DETERMINING ADAPTABILITY OF POTATO GENOTYPES IN MOUNT ELGON REGION OF UGANDA

Abstract

Potato(*Solanumtuberos*u~~a~~*m*L.) in Uganda is mainly produced in the highland areas of Kabaleand Kisoro in southwesternand Bugisuand Sebei areas on the slopes of Mount Elgon in eastern part of the country. However, the yields have continuously reduced due to lack of suitable high yielding and disease resistant varieties. The purpose of this study was to identify high yielding disease resistant potato genotypes adapted to Mount Elgon region. Eight CIP potato clones were evaluated alongside ten commonly grown Ugandan varieties in RCBD for two seasons atBuginyanya station, Bulambuli District. Results showed significant differences (P<0.05) in tuber size, tuber uniformity, marketable tuber yield and the total tuber yield among genotypes. Potato clones 392797.22 and 398208.29 produced significantly (P<0.001) higher tuber yield 44.8t/haand 39t/ha respectively compared to the local check Cruzawith 34.5t/ha. rAUDPC for LB showed significant differences (P<0.001) among genotypes in both seasons. The most resistant genotypes were Kinigiand clone 399985.39 with rAUDPCof 0.0135and 0.025 respectively whereasBumbamagara(0.413)and 396036.201 (0.392) were the most susceptible. 396036.201(0.051)and Kinigi were the most resistant genotypes for bacterial wilt while Shangi (0.66)and Cruza (0.46) were the most susceptible to BW.Generally, genotype 392797.22and 398208.29 were the highest yieldingand disease resistant hence recommended for release as commercial varieties.

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Key words: Adaptability, clones, bacterial wilt,late ~~blight~~blight, genotypes

Introduction

Potato (*Solanumtuberos*u~~a~~*m*L.) is one ofthe most important crops in the world,with the current production estimated at 376 million tons from 18 million hectares (FAOSTAT, 2023). Potatois ~~consumed asa~~ a versatile~~vegetable and~~vegetable, and staple food consumed in most areas (Buru, 2015). The global shift in ~~Around the world,~~ consumer demand from fresh~~orpotato is shifting from fresh tubers to processed products and ever greater quantities of the crop are being~~

~~processed to meet rising demand for convenience food and snack~~tubers to processed products is a testament to the adaptability and potential of this crop. This expanding trend in potato consumption is mainly attributed to increasing urban populations, rising incomes, diversification of diets, and lifestyles that leave less time for preparing the fresh product for consumption (Lutaladio*et al.*, 2009). Development of the potato industry in sub-Saharan Africa (SSA), is critical for poverty eradication, as potato is an important food and cash crop. Potato has a short cropping cycle and a high productivity per unit area in a given time. It is one of the most efficient crops in converting natural resources, ~~labour~~labor and capital into a high-quality meal. Potato is considered as one of the cash crops suited for the future for the densely populated East African highlands and is a source of livelihoods for smallholder farmers.Potato affords a ~~reasonably-priced~~reasonably priced but nutritionally wealthy staple food required in the rapid growing population, contributing protein, nutrients, zinc and iron to peoples' diets(Schulte, 2013).

Potatoes in Uganda is mainly produced in the southwestern highland areas of Kabale and Kisoro and ~~in~~ onthe slopes of M~~m~~t Elgon in eastern ~~Uganda in~~Uganda, in~~areas of~~Bugisu and Sebei. (Bonabana, 2013). Statistics show that the Kabale district alone produces up to 50 - 60% of the potatoes consumed in Uganda (Bonabana, 2013). Potato~~growing~~cultivationin Uganda has been increasing over the years due to its high yields (more than 30 tons/ha), ~~marketability and~~marketability, and early ~~maturity~~ maturity, which~~that~~ allows it to be grown at least twice ~~in~~ a year (MAAIF, 2013).

Despite the importance of potatoes in Uganda, ~~its~~ theirproduction and marketing ~~is~~ are a~~mainly constrained by biotic~~battle againstbiotic stresses, especially late blight and bacterial wilt diseases. This is compoundedby the lack of suitable high yielding and disease resistant varieties coupled with poor agronomic ~~practices and~~practices, and a ~~poor~~ deficientpotato seed system that limits the use of good quality seed (Gildemacher, 2012, Muhinyuza, 2012). The short ~~shelf-life~~shelf life and high perishability of potatoes soon after harvesting leads to over -flooding in the market, resulting in low prices (Tewodros, 2014),~~;~~ thus reducing profits to ~~producers.~~producers. The situation calls for immediate action.~~There is therefore, need to diversify the range of potato varieties grown in Uganda with an aim of capturing those with the requisite attributes to increase yields, disease resistance, usability and hence marketability~~There is a pressing need to diversify the range potato varieties grown in Uganda to capture those with the requisite attributes to increase yields, diseaseresistance, usability, and marketability. This studywas designedto determine the performance, adaptability, and suitability of new potato genotypes in thehighland environments of Uganda.

