

Research Article

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A survey on potato productivity, cultivation and management constraints in Mbala district of Northern Zambia

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Abstract: In Zambia, potato (*Solanum tuberosum* L.) cultivation is ranked the third most important among root and tuber crops after cassava (*Manihot esculenta* Crantz) and sweet potato (*Ipomoea batatas* (L.) Lam.). In spite of its importance, the productivity and cultivation of potato remain low. In the light of this, a survey was conducted in Mbala district to obtain and document farmers' knowledge on potato cultivation and understand the constraints associated with potato cultivation and management. Four agricultural camps in Mbala district were purposefully sampled due to the high potato cultivation activity. Data were collected from 116 potato farmers through structured questionnaires and focus group discussions. Results showed that three major constraints in potato cultivation were white grub (*Phyllophaga* spp.), foliar wilts (*Ralstonia* spp. and *Verticillium* spp.) and seed source, with a farmer-ranked mean-derived score of 3.75, 3.5 and 2.75, respectively. Farmers ascribed 70% crop damage to white grub (*Phyllophaga* spp.) and 60% crop damage to foliar wilts (*Ralstonia* spp. and *Verticillium* spp.). Other information obtained indicated that the majority of the farmers (>85%) were married,

above 35 years and had at least primary education. The majority of the farmers involved in the study had less than 0.25 ha under potato production. To reduce the cultivation constraints for increased potato production in Mbala, direct breeding efforts, potato crop protection and other measures need to be employed.

Keywords: challenges, pests, potato, cultivation, mitigation

1 Introduction

The potato (*Solanum tuberosum* L.) is the world's fourth most important food crop both in total production and in area under cultivation (Zhang et al. 2017). Potato yields in Africa stand at 20 tonnes ha⁻¹ with a continental average of 13 tonnes ha⁻¹ (FAOSTAT 2019). Globally, potato is used as seed potatoes, ware potatoes and starch potatoes. Of these classes, ware potatoes are by far the most important in terms of hectareage (Muthoni and Nyamongo 2009). In Zambia, potato production stood at 13,547 metric tonnes in the 2017/2018 farming season (CSO 2019). Potato like any other crop is affected by a number of biotic and abiotic stresses (Kroschel et al. 2020). These stresses are serious production constraints in potato growing areas. They range from insect attack causing blemishes and therefore the loss of tuber quality to significant reduction in tuber yield (Okonya et al. 2014; Misganaw 2016; Demirel et al. 2020). In order to minimize these stresses, which induce damage to potato during growth, harvesting, postharvest and processing, good management of the potato crop would help to effectively and efficiently maximize productivity.

Although potato commands the third place in terms of production levels among root and tuber crops produced in Zambia, the production of potato is well below the expected potential (CSO 2019). For example, in the 2016/2017 growing season, the production levels in commercial farms stood at 18.7 tonnes ha⁻¹; whereas in the

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2017/2018 growing season, the production levels stood at 31.6 tonnes ha⁻¹. On the contrary, in small-scale farms, the production levels stagnated at about 7.3 tonnes ha⁻¹, which was far below the continental average of 36 tonnes ha⁻¹ in Africa (FAOSTAT 2019; CSO 2019). The low potato production levels in Zambia do not entail low consumer utilization of potato as this is reflected through the influx of imported Irish potatoes from the neighbouring countries such as Malawi, Tanzania and South Africa. The reasons for low production especially among small-scale farmers in Zambia are not well known. Furthermore, consumption of potatoes in Zambia and other countries has been increasing mainly because a number of places are hosting a growing number of local and international fast-food restaurants (Chalwe et al. 2015). Also, a number of households (HHs) are relatively wealthier and/or are in wage employment, allowing them to eat fast foods such as potato chips and crisps (Chanda 2013; Mpogole 2013; CUTS International and World Food Programme 2018). Potatoes that are used in restaurants are purchased from a number of places such as markets, streets, retail stores and at farm gates. The average potato consumption per capita reached 32.28 kg in 2015 in the world (FAOSTAT 2015); whereas the potato consumption per capita for Zambia was only 2.24 kg (Helgilibrary 2020). This consumption is extremely low compared to that of the world's average. Therefore, the low production and low per capita consumption of potato show the need to upscale the cultivation and productivity of potato. To this end, a survey was carried out to understand the reasons for low cultivation.

The specific objectives were to obtain and document farmers' knowledge on potato cultivation and understand the constraints associated with local Irish potato cultivation and management in order to establish the reasons for low cultivation and look out for mitigation strategies.

2 Materials and methods

2.1 Geographical location of study area

The survey was conducted in four agricultural camps Kasesha, Kaka, Kawimbe and Kakungu of Mbala district due to their involvement in potato production in August 2018. Mbala district is located between S 08°50.545' and E 031°22.246' (Figure 1). A total of 116 potato farmers were randomly selected from the crop forecast list that was accessed from the District Agriculture Coordinator's office targeting the above-listed agriculture camps.

