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Report on NCST Seed Potato Project 2013- 2014

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EXECUTIVE SUMMARY

The potato project was financially supported by National Council for Science and Technology (NCST). This workshop was intended to share the project findings from the third year activities, with stakeholders, and map out future strategies and opportunities in Potato research. The meeting had been called to present findings of the study from, the third phase studies. The programme was organized in form of presentations, which were accompanied by discussions emanating from the presentations. The workshop was attended by participants from potato industry (researchers, farmers, extension service providers, farmer association, county officials and potato council).

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1. PUBLICATIONS

1.1 Yield Performance of Potato Seed Tubers after Storage in a Diffuse Light Store (DLS)

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Abstract

An on-farm trial was carried out at KARI (Tigoni) and in Nyandarua County in central Kenyan highlands to determine the yields of some common potato cultivars following storage in a diffuse light store (DLS) for eight months. The trial was carried out for two consecutive seasons i.e. March-July 2012 (first season) and October 2012 to February 2013 (second season). Eight potato cultivars commonly grown in Kenya and of different maturity periods were used. In Nyandarua, the experiment was carried out in three farmers' fields while the KARI Tigoni station was meant for comparison. In each site, the experiment was a split-plot with potato cultivars as main-plot factor and storage as sub-plot factor. There were three replications in each site. Planting of tubers after storage in DLS gave significantly ($P \leq 0.05$) more yields than planting freshly harvested tubers. This difference was observed both on the farmers' fields and at KARI Tigoni research station.

Keywords: diffuse light store, potato cultivars, on-farm storage

1. Introduction

The potato is an important food security crop in Kenya second only to maize in terms of production and utilization. It is grown in the highlands (1800-3000) mostly by small-scale farmers as an important food and cash crop (MoA, 2008; ANN, 2009). In the Kenyan highlands, potato is grown by about 800 000 farmers, on 158 000 hectares per season, with an annual production of about 1 million tonnes in two growing seasons (Riungu, 2011). In these highlands, farmers can grow three potato crops per year unlike maize, which takes up to 10 months to mature (Kinyae et al., 2004). Therefore potato is a steadier source of income in these areas. Despite the importance of the crop, potato sector is plagued by numerous problems such as lack of proper pest and disease management, a disorganized marketing system, lack of clear policies on packaging, lack of clean seeds and poor storage facilities (Riungu, 2011;

The Organic Farmer, July 2012). Kenya produces less than 1% of the national certified seed demand. Because of this, the certified seeds are highly priced and are beyond reach of most small-scale farmers.

Because of shortage of clean planting materials, farmers are forced to plant seeds from informal sources such as farm-saved (self supply), local markets or neighbours. The use of seeds from informal sources has led to low yields, poor quality produce, and spread of pests and diseases (GIZ-PSDA Kenya, 2011; Riungu, 2011). What worsens the situation is that although 90% of farmers store their own seeds, only four percent have received training on proper seed storage (The Organic Farmer, July 2012). Therefore, when the rains finally come, farmers are forced to plant whatever potato tubers are available, whether well sprouted or not. Planting of unsprouted seed tubers results in plants with one or two stems and poor stand establishment leading to low yields. Such tubers also take long to emerge in the field and the plants mature late in the season; such a crop suffers from moisture stress and other pests such as aphids. In addition, climate change has led to low and erratic rainfall. In such uncertain situations, only well sprouted seed tubers have a chance of carrying a potato crop to maturity. Therefore, availability of well sprouted seed tubers at the beginning of each planting season will go a long way in increasing potato productivity and yields in the Kenyan highlands.

Potato seed tubers should be allowed to pass through their normal period of dormancy and to sprout naturally. However, in the intensively cultivated Kenyan highlands where two or three potato crops are grown in a year, the seeds are needed before the natural dormancy-breaking is over. Although various chemicals have been used to break dormancy, most of them are either expensive or unavailable to local farmers or have been banned due to environmental pollution. The resource-poor farmers accelerate seed tuber sprouting by placing them in pits, trenches or in sisal gunny bags. However, these methods lead to high storage losses due to pests such as potato tuber moth and diseases (Shibairo et al., 2006). In addition, potato seed sprouted in pits show apical dominance, they may rot or have shoot etiolation due to dark conditions. Diffuse light store (DLS) developed by the

International Potato Centre (CIP) can be used for seed storage for up to five or six months (Demo, 2002). Storage in DLS has been shown to delay the physiological ageing of the tubers and to reduce apical dominance resulting in more, short and firm sprouts per tuber (CIP, 1985). This translates into more stems and hence more yields since potato is a stem tuber. In addition, there are less storage losses from pests and diseases because the crop can be easily monitored. Against this background, an experiment was set up whose objective was to determine the yields of some potato cultivars commonly grown in Kenya after storage in DLS for eight months.

2. Materials and Methods

The experiment was carried out for two consecutive seasons i.e. March-July 2012(first season) and October 2012 to February 2013 (second season). Eight potato cultivars of different maturity periods were used (Table 1).

Table 1. Characteristics of the potato cultivars used in the study

Potato cultivar	Source of original germplasm	Year of release in Kenya	Yield (ton/ha)	Maturity period (months)
Kenya Karibu	CIP	2003	35-45	3-4 (>110 days)
Kenya Mavuno	CIP	2003	35-40	4 (>120 days)
Sherekea	CIP	2010	35-45	3-4 (>110 days)
Tigoni	CIP	1998	35-45	3-4 (>110 days)
Asante	CIP	1998	35-45	3-4 (>110 days)
Dutch Robyjn	Netherlands	1945	35-40	3-4 (>110 days)
Desiree	Netherlands	1972	35-45	3-4 (>110 days)
Roslin Bvumbwe	Scotland	1974	35-45	3-4 (>110 days)

Ten kilograms of seed tubers of each cultivar were placed in a net bag and stored in a DLS at KARI Tigoni and also with six farmers in Nyandarua County for eight months at ambient temperatures and natural ventilation. The DLS at KARI Tigoni consists of a wooden structure with iron sheet roofing. The wooden planks on the sides are spaced and some iron sheets replaced with transparent sheets to allow in more light. The inner side of the DLS is lined with netting to keep off insect pests and vectors. The farmers' DLS are similar to the one at KARI Tigoni except there is no insect-proof netting. After storage, the potato cultivars were planted out at KARI Tigoni (2100 masl) and at six farmers' fields (>2600 masl). In each site, the experiment was a split plot laid out in a randomized complete block design with cultivars as main plots and storage as sub-plot and with three replications. The subplot had two levels: tubers stored under DLS for eight months and freshly harvested tubers. Each subplot consisted of one 10 meter long row with a plant population of 33 plants. Plants were spaced at 75 x 30cm and during planting, DAP (18%N: 46%P₂O₅) was applied at the recommended rate of 500 kg/ha. Weeding, earthing-up and spraying against pests and late blight were carried out as per recommendations for potato production in Kenya. Data was collected at KARI Tigoni and at three farms (Kagama, Pyhort and Mr. Wairegi's). The other three farmers did not have credible data and so were not included in the analysis. For data collection, ten plants in each subplot were randomly sampled. Tubers from each sampled hill were

separately harvested. Data collected included number and weight of tubers per hill as well as the weights of various categories of tubers. These categories were ware (>60mm in diameter), seed (28-60 mm) and chatts (<28 mm). These were then averaged across the ten hills.

Data was analyzed using Genstat statistical package, 14th edition (Payne et al., 2011) and means separated using Tukey's Test at 5% (Steel & Torrie, 1980). Weather data was collected from the nearest meteorological stations which were less than 300 meters from the experimental sites.

3. Results and Discussion

Generally the second season experienced higher temperature than the first season at KARI-Tigoni (Table 2). Generally, KARI-Tigoni experienced higher temperatures than the other sites (Table 2, 3, 4). All the sites had cool temperature and ample rainfall that are favourable for potato production.

Table 2. Weather data during the experimental period at KARI-Tigoni

Month	2012							2013				
	First season							Second season				
	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Total rainfall (mm)	49.1	690.1	3751.3	521	26	100.3	113.1	413.3	248.3	291.5	91.2	5.1
Number of rainy days	3	20	24	10	4	2	4	13	15	10	6	2
Mean air temp (°C)	19.3	16.5	17	14.1	13.9	16.0	22.6	23.5	22	21.7	24	45.3

Table 3. Weather data during the experimental period at Pyhort and Kagea

Month	2012							2013				
	First Season							Second season				
	March	April	May	June	July	Aug.	Sept	Oct.	Nov.	Dec.	Jan.	Feb.
Total rainfall (mm)	3.5	267	206	106	173.6	142.3	80	120.7	34.6	77.2	55.3	0
Number of rainy days	1	18	0	13	20	14	3	10	4	5	3	0
Mean air temp. (°C)	15.9	16.5	15.1	14.4	15.8	13.9	14.1	15.1	15.3	16.9	15.1	18

Table 4. Weather data during the experimental period at Mr. Wairegis

Month	2012							2013				
	First Season							Second season				
	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.
Total rainfall (mm)	65.3	830	2013	1123	120	150	95	351	325	312	65	10
Number of rainy days	5	19	21	12	3	2	3	6	5	5	3	1
Mean air temp. (°C)	17.2	14.2	13.2	10.2	11.2	14.2	15.3	16.2	14.3	15.6	14.6	13.5

There were significant ($P \leq 0.05$) differences among potato cultivars, between the storage methods and in cultivar x storage interaction in terms of total tuber yields in both seasons at KARI Tigoni (Table 5). This could have been due to the wide genetic variation that exists among potato cultivars with regards to tuber dormancy (Suttle, 2007).

Table 5. Total tuber yields (ton/ha) over the two seasons at KARI Tigon

Source of variation	d.f.	Second season		First season	
		m.s.	F pr.	m.s.	F pr.
Block	2	15.32		104.79	
Potato cultivar	7	173.55	0.041*	98.11	0.003**
Error a	14	59.21		18.00	
Storage	1	4502.75	<.001**	5845.46	<.001**
Cultivar x Storage	7	96.88	0.036*	49.21	0.014*
Error b	16	33.31		13.26	
Total	47				

*=significant at $P \leq 0.05$; **=significant at $P \leq 0.01$; ns= non significant.

In addition, the mean yields in the second season (44.86 tons/ha) were higher than the first season (28.76 tons/ha). This could have been due to the higher temperature experienced in the second compared with the first season (Table 2).

Generally, the DLS – stored seed tubers out-yielded the freshly harvested ones (Figures 1 and 2). In the first season Sherekea gave the highest yields followed by Kenya Karibu while in the second season, Sherekea gave the highest yield followed by Asante (Figure 2).

