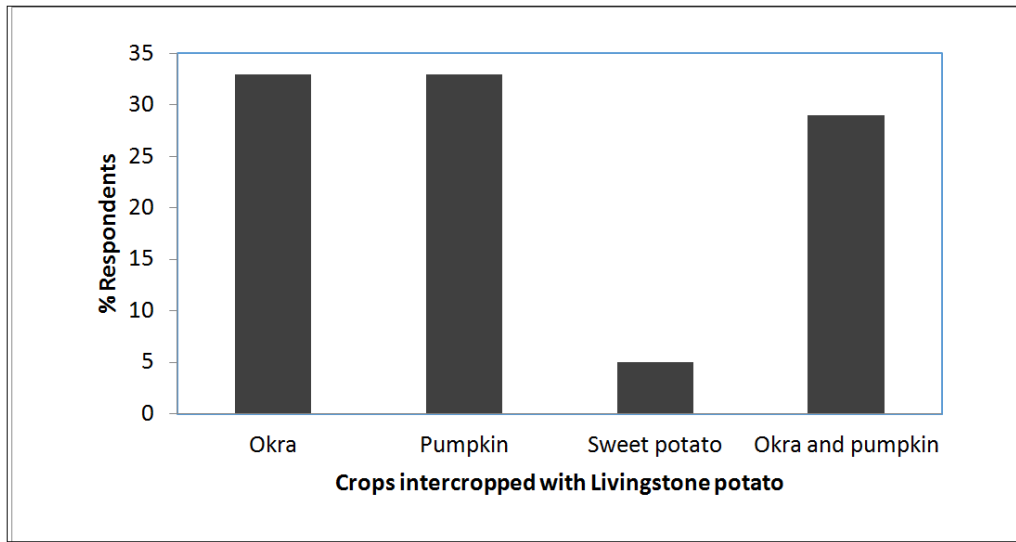


Fig. 3. Crops intercropped with Livingstone potato expressed as a percentage (n = 21)

Table 4. Criteria for selecting landraces used in production expressed as a percentage of the total respondents (n=103)

Selection criteria	Percent response
Availability of seed	33.3
Good taste and quality, high yielding	52.4
Less laborious to produce	6.8
Availability of seed, good taste, popularity and high yielding	6.8
No criteria used	1.0

were galls/lumps while a few indicated that leaf blights and soft rots were of concern (Table 5).

3.10 Problems Associated with Post-harvest Handling and Storage of Livingstone Potato

The majority of farmers do not have any problems when processing the crop for the market, while a few expressed that it required thorough cleaning, caused discolouration of the hands, was hard to peel and broke easily (Table 6). Most respondents have no problems with regards to the storage of Livingstone potato with a few indicating the loss of quality due to the highly perishable nature of the harvested tubers.

3.11 Marketing of Livingstone Potato and Problems Associated with Marketing

The majority of the respondents sold their produce locally (from the field, nearby shops, home gate) while 18.4% sold externally to towns

and cities. Most respondents cited poor prices on the market (Fig. 4).

3.12 Consumption of Livingstone Potato and Preparation Methods

The tuber is the only consumed part of Livingstone potato and the normal preparation practice is to wash, peel, and eat raw or cooked/boiled. Although the respondents cleaned and graded their tubers, the majority simply harvested and sold the produce (Table 7).

3.13 Current Status of Livingstone Potato Production in Zimbabwe

The respondents noted that there was a decline in production due to various reasons. Most growers cited poor rainfall / limited wetlands and the amount of work involved in production, as the major factors causing the decline in production. Other reasons included poor markets, lack of appreciation by the younger generation, lack of planting material, reduced soil fertility as well as

pests and diseases (1.9 - 17.4%) (Table 8). Despite the alleged decline in production, the majority of the respondents (97.1%) indicated that they would be interested in growing new landraces or improved varieties from other countries if they were available.