2.2 Demographic characteristics of the sampled respondents' HHs

A pre-tested, partly structured and partly open questionnaire was used to obtain primary data and information from potato farmers (respondents) across the target area.

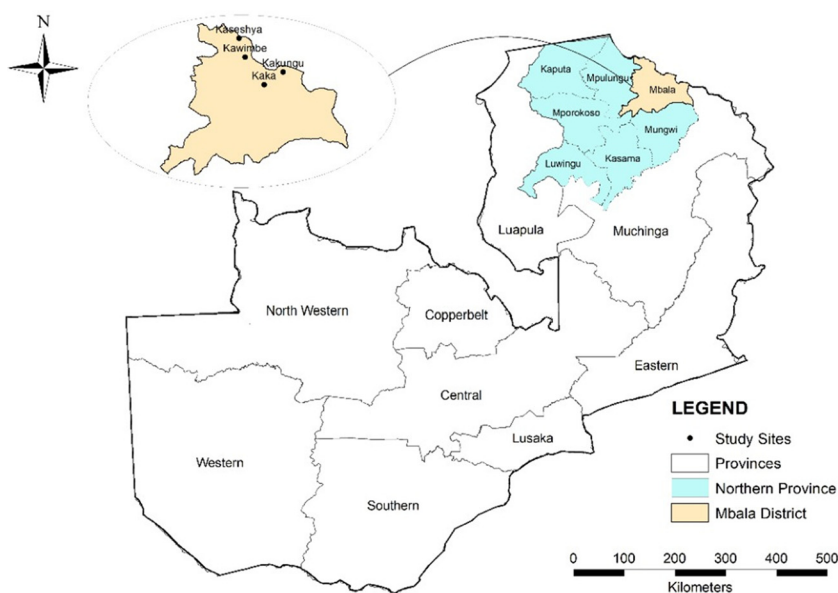


Figure 1: Map of Zambia showing agricultural camps in Mbala district, northern Zambia, used in the survey conducted in August 2018.

The objectives of the survey were explained to all the farmers who were selected and only those who expressed willingness to participate were interviewed by the survey team (research and extension officers). Each respondent was asked to provide information on HH characteristics such as gender, marital status, level of education, age, the average area under potato production and years of engagement in potato growing. The information on HH characteristics concerning gender was further used to elucidate the role of gender in weeding and fertilizer application in potato production.

2.3 Area under potato cultivation, varieties grown, abandoned and constraints

Additional information was obtained through a comprehensive set of questions on potato cultivation and constraints associated. The respondents were also asked to indicate their sources of seed, information on potato cultivation and weather. To understand the effects of weather variability on potato cultivation, farmers were asked to give information on notable changes in rainfall patterns and temperatures.

Focus group discussions were conducted according to Tembo *et al.* (2016) to get more information on the potato cultivation. The survey team was comprised of research and extension officers. Extension officers (enumerators) were able to speak and understand local languages that are commonly spoken in the district. Therefore, farmers who were not able to express themselves in English were encouraged to use their local languages during the discussions. Farmers were equally allowed to make consultations among themselves to remind one another of the local names for potato varieties grown, abandoned as well as cultivation challenges thereof. For each focus group meeting, farmers were asked to list and rank the major challenges associated with potato cultivation according to their importance. The farmers were further asked to provide information on how they managed the challenges associated with potato cultivation. To capture information on varieties, farmers listed the varieties grown, abandoned and their associated attributes.

2.4 Data collection

Primary and secondary data were used in this study. Through partly structured and partly open survey questionnaires

and focus group discussions, primary data were obtained from 116 respondents. Of the 116 farmers interviewed, 54 and 46% were males and females, respectively. Secondary data were obtained from various sources including previous studies, publications, research reports, Ministry of Agriculture in Zambia and international and local databases including the International Potato Center (CIP), Food and Agriculture Organization (FAOSTAT) and Central Statistics Office (CSO).

2.5 Data analysis

After the completion of data collection, all completely filled up questionnaires were properly stored for processing and data analysis. The completely filled up questionnaires were coded, and data entry were completed using Microsoft Excel. After which, the data were cleaned and analyzed based on different factors using descriptive statistics such as percentages, averages and frequencies, while rank orders were obtained through the Statistical Package for the Social Sciences (SPSS) version 22 (Allen *et al.* 2014). The primary data were then organized in tables.

3 Results

3.1 Description of demographic characteristics of the sampled respondents' HHs

More male (54%) than females respondents (46%) were interviewed in Mbala district. Three out of four camps sampled, namely, Kaka, Kasesha and Kawimbe, had more male respondents (61, 55 and 62.1%, respectively), whereas Kakungu had more female respondents (61%) (Table 1).

Analysis of the distribution of HH members in three main categories showed that 50% of respondent HH members was below 15 years, 28% was aged between 15 and 35 years and 22% represented HH members who were above 35 years old. Of all the respondents interviewed, 88.4% was married and had at least primary education. The results also showed that 63.3% HH heads had primary education, while 28.1% had secondary education. Overall, none of the HH heads had tertiary education and only 8.6% did not attain any form of formal education.