Materials and Methods

Description of the study area

Field experiments were conducted under rain-fed conditions for the two cropping ~~seasons~~seasons of 2015B and 2016A at Buginyanya Zonal Agricultural Research and Development Institute (BugiZARDI) in the Mt Elgon region in Eastern Uganda. ~~BugiZARDI~~ The instituteis located at an altitude of 1800m above sea level, and its~~with~~ soils generally described as well-drained deep sandy loam.

Experimental treatment and design

A total of 18 potato genotypes, comprising of 8 potato clones from CIP and 7 released commercial varieties in Kenya. Popular Ugandan commercial varieties Nakpot 5 and Cruza were included as tolerant local checks while Victoria was included as a susceptible check for late blight (Table 1). The experiment was laid out in a Randomized Complete Block Design (RCBD) with four replicatesin plots measuring 0.7m by 3.0m wide consisting of two rows at spacing of 70cm by 30cm. ~~Planting~~planting was done on the 10th October 2015 and 20th April 2016.Soil fertilization was done using NPK (17:17:17) applied at a rate of 60g/~~ per 1 ~~m in the ridges ~~at~~ during the planting. The crop was maintained following standard agronomic practices for potato including dehaulming 10-15 days before harvest.

Table 1: Identity and description of potato genotypes used in the study

Genotype	Origin	Status	Attributes
393077.159	CIP	Advanced line	High yielding, resistant to LB, potato virus X, potato leaf roll virus.
398208.29	CIP	Advanced line	Resistant to potato virus X and Y, LB
392797.22	CIP	Advanced line	Resistant to potato virus X and Y, root knot nematode.
393079.4	CIP	Advanced line	Resistant to LB, PVX and PLRV
393385.39	CIP	Advanced line	Resistant to LB, PVX and high yielding
396036.201	CIP	Advanced line	Resistant to LB and high yielding
398208.704	CIP	Advanced line	Resistant to LB and PVX
Bumbamagara	CIP	Released in Kenya	Early maturing

Cruza	CIP	Released in Uganda	BW tolerant
Katchpot 1	CIP	Released in Uganda	Early maturing
Kimori	CIP	Released in Kenya	Early maturing
Kinigi	CIP	Released in Kenya and Rwanda	High yielding
Nakpot 5	CIP	Released in Uganda	High yielding
Rutuku	CIP	Released in Kenya	LB tolerant, high yielding
Rwangume	CIP	Released in Kenya and Rwanda	High yielding
Rwanshaki	CIP	Released in Kenya	High yielding, early maturing, big tuber size
Shangi	CIP	Released in Kenya	High yielding, tolerant to LB
Victoria	CIP	Released in Uganda	High yielding, early maturing, LB and BW susceptible

Data was collected on ~~a number of~~several~~parameters which~~parameters, including the~~included:~~n~~N~~umber of emerged tubers (NPE) ~~was~~ ,determined 40 days after planting by counting emerged tubers. Plant uniformity data were also recorded 40 days after planting using a 1 to 9 scale~~as~~ developed by Salas, (2007). Plant vigor was determined 40 days after planting and scored using a 1 to 9 scale (Salas, 2007). Flowering Degree (Flower) was determined 60 days after planting for every genotypeusing a scale from 0 to 7 according to (Biodiversity & CIP, 2009; Gomez, 2004). Senescence stage was evaluated 90 days after planting using a scale of 1 to 9.Late blight severity was recorded at an interval of 10 days after plant emergence. Severity was assessed as a percentage of the blighted foliage~~;~~ and then converted into Area under the Disease Progress Curve (AUDPC) to measure resistance. AUDPC was calculated from the estimated percentages of leaf area affected recorded at different times during the epidemic according to Campbell and Madden (1990) as shown below.

$$AUDPC = \sum_{i-1}^{n-1} \frac{y_1 + y_{i+1}}{2} \; X \; (t_{i+1} - t_i)$$

Where y_i is an assessment of a disease (percentage) at the i^{th} observation, t_i is time (in days) at the i^{th} observation, and n is the total number of observations. The AUDPC was standardized to RAUDPC values according to Fry (1978). The relative AUDPC (rAUDPC) was calculated by dividing the AUDPC by the maximum potential AUDPC. AUDPC was calculated from the date of first occurrence of late blight until the last observation of the disease in the trial at 90 days after planting.