Table 5. Problems associated with production of livingstone potato in the field expressed as a percentage of the total respondents across all districts (n=103)

Problem	Responses	Percent response
General problems	None	8.7
	Poor rainfall	30.1
	Poor soils	10.7
	Water logging	11.7
	Pests and diseases	15.5
	Laborious	11.7
	Access to fertilizer	8.7
Common pests	Wild animals	6.7
	Rats and moles	48.1
	Aphids	1.0
	Caterpillars	16.3
	Worms in the soil	6.7
	None	21.2
Common diseases	Galls/ lumps on harvested tubers	48.5
	Soft rot	4.9
	Leaf blights	9.7
	No problems	36.9

Table 6. Problems associated with post-harvest handling and storage expressed as a percentage of the total respondents (n=103)

Stage	Problem	Percent respondents
Processing for sale	Discolouration of hands	10.7
	Requires thorough cleaning	16.5
	Hard to peel/breaks easily	4.9
	Rotting tubers	1.0
	No problems	67.0
Storage	No problems	57.3
	Pests	8.7
	Diseases	4.9
	Loss of quality	19.4
	Poor storage facilities	9.7

Table 7. Preparation for consumption and marketing expressed as a percentage of the total respondents (n=103)

Level	Preparation process	Percent respondents
Part consumed	Tuberous roots	100.0
Preparation for consumption	Wash, peel and eat raw	28.2
	Wash peel, cooked/fry	26.2
	Wash peel, eat raw or cooked/ boiled	45.6
Preparation for marketing	Harvest and sell	50.5
	Harvest, clean and grade	17.5
	Harvest, grade and sell	32.0

Table 8. Reasons for decline in production of Livingstone potato expressed as a percentage of the total respondents (n=103)

Problem	Percent response
Poor accessibility and availability of markets	17.4
Poor / change in rainfall patterns, limited wetlands	27.2
Young generation lack appreciation	11.7
Labour intensive	26.2
Lack of planting material	4.9
Pests and diseases	1.9
Reduces soil fertility	6.8
No problems	1.9

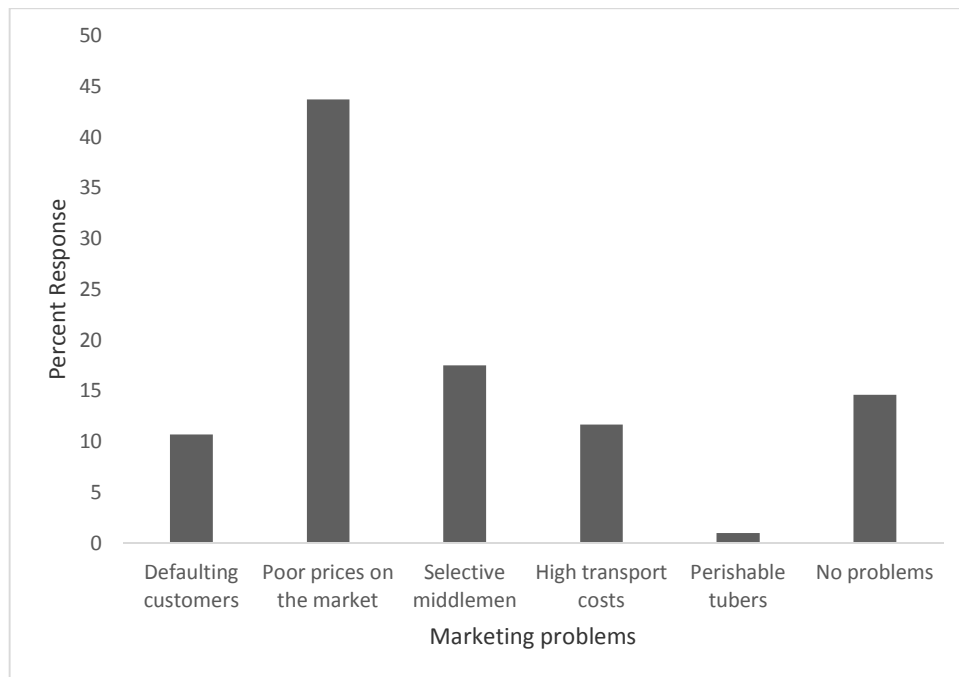


Fig. 4. Problems associated with marketing of Livingstone potato expressed as a percentage (n = 103)