Table 1: Description of demographic household characteristics of sampled respondents' households in Mbala district during August 2018 Survey

Variable	Agricultural camps				Average
	Kaka	Kasesha	Kakungu	Kawimbe	
Number of farmers interviewed	28	31	28	29	29
Gender (%)					
Males	61	55	39	62.1	54
Females	39	45	61	37.9	46
Age groups of respondents HH (%)					
≤15 years	46	56	49.5	47	50
15 ≥ 35 years	28	21	33.7	30	28
≥35 years	26	23	16.8	23	22
Marital status of HH head (%)					
Single	0	0	15.4	0	3.9
Married	100	85.7	76.9	90.9	88.4
Divorced	0	7.1	0	0	1.9
Widowed	0	7.2	7.7	9.1	5.8
Highest educational level attained by HH head (%)					
None	0	18.2	7.1	9.1	8.6
Primary	45.5	81.8	71.45	54.5	63.3
Secondary	54.5	0	21.45	36.4	28.1
Tertiary	0	0	0	0	0

HH: household.

3.2 Area under potato production in Mbala

To understand the cropping system under which potato are cultivated in Mbala, we analyzed the data of the respondents on five selected aspects of potato cropping (Table 2).

The results showed that more than half of the farmers (78.3%) interviewed practiced sole cropping, growing only one variety on a parcel of land. The rest of the farmers (20.1%) was involved in growing of only two varieties, while 21.7% was intercropping potato with other crops. None of the farmers grew more than two varieties of potatoes. The results also showed that 61.9% of the farmers was aware of improved potato varieties. The study further revealed that majority of the farmers (40%) cultivated potatoes on parcels of land ranging from 0.25 to 0.5 ha, and only 8.6% of the farmers grew potatoes on parcels of land greater than 0.75 ha. In addition, farmers' experience in growing potato ranged from 4.5 years in Kakungu to 28 years in Kawimbe, with an average potato cultivation experience of 13.9 years across agricultural camps.

Table 2: Area under potato cultivation and cropping system mentioned during August 2018 Survey, Mbala (% of respondents)

Potato cultivation	Agricultural camps				Average
	Kaka	Kasesha	Kakungu	Kawimbe	
Cropping type					
Intercropping	27.3	0	23.1	36.4	21.7
Sole cropping	72.7	100	76.9	63.6	78.3
Number of varieties grown					
Growing 1 variety	90.9	71.4	84.6	72.7	79.9
Growing 2 varieties	9.1	28.6	15.4	27.3	20.1
Growing more than 2 varieties	0	0	0	0	0.0
Variety awareness					
Aware of improved Irish potato varieties	63.6	100	38.5	45.5	61.9
Area* under potato cultivation					
<0.25 ha	36.4	14.3	61.5	9.1	30.3
0.25–0.5 ha	27.3	64.3	23.1	45.4	40.0
0.5–0.75 ha	18.2	14.3	15.4	36.4	21.1
>0.75 ha	18.2	7.1	0	9.1	8.6
Cultivation years					
Average years of potato cultivation	11	12	4.5	28	13.9

*Area range for potato field to which household head belongs.

3.3 Potato varieties grown and those abandoned

Farmers in the agricultural camp grew a number of potato varieties. Respondents also reported having had varieties they had abandoned. Eight varieties were grown across the surveyed area in Mbala (Table 3).

The eight varieties grown were Kalunga, Nakonde 1, Nakonde 2, Katembele, Myenje, Chifalansa, Namboard and Viyenzu. Only two varieties, Kalunga and Nakonde 1, were commonly grown across all four agricultural camps. The attributes of Kalunga and Nakonde 1 varieties were white skin, elongate in shape, big in size, resistant to insect pests and disease and marketable. Variety Nakonde 2 was commonly grown in only three agricultural camps and had the following attributes: red skin, high yielding and resistance to pests. On the other hand, varieties Viyenzu and Katembele were not grown in three of the agricultural camps and had the following attributes: red skin, hard skin, small tuber, prone to insect attack, cream white,

Table 3: Potato varieties grown and those abandoned as reported by the farmers during the focus group discussion in August 2018 Survey, Mbala

Potato varieties	Attributes	Agricultural camps			
		Kaka	Kasesha	Kakungu	Kawimbe
Kalunga	White skin, elongate, big in size, resistant to disease, marketable	Grown	Grown	Grown	Grown
Nakonde 1	White skin, resistant to pests and diseases	Grown	Grown	Grown	Grown
Nakonde 2	Red skin, high yielding, resistant to pests	Grown	Grown	Grown	Not grown
Katembele	Cream white, round, small tubers, susceptible to disease and pests	Not grown	Abandoned	Grown	Abandoned
Myenje	White skin, medium round, cream to yellow inside	Not grown	Not grown	Grown	Grown
Chifalansa	Red skin, yellow inside, not very marketable	Not grown	Grown	Grown	Not grown
Namboard	White skin, round small tubers	Not grown	Grown ^a	Grown	Not grown
Viyenzu	Red skin, hard skin, small tuber, prone to insect attack	Not grown	Not grown	Abandoned	Grown

^a Variety not abandoned but seed ceased to be available.

round shape and susceptible to disease. Uniquely, one variety Namboard ceased existence in Kasesha agricultural camp. The farmers' reasons for growing or abandoning particular varieties are discussed.

groups/cooperatives and own/recycled seed. Three agricultural camps, Kaka, Kakungu and Kawimbe, had one seed source (local seed producers) in common and were using more than one source to acquire their seed. Other seed sources used were, on-farm trials, seed retailers and Fertilizer Input Support Programme (FISP).

