

NATIONAL AGRICULTURAL RESEARCH ORGANISATION (NARO)



**SUBMISSION TO THE VARIETY RELEASE
COMMITTEE**

**FOR THE RELEASE OF FOURTEEN (14)
POTATO VARIETIES 2021**

BY

THE NATIONAL POTATO PROGRAM

**KACHWEKANO ZONAL AGRICULTURAL RESEARCH AND
DEVELOPMENT INSTITUTE (KAZARDI)**

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Table of Contents

Summary	5
1.0 Introduction	6
2.0 Methodology	7
2.1 Test varieties	7
3.2 Site selection and land preparation	8
3.3 Planting of the experiment	9
3.4 Field management	9
3.5 Evaluation for growth and yield parameters of the different Dutch based potato varieties	9
3.6 Data recording and analysis	10
3.6.2 Data analysis	10
3.7 Selection criteria of potential varieties for Uganda	10
3.7.1 Data analysis for dry matter content	11
4.0 RESULTS AND DISCUSSION	11
4.1 Yield performance of the Dutch based potato varieties across different locations and seasons in Uganda	11
4.2 Adaptability and yield stability assessment of the varieties in different environmental condition	19
Total tuber Number / plant sensitivity assessment.	24
4.3 Dry matter content of the Dutch based potato varieties.	25
Processing Qualities for NARO bred varieties	32
Weather data for the study site during the study period (March –June 2018-2020) ...	34
Proposed Names	40
Production and management package of the new varieties	40
Production costs and benefits associated with growing of these varieties	46

List of tables

Table 1: Name of the Test varieties	7
Table 2. GPS position and altitudes location of the trial sites in Uganda for national performance trial of Dutch based varieties	8
Table 3: Marketable yield (T/Ha) across sites and season of testing.....	11
Table 4: Seasonal yield and site performances for all the test varieties	12
Table 5 :Marketable yield (T/ha) for test varieties across sites and the 3 seasons (2018-2020)	14
Table 6: Total yield (T/Ha) across sites for 3 seasons)-2018-2020	15
Table 7: Marketable tuber number per plant among varieties tested across different sites for 3 seasons (2018-2020).....	16
Table 8: Total tubers harvested per plant /variety across the sites (2018-2020)	17
Table 9: Yield of NARO bred genotypes across the different environments.....	18
Table 10: Total Yield (T/Ha) and Ranking across the experimental sites for NARO varieties 19	
Table 11 : ANOVA for the effects of the environment on variety performance on Dutch varieties	20
Table 12: Means for the environmental effects on variety performance	20
Table 13: Variety sensitivity to different environments.....	21
Table 14: Sensitivity to different environment among NARO bred Varieties.....	21
Table 15: Stability superiority measure coefficients for the yield components among Dutch varieties	22
Table 16: Static stability measure coefficients	23
Table 17: Static stability for Marketable yield among NARO bred varieties	23
Table 18: Wricke's ecovalence stability coefficients for the yield components.....	24
Table 19: NARO Bred varieties- Wricke's ecovalence stability coefficients for marketable Yield	24
Table 20: Total tuber Number / plant sensitivity assessment.	25
Table 21: Dry matter content of the Dutch based potato varieties.	25
Table 22: Dry matter content for NARO bred varieties	26
Table 23: Crisping qualities of the test varieties	27
Table 24: Preference ranking of the NARO bred varieties (Table 18)	30
Figure 4: Cooking (Fry qualities) of the varieties tested In Uganda.....	31
Table 25: Cooking properties and composition analysis of NARO varieties	33
Table 26 : Varieties recommended for release based on national performance and general acceptability by end users and processing qualities.....	36
Table 27: Summary of the varieties recommended for release and their attributes....	38

11

11

11

11

11

11

11

11

11

11

11

11

11

11

11

11

11

11

List of figures

Table of Contents	2
Figure 1: Map of Uganda showing the different agro ecologies where potatoes were tested for National performance	9
Figure 2: Box plots indicating the variation in yield components across the sites.....	13
Figure 3: Box plots indicating the variation in yield components across the sites.....	19
Figure 4a: Crisp quality assessment for the Dutch potato varieties	28
Figure 4b: Crisp quality assessment for the NARO bred potato varieties	29
Figure 5: Cooking (Fry qualities) of the varieties tested In Uganda.....	31
Figure 6: Pasting curves during cooking of NARO bred varieties	32
Figure 7: Weather data for the period March –June of the experimentation period 2018-2020: source UNMA	35

VARIETY RELEASE TECHNICAL DOSSIER

Summary

The national potato program based at Kachwekano ZARDI wishes to present fourteen candidate potato varieties to national variety release committee for official release and inclusion on national variety list for Uganda. The fourteen varieties being presented have been evaluated for three years from 2017 to 2020 and have been observed to have good attributes in terms of yield, processing qualities and adaptability in key agro-ecological zones for potato production. The yield of these varieties range 24-36 T/ha. These varieties, have good processing qualities (crisping and chipping) and can as well be used as table potato. The varieties being presented include; two NARO bred varieties; 20151.5 and 20158.14 and 12 Dutch varieties (Jelly, Farida, Manitou, Acoustic, Sunred, Caruso, Masai, Georgina, Zarina, Rumba, Allison and Lady Terra).

The majority of the varieties have tuber shapes that are meet the processing qualities and with high acceptability degree for uptake by the market. Therefore if these varieties are released and utilized by farmers under good management systems, they will contribute significantly to household income and nutritional food security. The proposed names of the NARO bred varieties are; NAROPOT 5 (20151.5) and NAROPOT 6 (20158.14) while the Dutch varieties will maintain their accession names from the breeding companies. The research team is convinced that they should be released to farmers for uptake and utilization. KAZARDI pledges to provide the foundation seed to the above varieties listed for multiplication and utilization in Uganda.

1.0 Introduction

Potato is an important staple food crop as well as a cash crop more especially for the highlands areas of Uganda. The potato has a prime position in terms of both the realized and potential contributions to food security, poverty eradication and economic development in areas and countries where it is grown. In Uganda, potato is ranked as 8th most important crop and plays a major role in national food and nutritional food security by providing a cheap but nutritionally rich staple food required in the fast growing population of Uganda, contributing protein, vitamins, zinc and iron to the diet. It provides more nutritious food per land unit in less time and often under more adverse condition than any other food crops due to its efficient water use. The net income generated from potato production is higher compared to other food crops.

However, the potato productivity is rated low with national figures ranging from 4.5- 7.5t/ha, yet the potential is > 30 T/ha using good agronomic practices and high yielding varieties. On-station experiments indicate productivity of over 25T/ha of the marketable yield under good management. A number of potato varieties have been released by the National Variety Release committee in Uganda to bridge the yield gap and of recent capturing processing and culinary qualities. Some of varieties released in 2016 were of Netherlands origin and included, Sarpo Mira, Connect, Arizona, Markies, El Mundo, Sagitta, and Voyager with some of the varieties having good attributes for making French fries suitable for the fast-food industry with some varieties like Voyager for processing of crisps.

With the growing markets in East Africa, there was need to have a diversity of potatoes varieties with higher yield/ output per unit area for generation of value added food products to serve the growing urban populations. Through collaborative arrangement with IFDC and Dutch companies, a set of 15 potato varieties were accessed by Kachwekano Zonal Agricultural Research



and Development Institute (KAZARDI) which were evaluated between 2018-2020 to establish their yield performance, processing qualities across the major agro-ecologies suitable for potato production in Uganda. In addition, the potato breeding program has been developing other processing varieties in response to the demands from the potato industries. This report therefore presents the results obtained under national performance trial (NPT) for season 1, 2 and 3 from 2018-2020 covering both Dutch and NARO bred varieties and highlight the varieties fit for release for the benefit of Ugandan farmers.

2.0 Methodology

2.1 Test varieties

A set of 15 Dutch based varieties were acquired from Netherlands for evaluation for adaptability and processing and marketing qualities under Ugandan conditions with clearance from Ministry of Agriculture Animal Industry and Fisheries. Additionally, six NARO bred potato candidate genotypes were also evaluated separately from the Dutch varieties.

The list of varieties that were evaluated during; 2018A, 2019A and 2020A season are; (Table 1),

Table 1: Name of the Test varieties

S/N	VARIETY		VARIETY
1	CMK 2006-070-005 (ACOUSTIC)	13	RUDOLPH
2	CONCORDIA	14	RUMBA
3	FARIDA	15	SUN RED
4	GEORGINA	16	CARUSO
5	HZA 08-2223 (ZARINA)	17	Destiny
6	HZD 06-1249 (ALLISON)	18	20151.28
7	JELLY	19	20151.5
8	LADY AMARILLA	20	20158.14
9	LADY TERRA	21	20158.15
10	MANITOU	22	201510.7
11	MASAI	23	NAROPOT 4
12	VICTORIA (local check)		

3.2 Site selection and land preparation

Five sites were selected for National performance yield and adaptability assessment in different agro-ecologies of Uganda representative of the traditional potato production areas (Kabale district (Kachwekano ZARDI), Kisoro (Maziba), Zombo district (Zeu DFI), Bulamburi district (Buginyanya ZARDI), Kabalore district (Rwebitaba ZARDI). The sites were bush cleared and made ready for planting by conducting 1st and 2nd land preparation.

Table 2. GPS position and altitudes location of the trial sites in Uganda for national performance trial of Dutch based varieties

District	Trial Site location	Altitude (m.a.s.l.)	Latitude	Longitude
Kabale	Kachwekano	2225	1°15'01.44 S	29°56'16.45 E
Kisoro	Maziba	1867	1°29'58.30 S	29°94'23.62 E
Kabalore	Rwebitaba ZARDI	1531	0°41'36.81N	30°19'57.76 E
Bulamburi	Buginyanya ZARDI	1887	1°16'50.41N	34°22'19.25 E
Zombo	Zeu-DFI	1642	2°30'34 N	30°48'49.25 E