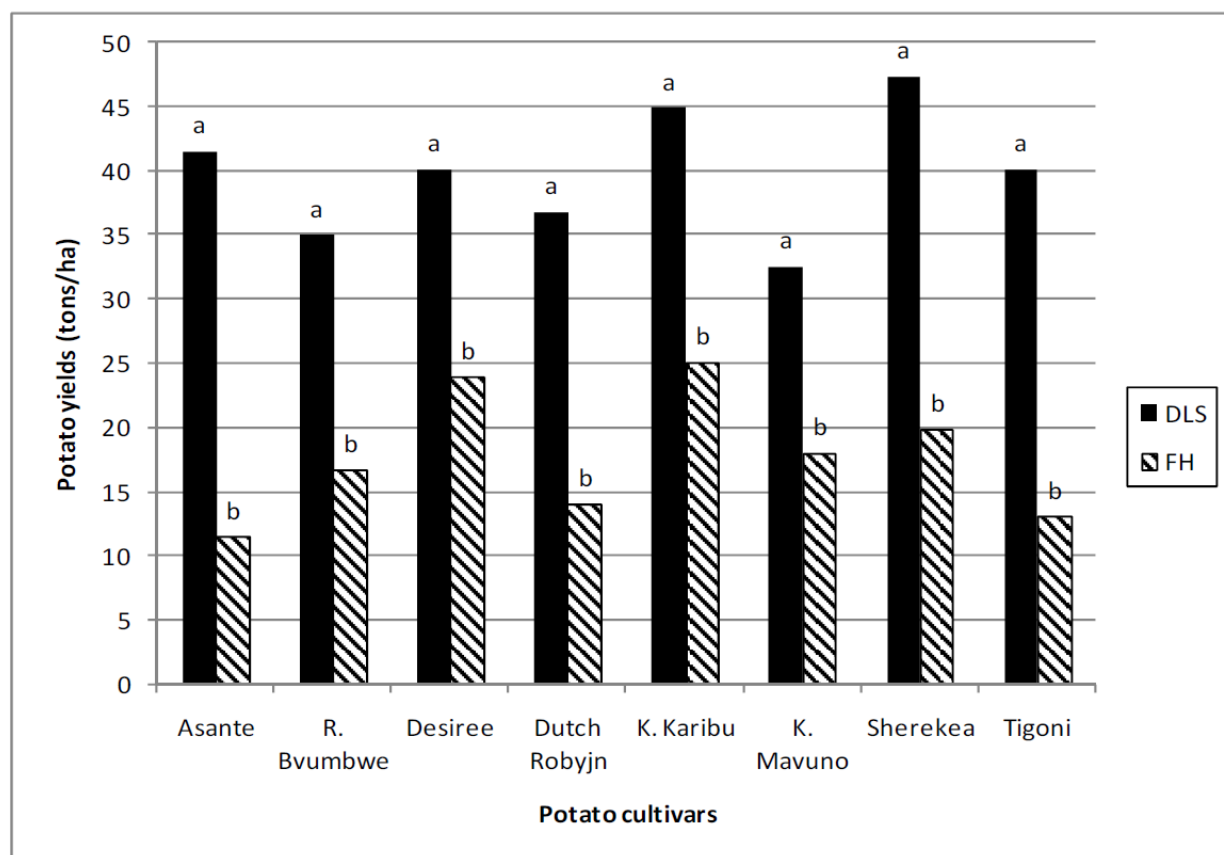


Figure 1. Tuber yields of the various potato cultivars in the first season at KARI Tigon

DLS= Diffuse light store; FH= Freshly harvested. For each potato cultivar, columns headed by the same letter are not significantly ($P \leq 0.05$) different from each other.

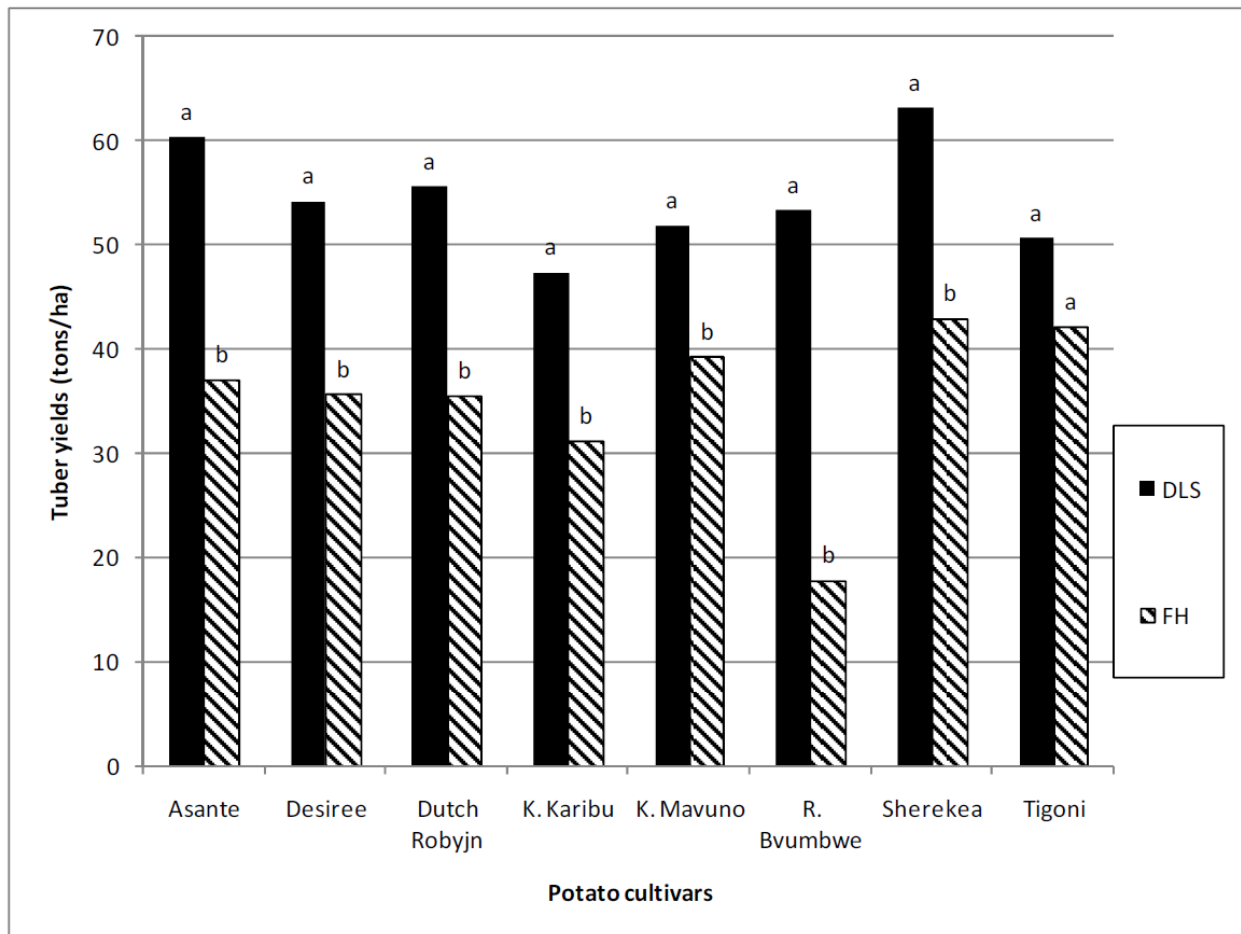


Figure 2. Tuber yields of the various potato cultivars in the second season at KARI Tigoni

DLS= Diffuse light store; FH= Freshly harvested.

For each potato cultivar, columns headed by the same letter are not significantly ($P \leq 0.05$) different from each other.

There were significant differences in yields of different tuber size categories among the potato cultivars and between the storage methods in both seasons at KARI Tigoni (Table 6).

Table 6. Yields (ton/ha) of different tuber sizes in both seasons at KARI Tigoni

Source of variation	d.f.	First season			Second season		
		Ware	Seed	Chatts	Ware	Seed	Chatts
Block	2						
Potato cultivar	7	0.002**	0.148ns	0.620ns	0.002**	0.023*	0.003**
Error a	14						
Storage	1	<.001**	<.001**	<.001**	0.005**	<.001**	<.001**
Cultivar x storage	7	0.005**	0.110ns	0.317ns	0.023*	0.018*	0.247ns
Error b	16						
Total	47						

*=significant at $P \leq 0.05$; **=significant at $P \leq 0.01$; ns= non significant.

In the first season, storage methods gave significantly ($P \leq 0.01$) different yields in all the three potato tuber size categories. The potato cultivar and the interaction between cultivar and storage gave significantly ($P \leq 0.01$) different yields in the ware size category only (Table 6).

In the second season, seeds were the most followed by ware while chatts were the least across all potato genotypes (Table 7). Seed tubers stored under DLS gave significantly ($P \leq 0.05$) higher yields than freshly harvested ones in terms of ware and seed sizes; no significant differences were observed in the chatts.

Table 7. Yields (tons/ha) of different potato tuber size categories in the second season at KARI Tigoni

	Ware		Seed		Chatts	
	DLS	FH	DLS	FH	DLS	FH
Asante	22.3b	12.7a	33.7b	20.0a	4.4a	4.4a
Desiree	6.5a	5.2a	40.7b	25.2a	7.0a	5.2a
Dutch Robyjn	15.5a	10.4a	33.4b	20.8a	6.7a	4.3a
Kenya Karibu	10.1a	13.6a	32.9b	14.8a	4.4a	2.7a
Kenya Mavuno	16.7a	18.5a	30.7b	17.8a	4.5a	2.9a
Roslin Bvumbwe	18.3b	7.4a	30.5b	6.8a	4.6a	3.6a
Sherekea	31.1b	19.0a	27.4b	19.6a	4.7a	4.4a
Tigoni	12.7a	14.7a	32.1b	22.8a	5.8a	4.7a
Mean	16.6	12.7	32.7	18.5	5.2	4.0
Mean	Ware = 14.7		Seed = 25.6		Chatts = 4.7	

Within each tuber size category and within each potato cultivar, numbers followed by the same letter are not significantly ($P \leq 0.05$) different from each other.

Across the two seasons, the farmers had significantly different yields (Figure 3). The cultivars were also significant and the interaction between storage method, cultivar and farmer was significant (Figure 3). Generally, Wairegi had lower yields than the other two farmers; his field was flooded most of the times during crop growth. All the three farmers got more than the national average of less than 10 ton/ha.

This is probably due to the fact that they had previously been taught on good potato management practices.