3.4 Sources of seed for potato cultivation

A number of seed sources are used by the potato farmers in the four agricultural camps (Table 4).

Three most used seed sources were own/recycled seed (35%), followed by farmer groups/cooperatives (19.9%) and local seed producers (14.5%). All the agricultural camps had two sources of seed in common, farmer

3.5 Farmers' knowledge and sources of information on potato cultivation

Potato farmers obtained information relating to potato production from a number of organizations and trainings provided (Table 5).

Table 4: Sources of seed for potato cultivation in Mbala district (% of respondents)

Seed source	Agricultural camps				Average
	Kaka	Kasesha	Kakungu	Kawimbe	
On-farm trials	9.1	7.1	0	0	4.05
Extension demo plots	0	0	0	0	0
Farmer groups/coops	9.1	35.7	7.7	27.2	19.93
Local seed producers	9.1	0	30.7	18.2	14.5
Seed retailers/agro-dealers	0	28.6	7.7	0	9.06
Private seed suppliers	0	0	0	0	0
FISP	9.1	0	0	0	2.28
Club/association	0	14.3	0	0	3.58
More than one source	18.1	0	7.7	18.2	11.0
Own (recycled)	45.5	14.3	46.2	36.4	35.6

FISP: Fertilizer Input Support Programme.

Table 5: Summary of farmer information sources in the cultivation of potato in Mbala district, Zambia, 2018 (% of respondents)

Organization	Agricultural camps				Average
	Kaka	Kasesha	Kakungu	Kawimbe	
Self Help Africa	9.1	0	0	0	2.3
Department Agriculture (Extension)	36.4	14.3	46.2	54.5	37.9
Cooperative/farmer group	0	0	0	9.1	2.3
World Vision	9.1	0	7	0	4.0
Mtos	18.2	42	23.1	9.1	23.1
Nis	27.3	42.9	23.1	27.3	30.2
Trainings					
Agronomic practices	9.1	21.4	7.7	18.2	14.1
Herbicide use	0	7.1	0	0	1.8
Pest management	0	21.4	0	0	5.4
Disease management	0	21.4	0	0	5.4
Post-harvest operations	0	7.1	0	0	1.8
Processing/value addition	0	0	0	0	0
Post-harvest technology management	0	0	0	0	0
Fertilizer application	0	14.3	7	9.1	7.6
Soil fertility management	0	14.3	0	0	3.6
Soil conservation	0	7.1	7	0	3.5
Farming potato as a business	9.1	21.4	0	18.2	12.2

Nis means not aware of any organization providing agriculture information; Mtos means more than one source of agriculture information.

The survey reviewed that three camps, Kaka (36.4%), Kakungu (46.2%) and Kawimbe (54.5%), had high number of farmers who acquired agricultural information through Department of Agriculture (Extension), while Kasesha had the lowest (14.3%). Self Help Africa, cooperative/farmer group and World Vision provided up to 9.1% agricultural information. On the other hand, Kasesha farmers (42.9%) were not aware of organization/s that provided information on agriculture. Information on agriculture was also provided to farmers through various trainings which included agronomic practice training (14.1%), post-harvest operations (1.8%) and herbicide use trainings (1.8%).

3.6 Farmers' ranked constraints in potato cultivation

Potato farmers in Mbala face a lot of potato cultivation constraints (Table 6). A total of 20 constraints in potato cultivation was identified from the different camps surveyed. Kaka had nine constraints with the four most important being white grub (*Phyllophaga* spp.), foliar wilts (*Ralstonia* spp. and *Verticillium* spp.), ants (*Dorylus* spp.) and seed source.

Kasesha had 13 constraints. Of 13, the major 4 included cutworm (*Agrotis* spp.), foliar wilts (*Ralstonia*

spp. and *Verticillium* spp.), potato beetles (*Epilachna* spp.) and ants (*Dorylus* spp.). In Kakungu camp, farmers listed eight constraints of which the most important were cutworm (*Agrotis* spp.), seed source, lack of strong market linkages and knowledge of time of planting. In Kawimbe camp, farmers listed 12 constraints. The most important of these included foliar wilts (*Ralstonia* spp. and *Verticillium* spp.), seed source, lack of strong markets and scorched leaves. The mean-derived score (MDS) which ranked the constrained across the four agricultural camps identified cutworm (*Agrotis* spp.) (MDS 3.75), foliar wilts (*Ralstonia* spp. and *Verticillium* spp.) (MDS 3.5), seed source (MDS 2.75) and lack of markets (MDS 2) as the major production constraints. Other constraints included aphids (*Myzus persicae* and *Macrosiphum euphorbiae*), white grub (*Phyllophaga* spp.), termites (*Microtermes subhyalinus* and *Trinervitermes oecconomus*), cold weather, unknown times of planting and unknown fertilizer types and fertilizer application rates.