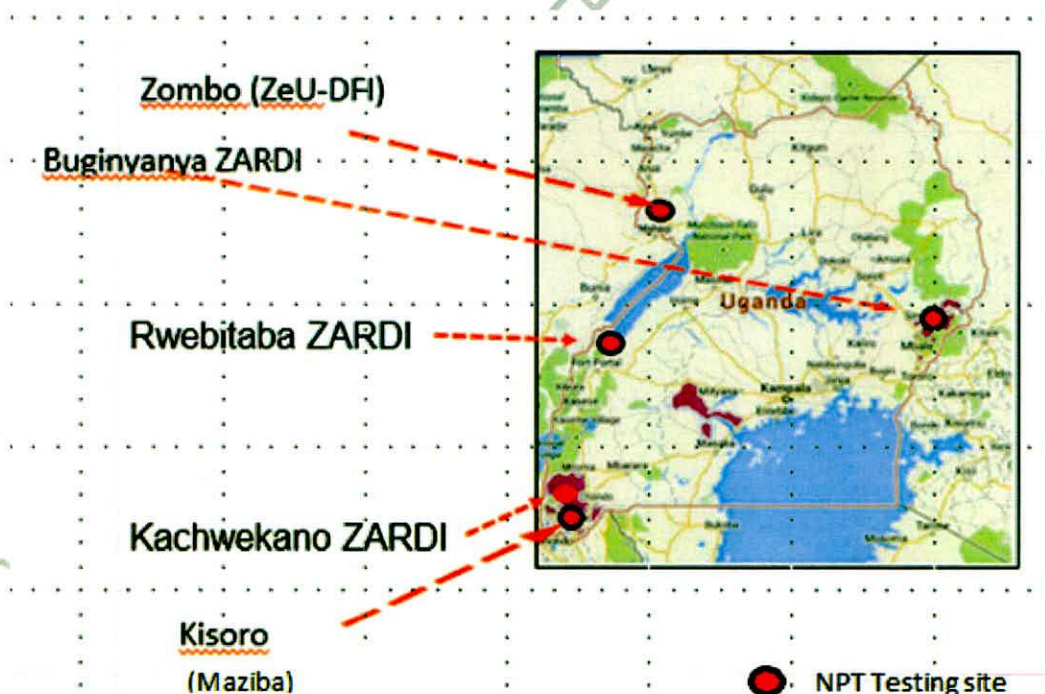


Figure 1: Map of Uganda showing the different agro ecologies where potatoes were tested for National performance

3.3 Planting of the experiment

100 tubers of each variety were planted per replicate in three replications at a spacing of 75 x 30cm using RCBD design in five sites. Three blocks were used and each variety was replicated 3 times at each site. Plot size of 3.75 X 6 m per replicate was used per potato variety. Straight line trenches of about 10 cm deep were dug and 200kg/acre of NPK 17:17:17 fertilizer was applied manually and then sprouted tubers were placed into the trenches with sprouts facing upwards and then covered making a mound on the tubers.

3.4 Field management

Standard agronomic practices which involved weeding, disease and pest control were done. Weeding was done 3 times across all sites while protection against late blight disease was done on a weekly basis (7 days interval using systemic fungicides (Macozeb 640g/kg+ 80g/kg of metalazyl) alternated with infinito fungicide (Propamacarb (55.3% w/w) + Fluopicolide (5.53% w/w) on a weekly basis depending on weather conditions at each site while pest protection was done using systemic insecticide Rocket (profenofos 40%+cypermethrin 4%).

3.5 Evaluation for growth and yield parameters of the different Dutch based potato varieties

Following trial establishment, data on growth parameters was collected during the growing phase of the varieties. Observations on late blight disease severity, bacterial wilt incidence, stem rot/blackleg and pest damage were taken and other diseases and data were recorded. At harvest, all tubers were graded into 3 categories. The weights and numbers of tubers in each category were recorded. The following categories were used:

1. Category I: commercial tubers/big tubers or measuring >60 mm in diameter.

2. Category II: commercial tubers/medium tubers 30-60 mm in diameter.
3. Category III: non-commercial/small tubers or measuring < 30 mm in diameter.

Tuber dry matter and processing qualities were also assessed after harvest.

3.6 Data recording and analysis

3.6.1 Data recording

All collected data were entered in the tuber yield data sheet. In order to facilitate comparisons between test varieties and locations, data for yield assessment (such as total weight or commercial weight) was expressed in tons/ha.

3.6.2 Data analysis

Data analysis was done using Breeding View platform of Genstat statistical software to generate mean values for all the yield components and was analyzed using variance analysis (ANOVA) and means compared using LSD with the control. Adaptability was assessed through the genotype stability analysis across different environments following a procedure of Manrique and Hermann, (2000) using breeding view software.

3.7 Selection criteria of potential varieties for Uganda

Performance of each candidate variety was compared with the performance of the control (Victoria and NAROPOT 4) using marketable yield of the entry rather than the total yield. The ability of variety to develop numerous small tubers was viewed as a negative characteristic.

For selection of varieties for specific uses from fresh consumption to processing;

- Processability for French fries and crisps
- Information on palatability and cooking quality was generated and used to guide the selection.

The varieties were tested for the following:

1. Dry matter content
2. Chip/fry performance
3. Cooking quality
4. Crisps performance

3.7.1 Data analysis for dry matter content

— Data on dry matter content as percentage was analyzed using 4 entry repetition of samples taken from the field using Genstat and means separated using LSD.

4.0 RESULTS AND DISCUSSION

4.1 Yield performance of the Dutch based potato varieties across different locations and seasons in Uganda

All tubers were harvested, counted and grouped into three categories;

1= small tubers (<30mm), 2= medium (45-60mm) and 3= large (>60mm). The marketable grade comprised of medium and large tubers. The ability of variety to generate small tuber was regarded as bad attribute towards selection of the best varieties.

The results from the 3 season study indicated yield components (marketable tuber yield and number of tuber /plant) varied across the sites and seasons. Rwebitaba had highest average marketable yield (36.1T/ha) followed by Buginyanya (29.2T/ha), Kachwekano (28.9t/ha), Kisoro (26T/ha) and Zombo (25.6) respectively (Table 3)

Table 3: Marketable yield (T/Ha) across sites and season of testing

season	Sites					Grand Mean
	Buginyanya	Kachwekano	Kisoro	Rwebitaba	Zombo	
1	24.2	21.2	30.7	36.9	38.0	30.3
2	29.6	20.6	16.8	37.1	21.4	25.1
3	33.7	44.8	29.6	34.3	16.2	31.7
Grand Mean	29.2	28.9	26.0	36.1	25.6	29.2

The potato yields across sites and season was higher for season 3 (2020), compared to season 2 (2019) and season 1 (2018) (Table 4)

Table 4: Seasonal yield and site performances for all the test varieties

Season	Site	Total tuber number/plant	Marketable tuber Number/plant	Marketable Yield (T/Ha)	Total Yield (T/ha)
Season 1 (2018)	Mean	8.5	6.7	30.3	31.4
	Buginyanya	7.5	5.7	24.2	25.2
	Kachwekano	6.7	4.8	21.2	22.6
	Kisoro	9.7	7.3	30.7	31.7
	Rwebitaba	9.8	7.7	36.9	37.9
	Zombo	8.8	7.8	38.0	38.8
Season 2 (2019)	Mean	7.7	6.6	25.1	25.8
	Buginyanya	7.8	7.0	29.6	30.0
	Kachwekano	6.0	5.0	20.6	21.2
	Kisoro	5.1	4.2	16.8	17.5
	Rwebitaba	12.0	10.3	37.1	38.1
	Zombo	7.7	6.4	21.4	22.3
Season 3(2020)	Mean	7.8	6.4	31.7	32.9
	Buginyanya	7.0	5.9	33.7	34.7
	Kachwekano	8.7	7.7	44.8	45.6
	Kisoro	6.5	5.3	29.6	30.7
	Rwebitaba	9.4	7.6	34.3	35.9
	Zombo	7.3	5.4	16.2	17.7
Grand Mean		8.0	6.5	29.2	30.1

The box plot analysis showed variation in the yield across sites with much more in tuber number at Rwebitaba compared to other sites where the potatoes were tested.

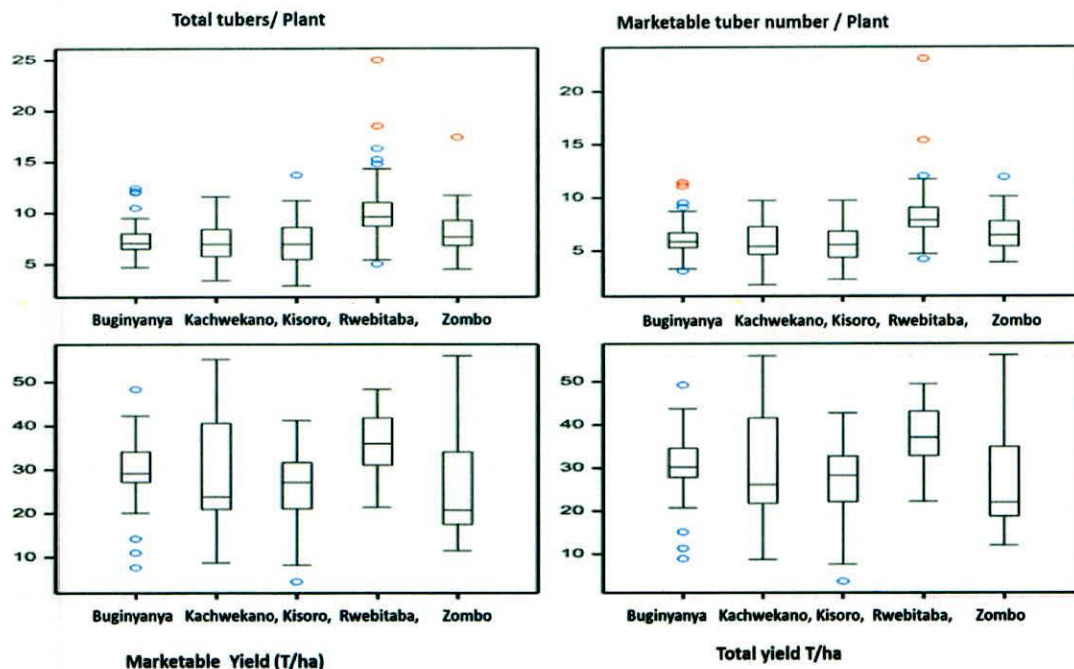


Figure 2: Box plots indicating the variation in yield components across the sites

The varieties performance in regard to the yield (marketable yield) varied across the sites and seasons. The varieties with highest marketable yield for 3 seasons were; Jelly (34.6T/ha), followed by Farida (34.1T/ha), Manitou (34.1T/ha), Rudolph (32.2T/ha), Acoustic (30.3t/ha), Sun red (30.2t/ha), Masai (29.7T/ha), Caruso (29.8T/ha), Georgina (28.4T/ha), Zarina (27.2 T/ha), NAROPOT 4 (27.1 T/ha), Rumba (26.8T/ha), Lady Terra (26.3T/ha), Allison (26.5T/ha), Victoria (25.8t/ha), Lady Amarilla (24.7T/ha), Concordia (24.2T/ha), Destiny (21.6T/ha) (Table 5).