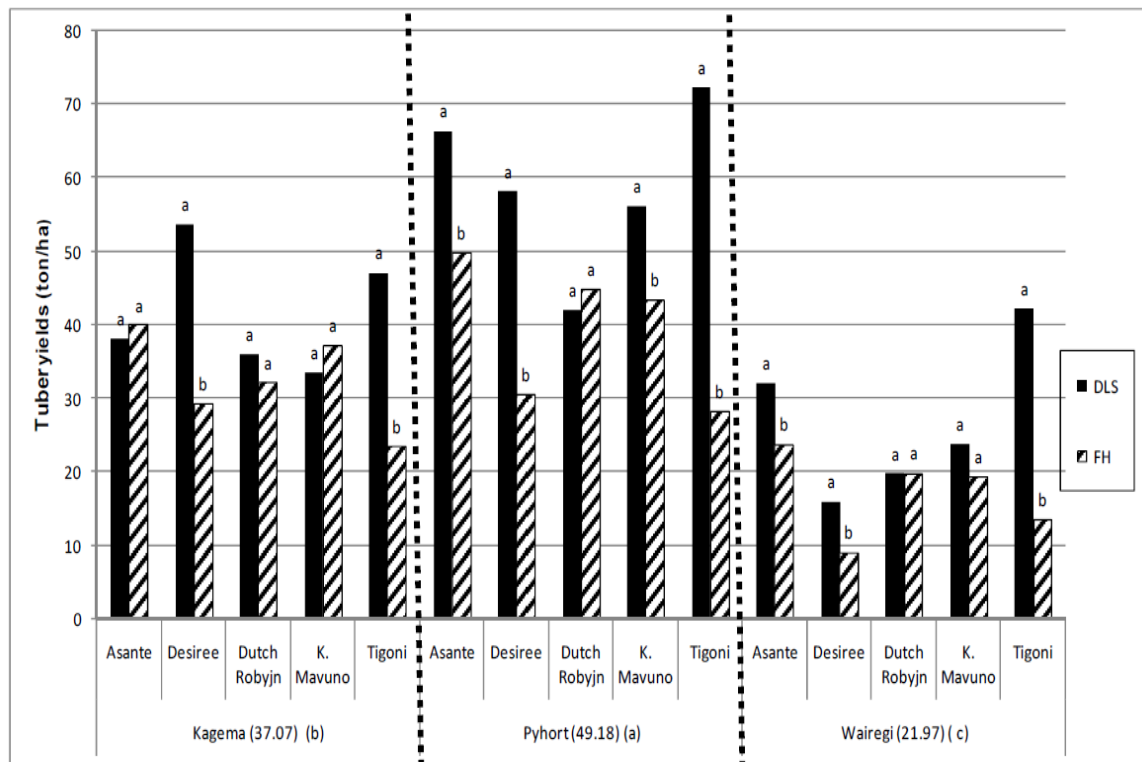


Figure 3. Average tuber yields of the various potato cultivars among the three farmers across the two seasons DLS= Diffuse light store; FH= Freshly harvested.

Within each farmers and within each potato cultivar, numbers followed by the same letter are not significantly ($P \leq 0.05$) different from each other. Five potato cultivars planted by both the farmers and at KARI Tigoni (i.e. Asante, Tigoni, K. mavuno, Desiree and Dutch Robyjn) were used to compare the farmers (site1) and KARI Tigoni (site 2). There was no significant difference between the total tuber yields attained by the three farmers averaged across the two seasons (site 1) and the yields attained at KARI Tigoni averaged across the two seasons (site 2) (Table 8). There was a highly significant difference ($P \leq 0.01$) in total tuber yields between the storage, its interaction with site, cultivar and the interaction of all the three (Table 8).

Table 8. Analysis of variance. Comparison of total yields between farmers and Kari Tigoni in both seasons

Source of variation	df	ms	Fpr.
Block	2	4.747	
Site	1	6.534	0.225ns
Error a	2	2.176	
Cultivar	4	52.119	0.028*
Site x cultivar	4	47.548	0.038*
Error b	16	14.418	
Storage	1	3878.496	<.001**
Site x Storage	1	153.600	<.001**
Cultivar x Storage	4	129.190	<.001**
Site x Cultivar x Storage	4	153.873	<.001**
Error c	20	7.961	
Total	59		

The lack of difference between farmers' yields and the yields attained at KARI Tigoni (Table 8) could possibly be due to the fact that these farmers had been taught on good ware potato production practices and they are applying these practices on their farms. All the seven farmers come from Nyandarua; farmers and extension agents in this area have previously received a lot of training on potato production by researchers from KARI Tigoni. From this experiment, it appears that storing potatoes in DLS for 8 months led to an increase in yields compared to planting freshly harvested tubers in all the cultivars tested.

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1.2 Feasibility of Low-Cost Seed Potato Storage in Kenya: The Case of Diffused Light Storage in Nyandarua County

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Abstract

An on-farm storage trial was conducted at six sites in Nyandarua County using seed tubers of eight officially recognized Kenyan potato varieties and one commonly grown farmers' variety called *Cangi*. The seeds were stored under diffuse light store (DLS) conditions in low-cost structures owned by the growers to test the feasibility of prolonged seed storage under on-farm conditions. Three farmers' groups and three individual farmers were used in this study. In general, DLS wooden structures with iron sheet roof or mud-walled with iron sheet roofs were used for storage.

Most of the varieties stored satisfactorily for up to 8 months. Kenya Mpya and Kenya Mavuno had higher overall acceptability than Sherekea, Asante, Desiree, Kenya Karibu, Tigoni and Dutch Robjin. Kenya Mpya, Sherekea and Kenya Mavuno had the least shrinkage following 8 months of storage. The unofficial cultivar Cangi which is the most popular in Nyandarua had poor storability but could be planted 2 to 3 months following harvest. Results indicated that DLS could be used by ware potato growers for prolonged seed storage the following season. This way the growers could be assured of good potato harvests due to the use of well sprouted tubers. This is critical in case of seasons with low or less than average rainfall as experienced in recent years.

Keywords: diffuse light store, potato storage

1. Introduction

The potato (*Solanum tuberosum* L) is an important food and income security crop in Kenya being second to maize in production and utilization. This crop is grown in most highlands (1800-3000 m above sea level) wherever maize performs poorly. Availability of good quality seed is a major constraint to increased ware potato production to meet the food demands of increasing rural and urban populations besides processing requirements. In order to improve the quality of farm-saved seeds, farmers are

usually encouraged by extension workers and researchers to conduct positive seed selection (MoA, 2008). If such “clean seeds” are well-sprouted before planting, the on-farm yields can be improved substantially when complemented with adequate agronomic practices (Kabira et al., 2006; Kinyua et al., 2012; Nyongesa et al., 2012).

In production areas adjacent to the Aberdares selected for this study, the rains have dwindled in certain years compared with their levels in the 1980s. Changed weather patterns with erratic rainfall patterns have negatively affected potato productivity, particularly when unsprouted or even poorly sprouted seed is used by farmers for planting. Well-sprouted seed which leads to early crop establishment and consequently higher yields can be obtained through simple and low-cost technologies such as diffused light storage (Kabira et al., 2006). Individual farmers and farmers’ groups cannot afford refrigerated storage however attractive it is for prolonged seed storage.

The later system is currently used for storage of basic seeds at KARI-Tigoni and for certified seeds at Agricultural Development Corporation (ADC), Molo (Kaguongo et al., 2010).

Although Nyandarua is one of the largest potato producing counties in Kenya, the average yields have remained at less than 10 t/ha compared to on-station figures of 30-60 t/ha. Many farmers store their seed potato tubers in dark stores instead of using better techniques such as diffused light stores (Kinyua et al., 1996; Kipkoech et al., 2012). The great preference of the short-dormancy variety Cangji, has denied farmers other recently released varieties, particularly the processing types which have longer keeping quality (Kipkoech et al., 2012). Encouraging small-scale farmers to store farm-saved seed stocks is required for farmers to keep up their own seed potato supplies for planting the following season under low-cost conditions which they can afford. The main objective of this study was to investigate the feasibility for on-farm seed potato storage of seed potatoes in selected areas in Nyandarua.

2. Materials and Methods

On-farm seed storage trials were conducted amongst three farmers’ groups (Kagama Fukuza Njaa in Ol-Joro-Ok, Pyhort in Ol-Joro-Ok and Gatarwa Evergreen in Ol-Kalou) and three individual farmers (Miss Jane Wanjiku of Kipipiri Manunga, Hellen Wairimu of Kipipiri Githioro, and Mr. and Mrs Wairegi of Njabini) in Nyandarua County. The farmers had naturally ventilated seed storage structures with diffused light (DLS) built according to their own requirements. The stores ranged from (1) ordinary wooden store with ironsheet roof, (2) ordinary structure covered with polythene sheet; (3) mud-walled, iron-sheet roof; and (4) wooden structure with mesh wire sides and iron sheet roof.

Triplicate samples of fifteen kilogrammes of certified seed tubers of 8 varieties (Asante, Desiree, Dutch Robjin, Kenya Karibu, Kenya Mavuno, Kenya Mpya, Sherekea, and Tigoni) and Cangji, a popular

unofficially recognized cultivar, were placed in wooden crates and stored for approximately 8 months for planting the following season.

Three crates of each variety were stacked together to create more space in the stores. The tubers were stored for two seasons following a short rains season harvest (season 1) and a long rains season harvest (season 2). Tubers were checked periodically for sprout growth, shrinkage and rotting. Chemical control was used against tuber moth damage and aphid infestation. Any rotting tubers were periodically removed. Determination of sprout growth, total weight loss, shrinkage and overall acceptability of tubers as seed were done at the end of storage. The seed tubers were weighed using a balance to determine total weight loss while the length of sprouts was measured using a ruler. Four panelists familiar with potato seed tuber quality used a 9-point scoring scale to evaluate tuber shrinkage (firmness) and overall acceptability of the seed. On this subjective scale a score of 1 was the least acceptable while 9 was the most acceptable; a score of 5.0 and above was acceptable.

3. Results and Discussion

Mean tuber growth of 8 varieties across two seasons in various on-farm sites in Nyandarua is given in Table 1.

Table 1. Mean sprout length (mm) and standard deviation of the means of potato varieties stored for eight months over two seasons by six farmers in Nyandarua County

Potato variety	Short rains (Season 1)	Long rains (Season 2)	Overall Mean
Asante	42.17 ± 8.53 ¹	52.92 ± 25.8	47.54
Desiree	39.89 ± 22.61	31.17 ± 11.8	35.53
DutchRobjin	27.33 ± 3.88	38.89 ± 9.60	33.11
Kenya Karibu	23.63 ± 6.28	68.33 ± 34.90	45.98
Kenya Mpya	32.18 ± 10.17	-----	32.18
Kenya Mavuno	25.00 ± 10.00	41.25 ± 11.30	33.13
Sherekea	34.50 ± 12.70	-----	34.50
Tigoni	29.58 ± 8.76	40.00 ± 8.52	34.79

¹ Standard deviation of the mean.

Generally, variety Asante had the longest sprouts across the two seasons. Kenya Karibu had long sprouts during season 2 possibly because the long rains crop may have been harvested when not fully matured leading to early sprouting. Kenya Mavuno and Tigoni had long sprouts, but shorter than those for Asante. Early sprouting varieties can be planted 2-3 months after harvest although fully mature tubers can keep for planting much later. The farmers' cultivar Cangi broke dormancy and sprouted within a period of only 6 weeks and was discontinued from the trial.

This cultivar however could be planted soon after harvest, an important trait preferred by farmers because of early crop establishment in case of decreased rainfall later in the season.

The mean tuber weight loss of 8 varieties under on-farm storage in two seasons is given in Table 2.

Table 2. Mean percent (%) weight loss and standard deviations of the potato varieties stored for eight months by the 6 farmers in Nyandarua County

Potato variety	Short rains (Season 1)	Long rains (Season 2)	Overall Mean
Asante	33.00 ± 24.47 ¹	47.67 ± 8.90	40.34
Desiree	21.33 ± 9.43	55.83 ± 4.04	38.58
Dutch Robjin	60.44 ± 21.72	29.56 ± 25.68	45.00
Kenya Karibu	27.75 ± 19.20	63.33 ± 5.16	45.54
Kenya Mpya	26.94 ± 6.82	-----	26.94
Kenya Mavuno	38.22 ± 17.13	52.00 ± 15.52	45.11
Sherekea	24.67 ± 12.62	-----	24.67
Tigoni	22.33 ± 8.13	59.67 ± 6.97	41.00

¹ Standard deviation of the mean.