4. DISCUSSION

Production of Livingstone potato is by communal farmers in Zimbabwe. Results of a survey carried out in 2001 showed that Livingstone potato was mainly produced in Nyanga, Makoni and Mutasa Districts of Manicaland Province with a few growers being found in parts of Mashonaland East province [3]. In this study, results showed that although there were growers in Makoni and Nyanga Districts, farmers in Mutasa District in Manicaland Province were no longer growing the crop. A significant number of growers were, however, recorded in Marondera District of Mashonaland East province. It is possible that these numbers were overlooked during the 2001 study. Not all the wards were accessed in

Nyanga district during the study due to various factors. The small number of respondents in Nyanga could also have been an indicator of a decline in the number of growers in the district.

Women are the main producers and sellers of Livingstone potato in Zimbabwe and the practice is similar in other countries like South Africa [5] as well as Nigeria [7]. Dhlwayo [3], identified 16 varieties (landraces) which were coded and named by the Horticulture Research Institute. In this study, additional landraces were discovered and these were added to the existing list. The list contained the landraces known by the respondents and those which they actually grow. Some of the known and listed landraces are no longer being produced for various reasons. This

is also an indicator of the loss of Livingstone potato germplasm currently taking place which, if left unchecked, could lead to the extinction of this minor indigenous crop. This was the case in South Africa whereby the advent of Irish potato led to the growers neglecting the production of Livingstone potato. Due to this neglect, there was a serious loss of planting material such that the communities were no longer able to maintain the diversity [5]. The Plant Genetic Resource Centre in Zimbabwe does not have any Livingstone potato landraces in stock and all the germplasm available is what the growers have in the communal areas. The Horticultural Research Institute in Marondera made an effort of collecting and maintaining the germplasm in 2001, but due to various factors, the storage and maintenance was abandoned (Muusha. L, Head of HRI, personal communication, 2014). It is imperative therefore that the germplasm is collected, identified and maintained to help preserve Livingstone potato landraces and diversity.

Livingstone potato can be propagated sexually using seed but the development of the crop is slow and the offspring is heterogeneous [1]. Farmers commonly produce the crop asexually using small tubers and in Zimbabwe, the main source of Livingstone potato seed is the retained tubers from last season's crop which the farmers break into small tubers and plant. Although this ensures the maintenance of lines, the risk of disease carryover into the next season is very high. Some farmers make efforts to preserve the seed by treating with chemicals or ash to prevent pest and disease incidence in storage but the majority do not. Tissue culture has been used to provide Livingstone potato planting material to facilitate the re-establishment of the crop in the Northern Province of South Africa [8]. This provides scope for research to produce virus free planting material in Zimbabwe.

Wetland production of crops is quite prevalent in Zimbabwe. The major crops grown on wetlands included vegetables, maize, (edible tubers), yams and rice [9]. Livingstone potato is also one of these crops grown in wetlands and production is mainly done on ridges in all the provinces, although in Nyanga district production was on flat beds under dry land conditions. This confirms earlier findings by [3] who also indicated that dry land production was possible and that farmers in other districts were not even aware of this practice. In Zambia and Malawi, Livingstone potato is normally cultivated on mounds while in

Burkina Faso ridges are used [10]. Planting of Livingstone potato is mainly done from July to October prior to the onset of the rain season. Schippers [1] states that the plant spacing is 100 x 100 cm, while a range of 50 - 90 cm in row on ridges and 60 - 70 cm on beds and 15-30 cm between tubers has been reported by [11,12]. The communal growers in Zimbabwean plant the tubers haphazardly with no specific plant spacing or plant density.