3.7 Farmer crop management practices

Potato farmers in Mbala use several insect pest, disease and weed management strategies (Table 7).

On average, three most used insect pest and diseases control strategies were use of chemical pesticides

Table 6: Farmers' rating constraints of potato production in four agricultural camps of Mbala district during August 2018 Survey

Constraints	Agricultural camps				MDS ^b
	Kaka	Kasesha	Kakungu	Kawimbe	
White grub (<i>Phyllophaga</i> spp.) (Kulila) ^a	5	4	5	1	3.75
Foliar wilts (<i>Ralstonia</i> spp. and <i>Verticillium</i> spp.)	4	5	—	5	3.5
Seed source	2	1	4	4	2.75
Lack of strong market	1	1	3	3	2
Ants (<i>Dorylus</i> spp.) (Intwatwa) ^a	3	2	—	1	1.5
Potato beetles (<i>Epilachna</i> spp.)	—	3	—	1	1
Tuber rots (<i>Erwinia</i> spp.)	1	1	1	1	1
Scorched leaves	—	1	—	2	0.75
Aphids (<i>Myzus persicae</i>)	—	—	1	1	0.5
Cutworm (<i>Agrotis</i> spp.) (Nkuse) ^a	1	—	—	1	0.5
Termites (<i>Microtermes</i> spp., <i>Trinervitermes</i> spp.)	1	—	1	—	0.5
Time of planting	—	—	2	—	0.5
Unknown fertilizer types and application rates	—	1	—	1	0.5
Cold weather	—	1	—	—	0.25
Low and fluctuating prices	—	1	—	—	0.25
Mole rats (<i>Fukomys</i> spp.) (Imbeba) ^a	—	—	1	—	0.25
Post-harvest care of seed	1	—	—	—	0.25
Soil fertility	—	1	—	—	0.25
Cricket (<i>Neoscapteriscus</i> spp.) (Utunyense) ^a	—	—	—	1	0.25
Viral diseases (potato leaf roll virus and potato virus Y potyvirus)	—	1	—	—	0.25

^a Local name of insect pest. ^b Mean-derived score is average score of constraints across agricultural camps. First criterion receives a ranking score of 5; second, a ranking score of 4; third, a ranking score of 3; fourth, a ranking score of 2; others, a ranking score of 1; and “—” means a ranking score of 0.

(26.7%), crop rotation (17.1%) and indigenous/local traditional methods of pest control (11.8%); while 14.2% of the farmers used more than one insect pest/disease management practice. The largest proportion (30.2%) of farmers was not practising crop protection management strategies, and also, no farmer used resistant varieties as a pest management strategy. On weed management,

89.3% of farmers practised mechanical weeding, 8.4% practised hand weeding and 2.3% practised a combination of hand weeding and mechanical weeding. Among all the camps surveyed, Kakungu camp had the highest proportion (15.4%) of farmers who practised hand weeding. None of the farmers used any chemicals to control weeds.

Table 7: Farmer crop management practices (% respondents)

Crop management practices	Agricultural camps				Average
	Kaka	Kasesha	Kakungu	Kawimbe	
Disease/pest/weed management practices					
Chemical pesticide	18.2	21.2	30.8	36.4	26.7
Crop rotation	9.1	18.1	23.1	18.2	17.1
Use of resistant varieties	0	0	0	0	0
More than one practice	0	25.3	13.3	18.2	14.2
Indigenous/local traditional* methods	36.3	7.2	1	2.8	11.8
Not practising any control	36.4	28.2	31.8	24.4	30.2
Weed management practices					
Hand weeding	9.1	0.0	15.4	9.1	8.4
Mechanical weeding (hand hoe)	81.8	100.0	84.6	90.9	89.3
More than one method	9.1	0.0	0.0	0.0	2.3

*Tephrosia and chili formulations.

3.8 Roles of men, women and the youth in weeding and fertilizer application

Potato cultivation in Mbala was performed by men, women and the youth (Table 8). Through the survey, the role and percentage of men, women and the youth involved in weeding, fertilizer application and supplement application were recorded.

The highest proportion of individuals who participated in all activities of weeding, fertilizer and supplement application was 39.47%. This involved the participation of all HH members, followed by 20.7% which involved the participation of spouses (women) and 16.73% involved the participation of HH heads (men). Notably, more HH heads (men) participated in the activities of fertilizer (19.8%) and supplement (26.3%) application compared to their spouse.