Tuber weight loss was generally greater in the second than in the first season (Table 2). In season 2, Kenya Karibu, Tigoni, Desiree and Kenya Mavuno suffered the biggest weight loss over the 8 month storage period compared with Dutch Robjin. Probably tubers of these varieties were not fully mature during harvesting due to the long rains leading to early sprouting and hence excessive weight loss during the subsequent storage. In both seasons tubers in the lower crates had more sprout growth than those at the top that received more light. Light limits the excessive growth of white, thin sprouts while it induces growth of short, stout, coloured sprouts. Insufficient light intensity is indicated by the development of long, white sprouts which promote quick shrinkage in the tubers.

The mean overall acceptability scores of seed potato tubers following 8 months of storage for two seasons are given in Figure 1.

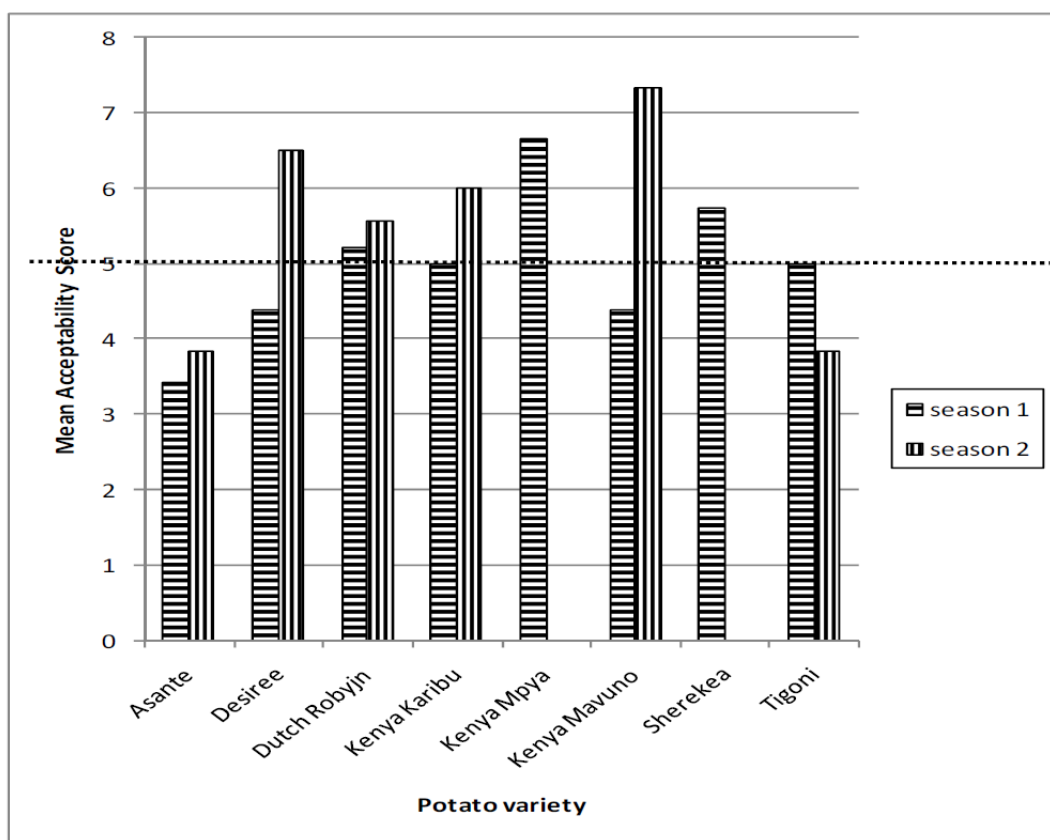


Figure 1. Mean overall acceptability scores of potato varieties after 8 months on-farm storage in Nyandarua County storage in two seasons. Scores below 5 (dotted line) were unacceptable

There were noticeable differences in acceptability among the varieties after eight months' storage in both seasons (Figure 1). In the first season involving seed tubers harvested after the short rains season, mean panelists' scores indicated that Kenya Mavuno, Asante and Desiree were not acceptable as seed tubers probably due to excessive sprouting. Tigonii, Dutch Robjin and Kenya Karibu were just acceptable. Kenya Mpya outperformed Sherekea which also performed better than all the other varieties. In the second season, Kenya Mavuno, followed by Desiree and Kenya Karibu were the best performers. In general, tubers of most varieties had lower acceptability as seed following storage of the crop harvested in the first season (i.e short rains). Shrinkage of seed tubers across 6 on-farm sites following 8 months of storage in two seasons is given as firmness scores in Figure 2. Figure 2. Mean firmness (shrinkage) scores potato varieties under on-farm storage in Nyandarua County after 8 months of storage by six farmers. Firmness scores below 5 (dotted line) were unacceptable There were differences in seed tuber shrinkage among the varieties after eight months' storage in both seasons (Figure 2). Varieties Dutch Robjin, (5.8), Kenya Karibu (5.3), Kenya Mpya (7.1), Sherekea (6.7) and Tigonii (5.2) had firmness scores 5.0 and above during the first season. Kenya Mpya with a score above 7.0 performed the best during the first season. During the second season, all varieties except Tigonii had acceptable firmness scores. Kenya Mavuno had the highest scores.

Data on mean firmness scores of 8 varieties showing performance during storage by different farmers is given in Figure 3. All farmers had fairly good seeds of Kenya Mpya (scores of 7.0 and above) and Sherekea (6.0-7.0 scores). Tigoni and Asante had poor firmness scores in most farmers.

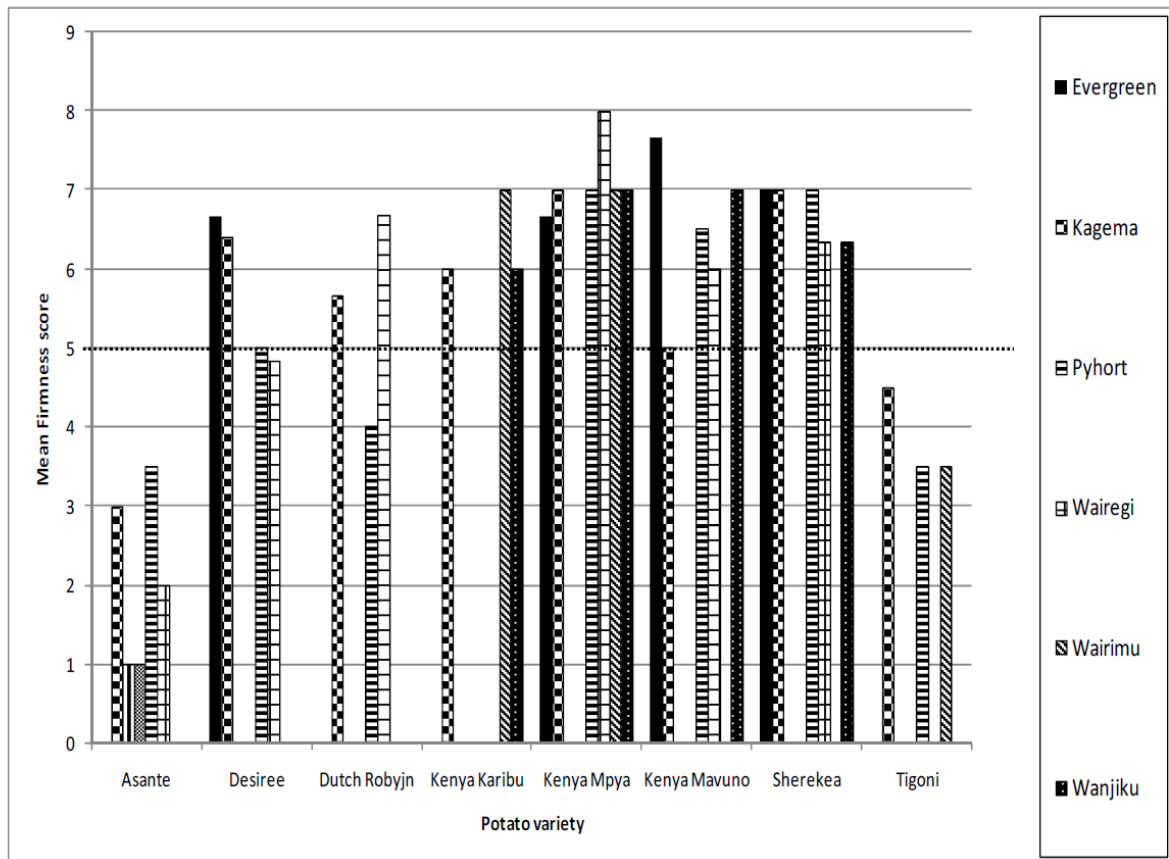


Figure 3. Mean firmness of potato varieties evaluated by six farmers for two consecutive seasons in Nyandarua County. Firmness below 5 (dotted line) was considered unacceptable

Potato varieties differed in firmness scores among sites (Figure 3). Long dormancy varieties can be stored for up to 8 months for later planting. Short dormancy varieties though not suitable for prolonged storage can supplement DLS and should be promoted as they sprout early for planting 3-4- months after harvest after harvest. Seed tuber acceptability scores at 6 on-farm sites following 8 months of storage are shown in Figure 4.