Dhliwayo [3] in a survey conducted in Zimbabwe in 2001, reported that Livingstone potato producers did not apply any fertilizers but still obtained satisfactory results. Burkhill [10], recommended the use of fertilizers to improve yields. The use of fertilizer in the production has been reported by [13]. Their work resulted in recommendations of an application of 200 kg/ha of a 15:15:15 NPK fertilizer to obtain good yields. In this study, 54.4% of the respondents indicated that they used fertilizers. The fertilizer types used were mainly organic manures which they obtained from livestock. Very few farmers use inorganic fertilizers and this could be due to the cost as well the fact that the available inorganic fertilizers are used for the production of major crops like maize, tobacco, beans and groundnuts at the expense of the Livingstone potato.

The growers practice manual hand and hoe weeding and this is done mainly twice during the production process. Experimental work by [14] has demonstrated that herbicides like gramoxone and atrazine can be used in the production of Livingstone potato. This is quite significant as it can help to alleviate the labour issues associated with the production of this crop. Livingstone potato can be grown in pure stands or intercropped with some low growing crops [12]. Xaba et al. [15], also indicate that Livingstone potato can be produced together with a low growing crop. The majority of the growers in Zimbabwe produce Livingstone potato as a sole crop with a small percentage practicing intercropping with pumpkins, okra and to a lesser extent sweet potato. The effectiveness of intercropping Livingstone potato has not been evaluated in Zimbabwe. Research has shown that the advantages of intercropping could lead to better land use efficiency [16] and higher yields. The crop mixtures should always be species compatible [17].

Schippers [1] states that Livingstone potato is susceptible to pests compared to the Hausa potato (*Solenostemon rotundifolius*). Okorocho

et al. [14] pointed to the root-knot nematodes (*Meloidogne* spp) as being the most destructive plant nematode pests of root and tuber crops worldwide. In this survey, the major pests were rats and moles as well as caterpillars to a lesser extent. The respondents stated that galls or lumps on harvested tubers were the main disease problem and were not very clear on what caused them. Dhliwayo [3], identified the galls or lumps as being caused by nematodes. There is a need to investigate and clarify what these galls/lumps are so that an effective control method can be implemented. Very few diseases have been noted on Livingstone potato [1] and the few incidences of leaf blights and soft rot of tubers noted by the growers bear testimony to the ability of the crop to resist diseases. Schippers [1], further proposes that Livingstone potato could have antifungal and /or anti-bacterial properties, a proposal that is worth investigating. The growers do not normally practice pest and disease control. However the few that do so, use cultural and chemical control. Harvesting of the crop is mainly from April to June although it can extend to September. It is possible that amongst the different landraces, some are early, medium and late maturing. Research would need to be carried out to distinguish the landraces according to their maturity times as this can also have a bearing on potential yield and thus income.

The respondents indicated that they experienced various problems with regards to the production of Livingstone potato in the field and noted that production was on the decline. The absence of growers in Mutasa District in Manicaland province, bears testimony to this. The decline was linked to various factors, chief amongst them being the poor rainfall and the amount of labour required to construct the ridges. The poor rainfall has a bearing on the availability of wetlands where Livingstone potato is mainly produced. The decline in wetlands has also affected the production of other root vegetables like cocoyams in Zimbabwe. Sivotwa et al. [9], stated that the pressure factors leading to exploitation of the wetland resources include: the need to increase income levels, decreasing soil fertility in the upland soils, recurrent drought episodes and increasing land scarcity among the rural communities. There is therefore a need to look into alternative methods of producing this crop instead of relying on wetlands.