Table 5 :Marketable yield (T/ha) for test varieties across sites and the 3 seasons (2018-2020)

Variety	Buginyanya			Kachwekano			Kisoro			Rwebitaba			Zombo			Grand mean	Rank
	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020		
Acoustic	31.1	32.5	39.1	23.9	20.6	44.2	31.9	23.5	27.5	37.7	42.1	32.3	38.9	20.1	13.1	30.3	5
Allison		20.1	29.1	21.3	14.5	45.9	35.9	23.2	21.9	30.6	22.3	33.6	32.4	20.0	18.2	26.5	14
Caruso	29.2		30.0	25.7		37.9	27.9		28.3	33.3		31.0	38.9		16.0	29.8	8
Concordia	11.0	20.9	26.5	16.2	15.0	40.4	39.0	10.3	26.0	42.8	28.8	29.9	27.0	19.6	11.7	24.2	17
Destiny	7.6			14.1			21.2			29.6			35.6			21.6	18
Farida	25.1	35.4	48.3	22.6	22.7	50.2	31.4	19.1	41.2	39.5	45.6	41.4	42.1	31.9	18.2	34.1	2
Georgina	14.2	30.5	34.1	22.6	13.0	47.7	32.2	4.4	23.2	39.3	48.3	36.2	43.5	27.3	15.6	28.4	9
Jelly	30.7	30.7	34.1	28.0	22.6	46.1	30.6	36.7	39.4	35.6	45.5	43.4	55.9	24.6	17.8	34.6	1
Lady Amarilla	28.4	20.6	27.2	21.5	14.6	34.2	26.4	15.5	23.5	31.0	32.5	21.4	36.3	22.1	12.7	24.7	16
Lady Terra		21.7	28.6	22.1	12.8	40.8	37.6	8.2	22.1	46.4	28.1	33.7	29.4	19.5	17.7	26.3	13
Manitou	29.6	32.8	42.3	23.7	30.9	55.1	38.3	12.8	32.3	40.2	38.2	42.1	48.4	28.3	17.8	34.1	3
Masai	27.5	35.7	38.2	8.7	27.1	46.1	26.7	13.0	33.3	43.2	44.4	33.0	41.5	17.3	14.9	29.7	7
NAROPOT 4	21.5			23.4			30.5			33.8			26.4			27.1	11
Rudolph	27.3	41.3	38.0	22.6	26.0	52.7	28.5	21.0	38.1	38.4	46.6	43.5	46.3	19.4	18.9	33.2	4
Rumba	22.5	27.4	28.8	17.7	18.7	44.2	25.9	14.6	28.7	40.6	37.1	30.9	36.0	11.5	15.7	26.8	12
Sun red	28.0	34.3	33.1	21.4	22.1	50.7	29.1	16.4	31.1	32.7	37.5	38.4	37.3	22.4	21.1	30.2	6
Victoria		28.8	27.2		30.2	39.6		15.0	31.2		26.5	29.0		17.1	17.3	25.8	15
Zarina	29.1	30.7	34.4	25.1	17.3	41.6	28.6	18.5	25.4	32.7	32.8	29.6	30.3	20.4	13.0	27.2	10

*** Marketable yield = large and medium tubers only without small tubers

The overall tuber yield also varied depending on the variety and ranged from 23.1-35.5T/ha with highest observed for Jelly (35.5T/ha), Manitou (35.0), Farida (34.9), Rudolph (33.7) and least with Destiny (23.1) (Table 6)

Table 6: Total yield (T/Ha) across sites for 3 seasons)-2018-2020

	Buginyanya			Kachwekano			Kisoro			Rwebitaba			Zombo				
Variety	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	Grand mean	Rank
Acoustic	32.5	32.0	40.3	26.4	21.6	45.0	32.9	24.3	28.8	37.9	43.3	34.1	39.8	21.1	14.1	31.3	5
Allison		20.7	30.5	23.2	15.5	47.4	37.3	23.8	23.4	31.6	23.4	35.9	33.6	21.1	20.4	27.8	12
Caruso	32.0		31.5	27.2		38.7	28.6		29.5	34.8		33.3	39.2		18.7	31.3	6
Concordia	11.3	21.6	27.5	17.8	15.5	41.0	39.5	11.0	27.3	44.1	30.2	31.5	28.1	20.6	13.4	25.2	16
Destiny	8.9			15.9			22.6			31.1			36.7			23.1	18
Farida	25.3	35.6	49.2	23.9	23.4	51.0	31.7	20.1	42.7	40.5	46.3	42.9	42.8	32.5	19.8	34.9	2
Georgina	15.1	31.2	35.2	23.8	13.6	48.4	33.0	3.6	24.5	40.4	49.4	38.0	44.8	28.3	16.8	29.3	9
Jelly	32.3	31.2	35.2	29.0	23.3	46.9	31.7	37.4	40.4	36.4	46.7	44.7	56.1	25.4	19.4	35.5	1
Lady Amarilla	29.3	21.1	28.0	22.2	15.3	34.7	27.8	16.5	24.4	31.4	33.6	22.2	36.5	23.3	13.9	25.5	17
Lady Terra		22.2	29.8	23.2	13.4	42.1	39.3	7.6	23.6	47.0	28.8	35.2	29.7	21.0	19.2	27.3	15
Manitou	29.8	33.0	43.7	25.6	31.8	55.9	39.8	13.2	33.6	41.1	38.9	43.8	48.9	28.7	18.8	35.0	3
Masai	28.6	36.4	39.5	8.7	27.7	46.7	27.3	14.3	34.8	44.0	45.1	34.6	41.7	17.8	16.0	30.6	8
NAROPOT 4	23.5			26.1			32.0			36.4			30.4			29.7	10
Rudolph	27.8	41.5	38.8	23.3	26.1	53.1	29.7	21.7	38.6	38.9	47.1	44.1	46.3	19.6	19.8	33.7	4
Rumba	23.4	27.8	29.5	19.2	18.9	44.6	26.8	16.0	29.8	41.1	38.0	32.2	36.2	12.0	16.8	27.6	13
Sun red	28.8	34.6	33.6	21.9	22.7	51.1	29.4	16.9	31.5	33.3	37.7	39.3	37.5	23.2	22.2	30.8	7
Victoria		29.5	28.0		31.2	40.4		15.9	32.5		28.1	31.0		18.0	18.7	26.9	14
Zarina	29.3	31.5	35.4	26.6	18.3	43.0	29.1	20.3	26.0	34.4	35.4	31.2	30.7	21.8	15.2	28.4	11

Across the 3 seasons, the Marketable tuber number per plant was noted to range from 4.5 to 8.8/plant. The yield performance per plant varied across different sites and seasons. The mean marketable tuber number for the 3 season was highest for NAROPOT 4 (8.8), followed by Caruso (8), Zarina (7.5), Jelly (7.5), Acoustic (7.1), Allison (6.8), Victoria (6.7), Farida (6.6), Manitou (6.3), Concordia (6.3), Rumba (6.3), Lady Terra (6.2), Destiny (6), Rudolph (6), Georgina (6), Lady Amarilla (5.9), Masai (5.7) and Sun red (4.5). Among the sites Rwebitaba site had the highest number of marketable tubers/plants with (8.5), followed by Zombo (6.6), Buginyanya (6.2), Kachwekano (5.8), and lastly Kisiro (5.7) (Table 7)

Table 7: Marketable tuber number per plant among varieties tested across different sites for 3 seasons (2018-2020)

	Buginyanya			Kachwekano			Kisoro			Rwebitaba			Zombo			Grand mean	
Variety	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020		Rank
Acoustic	7.7	6.6	6.7	5.8	5.1	8.7	7.7	5.2	5.2	8.9	12.0	7.6	8.1	7.7	4.6	7.1	5
Allison		5.7	6.2	5.9	5.2	9.1	6.7	4.0	5.4	8.0	7.7	9.4	8.0	7.5	6.8	6.8	6
Caruso	6.8		8.7	5.8		9.7	7.2		6.9	7.3		11.0	9.2		7.2	8.0	2
Concordia	3.3	7.0	5.8	3.2	4.7	8.8	7.9	4.0	5.6	9.2	10.3	8.0	6.2	6.9	5.4	6.3	10
Destiny	3.1			3.7			5.0			7.8			10.1			6.0	13
Farida	5.7	6.3	6.5	4.9	5.4	7.8	7.5	5.1	6.3	8.1	8.9	7.7	7.4	6.5	6.1	6.6	8
Georgina	4.2	6.1	5.9	6.0	3.6	7.7	6.7	2.3	4.3	8.4	9.2	7.6	7.7	5.5	6.2	6.0	15
Jelly	5.9	11.4	5.3	5.3	4.8	7.4	7.6	5.7	6.2	7.3	23.1	7.7	9.1	5.8	5.6	7.5	4
Lady Amarilla	7.0	5.8	4.5	5.2	4.8	7.0	6.4	4.3	4.4	6.3	8.2	5.6	7.0	7.9	4.3	5.9	16
Lady Terra		6.0	5.7	4.4	4.0	7.3	8.5	2.7	4.5	10.4	7.3	7.8	6.4	6.6	5.5	6.2	12
Manitou	5.0	5.4	6.1	4.8	5.4	7.6	9.7	3.6	6.1	6.3	8.0	7.1	6.4	7.8	5.6	6.3	9
Masai	5.6	6.7	5.3	1.8	4.6	5.2	7.0	3.9	5.6	6.1	15.4	6.7	6.8	4.3	3.9	5.7	17
NAROPOT 4	9.5			5.4			7.8			9.5			11.9			8.8	1
Rudolph	5.5	5.8	5.6	4.5	4.1	6.8	9.1	4.9	4.7	7.1	8.6	7.9	7.1	4.5	4.8	6.0	14
Rumba	5.2	6.7	5.3	4.3	7.2	7.4	6.1	3.9	4.7	7.6	7.8	6.6	7.8	8.6	5.4	6.3	11
Sun red	4.4	4.7	4.1	4.6	3.6	5.6	6.9	3.1	3.6	4.2	5.1	4.7	4.3	3.9	4.8	4.5	18
Victoria		11.1	5.2		6.6	8.1		4.2	5.3		11.0	6.9		4.4	4.4	6.7	7
Zarina	7.0	9.1	7.2	5.8	5.3	9.7	6.4	5.5	6.0	8.7	11.7	8.5	8.3	8.7	5.4	7.5	3

The total tubers/ plant which comprised both non marketable (Very small) and marketable tubers (medium and large).