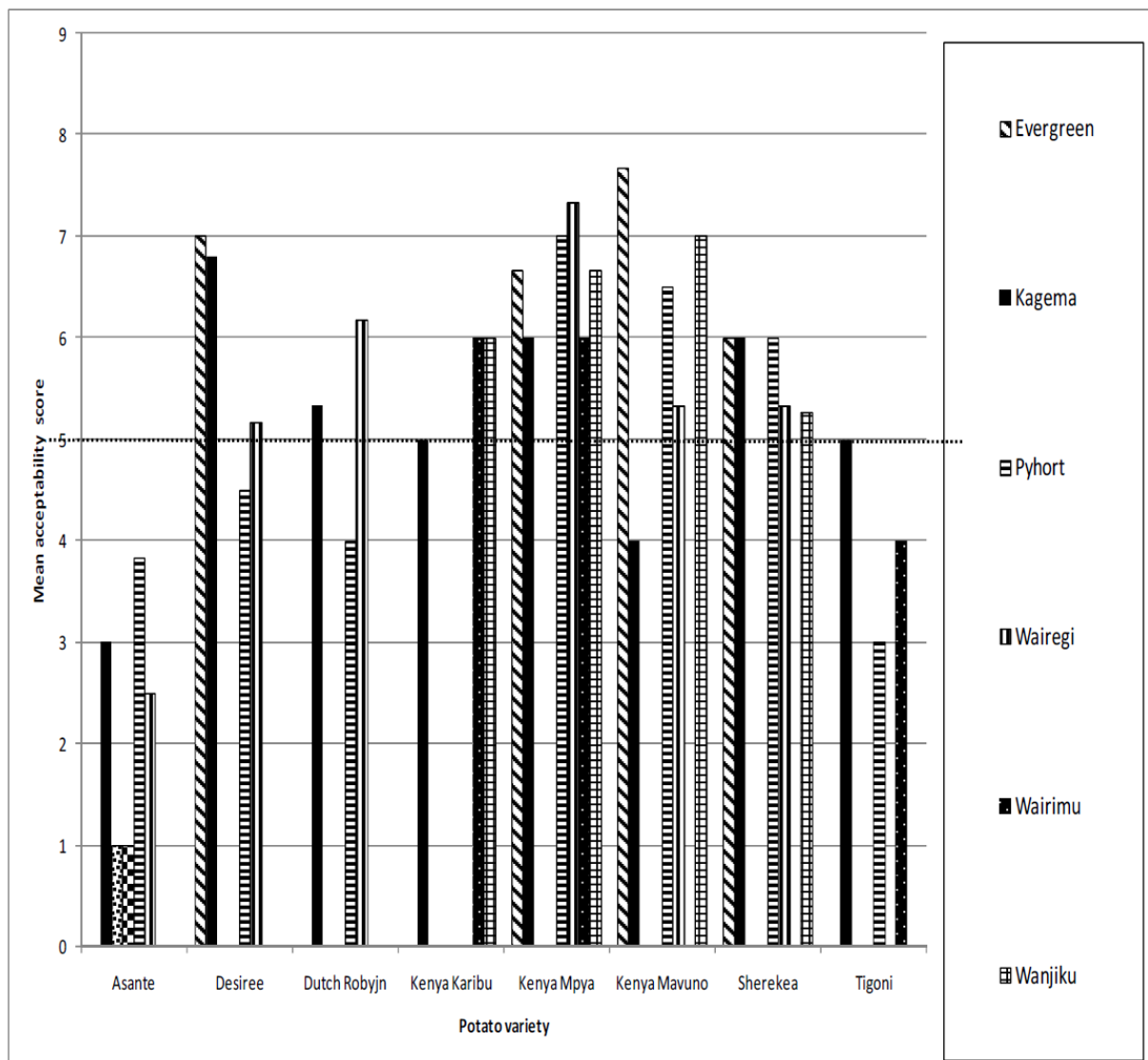


Figure 4. Seed tuber acceptability scores of potato varieties evaluated over two seasons by six farmers in Nyandarua County. Scores below 5 (dotted line) were unacceptable

Seed storage farmers did not have much effect on seed tuber acceptability scores except for stacking in crates which produced excessive sprouting in lower layers due to limited availability of light. Varieties had the most effect (Figure 1). Poor storing varieties like Asante performed poorly under all DLS while Kenya Mpya, Kenya Mavuno and Sherekea performed well.

4. Conclusion and Recommendation

Results of this study have shown that it is feasible to store seed tubers of currently available potato varieties in Kenya under low-cost on-farm conditions. Modification of existing storage structures to include shelves and aphid proofnetting can enhance storage of farm-saved seeds for planting the following season. Varieties selected for long storage should have long dormancy and have high market demand for domestic consumption such as Kenya Mpya or for processing such as Dutch Robijn or

Desiree. When healthy or preferably certified seed stock has been widely used for initial planting, it is ultimately possible for the Government to use protocols and standards developed by the FAO (Farjado et al., 2010) to legalize trade in farm-produced seeds to ease current shortage of planting materials. This, in conjunction with clean seed production protocols such as positive seed selection could ensure farm-produced seed can be certified for own-use for storage to ensure good seeds the following season. Farmers' cultivars such as Cangi having short dormancy periods should be officially recognized as quick sprouting could be a good characteristic to complement on-farm-storage to mitigate climate change.

Acknowledgement

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1.3 Thesis draft:

[Influence of Diffused Light Storage Seed Treatment and Production Location on the Physico-Chemical Characteristics and Processing Suitability of Selected Kenyan Potato Varieties by Martha N. Wekesa, Department of Food Science, Nutrition and Technology, University of Nairobi](#)

1.3.1 Abstracts

[1.3.1.1 EFFECTS OF SOIL CHARACTERISTICS ON POTATO TUBER MINERALS COMPOSITION: A CASE OF SELECTED AREAS IN NYANDARUA AND KIAMBU COUNTIES IN KENYA](#)

Authors: Martha N. Wekesa¹, Michael W. Okoth¹, George O. Abong¹, Jackson N. Kabira² and Prof. John H. Nderitu³

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Abstract

The current study was set up to evaluate the effects of soil characteristics on selected potato tuber minerals composition. Eight sites were involved: National Potato Research Centre KARI-Tigoni (control station) and seven farmers (Njabini Sub Center, Pyhort, Kageema, Hellen, Evergreen, Jane and Gitahi) located in Nyandarua County in Kenya. This study was carried out between April and September 2013. Random sampling method was used where individual soil samples were collected from locations that were randomly distributed across the representative portion of the field using a zigzag soil sampling method. All the samples from each locality were packed and taken for laboratory analysis at the National Agricultural Research Laboratories- Nairobi (KARI-NARL) for minerals analysis. Well sprouted

diffused light stored seeds and fresh potato seeds belonging to the four varieties (Kenya Mpya, Dutch Robjin, Tigoni and Cangji) were grown in the four localities (Pyhort, Kagema, Hellen and Tigoni-KARI) under standard conditions. After harvesting, ten mature tubers of each variety per location and seed treatment were packed in net bags and taken to KARI-NARL in Nairobi for minerals evaluation. The results showed that pH, organic carbon, nitrogen, phosphorus and the rest of the soil minerals in the study areas differed significantly ($p \leq 0.05$) with sites. Generally, potato tuber minerals significantly ($p \leq 0.05$) differed with sites potato varieties and seed potato storage (fresh or eight-month DLS seed). There was positive a correlation between potato and soil mineral composition potatoes minerals levels and those existing in the soils from plant locations. Potato minerals were thus affected by potato variety, seed storage and soil characteristics in a production locality.

Thus acidifying fertilizer like DAP should be discontinued, pH ought to be raised by applying agricultural lime (dolomite) and proper crop rotation should be practiced to restore soil fertility which will ensure high potato mineral nutritional quality.

1.3.1.4 EFFECT OF DIFFUSED LIGHT SEED POTATO STORAGE AND PRODUCTION LOCATION ON THE PHYSICO-CHEMICAL PROPERTIES OF SELECTED KENYAN WARE POTATO VARIETIES

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Abstract

This study was conducted to evaluate the effect of diffused light storage (DLS) seed potato treatment and production location (Potato Research Centre KARI-Tigoni (control station) and three farmers (Pyhort, Kagema and Hellen) on the physico-chemical properties (specific gravity, dry matter, reducing sugars and vitamin C) of Kenya Mpya, Dutch Robjin, Cangji and Tigoni varieties for their suitability in processing into French fries and crisps. DLS and fresh seeds were grown under standard conditions in the four locations. They were then harvested upon maturity, packed in net bags and cured for 2 weeks and evaluated for the above parameters. Specific gravity, dry matter, reducing sugars and vitamin C significantly ($p \leq 0.05$) differed with plant localities, varieties, treatment of the seed potato (fresh or eight-month DLS seed) and with interactions among plant locality, variety and seed treatment. There was a significant ($p \leq 0.05$) correlation between soil phosphorus and potato tubers dry matter content. The plant locality can affect the quality of ware potatoes. DLS seed treatment can indeed produce tubers of superior physico-chemical properties as compared to those from fresh potato tuber seeds. Thus based on the physico-chemical properties of ware potatoes, DLS seed potato treatment should be

adopted by farmers so as to yield more and better quality ware potatoes to meet their ever increasing demand.

1.3.1.5 INFLUENCE OF DIFFUSED LIGHT SEED POTATO STORAGE AND PRODUCTION LOCATION ON THE QUALITY OF FRENCH FRIES AND CRISPS FROM SELECTED KENYAN WARE POTATO VARIETIES

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Abstract

The study was conducted to assess the influence of diffused light seed potato storage (DLS) and production location on the quality of processed French fries and crisps from four selected Kenyan varieties (Kenya Mpya, Dutch Robjin, Tigoni and Cangii). The seeds (both from DLS and fresh) were grown in four localities (KARI-Tigoni located in Kiambu County and three farmers (Pyhort, Kagema and Hellen) located in Nyandarua County in Kenya) under standard conditions. The tubers were harvested upon maturity and were all cured for two weeks at KARI-Tigoni. The tubers were then processed immediately into French fries and crisps at KARI-Tigoni then evaluated for sensory quality at the same venue but moisture and oil contents in the products were determined at the College of Agriculture and Veterinary Sciences of the University of Nairobi. Tubers dry matter contents showed significant correlations ($r = -0.63$ and $r = -0.93$) with oil contents of the corresponding French fries and crisps respectively depicting inverse relationship. Significant correlations ($r = 0.93$ and $r = 0.82$) were observed between PC/SFA colors for processed French fries and crisps respectively with the corresponding tubers total sugars implying a direct relationship. PC/SFA colors correlated negatively with panelists French fries and crisps colors ($r = -0.59$ and $r = -0.68$) correspondingly showing an inverse association. All the sensory attributes of freshly processed French fries and crisps, differed significantly ($p \leq 0.05$) with plant localities, varieties, treatment of the seed potato and with interactions among plant locality, variety and seed treatment. French fries on the basis of panelists' overall acceptability were all preferred having been rated above threshold acceptability score (≥ 4.0 on a 7-point hedonic scale) from all the potato varieties in all the locations except those from fresh and DLS Dutch Robjin seeds in Pyhort. Order of preference for French fries in a decreasing manner on the basis of plant locality, variety and seed treatment respectively was as follows: Tigoni-KARI, Kagema, Hellen then Pyhort; Cangii, Dutch Robjin, Tigoni after that Kenya Mpya; DLS seed and lastly fresh seed. The freshly processed crisps on overall acceptability aspect were all ideal excluding those from Tigoni fresh seed in all plant localities and Dutch Robjin from fresh seed in Pyhort whose scores were below sensory threshold of 4.0. The crisps preference basing on plant locality was highest at

Tigoni-KARI, followed by Kagemu, then Hellen and lowest at Pyhort. Kenya Mpya's crisps were the best but Tigoni's were worst and those from DLS were superior as compared to those from fresh seeds.

The potato plant localities, varieties and seed treatment do influence the quality and hence acceptability of French fries and crisps. Since crisps and French fries from the DLS seed were superior, DLS seed storage should be adopted so as to get higher yields of ware potatoes to assist meet the high potato market demand and at the same time process good quality French fries and crisps.

2. FARMERS' TRAINING WORKSHOP ON LOW COST SEED STORAGE IN NYANDARUA COUNTY: 4TH APRIL 2014, AT OLIJOROK ATC, NYANDARUA COUNTY.



2.1 Background

The goal of the workshop was to give the low cost seed storage findings back to farmers and other stakeholders. Farmers who participated in the project were invited to give their views concerning challenges they faced in implementing the project. The workshop kicked off with a brief explanation of the key findings by the principal investigator (PI) of the project Prof. John Nderitu (Mount Kenya University). Apart from giving the project outputs, he stressed that the major challenges bedeviling potato industry in Kenya were;

- i. Rent seeking at various levels of value chain;
- ii. Imperfect market and marketing;
- iii. Failure to enforce the law;
- iv. Inadequate support by government in term of infrastructural, financial and human resources in basic seed production;
- v. Inadequate quality seed production and distribution;
- vi. Lack of a clear strategy to revolutionise the sector given its role as a food security crop in the country.