The production of Livingstone potato is mainly from July to October before the onset of the

summer rains. The tuberous roots are normally left in the production beds and are only dug up for consumption or for sale. Xaba et al. [15], state that the tubers can also be stored in baskets in the shade or layered in dry sand for later use. The growers indicated that the tubers are highly perishable and the quality deteriorates quickly due to the short shelf life. Research into this crop should address issues of processing and value addition. Livingstone potato tubers are marketed in the fresh form. The tubers are the only plant parts used and these are consumed raw or cooked. However, in South Africa, both the tubers and leaves are consumed. Community members in the Eastern Cape sell the cooked leaves of Livingstone potato [5]. In Nigeria, processed raw tubers are sold during the main season while processed dried forms are sold during the off season [13]. The consumption of leaves as well as the ability to dry the tubers for later use can be attributed to the differences in lines found in the different countries where Livingstone potato is produced.

Livingstone potato is mainly grow for sale, with 76.7% of the respondents selling their crop locally from the field, home gate and nearby shops while about 18.4% sold to external markets in towns and major cities. The producers complained about the poor prices they get from the middle men who also tend to be very selective when purchasing the product. However, in South Africa where the crop was successfully reintroduced, production increased and the price of Livingstone potato was reportedly higher compared to that of Irish potato.

The choice of landraces to grow is influenced by various factors which include taste, quality and potential yield while other growers consider seed availability. There is evidence of a decline in production as some of the landraces collected and identified by the HRI in 2001 [3] are no longer being cultivated. The germplasm collected during the survey needs to be maintained and preserved. The availability of germplasm will also serve as a resource pool for plant breeders to develop new cultivated varieties. The introduction of new landraces or improved varieties of from other countries would be a welcome move according to the respondents, especially if the landraces are able to adapt to local environmental conditions. This would also improve diversity. In countries like Nigeria where the crop is also grown, research efforts have been initiated along with other minor root crops, with the purpose of harnessing their potentials

[18]. In N'Djamena, Chad, Livingstone potato is highly appreciated and the government put in place a programme that aims at the rehabilitation of the crop through varietal improvements [1].

In South Africa, the yield of Livingstone potato was over 60 t/ha under good management practices [19]. Currently most farmers are getting an average of only 5 t/ha [20]. These low yields have been largely caused by inappropriate agronomic practices such as intercropping with incompatible crops and also severe attacks from root knot nematodes [20].

Dhliwayo [3] suggested the collection and evaluation of Livingstone potato landraces, the development of techniques for rapid multiplication and distribution of improved varieties, as well as research on agronomic practices, pest and disease control, nutritional studies, post-production handling and processing as well as value addition. To date, these research needs have not been addressed and results from this study bear testimony to this. The possibility of improving yields is high with the implementation of defined agronomic practices and better seed material [10]. As such the research into this crop is critical.

5. CONCLUSIONS

Livingstone potato is a minor crop whose potential has not been tapped in Zimbabwe. It is grown mainly by women in wetlands for food and for sale. The cultivation of the crop is on the decline as shown by the absence of growers from the Mutasa District a key production area in Manicaland where the crop was commonly grown. In addition, of the 25 identified landraces, only 12 are still being cultivated indicating the loss of Livingstone potato germplasm. Current production practices have not been evaluated to enable improved production. There is therefore an inherent need to conduct research and evaluate the current agronomic practices so that production can be improved. The germplasm collected also needs to be maintained and multiplied to prevent any further losses. Growers are also keen to continue producing this crop as shown by their eagerness to grow varieties from other countries.

ACKNOWLEDGEMENTS

The authors would like to acknowledge the International Foundation for Science (IFS) for providing financial assistance to carry out the