Table 8: Total tubers harvested per plant /variety across the sites (2018-2020)

	Buginyanya			Kachwekano			Kisoro			Rwebitaba			Zombo			Grand mean	
Season	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020	2018	2019	2020 s		Rank
Acoustic	9.5	7.4	8.2	7.5	6.3	9.9	11.1	6.2	6.8	10.9	14.3	10.3	9.2	9.4	6.4	8.8	4
Allison		6.8	8.1	8.3	7.1	10.8	8.6	5.8	7.0	9.3	10.1	12.4	9.7	9.5	9.7	8.8	5
Caruso	9.3		10.5	7.8		10.6	11.0		8.3	10.4		14.0	9.6		9.8	10.1	2
Concordia	6.4	8.1	7.1	5.9	5.4	9.6	11.1	5.3	7.1	11.3	12.7	10.2	7.6	8.8	8.0	8.2	8
Destiny	7.0			5.1			8.3			10.9			11.7			8.6	7
Farida	6.8	6.7	7.4	6.5	6.1	8.7	8.9	6.4	7.8	10.1	9.6	9.1	8.2	7.3	7.4	7.8	10
Georgina	6.9	7.4	7.2	8.6	5.7	8.8	8.7	2.9	5.6	9.7	10.9	9.9	9.0	6.7	8.2	7.7	11
Jelly	7.3	12.1	6.7	6.3	5.8	8.3	9.1	6.7	7.3	8.9	25.0	9.3	9.3	7.0	7.7	8.8	6
Lady Amarilla	8.0	6.7	5.2	6.0	5.7	7.7	8.6	5.0	5.3	7.4	9.5	6.6	7.4	9.5	5.6	7.0	15
Lady Terra		6.7	6.7	6.9	5.1	8.6	11.2	3.1	5.9	11.7	8.2	9.6	7.2	8.6	7.3	7.6	12
Manitou	5.6	5.9	7.7	6.5	6.3	8.5	10.8	4.1	7.4	7.8	9.2	9.1	6.9	8.5	7.3	7.4	13
Masai	6.9	7.7	6.6	3.4	5.3	5.8	9.0	5.3	7.1	7.6	16.3	8.3	7.3	5.2	5.3	6.9	16
NAROPOT 4	12.4			11.4			13.7			18.5			17.4			14.7	1
Rudolph	6.5	6.1	6.3	5.4	4.7	7.3	10.2	5.7	5.2	7.8	9.4	8.8	7.2	4.9	5.9	6.7	17
Rumba	7.1	7.3	6.0	5.7	7.7	7.9	7.6	5.3	6.1	8.6	9.0	8.2	8.4	9.7	7.0	7.4	14
Sun red	5.6	5.0	4.7	5.3	4.2	6.0	7.8	3.5	4.0	5.0	5.4	5.5	4.5	4.7	6.2	5.1	18
Victoria		12.0	6.0		8.0	9.0		5.0	6.2		15.2	9.0		5.2	6.1	8.1	9
Zarina	7.9	10.5	8.3	7.7	7.0	11.6	8.6	6.9	6.8	11.1	14.8	10.3	9.1	11.1	8.3	9.2	3
Grand Total	7.5	7.8	7.0	6.7	6.0	8.7	9.6	5.1	6.5	9.8	11.8	9.4	8.8	7.4	7.3	8.3	

For NARO bred varieties, their performance was as below.

Table 9: Yield of NARO bred genotypes across the different environments

Location	Genotype	2018 season 1		2019 season 2		Mean Total Yield T/Ha	Mean Marketable Yield T/Ha
		Total Yield T/Ha	Marketable Yield T/Ha	Total Yield T/Ha	Marketable Yield T/Ha		
Buginyanya	20151.28	21.8	20.3	42.5	40.7	34.2	32.6
	20151.5	24.8	22.0	45.5	43.7	35.2	32.9
	20158.14	19.7	17.6	24.3	21.8	22.3	20.0
	20158.15	18.9	14.3	35.7	32.6	31.5	28.0
	201510.7	6.4	3.5	13.5	11.5	10.6	8.3
	NAROPOT 4	20.4	15.2	30.0	26.5	26.2	22.0
Kachwekano	20151.28	18.3	17.3	28.8	28.3	26.2	25.5
	20151.5	31.7	31.2	37.5	36.4	35.2	34.3
	20158.14	27.4	25.1	27.9	26.0	27.7	25.7
	20158.15	16.5	13.1	19.2	17.7	18.1	15.9
	201510.7	8.9	5.5	2.4	1.9	4.0	2.8
	NAROPOT 4	20.2	15.7	23.8	21.5	22.3	19.2
Kisoro	20151.28	10.0	8.6	7.9	7.8	8.5	8.0
	20151.5	21.5	20.1	19.2	18.9	19.8	19.2
	20158.14	15.2	12.8	12.2	11.3	13.0	11.7
	20158.15	13.3	11.8	8.4	7.6	10.4	9.3
	201510.7	2.2	1.4	0.2	0.2	1.0	0.7
	NAROPOT 4	14.9	12.7	10.9	9.1	11.9	10.0
Rwebitaba	20151.28	64.4	60.7	46.5	45.7	55.4	53.2
	20151.5	53.7	52.6	61.0	59.4	57.4	56.0
	20158.14	43.3	35.0	28.9	27.2	36.1	31.1
	20158.15	28.2	21.7	30.4	26.9	29.3	24.3
	201510.7	18.9	14.9	10.6	8.9	14.7	11.9
	NAROPOT 4	40.1	28.5	37.4	32.0	38.7	30.3

Table 10: Total Yield (T/Ha) and Ranking across the experimental sites for NARO varieties

Genotypes	Buginyanya	Rank	Kachwekano	Rank	Kisoro	Rank	Rwebitaba	Rank	Mean	Rank
20151.28	34.19	2.00	26.19	3.00	8.45	5.00	55.43	2.00	31.06	2
20151.5	35.18	1.00	35.16	1.00	19.80	1.00	57.36	1.00	36.88	1
201510.7	10.63	6.00	4.04	6.00	0.99	6.00	14.72	6.00	7.60	6
20158.14	22.25	5.00	27.69	2.00	12.99	2.00	36.09	4.00	24.75	4
20158.15	31.48	3.00	18.13	5.00	10.39	4.00	29.31	5.00	22.33	5
NAROPOT 4	26.15	4.00	22.35	4.00	11.91	3.00	38.72	3.00	24.78	3

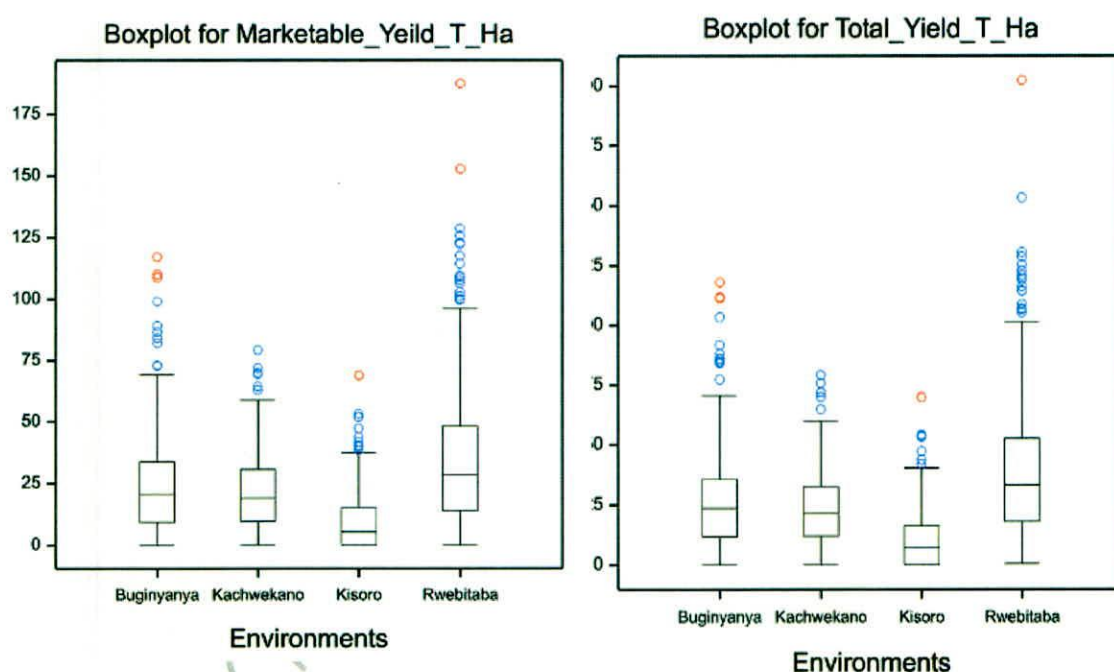


Figure 3: Box plots indicating the variation in yield components across the sites Yield of NARO bred varieties across the four environments

4.2 Adaptability and yield stability assessment of the varieties in different environmental condition

Differences in genotype yield and within a location were assessed using REML using breeding View software in Genstat 11th edition. The locations represented the main geographies for potato production and exhibited differing climatic conditions that influence potato growth. Each location constituted an environment, resulting in 5 environments. To identify the most adaptable variety

with a stable yield among the test varieties, stability and sensitivity, analysis was done on results of yield component in five locations where the potatoes were tested. Genotype mean yields were separated using the least significant difference (LSD).

Analysis of the environmental effects showed that environment significantly ($P < 0.05$) influenced the performance of the varieties and most varieties were sensitive to environmental influences (Table 11)

Table 11 : ANOVA for the effects of the environment on variety performance on Dutch varieties

Source	d.f.	s.s.	m.s.	v.r.	F pr.
Genotypes	17	2923.506	171.9709	1.94	0.017
Environments	4	3564.93	891.2326	10.05	<0.001
Sensitivities	17	518.9898	30.5288	0.34	0.993
Residual	199	17638.73	88.6368		
Total	237	24646.15	103.9922		

Environmental effects were more noticed in Rwebitaba and Buginyanya compared to other sites which influenced the performance of the varieties in these sites (Table 12)

Table 12: Means for the environmental effects on variety performance

Environment	Effect	s.e.	Mean	Rank
Buginyanya	0.203	1.153	30.02	2
Kachwekano	-0.36	1.138	29.46	3
Kisoro	-3.399	1.138	26.42	4
Rwebitaba	7.087	1.138	36.91	1
Zombo	-3.53	1.138	26.29	5

The varieties less influenced by the environmental conditions were Destiny, Allison, Caruso and NAROPOT 4 and most affected were Georgina and Masai (Table 13)

Table 13: Variety sensitivity to different environments

	Genotype	Sensitivity	s.e.	Mean	s.e.	Mean square deviation
1)	Destiny	0.1357	1.0914	23.04	4.21	167.1
2)	Allison	0.3442	0.6302	27.7	2.516	78.84
3)	Caruso	0.4694	0.7717	31.35	2.977	35.9
4)	NAROPOT 4	0.5004	1.0914	29.68	4.21	27.81
5)	Lady Amarilla	0.5114	0.6301	25.35	2.431	49.24
6)	Jelly	0.7238	0.6301	35.74	2.431	97.74
7)	Victoria	0.7433	0.7717	27.33	2.977	55.21
8)	Zarina	0.9332	0.6301	28.55	2.431	43.91
9)	Sunred	0.9396	0.6301	30.91	2.431	68.02
10)	Manitou	1.001	0.6301	35.11	2.431	118.75
11)	Acoustic	1.1099	0.6301	31.61	2.431	64.43
12)	Farida	1.116	0.6301	35.18	2.431	103.23
13)	Concordia	1.127	0.6301	25.36	2.431	102.1
14)	Lady Terra	1.2902	0.6302	27.31	2.516	99.95
15)	Rudolph	1.3373	0.6301	34.43	2.431	100.49
16)	Rumba	1.3398	0.6301	27.49	2.431	72.4
17)	Masai	1.5305	0.6301	30.88	2.431	118.48
18)	Georgina	1.6407	0.6301	29.74	2.431	151.96

Table 14: Sensitivity to different environment among NARO bred Varieties

	Genotype	Sensitivity	s.e.	Mean	s.e.	Mean square deviation
1)	201510.7	0.477	0.1082	6.05	0.9783	66.9
2)	20158.15	0.621	0.1084	18.84	0.9794	164.0
3)	20158.14	0.752	0.1143	22.24	0.9975	277.6
4)	NAROPOT 4	0.830	0.1138	20.37	0.9851	266.8
5)	20151.5	1.534	0.1138	35.39	0.9614	478.9
6)	20151.28	1.876	0.1141	29.91	1.0125	454.5

Among the NARO varieties, genotypes 201510.7, and 20158.15 were less sensitive to environmental changes as indicated by low sensitivity coefficients.