2.1.1 Overview

Prof. John H. Nderitu said that in each of the project outputs below, there were corresponding publication for future reference on low cost seed storage in the country. Of interest as the project ends is how the good results of the project will be up-scaled to reach approximately 800,000 potato growers in the country. It is known that majority of farmers' store their seed potato for the next season planting but how they do it is wanting. He emphasized that it is upon the County Government to take up from where the project left for the common good of the potato farmers approximated at 96% of the households and produce 33% of the total potato production in the country. The project outputs were;

- a. Promising on-farm seed storage technologies were identified;
- b. Seed storage potential of various cultivars under different on-farm storage practices were evaluated and documented;
- c. On-farm field performance of major potato cultivars under different storage periods was evaluated and documented;
- d. Promising on-farm seed storage technologies were promoted and adopted by participating farmers;
- e. Information sharing and publication was done in terms of articles in conferences and refereed journals, print and mass media, workshops and field demonstrations.

Dr. Jackson Kabira (Centre Director, KARI NPRC-Tigoni), said all along researchers have dwelled on basic research on varieties that are high yielding and resistance to diseases. But fundamental question is that why was that farmers have stuck on their own varieties like *Ciangi*, *Tana Fake*, *Ndera Mwana*, *Tigoni Long*, *Discus* and others. The Low cost seed storage had fantastic results in terms of varietal storability, acceptability and firmness of improved varieties after storing for 8 months, but still farmers could not commercialise them. Thus it will not be business as usual for research. They should go back to the drawing board to devise new strategies relevant to research for development. The regulatory and policy issues need to be amended in the current situation whereby farmers are facing challenges brought about by biotic and abiotic elements. Land fragmentation renders farms to be small and quarantines measures are no long tenable.

Globalisation is with us, thus we need to shape up with its challenges otherwise national research will be renegaded to periphery. Food safety issues are dictating specific product supply chain for instance Kentucky Fried Chicken (KFC) get potatoes from Egypt because of traceability. Farmers

produce potatoes here but it does not meet food safety requirements, this means there is something wrong with our supply chain.

Mr. Wachira Kaguongo (CEO, NPCK) started by giving a brief introduction of the role of NPCK in the potato industry. He said NPCK was public-private institution which brings together all potato stakeholders in the country. It is a platform which promotes interaction and linkages among the potato stakeholders. It advocates for an efficient and effective potato supply chain. The future goal of NPCK will be to be a *one-stop-shop* for potato information to assist chain actors to perform adequately. This will be done through ICT (e-marketing), bulletins, articles, web site, SMS (31155 for seed availability), seed catalogue, potato processors inventory and agitating for appropriate and functional potato policies.

Dr. Stephen Karimi (Chief Science Secretary, National Commission for Science, Technology & Innovation (NACOSTI)) raised fundamental issues on being innovative in tackling farmers' problems. *'Listen to the farmer first, know what they want', see if your strategy to solve their problems is in line with government regulation and funding will not be a problem'*, he said. Current Kenyan government is particular in funding some specific areas of agricultural development. *Innovation and technology to boost productivity is key, shifting agricultural practice to agribusiness and commercialisation is fundamental and food security is a necessity.* A well written proposal supported with relevant and up to date statistics will always attract funding. Jubilee Government is keen on irrigated agriculture, mechanisation, value addition and linking farmers to market.

M/s Agatha Thuo, (Minister of Agriculture, County Government of Nyandarua) said potato is one of the priority crops in Nyandarua with a mandated officer to oversee planning, implementation and budgeting for potato activities. Value chain development is County's strategy to enhance productivity in agriculture in the county, she said. So far the county government official has gone round talking to farmers and to get to know their challenges. To show the seriousness the County has in agriculture, KES 10 million has been set aside for irrigation, 3 markets built (Soko Mpya, Murungaru and Oliondo markets). She said ATCs (Njabini and Oljororok) will be used for seed potato multiplication to increase its accessibility and distribution. Development partners will continue to contribute significant resources in research for development in the county, she emphasized.

Hon. Beatrice Elachi (Senator and Chairperson of Senate Committee on Agriculture) officially opened the meeting with clear remarks on potato production in the country. Potato is a food and cash crop in Nyandarua that is why everyone who likes to invest in it will always come here, she said. It is also gaining some importance regionally if the surging interest by international seed companies in the country is anything to go by. Trade law is a playing ground for investors and Kenya ratified

various international trade treaties, we have to play it safe. As we need a fair share of the trade, thus negotiation with trading partners like EU is vital. What we need to do is for our farmers' and supporting institutions to be more competitive and beat the rivals in their own game. This is not the time to lament and sit down, we have to move the talk and make potato production efficient and commercially viable for farmers to continue producing. We might be lagging behind technologically, but let us use what we have innovatively and efficiently to achieve our goals, she continued.

Currently, there is a bill in the Senate house (Amendment of National Youth Service) to make our young people involved in development and defence of the country. It will be prudent to put a cause to include NYS in provision of agricultural service to the Country.

Farmers (**David Kariuki, Hellen Wairimu, Jane Kingaru**) gave their side of the story and challenges they faced in commercialisation of improved potato varieties and what need to be done as follows;

- i. No market for improved varieties, look for market and they will supply;
- ii. Produce more clean seed for ciangi;
- iii. Inappropriate packaging and recommended selling per weigh not per bag;
- iv. Device a strategy of linking farmers to the market;
- v. Do more demonstration of seed stores and help in construction;
- vi. Promote new potato varieties so that it can penetrate the market easily;
- vii. Give long term loans to farmers and prosecute those who give farmers fake inputs as loans.

Way forward:

- i. Construct more stores in the county
- ii. Nyandarua to participate in awareness science week by NCST
- iii. Potato germplasm collection and conservation to be done in Nyandarua
- iv. Promote drip irrigation
- v. Next phase of the project should introduce contract farming by forming marketing groups or organisation in the county
- vi. Training of National Government on potato policy by NPCK
- vii. Devolution should be accompanied by effective devolved fund
- viii. There is need for few flagship projects in extension and research, then upscale them instead of many fragmented small projects here and there
- ix. County Government should fund externally generated project proposals

2.2 Performance of seed potato tubers after storage in a diffuse light store (DLS): Jane Mbugua

2.2.1 Introduction

Timely availability of well sprouted seed potato tubers at the onset of rains is pre-requisite for attaining high yields.

Planting dormant seed = in delayed plant emergence, poor crop establishment and low yields.



A diffuse light store





Inside a diffuse light store



2.2.2 Objective

To determine the yields of some potato cultivars commonly grown in Kenya after storage in diffuse light store (DLS) for eight months.

2.2.3 Materials and Methods

- Diffuse light storage at KARI Tigoni, Njabini + seven farmers in Nyandarua county
- 8 potato cultivars of different maturity periods were used.
- Stored for 8 months before planting.
- Cangi was used but not stored due to short dormancy

2.2.3.1 Seed potato stores used by some farmers



2.2.3.2 Characteristics of the potato cultivars used in the project

Potato cultivar	Source of original germplasm	Year of release in Kenya	Yield (ton/ha)	Maturity period (months)
Kenya Karibu	CIP	2006	35-45	3-4 (>110 days)
Kenya Mavuno	CIP	2006	35-40	4 (>120 days)
Sherekea	CIP	2010	35-45	3-4 (>110 days)
Tigoni	CIP	1998	35-45	3-4 (>110 days)
Asante	CIP	1998	35-45	3-4 (>110 days)
Dutch Robyjn	Netherlands	1945	35-40	3-4 (>110 days)
Desiree	Netherlands	1972	35-45	3-4 (>110 days)
Roslin Bvumbwe	Scotland	1974	35-45	3-4 (>110 days)

2.2.3.3 Farmers/farmer groups involved

Farmer/farmer group	Site
Kagama Fukuza Njaa (Group)	Ol joro Orok
Kagama Pyhort (Group)	Ol joro Orok
Gatarwa Evergreen (Group)	Ol Kalou
Jane Wanjiku	Manunga (Kipipiri)
Hellen Wairimu	Githioro (Kipipiri)
Mr. Gitahi	Mukungi(Engineer)
Mr. Wairegi	Njabini
KARI-subcenter	Njabini
KARI-Tigoni	Tigoni

2.2.4 Data collected during storage

- At the end of storage:
 1. Sprout length
 2. Total weight loss
 3. Shrinkage
 4. Overall acceptability of tubers as seed.
- ❖ Four panelists familiar with potato seed tuber quality used a 9-point scoring scale to evaluate tuber shrinkage (firmness) and overall acceptability of the seed.
- ❖ 1 = least acceptable, 9= most acceptable, 5.0 ≤ acceptable.

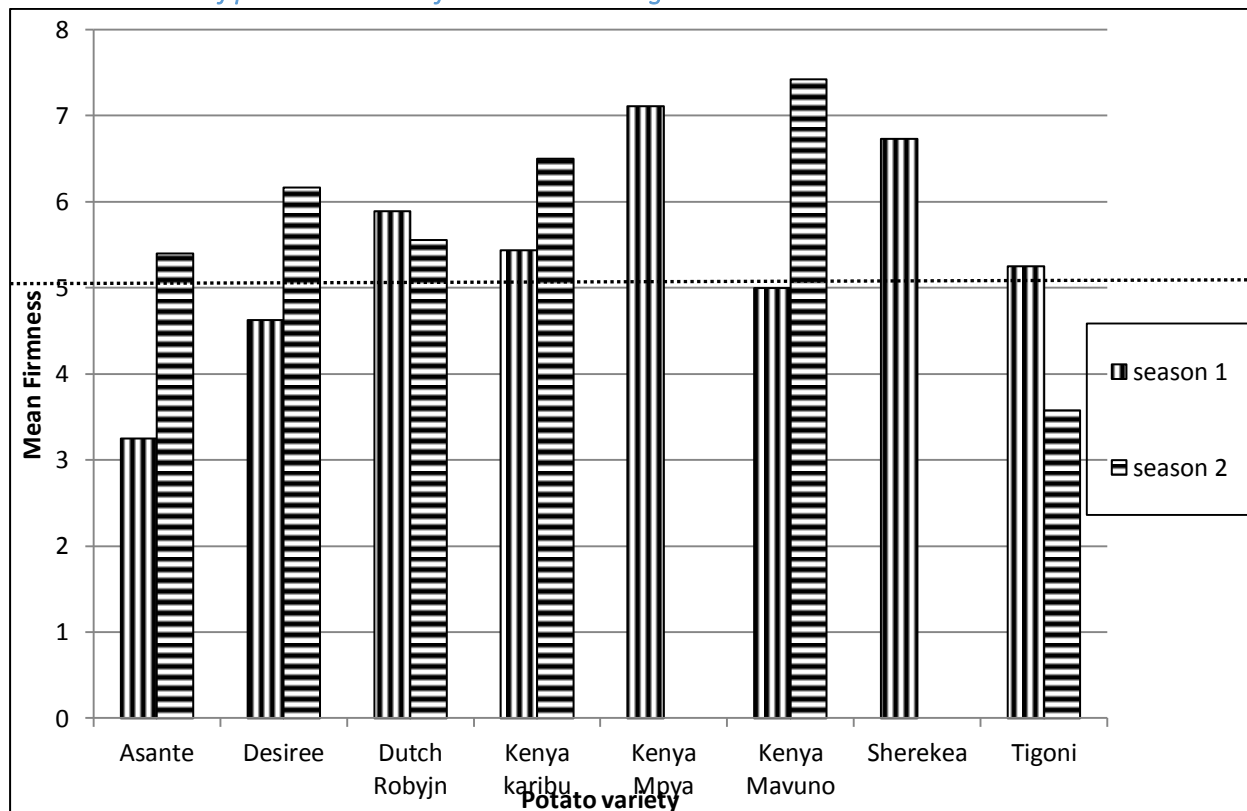
2.2.5 Data collected in the field

- Number and weight of tubers per hill; weights of various categories of tubers. i.e. ware (>60mm in diameter), seed (28-60mm) and chatts (<28 mm).
- Genstat statistical package, 14th edition and means separated using Tukey's Test at 5% .
- Weather data was collected from the nearest meteorological stations which were less than 300 meters from the experimental sites.