Only a small proportion (3.76%) of the hired labour individuals was used in weeding, fertilizer and supplement application. Participation of the youth (male child) in weeding, fertilizer and supplement application was at 2.77%. On the other hand, no female child (0%) participated in any activity of weeding, fertilizer and supplement application.

4 Discussion

The survey carried out in Mbala district revealed that the proportion of male respondents involved in potato cultivation was higher (8%) than female respondents (Table 1). This is expected in many African traditions as it is customary for men to head an HH. Gebru et al. (2017) also reported a high proportion (88%) of respondents

interviewed was male and HH heads. This could mean that most of the decisions on potato cultivation are made by or have to go through men. Some studies have shown advantages of male-headed HHs in decision-making on technology adoption (World Bank 2009). However, this might not be the situation in the case of land allocation for potato cultivation. For instance, in Zambia, potato might not be prioritized when compared with maize (staple crop) which is supported by Government FISP and has ready market through Food Reserve Agency. This decision could affect or reduce potato cultivation. The combination of being married plus primary/basic education meant decision-making and division of labour or activities is most likely easier than would be for the single or widowed with no primary/basic education HHs. Further, studies in other countries such as Tanzania by other researchers (Komba and Muchapondwa 2015) showed how education plays an important role in decision-making process as well as information digestion on potato cultivation.

Potato cultivation in Mbala district is characterized by sole cropping of one variety on a parcel of land. Taking into consideration that production is a product of the area planted to a crop (Miah et al. 2011). It can be envisaged that the low cultivation of potatoes in Mbala could be attributed partly to the small area under cultivation pegged at an average of 0.5 ha (Table 2). Further, most farmers growing only one variety are prone to low production due to diseases and insect pest attack. Garuma et al. (2013) indicated the importance of growing more than one variety as a form of mitigating risks associated with crop failure due to pest attack. On the other hand, only a small number of farmers (20.1%) grew two varieties, even though a high proportion (61.9%) of farmers knew about improved varieties (Table 2). This could suggest non-availability of improved varieties in the sampled area (Kolech et al. 2015). The low levels of farming experience averaging to 4.5 years in potato cultivation in Kakungu partly explain the reason the area has the largest proportion of farmers producing potato on land of less than 0.25 ha. The potato varieties that are grown in Mbala have been grown for a long time with an average of 28 years in Kawimbe (Table 2), and these varieties seem to have adapted to the local environment as seen by varieties grown across all agricultural camps. These results were consistent with Kolech et al. (2015) who reported that farmers of Gumer, Geta, Banja and Yilmana districts, Ethiopia, saved their “own seed” from the previous crop.

The farmers in Mbala cultivated eight potato varieties (local), namely, Kalunga, Nakonde 1, Nakonde 2, Katembele, Myenje, Chifalansa, Namboard and Viyenzu (Table 3).

Table 8: Roles of men, women and youth in weeding and fertilizer application (% of respondents)

Responsible individual	Activity			Average
	Weeding	Fertilizer	Supplements	
Household head	4.1	19.8	26.3	16.73
Spouse	23.7	16.0	22.4	20.7
Child female	0	0	0	0
Child male	1.9	1.9	4.5	2.77
Hired labour	6.8	4.5	0	3.76
All (household head, spouse, children)	63.5	34.7	20.2	39.47
Not done	0	23.1	26.6	16.57

They mentioned good and bad attributes associated with the cultivated potato varieties. The good attributes were high yield, colour, good marketability, tuber size and shape, and resistance to pests (Kolech *et al.* 2015). They also mentioned some bad attributes associated with their cultivated varieties, and these were number of tubers (too many), tuber size (small) for table potato, taste and susceptible to disease and insect pests (Byarugaba *et al.* 2013; Aheisibwe *et al.* 2015). Other researchers (Abong *et al.* 2010; Rahman *et al.* 2017), from Kenya and Bangladesh, in their studies found varieties that had attributes such as red and cream colour as those in Mbala. The farmers used colour for variety preference, and this indicates that even when locations are different some attributes desired by both farmers and consumers can be similar.

The list of the attributes of the commonly grown varieties (Table 3) showed that Kalunga and Nakonde 1 had attributes of resistance to insect pests and diseases and big size of tuber which was much liked by the farmers and consumers. Furthermore, for varieties Kalunga and Nakonde 1 to be grown across all four agricultural camps could possibly mean the varieties had inherent attributes that were more resilient to different environmental stresses (Chalwe *et al.* 2015). Despite the results in Table 2 which showed that farmers (61.9%) in all the agricultural camps knew about improved varieties, most of them were growing potato using only the local varieties. In other countries, potato farmers know a lot of improved varieties and utilize them in their cultivation (Rahman *et al.* 2017), making their production levels very high. Further, there was no single variety that was abandoned across all agricultural camps. Similar trends of adopting varieties with good attributes and abandoning those with bad attributes were observed through Ethiopian farmers (Wale 2012). The literature on variety attribute preferences (Wale 2012) suggests that varieties that do not have attributes that farmers demand are less likely to stay on farmers' fields.