4.2.1 Yield stability assessment as a measure of adaptability of the Dutch potato varieties for 3 seasons

1. The first part of the paper discusses the importance of the study of the history of the English language. It is noted that the English language has a long and rich history, and that the study of its history is essential for a full understanding of the language.

2. The second part of the paper discusses the development of the English language from its roots in Old English to the modern English of today. It is noted that the English language has undergone many changes over the centuries, and that these changes have been influenced by a variety of factors, including contact with other languages and the influence of new ideas and technologies.

3. The third part of the paper discusses the influence of the English language on other languages and cultures. It is noted that the English language has been a major force in the world, and that it has influenced many other languages and cultures in a variety of ways. This influence has been seen in the adoption of English words and phrases into other languages, and in the spread of English as a second language in many parts of the world.

4. The fourth part of the paper discusses the future of the English language. It is noted that the English language is still a dynamic and changing language, and that it will continue to evolve in the future. This evolution will be influenced by a variety of factors, including the continued influence of other languages and the development of new technologies and ideas.

5. The fifth part of the paper discusses the importance of the study of the history of the English language. It is noted that the study of the history of the English language is essential for a full understanding of the language, and that it is a field that is still actively being researched and explored.

Table 16: Static stability measure coefficients

Genotype	Coefficients for Total tuber plant	Coefficients for Marketable tuber Number/plant	Coefficients for Marketable Yield	Coefficients for Total Yield
Concordia	0.18	0.36	24.81	24.57
Georgina	0.20	0.12	42.90	40.27
Zarina	0.37	0.17	26.85	25.73
Lady Amarilla	0.45	0.60	22.15	19.91
Rumba	0.52	0.92	61.97	59.80
Acoustic	0.66	0.42	6.31	5.86
Manitou	0.90	0.45	5.16	6.16
Farida	0.97	0.33	35.54	32.04
Rudolph	1.00	0.50	29.91	29.82
Sun red	1.01	1.07	50.85	50.47
Jelly	1.02	1.76	24.89	25.42
Victoria	1.12	1.29	55.11	50.45
Caruso	1.18	1.03	44.68	44.64
Allison	1.82	0.30	8.29	6.56
Lady Terra	1.84	0.64	8.19	8.54
Destiny	5.06	2.89	39.65	36.80
Masai	7.72	8.07	30.07	30.23
NAROPOT 4	1313.48	1300.95	34.51	32.67

Based on Wricke's ecovalence stability coefficients test, Concordia, Jelly, Rumba, Georgina, Manitou, Zarina, Lady Terra, Allison, Caruso, Acoustic were identified to have lower values of coefficients, hence more stable compared to other varieties (Table 17)

Table 17: Static stability for Marketable yield among NARO bred varieties

	Clone	Static stability	Means
1)	201510.7	26.2	6.38
2)	20158.14	68.7	23.19
3)	NAROPOT 4	70	21.37
4)	20158.15	70.9	19.23
5)	20151.5	231.4	37.22
6)	20151.28	349.7	32.45

Genotypes 201510.7, and 20158.14 had static stable compared to other varieties

Table 18: Wricke's ecovalence stability coefficients for the yield components

Genotype	Coefficients for Total tuber/plant	Coefficients for Marketable tuber Number/ plant	Coefficients for Marketable Yield	Coefficients for Total Yield
Concordia	12.0	12.6	143.6	140.0
Jelly	14.8	13.8	61.5	65.3
Rumba	16.0	12.8	196.0	192.1
Georgina	16.2	16.8	78.6	72.5
Manitou	16.6	18.1	67.2	69.1
Zarina	17.0	13.9	112.8	113.4
Lady Terra	17.1	28.5	23.9	24.1
Allison	17.4	13.6	27.3	24.9
Caruso	17.6	17.9	88.4	90.3
Acoustic	18.9	18.0	13.5	14.1
Victoria	20.1	15.6	127.8	115.7
Sunred	21.8	20.4	185.4	183.3
Farida	27.9	25.1	87.5	77.1
Rudolph	28.0	23.2	48.7	50.4
Lady Amarilla	28.9	27.3	79.5	70.6
Destiny	34.5	25.5	81.9	80.5
Masai	51.1	47.9	105.7	106.8
NAROPOT 4	4674.8	4633.4	193.1	181.7

Table 19: NARO Bred varieties- Wricke's ecovalence stability coefficients for marketable Yield

	Clone	Wricke's ecovalence	Means
1)	NAROPOT 4	9.82	21.37
2)	20158.14	56.66	23.19
3)	201510.7	93.01	6.38
4)	20151.5	102.73	37.22
5)	20158.15	110.04	19.23
6)	20151.28	220.78	32.45

Genotypes NAROPOT 4, 20158.14, and 201510.7 had lower stability coefficients for marketable yield, indicating that they were more stable across environments

Total tuber Number / plant sensitivity assessment.

Total tuber number sensitivity was analyzed using Finlay and Wilkinson modified joint regression analysis. The sorted sensitivity estimates are presented in table 20. Genotypes

The first part of the paper is devoted to a study of the properties of the function $f(x)$ defined by the equation

$$f(x) = \int_0^x \frac{1}{1+t^2} dt$$

It is shown that $f(x)$ is an odd function and that it satisfies the functional equation

$$f(x) + f\left(\frac{1}{x}\right) = \frac{\pi}{2}$$

for all $x \neq 0$. The function $f(x)$ is also shown to be continuous and differentiable for all $x \neq 0$.

In the second part of the paper, the function $f(x)$ is used to define a new function $F(x)$ by the equation

$$F(x) = \int_0^x f(t) dt$$

It is shown that $F(x)$ is an even function and that it satisfies the functional equation

$$F(x) = F\left(\frac{1}{x}\right)$$

for all $x \neq 0$. The function $F(x)$ is also shown to be continuous and differentiable for all $x \neq 0$.

Table 21: Dry matter content of Dutch potato varieties tested

Genotypes	Dry matter 2018	Dry matter 2019	Dry matter 2020	Grand mean
Caruso	22.7		24.4	23.5
Acoustic	21.9	23.3	20.8	22.0
Destiny	21.7	-	-	21.7
Jelly	21.5	22.0	21.4	21.6
Farida	21.4	21.6	20.8	21.3
Lady Amarilla	21.3	23.6	23.1	22.7
Rumba	21.3	23.3	22.3	22.3
Rudolph	21.1	20.7	17.4	19.7
Naropot 4	21.0	-	-	21.0
Sun red	20.7	19.0	18.8	19.5
Lady Terra	20.5	22.0	20.5	21.0
Manitou	20.3	21.0	21.6	21.0
Concordia	20.2	21.3	18.6	20.0
Allison	19.8	21.0	20.9	20.6
Zarina	19.5	22.0	20.4	20.6
Georgina	19.4	19.0	20.4	19.6
Victoria	-	21.2	18.6	19.9
Masai	19.2	20.6	20.8	20.2

Table 22: Dry matter content for NARO bred varieties

	Genotype	Dry matter % 2019
1)	NAROPOT 4	23.0
2)	20158.14	20.6
3)	201510.7	-
4)	20151.5	24.0
5)	20158.15	24.0
6)	20151.28	22.1

Processing qualities of the Dutch based varieties

The test varieties were processed into crisps and chips, coded with numbers to avoid bias, and analyzed for processing quality and palatability by a panel of experts.

The test parameters included appearance, taste of the product, texture, color, size of the chip, processability and overall acceptability of the product by the processor/ farmer. The crisping properties were tested at Psalms Food Industries Ltd in Kampala and Uganda Industrial Research Institute incubation plant in Kabale, while fries/chip qualities were assessed by the farmers at the sites after harvesting and results are presented in Table 23.

Table 23: Crisping qualities of the test varieties

Genotype	CRISPS													General remarks			
	Appearance			Taste			Texture			Colour					Crunchiness		
	Good	Fair	Poor	Good	Fair	Poor	Hard	Soft	Intermediate	White	Yellow	Cream	Other colours		Good	Fair	Poor
1 Rudolph		X		X				X		X				X		Too brittle	
2 Lady Terra	X			X					X		X			X		Appears masked but good	
3 Allison		X		X				X		X					X	Too brittle	
4 Caruso	X			X				X						X		Brittle	
5 Georgina	X			X					X		X			X		Appears masked but good	
6 Acoustic	X			X					X			X		X		Brittle	
7 Rumba	X			X				X					Light yellow	X		Brittle	
8 Manitou	X			X					X		X			X		Brittle	
9 Farida		X		X				X				X		X		Brittle	
10 Masai		X		X				X			X			X		Brittle and masked	
11 Zarina	X			X				X					Light yellow	X		Brittle	
12 Lady Amarilla			X		X			X					Brown	X		Too brittle	
13 Sunred	X					X			X			X			X	Fairly good	
14 Jelly		X		X					X		X			X		Masked appearance	
15 Victoria		X		X				X				X		X		Small and brittle	

16	Concordia		X		X					X		X				X		Masked appearance
17	20158.14				X				X			X				X		
18	20151.5				X				X			X				X		

From the panel analysis, the varieties that made the best crisps were; Lady Terra, caruso, Manitou, Concordia, Zarina, Destiny, Naropot 4, Masai, Rumba, Acoustic and Farida respectively and were selected by the processor for crisps (Figure 3).



Figure 4a: Crisp quality assessment for the Dutch potato varieties

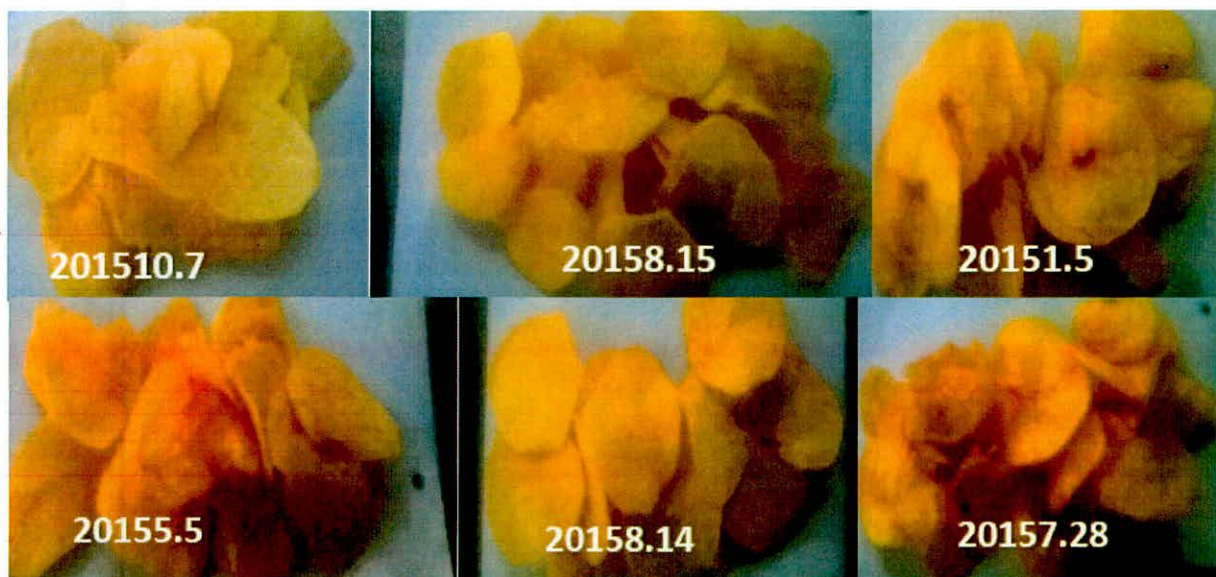


Figure 4b: Crisp quality assessment for the NARO bred potato varieties

Based on the quality of the crisps generated from the tubers of each variety processed, using ranking matrix, the order of selection for the best varieties was as below:-

1. Lady Terra
2. Rumba
3. Caruso
4. Georgina
5. Manitou
6. Masai
7. Acoustic
8. Jelly ✓
9. Allison
10. Sunred
11. Zarina
12. Concordia
13. Farida

14. Victoria

15. Rudolph

16. Lady Amarilla

Among the NARO bred varieties the best varieties the ranking preference in order of quality and acceptability level showed that 201558.14 and 20151.5 were the best and most preferred (Table 24).