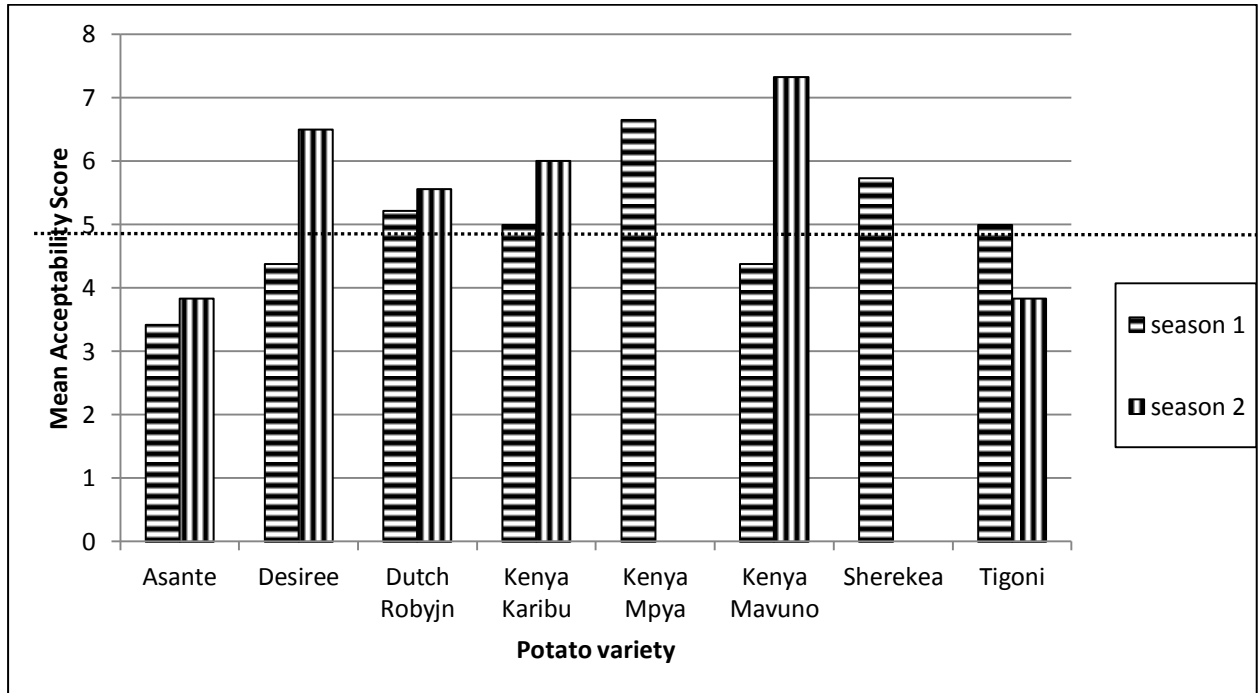
2.2.6 Results

- Most varieties had acceptable firmness after 8 month storage
- Most had overall good acceptability as seed
- Field establishment was good for stored seeds
- Significant ($P \leq 0.05$) differences among potato cultivars, between the storage methods and in cultivar x storage interaction in terms of total tuber yields in both seasons at KARI Tigoni.

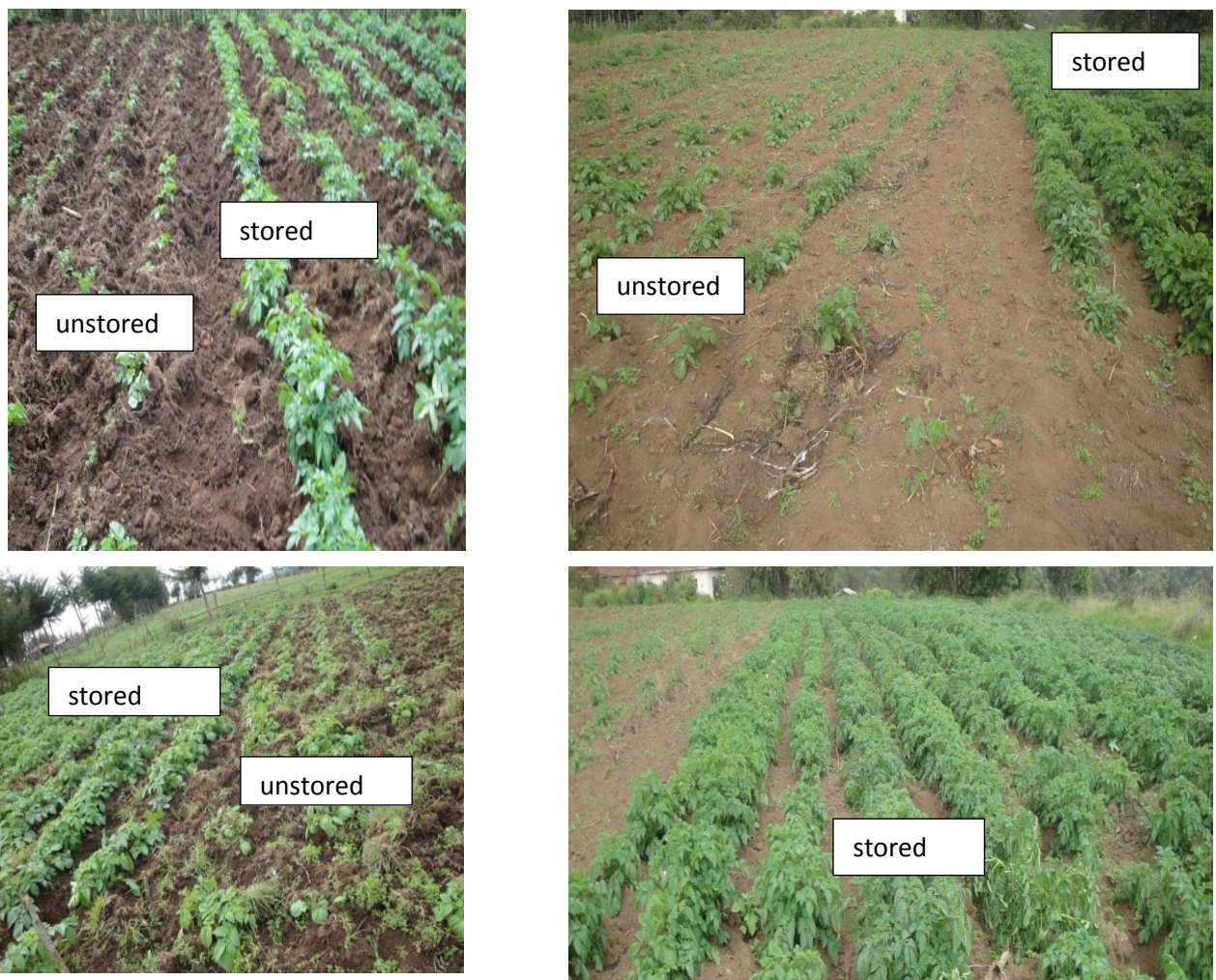
2.2.6.1 Firmness of potato varieties after 8 month storage



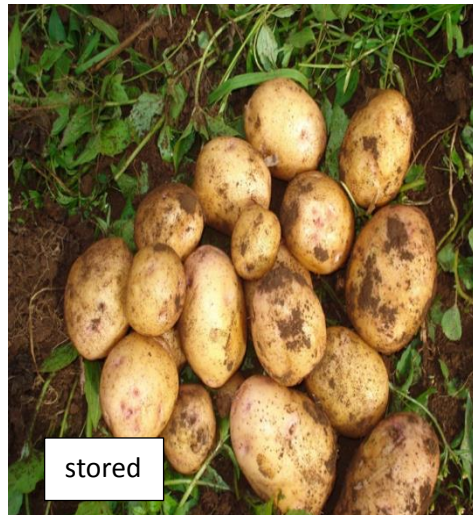
2.2.6.2 Acceptability of potato varieties after 8 month storage



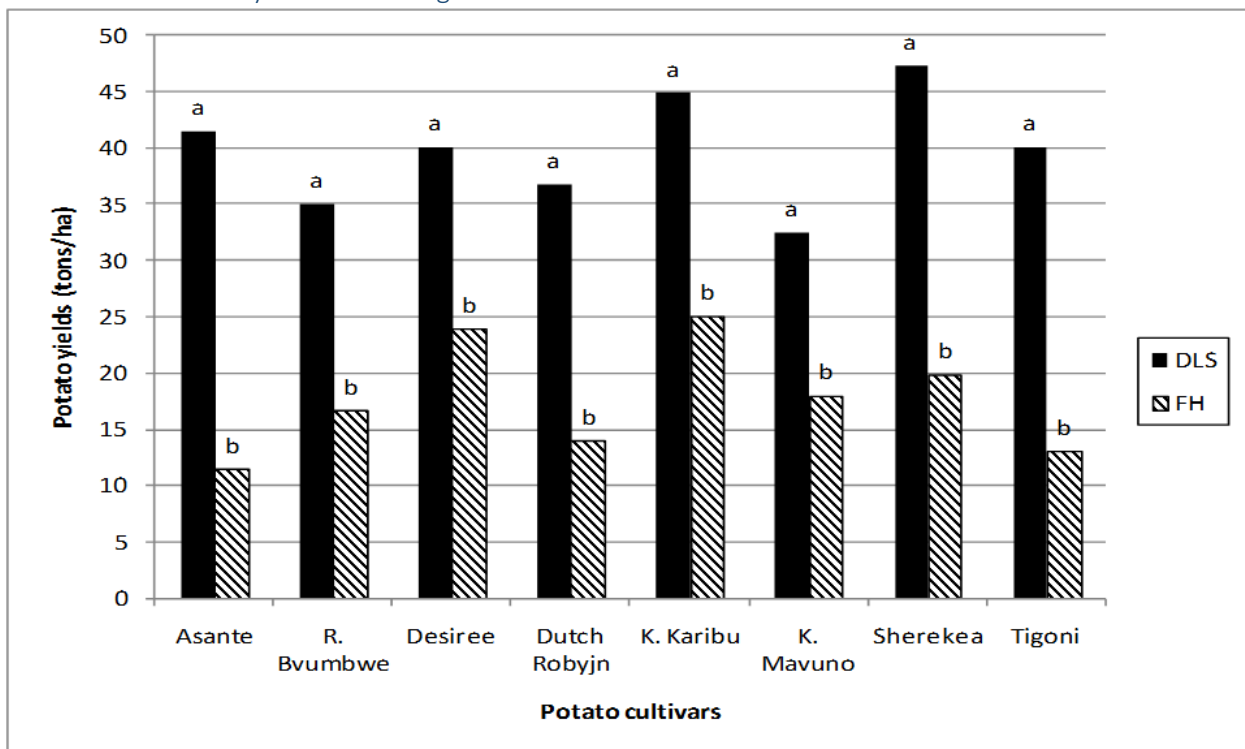
2.2.6.3 Field establishment of stored and unstored seed potato