Bacterial ~~wilt~~wilt (BW) incidence:~~(~~BW~~)~~incidence was assessed at an interval of 10 days until 90 days after planting. Disease incidence was calculated as the percentage of diseased plants over the total number of plants. In addition, the area under the disease progress curve (AUDPC) was calculated ~~then~~ andconverted to rAUDPC (Campbell and Madden, 1990).

~~At harvest, the following data were recorded~~The following data were recorded during the ~~:~~harvest:Number of Plants Harvested (NPH); Tuber Uniformity was determined by observing harvested tubers. A scale of 1 to 9 was then used to categorize tubers for ~~uniformity (~~uniformity(Amoros&Gastelo, 2011).Tuber size was determined based on a 1 to 9 scale. Tubers were categorized as~~;~~ very small (if tuberswere<2 cm), small (if tubers were between 2 and 4cm), medium tubers (for tubers between 4 and 6 cm), large (for tubers between 6 and 9 cm), very large (for tubers over 9 cm).Tubers were separated into ~~2~~ twocategories of marketability i.e., Marketable Tubers Category I and Category II. Marketable Tubers Category I comprised ~~was made up of~~ tubers weighing between 200-300g or with a diameter> 60 mm. On the other hand, Marketable Tubers Category II ~~were those that~~ weighed between 80-200g or ~~with a diameter ranging~~had a diameter ranging from 30 to 60 mm.

Data Analysis

Area under disease progress curve (AUDPC), for late blight and bacterial wilt were standardized to give relative AUDPC (rAUDPC). The rAUDPC for both diseases (LB and BW), yield and yield components data were then subjected to analysis of variance (ANOVA) using Genstat16thedition

Results

There were significant differences among the potato genotypes for plant ~~vigour~~vigor, flowering degree and senescence stage in the two study seasons (Table 2). The genotype effect for tuber size, tuber uniformity,marketable and total tuber yield was only significant during 2015B

Table 2: Mean squares for evaluation of potato genotypes for phenotypic and growth traits in cropping seasons 2015B and 2016A inBuginyanya ZARDI

Source of	d.f	TS	TU	PV	FD	S	MTY	TTY

variation							(T/HA)	(T/HA)
				2015B				
Rep	3	0.7778	0.8124	1.606	1.519	0.241	27.6	36.74
Geno	17	1.359**	2.6299**	17.416**	11.663**	29.529**	29.4**	160.54**
Residual	51	0.1895	0.6321	1.93	3.626	1.898	11.57	29.57
Total	71							
				2016A				
Rep	3	1.569	1.051	2.458	3.866	0.94	842.6	1547.5
Geno	17	3.24ns	3.739ns	7.89**	13.279**	21.739**	809ns	772.1ns
Residual	51	1.766	1.992	1.89	3.425	1.705	444.7	455.4
Total	71							

TS, Tuber Size; TU, Tuber Uniformity; PV, Plant Vigour; FD, Flowering Degree; S, Senescence, MTY, Marketable Tuber Yield; TTY, Total Tuber Yield. **Significant at $P \leq 0.001$, * significant at $P \leq 0.05$

Plant ~~vigour~~vigor

In ~~2015B~~2015B, many of the genotypes tested were categorized as medium with respect to plant ~~vigour~~vigor. Genotypes Rwangume, Kinigi and 398208.704 were vigorous with a score of 6.5. Genotypes 392797.22, Rutuku, Rwanshaki, Bumbamagara and Shangi, which had a mean score between 3 and 5 were categorized as weak. Four genotypes 396036.201, 393385.39, Kimori and Nakpot 5, had a mean ~~vigour~~vigor score of less than ~~3~~three and were described as very weak in ~~vigour~~vigor (Table 3). There was a great improvement in ~~vigour~~vigor registered during the second cropping season (2016A), with many genotypes having medium ~~vigour~~vigor compared to 2015B. Similar to 2015B, the potato genotype Kimori was also very weak in 2016A season, with a score of less than 3. However, genotypes 396036.201, 393385.39 and Nakpot 5 improved in ~~vigour~~vigor to a mean between 3 and 5 and were considered weak in ~~vigour~~vigor. Rwangume was vigorous with a mean score of 7 while genotypes 392797.22, 393077.159, 393079.4, 3398208.29, 398208.704, Cruza, Katchpot 1, Kinigi, Rutuku, Rwanshaki and Victoria had a mean score of between 5 and 6 and were categorized as medium in regards to plant ~~vigour~~vigor (Table 3).