Table 24: Preference ranking of the NARO bred varieties

Rank	Genotype
1	20158.14
2	20151.5
3	201510.7
4	20158.15
5	20151.28
6	NAROPOT 4

Among the Dutch varieties that were selected by food panelist for good chipping quality based on palatability tests included Acoustic, Zarina, NAROPOT 4, Jelly, Lady Terra, Manitau, Rumba, Masai, Concordia, Sunred and Farida respectively. The results of the quality of the fries is presented in Figure 4.



Figure 5: Cooking (Fry qualities) of the varieties tested In Uganda

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. 18. 19. 20. 21. 22. 23. 24. 25. 26. 27. 28. 29. 30. 31. 32. 33. 34. 35. 36. 37. 38. 39. 40. 41. 42. 43. 44. 45. 46. 47. 48. 49. 50. 51. 52. 53. 54. 55. 56. 57. 58. 59. 60. 61. 62. 63. 64. 65. 66. 67. 68. 69. 70. 71. 72. 73. 74. 75. 76. 77. 78. 79. 80. 81. 82. 83. 84. 85. 86. 87. 88. 89. 90. 91. 92. 93. 94. 95. 96. 97. 98. 99. 100. 101. 102. 103. 104. 105. 106. 107. 108. 109. 110. 111. 112. 113. 114. 115. 116. 117. 118. 119. 120. 121. 122. 123. 124. 125. 126. 127. 128. 129. 130. 131. 132. 133. 134. 135. 136. 137. 138. 139. 140. 141. 142. 143. 144. 145. 146. 147. 148. 149. 150. 151. 152. 153. 154. 155. 156. 157. 158. 159. 160. 161. 162. 163. 164. 165. 166. 167. 168. 169. 170. 171. 172. 173. 174. 175. 176. 177. 178. 179. 180. 181. 182. 183. 184. 185. 186. 187. 188. 189. 190. 191. 192. 193. 194. 195. 196. 197. 198. 199. 200. 201. 202. 203. 204. 205. 206. 207. 208. 209. 210. 211. 212. 213. 214. 215. 216. 217. 218. 219. 220. 221. 222. 223. 224. 225. 226. 227. 228. 229. 230. 231. 232. 233. 234. 235. 236. 237. 238. 239. 240. 241. 242. 243. 244. 245. 246. 247. 248. 249. 250. 251. 252. 253. 254. 255. 256. 257. 258. 259. 260. 261. 262. 263. 264. 265. 266. 267. 268. 269. 270. 271. 272. 273. 274. 275. 276. 277. 278. 279. 280. 281. 282. 283. 284. 285. 286. 287. 288. 289. 290. 291. 292. 293. 294. 295. 296. 297. 298. 299. 300. 301. 302. 303. 304. 305. 306. 307. 308. 309. 310. 311. 312. 313. 314. 315. 316. 317. 318. 319. 320. 321. 322. 323. 324. 325. 326. 327. 328. 329. 330. 331. 332. 333. 334. 335. 336. 337. 338. 339. 340. 341. 342. 343. 344. 345. 346. 347. 348. 349. 350. 351. 352. 353. 354. 355. 356. 357. 358. 359. 360. 361. 362. 363. 364. 365. 366. 367. 368. 369. 370. 371. 372. 373. 374. 375. 376. 377. 378. 379. 380. 381. 382. 383. 384. 385. 386. 387. 388. 389. 390. 391. 392. 393. 394. 395. 396. 397. 398. 399. 400. 401. 402. 403. 404. 405. 406. 407. 408. 409. 410. 411. 412. 413. 414. 415. 416. 417. 418. 419. 420. 421. 422. 423. 424. 425. 426. 427. 428. 429. 430. 431. 432. 433. 434. 435. 436. 437. 438. 439. 440. 441. 442. 443. 444. 445. 446. 447. 448. 449. 450. 451. 452. 453. 454. 455. 456. 457. 458. 459. 460. 461. 462. 463. 464. 465. 466. 467. 468. 469. 470. 471. 472. 473. 474. 475. 476. 477. 478. 479. 480. 481. 482. 483. 484. 485. 486. 487. 488. 489. 490. 491. 492. 493. 494. 495. 496. 497. 498. 499. 500. 501. 502. 503. 504. 505. 506. 507. 508. 509. 510. 511. 512. 513. 514. 515. 516. 517. 518. 519. 520. 521. 522. 523. 524. 525. 526. 527. 528. 529. 530. 531. 532. 533. 534. 535. 536. 537. 538. 539. 540. 541. 542. 543. 544. 545. 546. 547. 548. 549. 550. 551. 552. 553. 554. 555. 556. 557. 558. 559. 560. 561. 562. 563. 564. 565. 566. 567. 568. 569. 570. 571. 572. 573. 574. 575. 576. 577. 578. 579. 580. 581. 582. 583. 584. 585. 586. 587. 588. 589. 590. 591. 592. 593. 594. 595. 596. 597. 598. 599. 600. 601. 602. 603. 604. 605. 606. 607. 608. 609. 610. 611. 612. 613. 614. 615. 616. 617. 618. 619. 620. 621. 622. 623. 624. 625. 626. 627. 628. 629. 630. 631. 632. 633. 634. 635. 636. 637. 638. 639. 640. 641. 642. 643. 644. 645. 646. 647. 648. 649. 650. 651. 652. 653. 654. 655. 656. 657. 658. 659. 660. 661. 662. 663. 664. 665. 666. 667. 668. 669. 670. 671. 672. 673. 674. 675. 676. 677. 678. 679. 680. 681. 682. 683. 684. 685. 686. 687. 688. 689. 690. 691. 692. 693. 694. 695. 696. 697. 698. 699. 700. 701. 702. 703. 704. 705. 706. 707. 708. 709. 710. 711. 712. 713. 714. 715. 716. 717. 718. 719. 720. 721. 722. 723. 724. 725. 726. 727. 728. 729. 730. 731. 732. 733. 734. 735. 736. 737. 738. 739. 740. 741. 742. 743. 744. 745. 746. 747. 748. 749. 750. 751. 752. 753. 754. 755. 756. 757. 758. 759. 760. 761. 762. 763. 764. 765. 766. 767. 768. 769. 770. 771. 772. 773. 774. 775. 776. 777. 778. 779. 780. 781. 782. 783. 784. 785. 786. 787. 788. 789. 790. 791. 792. 793. 794. 795. 796. 797. 798. 799. 800. 801. 802. 803. 804. 805. 806. 807. 808. 809. 810. 811. 812. 813. 814. 815. 816. 817. 818. 819. 820. 821. 822. 823. 824. 825. 826. 827. 828. 829. 830. 831. 832. 833. 834. 835. 836. 837. 838. 839. 840. 841. 842. 843. 844. 845. 846. 847. 848. 849. 850. 851. 852. 853. 854. 855. 856. 857. 858. 859. 860. 861. 862. 863. 864. 865. 866. 867. 868. 869. 870. 871. 872. 873. 874. 875. 876. 877. 878. 879. 880. 881. 882. 883. 884. 885. 886. 887. 888. 889. 890. 891. 892. 893. 894. 895. 896. 897. 898. 899. 900. 901. 902. 903. 904. 905. 906. 907. 908. 909. 910. 911. 912. 913. 914. 915. 916. 917. 918. 919. 920. 921. 922. 923. 924. 925. 926. 927. 928. 929. 930. 931. 932. 933. 934. 935. 936. 937. 938. 939. 940. 941. 942. 943. 944. 945. 946. 947. 948. 949. 950. 951. 952. 953. 954. 955. 956. 957. 958. 959. 960. 961. 962. 963. 964. 965. 966. 967. 968. 969. 970. 971. 972. 973. 974. 975. 976. 977. 978. 979. 980. 981. 982. 983. 984. 985. 986. 987. 988. 989. 990. 991. 992. 993. 994. 995. 996. 997. 998. 999. 1000.

Processing Qualities for NARO bred varieties

Further analysis of the NARO bred varieties was done on cooking properties and primary metabolite composition.

The pasting properties were determined using the rapid viscosity analyzer (RVA, PERTEN INSTRUMENTS) using a potato profile. The parameters determined included: Pasting temperature, Peak time, Peak viscosity, Setback viscosity, Trough viscosity and Final viscosity (Figure 6). These parameters are descriptive of the cooking and heating cycle of potato products during boiling and heating and other processing procedures

Behavior of the different varieties during cooking and cooling.