The most important source of seed for potato in Mbala district was own or recycled seed. From all agricultural camps, an overall 35.6% of the farmers was using local seed for potato cultivation (Table 4). This is a common practice among poor small-scale resource farmers in most countries especially in Africa (Kakuhenzire *et al.* 2000; Kinyua *et al.* 2011). However, the recycled seed tends to lose attributes preferred by farmers such as vigour and pests resistance which leads to low cultivation levels (Aheisibwe *et al.* 2015). Furthermore, other attributes important in marketing such as the size of tubers are equally affected by disease and insect attack (Rehman *et al.* 2010; Martin 2016; Okonya *et al.* 2019). There seems to be a lack of formal seed system for potato in Mbala

district as was reflected by the low participation of seed retailers/agro-dealers and non-existence of private seed suppliers in the potato production value chain. The situation of inadequate seed production and distribution system is similar to the one reported by Aheisibwe *et al.* (2015), where 93% of farmers in Uganda depended on informal sources of seed potato. Also, in Kenya, it was reported that more than 95% of seed potatoes is sourced from farmers' own harvests or markets or neighbours (Kinyua *et al.* 2011). However, this low participation of seed retailers/agro-dealers and non-existence of private seed suppliers could also be explained by other factors like inability of farmers to buy seed from them due to the lack of resources. The low proportion of farmers sourcing seed from on-farm trials and extension demo plots reflects the low levels of interaction/support/participation of research, NGOs, private seed companies as well as department of agricultural extension in the potato production chain. Unlike the Mbala district situation, in Uganda more interaction was observed between the farmers, government institute and other agencies, for example, more farmers in Kabale district were aware and utilized seed plot technology through Uganda National Seed Potato Producers Association and other agencies who were intensely engaged in the promotion of seed plot technology; hence, increased potato production (Aheisibwe *et al.* 2015). It is expected that seed from demo plots and on-farm trials would be distributed to farmers for free or at minimal resource expenditure which would deliberately lead to a higher proportion of farmers sourcing good seed.

Through the survey, information was obtained on farmers' knowledge in potato cultivation (Table 5). The information indicated that farmers were acquiring information and knowledge on potato production through organizations and through training in agriculture. Gillemacher (2012) had similar findings indicating that organizations are important sources of information. Information on agronomic practices, herbicide use, pest management and disease management, among many, were provided through training across all agricultural camps (CIP 2016). In addition, farmers, through their knowledge in potato cultivation, were able to provide information on varieties grown, cropping systems, constraints and management practices implemented at farm level (Tables 3, 5 and 6). Tafesse *et al.* (2018) also reviewed that farmers in Ethiopia-Gumer, Doyogena and Wolmera communities were able to provide information on cultivation and agronomic practices they were engaged in. The information obtained (Table 2) on the average years (13.9 years) farmers had been engaged in cultivation would imply farmers'

experience/acquired knowledge in potato cultivation and management issues, which are the key aspects for high production. Generally, the government organizations and some NGOs provided information on agriculture to farmers through services provided. The information obtained also showed that the best source of agricultural information was Department of Agriculture (Extension) (Table 5). Studies carried out by Tafesse et al. (2018) indicated that extension workers were number 1 source of information for farmers which was reflected in our study. In addition, the survey showed that the community (farmer groups/cooperatives) and traders were other dependable sources of information on potato seeds (Table 4), which demonstrated levels of interactions/information exchange among farmers.

Understanding the major constraints in crop production is important in any crop production system as it offers a base on which management strategies can be mounted or control measures recommended. In Mbala district, the three most important constraints were cutworm (*Agrotis* spp.), foliar wilts (*Ralstonia* spp. and *Verticillium* spp.) and seed source (Table 6). Other studies (Jacques and Fasulo 2015; Okonya et al. 2019) have shown that insect pests and diseases are production constraints which lead to reduced yields. Although foliar wilt was taken as one disease, a lot of pathogens could cause foliar wilts including bacterial wilt which is one of the most important diseases of potato (Kroschel and Zegarra 2013; Chalwe et al. 2015). In Uganda, bacterial wilt (*Ralstonia* spp.) was also found to be the most important foliar wilt (Namugga et al. 2017). The experienced severity and hence importance of the foliar wilts could also be as a result of farmers recycling seed (Thomas-Sharma et al. 2015). Recycled seed was the most important source of seeds for farmers; and since diseases like bacterial wilts are seed borne (Tafesse et al. 2018), it is likely that this practice has contributed to the wilts being an important constraint. Further, because most farmers use small pieces of land and do not practice crop rotations, the inoculum of pathogens left in the soil is likely to build up if the same fields are used from season to season (Larkin et al. 2010; Panth et al. 2020). The other reason for insect pests and diseases being important could be because most farmers (30.2%) (Table 7) are not practising any kind of control measures. Not disrupting the life cycle of insect pests and disease cycles increases the inoculum. Jaworski and Hilszczanski (2013) and Katsaruware-Chapoto et al. (2017) demonstrated that non-disruption of pest infestation increased the risks of insect outbreaks. There was no organized potato seed system in Mbala district, and this might be why source of seed is an important constraint.