Flowering Degree

Genotypes 393077.159, 393385.39, Nakpot 5, Rutuku, Rwangume, Shangi and Victoria were characterized as profuse, while 396036.201, 3398208.29, 398208.704, Cruza, Katchpot 1, and Rwanshaki considered moderate. Kinigi, Kimori, and Bumbamagara~~were characterized as~~had low ~~in terms of~~ flowering degrees (Table 3).

Senescence

Senescence ranged from early to very late. Genotypes Victoria, Shangi, Rwangume, Cruza, Bumbamagara and 393077.159 turned yellow 90 days after ~~planting~~planting, whichisconsideredas early maturing. Meanwhile, genotypes 393385.39, 396036.201 ,and 3398208.29 were still green at 90 DAP and thus categorized as very late (Table 3).

Table 3: Plant Vigour, flowering degrees and senescence stage of (2015B and 2016A), Buginyanya ZARDI

Genotype	2015B			2016A		
	Plant vigour	Flowering degree	Senescence	Plant vigour	Senescence	Flowering degree
392797.22	4.5	6	5	5	3	4.5
393077.159	6.5	7	7	6.5	7	7
393079.4	6	4	4	6	7	4
393385.39	0.75	7	1	4.5	5	2.5
396036.201	0	5	1	3.5	3.25	2.5
398208.29	5.5	5	2	6	7	3
398208.704	6.5	6	5	5.5	6	1
Bumbamagara	4	3	7	4.5	4	5
Cruza	5	5.25	7	5.5	7	5
Katch pot 1	5.5	6.5	3	5	6.5	7.5
Kimori	1.25	2.5	1.75	1.5	2.5	2
Kinigi	6.5	1.75	3	5.5	1.75	3
Nakpot5	1.75	7	0.75	3.25	5.25	2.25
Rutuku	4.5	7	3	5.5	7	3.5
Rwangume	6.5	7	7	7	7	8.5
Rwanshaki	4.5	6	4	5	6	6
Shangi	4.5	7	9	2.5	7	8

Victoria	5.5	7	9	5.5	7	7.5
mean	4.40	5.56	4.42	4.88	5.51	4.6
LSD	1.972	2.703	1.956	1.951	2.627	1.853
CV %	6.8	5.2	2.6	7.6	8.4	5

Yield parameters

The tuber sizes ranged between 0.25 – 2.75 cm in 2015B as opposed to betweenand 2.5- 6.5 cm in 2016A cropping season. The genotype 392797.22 generally had the biggest tuber sizes across the two seasons, while the genotype Kimori had the smallest tubers (Table 4).

There was high heterogeneity among genotypes for tuber uniformity. A large number of the genotypes were categorized as heterogeneous since all the tuber sizes were present but with a predominant size except for Kimori, which was very heterogeneous comprising all tuber sizes (Table 4).In 2016A, most of the genotypes were categorized as intermediate. However, Shangi and Bumbamagara scored 7, and they had uniform tubers. As for tuber shape, the genotype effect of genotype was innot significant (Table 4), with most of them being round shaped.

Marketable tuber yield

The genotype effect on marketable tuber yield was significant (P<0.001) in 2015B but non-insignificant in 2016A (Table 2). In generalGenerally, there was a very low marketable tuber yield recorded in 2015B season compared to 2016A cropping season. Generally, across both seasons ,genotype 392797.22 had the highest marketable tuber per hectare followed by 398208.29 with the least yielding being Katchpot 1 and Kimori (Table 4).The overall meanaverage marketable tuber yield registered in 2015B was 4.14 t/ha while in 2016A it was 38 t/ha (Table 4). The three best genotypes with respect to marketable tuber yield in 2015B were clones 392797.22 (8.45 t/ha), 398208.29 (8.26 t/ha), and 393079.4 (7.37 t/ha) whereas, in 2016A they were 392797.22 (63.7 t/ha), 398208.29 (57 t/ha), and variety Victoria (50.4 t/ha) (Table 4). In 2016A, the least marketable tuber yield was recorded from Kimori (11.5 t/ha), and Katchpot 1 (14.4 t/ha). Potato varieties Bumbamagara and Cruza were highly affected by drought in the

2015B season, resulting in no marketable yields. However, in 2016A ,they yielded 22 t/ha and 44.4 t/ha respectively (Table 4).