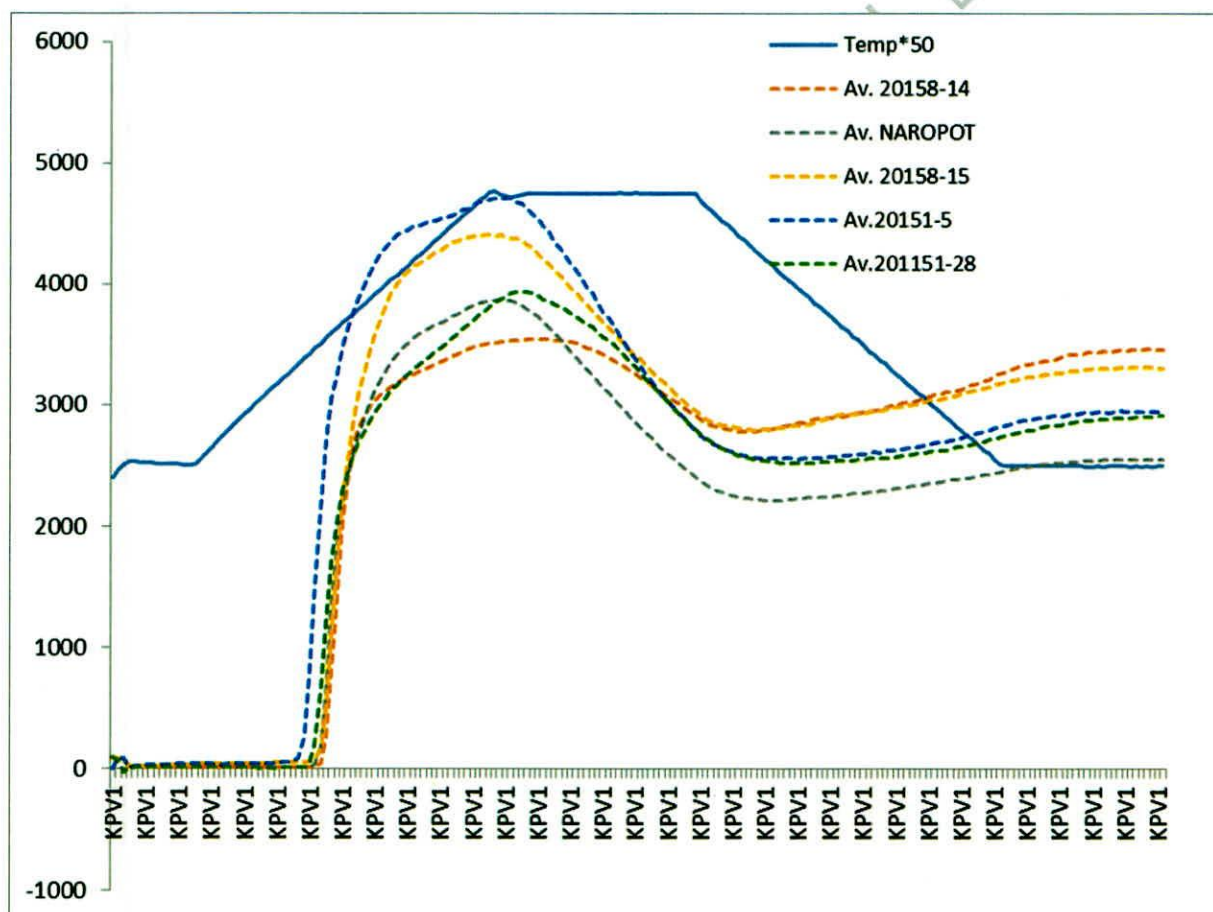


Figure 6: Pasting curves during cooking of NARO bred varieties

From the pasting curve, all the samples presented a normal potato pasting curve. The differences observed were in time to attain peak viscosity which represented the ease of cooking. The explanation of the pasting curve is as in the table 1 below.

The results of the cooking properties are presented in table 25, the following parameters related to cooking of potatoes can be defined as shown below

- Peak viscosity: The viscous load of the flour on pasting is defined by the peak viscosity which also defines the water holding capacity of the cooked material during heating and hence influences the final product quality
- Trough viscosity: The trough viscosity describes the ability of the sample to withstand heating and shear stress. This viscosity is dependent on the temperature and degree of mixing of sample during the heating process
- Peak time: The ease and time (peak time) taken to form pastes from different cassava varieties. Time taken by the sample to attain the highest viscous load.
- Pasting temperature: Is related to paste stability and gives an indication of the strength of associative forces within the granules
- Setback viscosity: The degree of association of flour molecules during cooling also known as the setback viscosity
- Final viscosity: A parameter that determines flour ability to form a gel after cooking and cooling

Table 25: Cooking properties and composition analysis of NARO varieties

| Parameter | Details | Variety | | | | |
|----------------------------------|-----------------------|---------|----------|----------|----------|-----------|
| | | 20151-5 | 20151-28 | 20158-14 | 20158-15 | Naropot 4 |
| Pasting viscosity | Peak viscosity | 5108.5 | 5188.5 | 5553 | 4869 | 5194.5 |
| | Trough viscosity | 3187.5 | 3466 | 3976 | 3363 | 4096 |
| | Breakdown viscosity | 1921 | 1722.5 | 1577 | 1521 | 1098.5 |
| | Final Viscosity | 5176 | 5739.5 | 6751 | 6581 | 7157 |
| | Setback viscosity | 1988.5 | 2273.5 | 3075 | 3248 | 3061 |
| | Peak Time | 5.3 | 5.43 | 5.083 | 5.738 | 5.8 |
| | Pasting Temp | 68.05 | 68.925 | 70.5 | 71.7 | 70.2 |
| Secondary metabolites and Sugars | Reducing sugars mg/g: | 6.204 | 11.148 | 9.986 | 8.5 | 7.234 |
| | ANTIOXIDANT POWER (%) | 8.629 | 5.311 | 10.584 | 8.431 | 9.923 |
| | Phenols (mg/g) | 26.332 | 21.093 | 23.311 | 22.055 | 21.494 |
| Carbohydrates | Starch Yield (%) | 11.25 | 15.25 | 8.75 | 16.75 | 9 |
| | Starch content (%) | 55.7191 | 79.1887 | 68.1228 | 75.0062 | 59.5461 |

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The primary metabolites were determined from the raw sample and included: Total reducing sugar content, Phenolic acid contents, Total antioxidant activity, and Starch content

The reducing sugar content ranged from 6-12mg/g of the tuber presented and was low for variety 20151.5 and higher for 20151.28. The reference variety NAROPOT had a medium range sugar content of 6.8-7.7mg/g.

The starch yield from the raw tubers ranged from 8.4-17% with high starch yield observed in 20151.28 and 20158.15. The starch content was variable ranging from 55-79%. Enzymatic degradation of starch was thus higher in 20151.28 while the dry matter content ranged from 20-24.7%.

Weather data for the study site during the study period (March –June 2018-2020)

Weather data (rainfall and temperature) that directly influence the growth of the potato plants was recorded during the experimental periods (Figure 7). It was observed temperature and rainfall were appropriate for the growth with rainfall fluctuation across the location. There was minimal temperature fluctuations across the growing season. The average temperature ranged from 18-24 °C with Zombo registering the highest average temperature during 2020 period. The average temperature were generally conducive for potato growth. Among the sites, Buginyanya had the highest cumulative rainfall through the growing season for the entire period of the evaluation compared to other sites. However the cumulative rainfall for all the sites was enough to support the crop growth.

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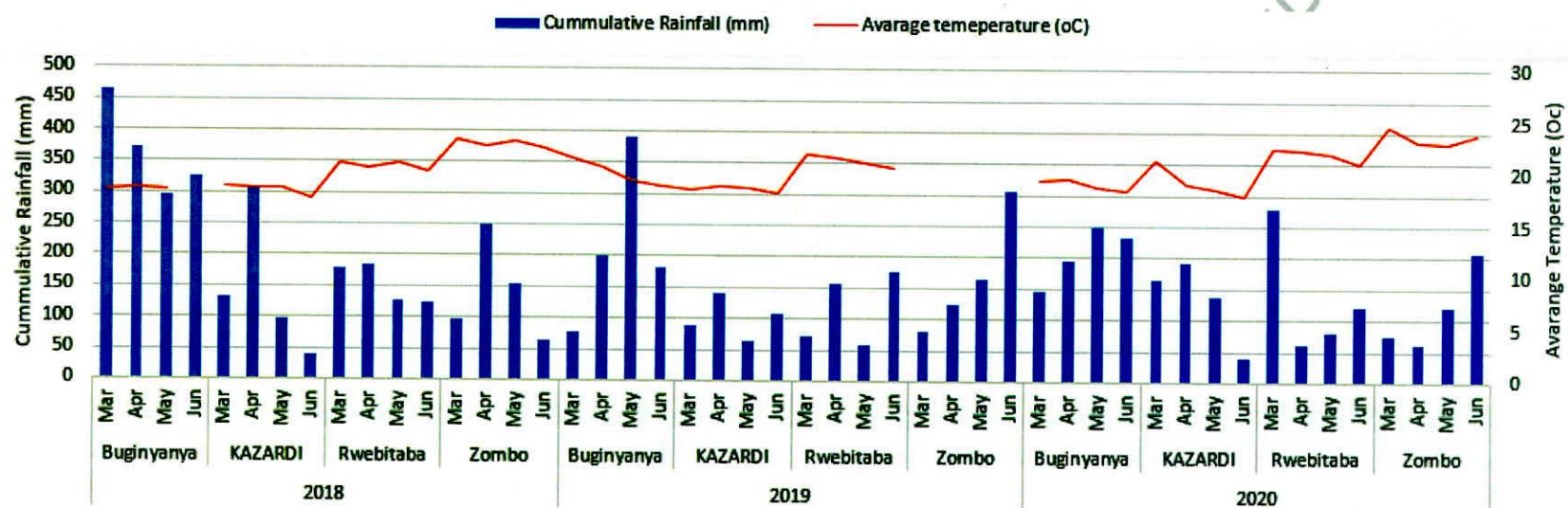


Figure 7: Weather data for the period March –June of the experimentation period 2018-2020: source UNMA

Table 26 : Varieties recommended for release based on national performance and general acceptability by end users and processing qualities

| S/
N | Variety | Mean marketable yield for 3 seasons | Yield Rank | Acceptability for French Fry processing | Acceptability for Crisp processing | Yield stability and environmental sensitivity | Recommendation |
|---------|------------|-------------------------------------|------------|---|------------------------------------|---|--|
| 1 | 20151.5 | 36.8 | 1 | √ | √ | Stable | Recommended for release |
| 2 | Jelly ✓ | 34.6 | 2 | √ | √ | Moderately stable | Recommended for release |
| 3 | Farida | 34.1 | 3 | √ | X | Less stable | Recommended for release |
| 4 | Manitou | 34.1 | 4 | √ | √ | Moderately stable | Recommended for release |
| 5 | Rudolph | 33.2 | 5 | X | X | Moderately stable | Not recommended due to palatability issues |
| 6 | 20151.28 | 31.06 | 6 | √ | √ | Less stable | Not recommended for release |
| 7 | Acoustic ✓ | 30.3 | 7 | √ | √ | Less stable | Recommended for release |
| 8 | Sunred ✓ | 30.2 | 8 | √ | √ | Moderately stable | Recommended for release |
| 9 | Caruso | 29.8 | 9 | X | √ | More stable | Recommended for release |
| 10 | Masai ✓ | 29.7 | 10 | √ | √ | Un Stable | Recommended for release |
| 11 | Georgina | 28.4 | 11 | √ | √ | Un stable | Recommended for release |
| 12 | Zarina | 27.2 | 12 | √ | √ | less stable | Recommended for release |
| 13 | Rumba | 26.8 | 13 | √ | √ | Un stable | Recommended for release |

| | | | | | | | |
|----|---------------|-------|----|---|---|-------------------|--|
| 14 | Allison | 26.5 | 14 | √ | X | Stable | Recommended for release |
| 15 | Lady Terra | 26.3 | 15 | √ | √ | Less stable | Recommended for release |
| 16 | Victoria | 25.8 | 16 | √ | X | Moderately stable | Already released |
| 17 | NAROPOT 4 | 24.78 | 17 | √ | √ | Stable | Already released |
| 18 | 20158.14 | 24.75 | 18 | √ | √ | Stable | Recommended for release |
| 19 | Lady Amarilla | 24.7 | 19 | √ | X | Moderately stable | Not recommended for release, Yield lower than control |
| 20 | Concordia | 24.2 | 20 | X | √ | Less stable | Not recommended for release, Yield lower than control |
| 21 | 20158.15 | 22.33 | 21 | √ | √ | Less stable | Not recommended for release, Yield lower than control. |
| 22 | Destiny | 21.6 | 22 | X | √ | Stable | Not recommended for release, Yield lower than control |
| 23 | 201510.7 | 7.6 | 23 | √ | √ | Less stable | Not recommended for release, Yield lower than control |