Furthermore, the lack of seeds from research institutes and low participation of the private sector in availing potato seeds contributed to the unavailability of good seeds in Mbala (Ogeto et al. 2012; Omoro 2013). In comparison, Tesfaye (2016) indicated that potato growers in Ethiopia had high productivity which was partly due to the use of improved varieties and practices obtained from Holetta Agricultural Research Centre. Apart from the research institute actively participating, encouraging agro-dealers to stock potato seed could help alleviate the constraint in Mbala (Chinsinga 2013). The study also brought to light weak market linkage for potato in Mbala. Since it is a growing town, market is limited to a few places like restaurants, lodges and tourism industry. Therefore, in search of better markets, most potatoes find their way to urban areas. This brings in challenges of transportation and storability. Linking farmers to markets (Chalwe et al. 2015) could help solve this problem.

Insect pest, disease and weed management in potato cultivation are very important practices, as they have negative effects that lead to reduced yields. Our study showed that farmers in Mbala district are employing a number of management strategies in their potato cultivation (Table 7). However, the proportion of farmers recorded as not practising crop management (30.2%) was quite high. These results were consistent with the previous findings (Echodua et al. 2019) where farmers failed to distinguish disease symptoms as a crop management strategy. This may have some bearing on low production as farmers would not realize the full potential of the crop yield. Furthermore, not using resistant varieties as a control measure could be due to the inability of farmers to purchase the resistant varieties, the unavailability of known resistant varieties and, to a lesser extent, the lack of knowledge of resistant varieties among farmers (Echodua et al. 2019). However, it was established through this study that (61.9 %) farmers had knowledge about improved varieties (Table 2) and were able to recognize resistance attributes in some of the varieties (Wale 2012). The majority of farmers (89.3%) were using hand hoes/mechanical for weeding their field. Unlike in other places such as Turkey, the United States and India, where farmers have moved away from mechanical weeding to herbicide use, well-planned crop rotation, planting cover crops, sanitation practices, optimum row spacing and timing of planting (Uremis et al. 2009; Boydston 2010; Singh et al. 2018). Farmers in Mbala do not use chemicals for weed control, which could be due to cost implications and/or lack of knowledge on the type of herbicides and their specific recommendations from the Ministry of Agriculture.

The high percentage of HH members were involved in weeding and supplement and fertilizer application in potato cultivation. Table 8 indicates that the activities were mainly carried out as a chore of all HH members (39.47%) and not as individual chores. Our findings tend to corroborate with Bakala and Tadesse (2018) who reported high percentages of women involved in weeding and fertilizer application in potato cultivation. It is expected that men would be involved in activities such as fertilizer and especially supplement application as they would want to control the amount of fertilizer and other nutrient supplements used due to the cost implications (Chalwe *et al.* 2015). On the other hand, other nutritional supplements such as manure application and boosters may not be easy for women to apply, which makes women shy away from such activities. The result of women's less involvement could have contributed to the larger proportion of supplement application falling under men (26.3%). The fact that some farmers (men) from the survey were involved and participated in supplement, fertilizer and weeding activities most likely gave a positive impact on potato production as gender equity in potato production is being advocated for (Petesch *et al.* 2018). Therefore, having 16.73, 20.7 and 39.47% of potato farmers (HH heads, spouse and all HH members, respectively) practising weeding and supplement and fertilizer application entail increased potato yields in Mbala district.

5 Conclusion

The survey was conducted to document farmers' knowledge and major constraints in potato cultivation, with the aim of finding out the management practices among the farmers in Mbala district of northern Zambia. Data showed that for most farmers, the cultivation of potato is carried out by both men and women on small parcels of land, which averaged from 0.25 to 0.5 ha. Farmers have been able to identify well-adapted varieties with desirable attributes suitable for market and own consumption. Over the years, farmers have been able to select against certain varieties based on undesirable variety attributes resulting in the extinction of some of the varieties in the area.

The major constraints associated with potato cultivation are soil insects, potato wilts, sources of seed and lack of strong market linkages. Most farmers do not use any control strategies for their insect pest and disease problems, which result in low cultivation of potato.

However, a good number of farmers believed that their current potato cultivation could increase through the introduction of improved potato varieties followed by training on potato cultivation, proper pest control, adequate quantity (dose) and timely availability of fertilizers.

In Mbala, the application of control measures and knowledge acquired through trainings and community agricultural information sources could be keys to improving potato cultivation. Important sources of information regarding potato cultivation were Ministry of Agriculture (extension workers) followed by Self Help Africa/farmer group and World Vision. On the other hand, a good number of farmers on average were aware of organizations that provided agricultural information but were not able to access the information. Radio/TV was the main information source for weather forecast for farmers in Mbala. In addition, key players in the potato value chain should ensure that information flows among different actors.

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