Total tuber yield

Total tuber yield was significantly (P<001) influenced by genotype in 2015B but not in 2016A. Results revealed a big gap between the mean total tubers yields recorded in the two cropping seasons. The highest mean total tuber yield was recorded in 2016A (46.9 t/ha), while the lowest mean total tuber yields (15.98 t/ha) was attained in 2015B (Table 4). Across seasons, genotype 392797.22 had the highest mean tuber yield, followed by Cruza. Katchpot 1 and Rwanshaki hadthe least tuber yield.. In season 2016A, 392797.22 (71.43 t/ha), 398208.29 (60.9 t/ha), Cruza (58.12 t/ha), Rutuku (57.91 t/ha), Victoria (57.25 t/ha), andKimori had the least total tuber yield.

Table 4: Yield components of the 18 potato genotypes grown in Buginyanya, during the cropping seasons of 2015B and 2016A

	2015B					2016A				
GENOTYPE	**Tuber size**	**Tuber uniformity**	**Tuber shape**	**Marketable tuber yield (t/ha)**	**Total tuber yield (t/ha)**	**Tuber size**	**Tuber uniformity**	**Tuber shape**	**Marketable tuber yield (t/ha)**	**Total tuber yield (t/ha)**
392797.22	2.75	4	2	8.45	18.13	6.5	5	2	63.7	71.4
393077.159	2.25	4.25	1.25	3.82	17.89	5	5.5	1	27.2	33.8
393079.4	2	4	1	7.37	20.68	4.5	5.5	1.5	38.8	54.6
393385.39	2	4	1	4.01	13.15	5.5	5.5	1	44	51.5
396036.201	2	4.5	1	2.81	11.24	5	6	1	41.4	47
398208.29	2.75	3.75	1	8.26	17.18	6	5	1	57	60.9
398208.704	2.5	4.25	1	6.12	19.19	5.5	5	1.5	44.4	52.7
Bumbamagara	1.5	5	1	0	7.65	4	7	1	22	38.4
Cruza	1.75	5	1	0	10.79	3.5	6.5	1.25	44.4	58.1
Katchpot 1	2.25	4.77	1	3.45	13.44	5	6.5	1	14.4	23.9
Kimori	0.25	1.25	0.5	0	0.3	2.5	3	0.75	11.5	17
Kinigi	2.25	4.25	1	4.03	19.55	5.5	6	1	42.6	53.2
Nakpot5	2.5	4.25	1.25	5.39	22.26	4.75	4.75	1.25	43.5	46.7
Rutuku	2.5	3.75	1	5.96	21.28	5	5	1	47.5	57.9
Rwangume	2	4.25	1	2.87	24.44	5	6	1	40.3	50.2
Rwanshaki	2.5	4.25	1	6.24	22.02	5	6.5	1	27.2	36
Shangi	1.75	4.75	2	0.99	8.44	4.5	7	1	22.6	33.5
Victoria	2.5	4.25	1	4.78	19.97	5	6	1	50.4	57.2
MEAN	2.111	4.14	1.111	4.14	15.98	4.88	5.65	1.125	38	46.9
LSD	0.618	1.1292	0.4111	4.83	7.72	1.886	2.004	0.5539	29.94	30.3
CV %	9.8	5.1	5.8	29.9	8.9	6.1	4.3	8.4	18	19.8

Genotype reaction to late blight and Bacterial wilt diseases

Relative AUDPC for late blight and bacterial wilt diseases

Relative areas under disease progress curves (rAUDPC) showed significant differences among the genotypes ($P<0.001$) in both 2015B and 2016A seasons for bacterial wilt and late blight diseases.

Table 5:Mean squares for rAUDPC for late blight and bacterial wilt diseases in cropping seasons 2015B and 2016A, Buginyanya ZARDI

Source of Variation	D.F.	LB2015B	LB2016A	BW 2015B	BW 2016A
Rep	3	0.03184	0.03425	0.05351	0.04561
Genotype	17	0.09009**	0.16138**	0.14172**	0.11946**
Residual	51	0.02226	0.07618	0.0473	0.02817
Total	71				

LB, late blight; BW, bacterial wilt; **Significant at $p \leq 0.001$, * significant at $P \leq 0.05$

~~Generally~~Generally, 2016A had significantly higher rAUDPC compared to 2015B for both late blight and bacterial wilt diseases. Genotype 396036.201(0.706) had the highest rAUDPC for late blight, followed by 398208.29 (0.497) and Bumbamagara (0.434). Genotypes Kinigi and 398208.704 were not affected by late blight at all. In the same season, bacterial wilt most affected genotypes 398208.29 (0.551) and 393079.4 (0.543) most.