research. Special thanks also to the Livingstone potato growers in Manicaland and Mashonaland East Provinces of Zimbabwe.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Schippers RR. African indigenous vegetables. An overview of the cultivated species. Chatham, U.K: Natural Resources Institute/ ACP-EU Technical Centre for Agricultural and Rural Cooperation. 2000;81-83.
2. FAO. Country Report on the state of plant genetic resources for food and Agriculture in Zimbabwe (1996-2008). A Country Report; 2009.
3. Dhliwayo PD. Underexploited tuber crops in Zimbabwe: A study on the production of Livingstone Potato (*Plectranthus esculentus*). PGR Newsletter, FAO-BIODIVERSITY. 2002;(130):77-80.
4. New Agriculturist 2004. Accessed 26 October 2014. Available:www.new-ag.info/en/focus/on.php?a=2624.
5. Haq N. Women Reintroducing Neglected Crops. LEISA Magazine. 2004;20(1): 28-29.
6. Vincent V, Thomas RG. An agricultural survey of Southern Rhodesia: Part I: agro-ecological survey. Government Printer, Salisbury; 1960.
7. NRCRI. Annual report. National Root Crops Research Institute, Umuahia, Nigeria: NRCRI; 2006.
8. Woodward B, Brink J, Berger D. Can agricultural biotechnology make a difference in Africa? AgBioForum. 1999; 2:(3&4):175-181. Available: <http://www.agbioforum.org>.
9. Sivotwa E, Manyanhere IO, Makombe P. Sustainable use of wetlands: A case for Mwaonazvawo village in Mutasa district of Manicaland province of Zimbabwe. Journal of Sustainable Development in Africa. 2007;(9):1.
10. Burkill HM. The useful plants of West Tropical Africa. Caesalpinoideae, 50-177; Mimosoideae, 177-267; Papilionoideae, 267-483. 1995;3:857.
11. Tindall HD. Vegetables in the Tropics. Macmillan Press. London; 1983.

12. Dupriez H, De Leener P. Land and Life. African Gardens and Orchards Macmillan Publishers, London, CTA, Wageningen, Netherland. 1989;333.
13. Olojede AO, Nwokocha, CC, Akinpelu AO, Dalyop TY. Optimum Plant Population and NPK Fertilizer Requirements for Livingstone Potato (*Plectranthus esculentus* N.E. Br) Production under Two Distinct Agro-Ecologies in Nigeria. Medwell Agricultural Journal. 2008;3(1):89-92. Available:<http://medwelljournals.com/abstract/?doi=aj.2008.89.92>
14. Okorochoa EOA, Dalyop TY, Olojede AO, Ogbuji RO, Nwauzor E, Onyenobi F, et al. Integrated pest management strategies for the control of root-knot nematode *Meloidogyne* spp. infestation of Livingstone potato (*Plectranthus esculentus*) and hausa potato (*Solenostemon rotundifolius* poir). The Journal of Advances in Agricultural Sciences and Technology. 2015;3(1):11-14.
15. Xaba P, SANBI, Kirstenbosch National Botanical Croeser P. Gardening with traditionally useful plants-Wild potato. SANBI, Kirstenbosch Natural Botanical Garden, Veld and Flora. 2011;180-181.
16. Guvene I, Yildrin E. Multiple cropping systems in vegetable production. In Proceeding of the Organic Agriculture Symposium, 21-23 June, Izmin, Turkey. 1999;288-296.
17. Baker E FI. Population, time and crop mixtures. In: Proceedings of theInternational Workshop on Intercropping. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), ed. W.Willey. Hyderabad, India: ICRISAT. 1982;52-60.
18. Olojede AO, Nwokocha CC, Eke-Okoro ON, Emehute JKU. Varietal response of livingstone potato (*Plectranthus esculentus* N.E Br) to NPK Fertilizer Application at Umudike. NRCRI Annual Report. 2004; 86-87.
19. Allemann J, Coertze AF. *Plectranthus*. Indegenous Root Crops A2; 1996.
20. Jonathan DE, Hedwig HT. 1991. Root-Knot Nematodes, *Meloidogyne* Species and Races. In: Manual of Agriculture Namatology, William R. and A. Nickel (Eds.). Marcel Dekker Inc., New York. 1991;191-192.

© 2015 Kujeke et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:

The peer review history for this paper can be accessed here:
<http://sciencedomain.org/review-history/10612>