Table 27: Summary of the varieties recommended for release and their attributes

| | Variety | Mean marketable yield for 3 seasons | Yield Rank | Acceptability for French Fry processing | Acceptability for Crisp processing | Yield stability and environmental sensitivity | Usability |
|----|----------|-------------------------------------|------------|---|------------------------------------|---|-----------------------------|
| 1 | 20151.5 | 36.8 | 1 | √ | √ | Stable | crisps and fries and mashed |
| 2 | Jelly | 34.6 | 2 | √ | √ | Moderately stable | crisps and fries |
| 3 | Farida | 34.1 | 3 | √ | X | Less stable | Fries |
| 4 | Manitou | 34.1 | 4 | √ | √ | Moderately stable | crisps and fries |
| 5 | Acoustic | 30.3 | 7 | √ | √ | Less stable | crisps and fries |
| 6 | Sunred | 30.2 | 8 | √ | √ | Moderately stable | crisps and fries |
| 7 | Caruso | 29.8 | 9 | X | √ | More stable | crisps |
| 8 | Masai | 29.7 | 10 | √ | √ | Un Stable | crisps and fries |
| 9 | Georgina | 28.4 | 11 | √ | √ | Un stable | crisps and fries |
| 10 | Zarina | 27.2 | 12 | √ | √ | less stable | crisps and fries |

| | | | | | | | |
|----|------------|-------|----|---|---|-------------|------------------|
| 11 | Rumba | 26.8 | 13 | √ | √ | Un stable | crisps and fries |
| 12 | Allison | 26.5 | 14 | √ | X | Stable | Fries |
| 13 | Lady Terra | 26.3 | 15 | √ | √ | Less stable | crisps and fries |
| 14 | 20158.14 | 24.75 | 18 | √ | √ | Stable | crisps and fries |

VARIETY RELEASE TECHNICAL DOSSIER

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Proposed Names

1. NAROPOT 5 (20151.5)
2. Jelly
3. Farida
4. Manitou
5. Acoustic
6. Sunred
7. Caruso
8. Masai
9. Georgina
10. Zarina
11. Rumba
12. Allison
13. Lady Terra
14. NAROPOT 6 (20158.14)

Production and management package of the new varieties

Management of these potato varieties is like any other potatoes. For increased production and productivity, it's important that farmers observe important practices involved in potato production and management which include;

- Field site selection
- Seed bed preparation
- Seed selection
- Planting
- Fertility and fertilizer application
- Contour ridging
- Seedling emergence
- Weed control and hilling
- Dehaulming
- Other cultural practices (residue destruction, volunteer control)

Field site selection: It's important to keep the history of the field to be used for potato production.

Considerations in field site selection:

- The field should not have been under potato or other solanaceous crops like tomatoes, pepper, egg plants et c for at least three seasons. This practice is aimed at controlling soil borne diseases and pests especially bacterial wilt.
- Depending on purpose of the crop, eg seed potato should be planted in raised areas to avoid water logging which may lead to tuber rotting.
- Soils should be well drained, friable and relatively fertile. Avoid heavy soils (clay soils)

Field preparation:

- The field should be prepared well in advance to allow decomposition of vegetation into humus.
- Soils should be well pulverised to improve on water infiltration, soil aeration and root development. This also enhances crop emergence, a key factor for good yields.

Seed selection:

Seed potato to be planted should be well selected:

- Undamaged tubers
- Disease-free tubers
- Physiologically mature (well sprouted tubers with multiple sprouts)

Planting:

- For proper crop growth, planting should be done timely at the on-set of rains
- Planting should be done at recommended spacing (75 x 30 cm) to have optimum plant population for increased yields
- Planting should be done in rows/furrows.

Fertility and fertilizer application:

- Potato crop requires a lot of nutrients such as Nitrogen, phosphorus and potassium.
- In most soils, fertility has been reduced hence need for addition of soil nutrients in form of inorganic or organic fertilizers.
- The right dose depends on the level of soil fertility.
- However, in some cases organic fertilizers such as farmyard manure, compost etc may harbor soil-borne pathogens and pests hence unsuitable for improving soil fertility especially in seed potato production.
- Soil improvement can also be achieved through use of rotational crops and fallowing.

Types of fertilizer

- N: P: K (17:17:17, 25:5:5, 20:10:10)
- SSP, TSP,
- Urea,
- muriate of potash
- Diamonuan phosphate (DAP) etc.

However, for potato, N:P:K 17:17:17 is recommended at a rate of 120kg/acre

Method of fertilizer application

- Inorganic fertilizers should be applied at planting; however, some foliar fertilizer can be applied during vegetative growth
- Place fertilizer in furrows, cover the fertilizer with light soil and place the seed tubers

Contour ridging:

This is addition of soil on seed tubers in form of ridges along the contours and it is done at planting. Ridging is important in that it controls water runoffs and soil erosion (soil and water conservation), control disease spread especially

bacterial wilt (pathogens can be spread from one field to another through water runoffs)

Seedling emergence:

- Seed tubers normally emerge 14-21 days after planting with well-sprouted tubers. Poor seedling emergence results into lower yields.

Causes of poor seed emergence

- Poor seed bed preparation (hard or crusted soil)
- Low/lack of soil moisture or rain
- Seed age (old seed results in poor emergence). The right physiological stage is planting tubers with multiple sprouts (about 1-2 cm long)
- Diseases and insect pests (may result into seed decay, seedling infections)

Weed control and hilling:

- Weeding is an important practice for increased yields. This is because weeds compete with potato for light nutrients and water hence reducing tuber yields and may also harbor pests and diseases. Weeds also provide conducive environment for late blight disease that affect most potatoes
- First weeding and hilling should be done at about 2 weeks after emergence while second weeding is done two weeks after the first weeding or when necessary

Hilling is done purposely,

- To cover stolons so as to form tubers. This also allows tuber enlargement
- Controls potato tuber moth in the field
- Controls tuber blight
- Conserves soil moisture

Late blight Management

Late blight is mainly managed through the use of fungicides. Studies have been conducted to ascertain the optimum spray regime and type of fungicide for control of late blight for economic production of the Dutch potato varieties in Uganda. The spray regime that can suppress late blight disease development on the highly late susceptible varieties follows the following regime;

- 1st Week apply contact fungicide (50g of macozeb /15 liters of water);
- 2nd Week apply contact fungicide (50g of macozeb /15 litres of water) ;
- 3rd Week apply; 30ml of conserto/15 litres of water;
- 5th Week apply; Contact fungicide (50g of macozeb /15 litres of water);
- 6th week apply: 27ml of infinito/15 mls of water;
- 7th week; apply Contact (50g of macozeb /15 litres of water)
- 8th week apply; 50g of systemic fungicide (Agrolaxyl)/15 litres of water
- 9th and 10th week -No fungicide application .

Dehaulming:

- Dehaulming is the cutting off haulms/stems when the crop is mature. Maturity date varies with varieties. These varieties mature between 80-100 days. Therefore they should be dehaulemd at 90 days after planting.

Reasons for dehaulming

- Hardening off tubers before harvest
- To control blight transmission from leaves to tubers
- To control seed size especially for seed potato

Residue destruction

- This is the way potato crop residues e.g stem, rotten tubers, potato peelings and potato remnants are disposed off. It is important for such residues to be properly disposed off to control diseases and pests

. This can be through: -

- Burning the residues
- Burying the residues

Rouging (uprooting) volunteers

- Volunteers are plants in a potato field that are not planted by the farmer. They originate from tubers that remain in the ground during harvesting. Hence rouging should be done;
 - To control diseases and pests build up in the field
 - To avoid mixtures of varieties

VARIETY RELEASE TECHNICAL DOSSIER

Production costs and benefits associated with growing of these varieties

The use of these varieties under intensive management would give a farmer a net profit of six million seven hundred thousand million. This will translate in to improvement of house hold income and general welfare.

Table 28: Production costs and benefits associated with growing of these varieties

| Input | Quantity / Acre | Unit price | Frequency | Total Cost |
|--|-----------------|------------|-----------|------------------|
| land cultivated acres (rent | 1 | 250,000 | 1 | 250,000 |
| seed (bags) of 80 kg | 12 | 150,000 | 1 | 1,800,000 |
| Fertilizer NPK 50kg bags | 5 | 150,000 | 1 | 750,000 |
| Pesticides/ Fungicides | | | | |
| Consento | 0.5litres | 100,000 | 1 | 50,000 |
| Infinito | 0.5litres | 130,000 | 1 | 65,000 |
| Waxal | | | | |
| Decis | | | | |
| Thurder | | | | |
| Macozeb | 1kg | 30,000 | 4 | 120,000 |
| Agrolazyl | 1kg | 70,000 | 1 | 70,000 |
| Field operations and management | | | | |
| Bush clearing | 1 | 100000 | 1 | 100000 |
| 1 st Land preparation | 1 | 150,000 | 1 | 150,000 |
| 2 nd land preparation | | 150,000 | 1 | 150,000 |
| Planting | 1 | 150,000 | 1 | 150,000 |
| weeding (weeding and hilling) | 1 | 180,000 | 2 | 360,000 |
| Fertilizer application | 1 | 50,000 | 1 | 50,000 |
| Labour for spraying different fungicides depending on the regime | | | | |
| consento | | 40,000 | 1 | 40,000 |
| Infinito | | 40,000 | 1 | 40,000 |
| Waxal | | | | |
| Decis | | | | |
| Thurder | | | | |
| Macozeb | | 40,000 | 4 | 160,000 |
| Agrolazyl | | 40,000 | 1 | 40,000 |
| Theft guarding | 1 | 50,000 | | 50,000 |
| harvesting | 1 | 100,000 | | 100,000 |
| Transporting from garden to home/ stores | 112 | 1000 | | 112,000 |
| Packaging bags | 74 | 1,500 | | 111,000 |
| Total costs | | | | 4,718,000 |
| Out put and revenue | | | | |
| Yield (100kg bags) | 74 | 100,000 | | 7,400,000 |
| Net profit per acre | | | | 2,682,000 |
| Net profit per hectare | | | | 6,705,000 |

***** Yield output has been computed based on marketable size tubers, but not overall yield from the field based on two season yield data**

VARIETY RELEASE TECHNICAL DOSSIER