Table 6: Relative Area under disease progress curve (rAUDPC) for late blight and bacterial wilt of the 18 potato genotypes grown in Buginyanya ZARDI during the seasons of 2015B and 2016A.

GENOTYPE	2015B		2016A	
	rAUDPC LB	rAUDPC BW	rAUDPC LB	rAUDPC BW
392797.22	0.034	0	0.233	0.221
393077.159	0.038	0.019	0.034	0.051
393079.4	0.008	0.122	0.239	0.543
393385.39	0	0	0.050	0.185
396036.201	0.078	0	0.706	0.051
398208.29	0.133	0	0.497	0.551
398208.704	0.057	0	0	0.069
Bumbamagara	0.392	0.428	0.434	0.355
Cruza	0.265	0.506	0.230	0.406
Katchpot 1	0.091	0.425	0.201	0.38
Kimori	0.093	0.250	0.291	0.083
Kinigi	0.027	0	0	0.054
Nakpot5	0.108	0	0.163	0.080
Rutuku	0.059	0.200	0.241	0.112
Rwangume	0.106	0.159	0.012	0.217
Rwanshaki	0.157	0.153	0.38	0.036
Shangi	0.538	0.512	0.003	0.145
Victoria	0.362	0.084	0.009	0.065
MEAN	0.141	0.159	0.207	0.2
LSD	0.2118	0.3087	0.3918	0.2383
CV %	29.8	34.3	21.1	25.1

rAUDPC (Relative Area under disease progress curve), BW (Bacterial wilt), LB (Late Blight).

In 2015B, genotype 393385.39 was neither affected with late blight nor bacterial wilt, while Bumbamagara (0.392) and Shangi (0.538) were the most affected ~~with~~ byLate blight. Shangi and Cruza had the highest Bacterial wilt with rAUPDC,~~of~~ 0.512 and 0.506 respectively (table 6).

Discussion

Variation in plant ~~vigour~~vigor among the genotypes is attributed to both genotype and environment factors (Ungerer*et al*., 2003). Plant ~~vigour~~vigoris influenced by nutrient uptake and utilization by the different genotypes. According to Salas (2007), genotypes with weak plant ~~vigour~~vigor have few leaves and thin stems. Genotypes 396036.201, ~~Kimori and~~Kimori, andNakpot 5 were weak in 2015B, while ~~the majority of the~~most genotypes had normal ~~vigour~~vigor. Genotypes ~~that exhibit~~exhibiting normal ~~vigour~~vigor under optimum environmental conditions exploit environmental resources ~~well resulting~~well, resulting in good yields. On the other hand, excessive ~~vigour~~vigor may be disadvantageous as it results in~~to~~ vegetative growth at the expense of tuberisation (Abbas *et al*., 2012), resulting in lower yields. Breeders, therefore, have to strike a balance between vegetative growth and maximum tuberisation. The genotypic differences in ~~vigour~~vigor seen in the study could also be attributed to differences in genetic backgrounds of the potato clones. It could also be due to the interaction of genotypes with environment. The season 2015B was ~~dry and~~dry, and~~recorded~~ more genotypes with poor ~~vigour~~vigor scoreswere recorded. Soil moisture is key in plant growth.

Flowering in potatoes is highly variable, with some genotypes not flowering at all. This trait is also attributed to differences in genetic makeup of the genotypes (Soares*et al*., 2013). This best explains the significant variation in flowering observed among the different genotypes tested in this study. The results showed that most of the genotypes had moderate and profuse flowering. According to Biodiversity and CIP (2009), such genotypes have either 8-12 and above 20 flowers per inflorescence, respectively. Much as flowering has nothing to do with tuber yield, it influences the choice of a genotype for use as parents in potato breeding programs. Genotypes Kinigi,whose flowers aborted ,and 392797.22, Bumbamagara, 396036.201, which had small rudimentary inflorescence, cannot be used in conventional breeding as they will never easily produce viable pollen and fertile stigma (Wyss *et al.*, 2001). This makes it hard to transfer any desirable attribute in such genotypes to another well adapted, farmer preferred variety that lacks the trait in question.

Maturity time was also variable among the tested genotypes, ranging from early to late. Genotypes that take a short time to mature are desirable because they have high chances of escaping the attack of pests andpests, anddiseases as well as,and drought. The results of this study indicated that genotypes Shangi, Victoria, Rwangume, and 393077.159 take a short time to senescence. These could potentially mature earlier than genotypes 393385.39, 396036.201, 398208.29. Late maturing genotypes tend to have higher yields due to having a longer time for tuber filling. A study by Amoros and Gastelo (2009) found that leaves of plants that senescence early turned yellow much earlier than the stem andstem, and the berries change colourcolor from green to yellow. This was the case with genotypes 393385.39, 396036.201, 398208.29, Shangi, Rwangume, and Victoria. The rest of genotypes,exceptBumbamagara, Cruza, Katchpot1 and Rwashaki were still green at 90 days after planting, implying that they were either late or very late meaning (Amoros and Gastelo, 2009).

Variation was also recorded for tuber size among genotypes. Results showed that all the genotypes in the first season had very small tubers. However, in the second season,,majority mostof the genotypes were medium sized, clearly indicating the effect of an improvement of environmental conditions that allowed better crop growth. tThe season had sufficient rainfall to support proper plant growth. Differences in tuber size influences growth and processing qualities. According to Pandy*et al*. (2000), large tubers have more sprouts hence andproduce more stems per plant. Stem numbers are positively related to tuber yield (Negero, 2017).

Tuber uniformity across genotypes was also variable.variable. Genetic and environmental factors couldalso account for the difference in potato tuber uniformityamong the Thegenotypes. The difference in the absorption rate potato tuber uniformity among the genotypes could also be accounted for by both the genetic and environmental factors. The difference in the rate of absorption of nutrients during tuberisation affects tuber uniformity and consequently yield, implying that very heterogeneous tubers result into lower yield and vice versa (Da Silva *et al.*, 2006). The mMajority of genotypes in 2015B were heterogeneous, while in 2016A, most of the genotypes were intermediate in uniformity,largely mainlydue to differences in rainfall received in the two seasons.

Only three improved genotypes 39279.22, 398208.29, and 398208.704 had higher marketable yield than the locally cultivated genotypes Bumbamagara and Katchpot 1 (Table 4). The variation in marketable tuber yield among genotypes is also be related to genetic and environmental factors (Abbas *et al.*, *(*2012). ~~According to~~ Kumar *et al*. (2007) state ~~genetic~~that genetic differences influence marketable tuber yield. Marketable tubers are ~~normally those which~~usually~~are~~ large in size (above 80 gm) (De Haan *et al.*, 2014). Therefore, the high marketable yield among the improved genotypes 39279.22, 398208.29, and 398208.704 compared to the local genotypes could be due to the latter producing a high number of small tubers. Many tubers on a plant may induce excessive competition for resources like photosynthates among themselves, thus resulting into small unmarketable tubers. Since marketable tubers are those ~~larger in size~~larger,~~is clear indication~~this clearly indicates ~~of~~ increased bulking of the tubers among these genotypes. The significantly low yield recorded in 2015B is largely attributed to the long dry spell during the period of November 2015 to January ~~2016 when~~2016, when the crop was at the critical stage of tuberization and tuber filling. This is in line with other studies that have reported considerable reduction in tuber yield and quality (Abbas and Ranjan, 2015; Shayannejad, 2009) when drought sets in at these critical growth stages. Apart from moisture stress another significant environmental factor that affects the quality of tubers is temperature. High temperature affects potato growth negatively. A study by Rykaczewska (2017) demonstrated that potato response to heat stress depends on the growth stage and ~~the level of moisture in the soil~~soil moisture level. ~~Therefore~~Therefore, the low yields observed during the 2015B could be attributed to the long dry spell and high temperatures in the month of November 2015 to February 2016.

Total tuber yield varied among the genotypes, with 392797.22 and Rwangume being the highest yielders. Although genotype 392797.22 had a high yield, it had lower tuber number compared to Kinigi and Bumbamagaraon account of their big tuber size. On the other hand, genotypes Kinigi and Bumbamagara had a high number of tubers, although most were unmarketable. These results suggest that the number of tubers a genotype produces ~~doesn't~~does not necessarily correlate positively with marketable yield, although it may correlate well with total yield. A genotype with very many small tubers will normally have a low yield of marketable tubers (Mehdi *et al*., 2008). Studies by Chandra, 2015 reported a high total yield among genotypes that had a high number of tubers.

Genotype Victoria despite the high rAUDPCs for both bacterial wilt in season 2016A and late blight in season 2015Bout yielded genotypes 393077.159, 393079.4, 396036.201, Shangi, Rwanshaki, Nakpot 5 and Katchpot 1. Victoria is early maturing (about 90 days after planting), therefore it is possible that most tuber bulking takes place before the disease peak stage. ~~Therefore~~Therefore, early maturing genotypes often escape the adverse effects of diseases thus producing high yields. Genotype Katchpot 1 had the lowest yield in the two seasons. It also produced the lowest number of tubers with a high number of undersized tubers. Cruza also had a high rAUDPC but still yielded high despite being late maturing. This implies that genotype Cruza is tolerant to the effects of the two diseases.

The Kenyan varieties Bumbamagara, Shangi, Rwanshaki and Kimori were as much affected by the LB as the local check Victoria. These findings are similar with what was reported by Kaguongo*et al.*, (2008). These genotypes are susceptible to ~~LB and~~LB, and their production will mostly rely on an integrated approach involving chemical sprays. However, as populations of *P. infestans*become increasingly aggressive, coupled with societal resistance against the usinge~~ of~~ environmentally unfriendly chemicals, breeding for resistance should be emphasised. On the other hand, genotypes like 393385.39 and 398208.704 were not affected~~with~~ by~~LB most~~LB, most likely because of possession of ~~resistance~~ genes that were resistant to~~against~~ the disease.

The genotypes Shangi and Cruza had the highest incidence of bacterial wilt in this study. It is worth noting that Cruzahad been variously reported to be resistant to BW (Adipala*et al.*, 2002). Bacterial wilt disease also affects tubers, making them rot in storage. These genotypes therefore may not be good for cultivation in fields infested with *R. solanacearum.*

Conclusion

Results showed significant differences (P<0.05) in tuber size, ~~tuber~~ uniformity, marketable tuber ~~yield and~~yield, and the total tuber yield across all genotypes. Of all the potato genotypes evaluated, 392797.22 (44.8t/ha) and 398208.29 (39t/ha) produced significantly (P<0.001) higher tuber yield compared to the local check Cruza (34.5t/ha) on average across both seasons. rAUDPC for LB showed significant differences (P<0.001) among genotypes in both seasons. The most resistant genotypes were Kinigi (0.0135) and 399985.39 (0.025) and the most susceptible were Bumbamagara (0.413) and 396036.201 (0.392). 396036.201(0.051) and Kinigi were the most resistant genotypes for bacterial wilt while Shangi (0.66) and Cruza (0.46) were the most susceptible to BW.Genotypes 392797.22 and 398208.29 which are high yielding and disease-resistant are recommended for release as commercial varieties or as donor parents for potato improvement programs.

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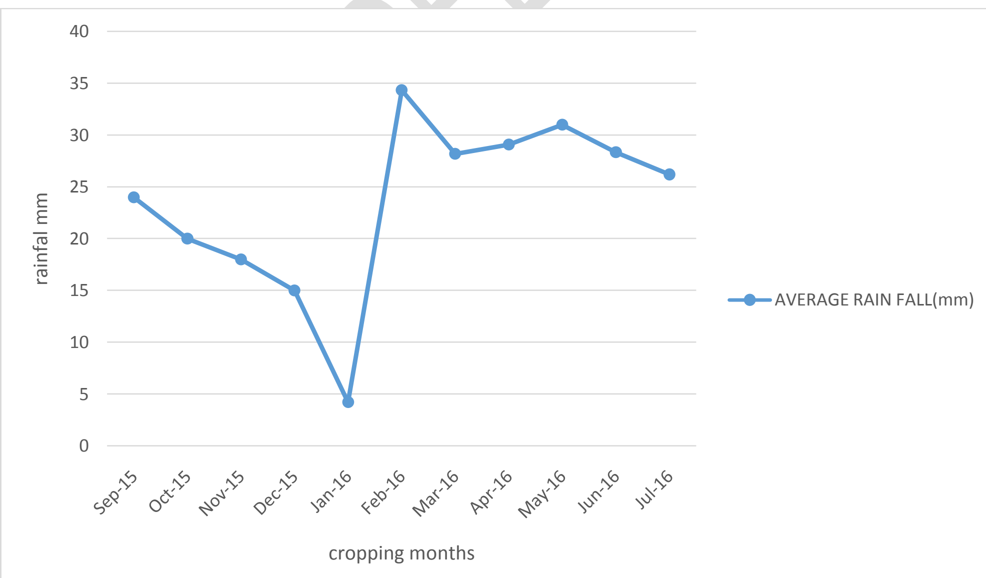
Annex 1. Annual monthly rainfall of the study area during the growing period in the year of 2015B and 2016A.



Source: Buginyanya metrology station