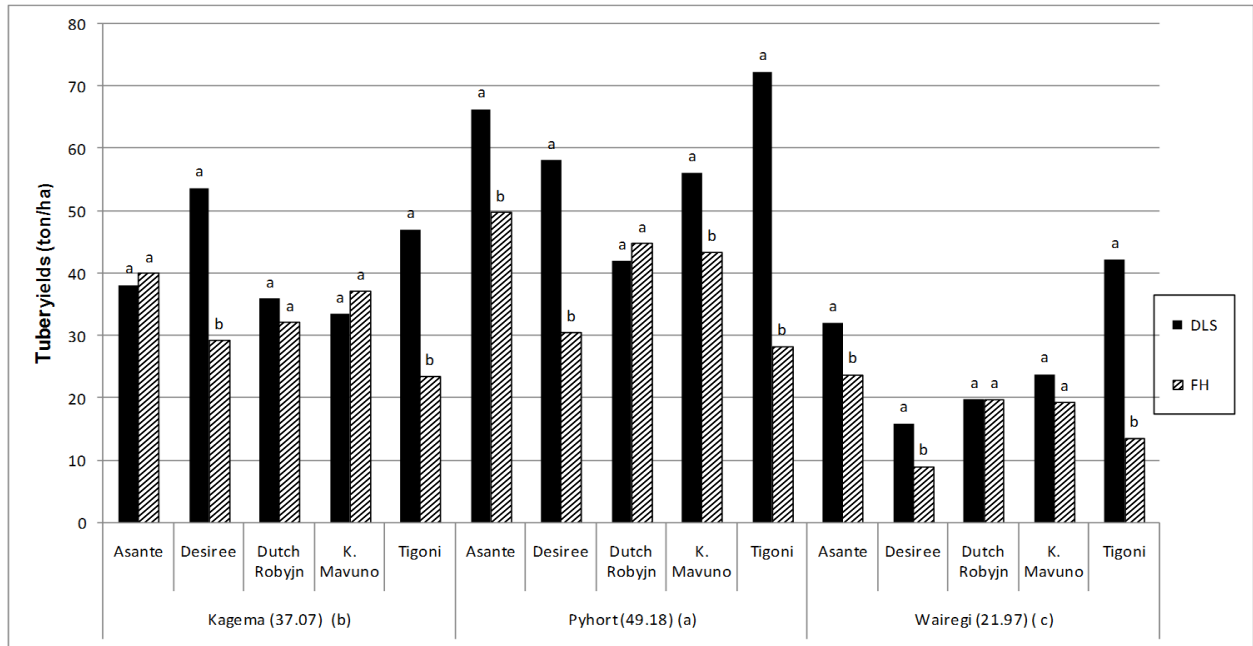
2.2.6.4 Tuber yields



2.2.6.4.1 Total tuber yields at KARI Tigoni



2.2.6.4.2 Tuber yields from selected farmers



2.2.6.5 Seed potato multiplication by farmers

- Some farmers were able to generate their own seeds from the 5 kg samples they were initially issued





2.2.7 Discussion and Conclusions

- Yield increase from planting stored seed potatoes could be due to more sprouts which eventually developed into stems: potato is a stem tuber.
- DLS could be a low cost technology for enhancing on-farm seed potato storage.
- Potato farmers in Nyandarua County may benefit from other potato varieties (besides Cangi) if they embrace on-farm seed storage using DLS.

2.2.8 Acknowledgement

- National Council for Science and Technology for funding this project.
- Staff members from KARI Tigoni, Mt. Kenya University and University of Nairobi for carrying out this project.
- Farmers from Nyandarua County who availed land and store without which the project could not have taken off.

2.3 The role of KARI-Tigoni in the potato value Chain: By Dr. Kabira & John Karinga

2.3.1 The mandate of KARI-Tigoni

- Research and development of new potato technologies.
- Multiplication of new and improved varieties.
- Supply of basic seed potatoes to certified seed multipliers.
- Maintenance of a potato gene-bank.
- Support of informal seed production

2.3.2 Challenges in the performance of the participation in the value chain:

1. Internal challenges at KARI-Station

- Lack of adequate land for seed multiplication and research.
- Frequent breakdown of infrastructures e.g. Irrigation system Lab and Cold room facilities.
- Inadequate funding for seed multiplication
- Inadequate personnel in the seed and variety development sections

2. External challenges

- Loss of high quality seed to ware potato growers.
- Entry of imported seed in the value chain.
- Low adoption of new technologies i.e DLS for seed by farmers.
- Misinformation in technology transfer.
- Frustrations of farmers by middlemen in the issue of extended bag.
- Lack of proper flow of information among the stakeholders.

2.3.3 Achievements by KARI-Tigoni

- Cleaning, multiplication and distribution of variety Cangi
- Transfer of technologies through on-station and workshop training of potato stakeholders.
- Improvement of existing infrastructure to accommodate new potato technologies
- Collection of local potato varieties from major potato growing regions for purposes of “cleaning”.
- Initiation of a local cross breeding programme

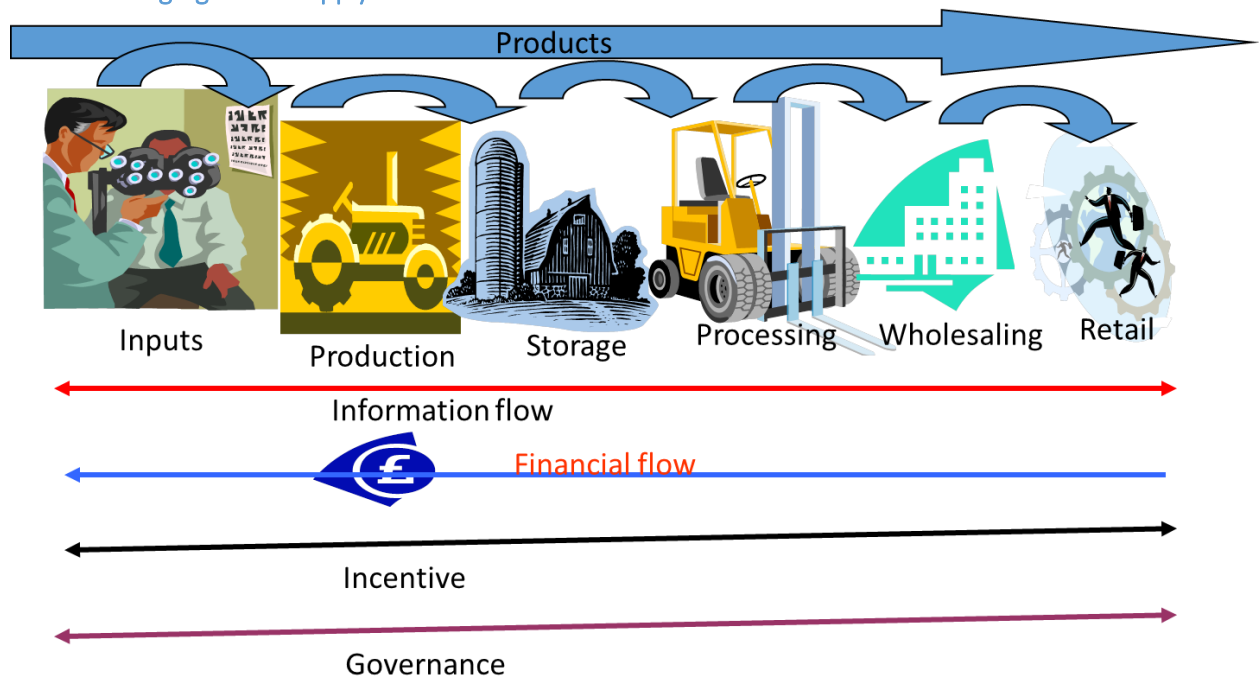






2.4 Potato agribusiness opportunities in Nyandarua County: Mr. David Kipkoeh, Agribusiness specialist, NPRC-Tigoni

2.4.1 Working Agri-food supply chain



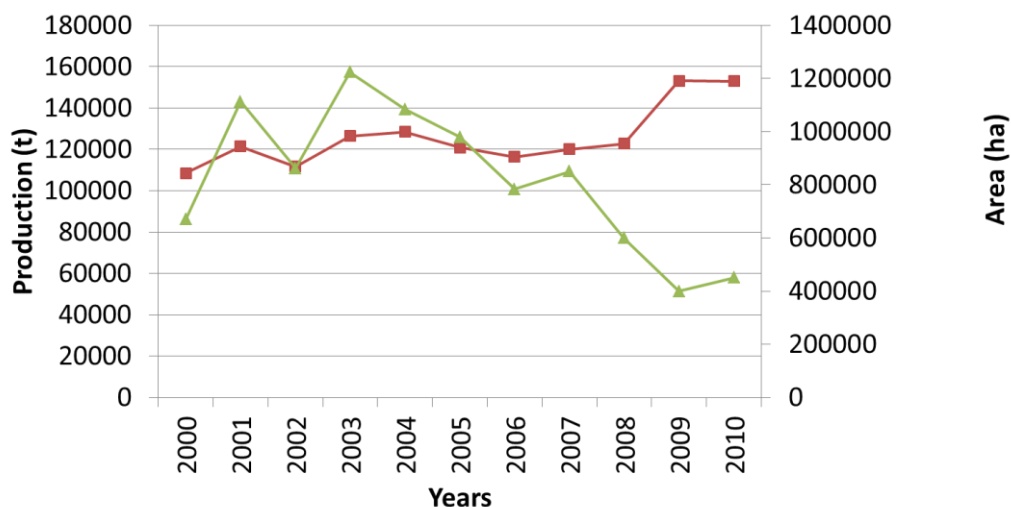
Improving production system

- ❖ Smallholder agriculture must be transformed from subsistence to a commercial and profitable agribusiness (Vision 2030)

Low Potato Productivity

Average potato production has remained low (less than 10 t/ha) compared to the average yields for Africa (10.8 t/ha), Europe (17.4 t/ha) and North America (41.2 t/ha).

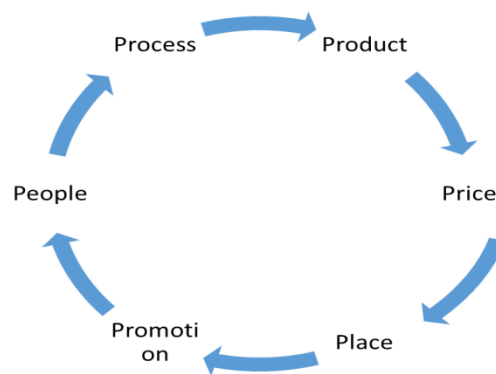
Nyandarua less than 10 t/ha



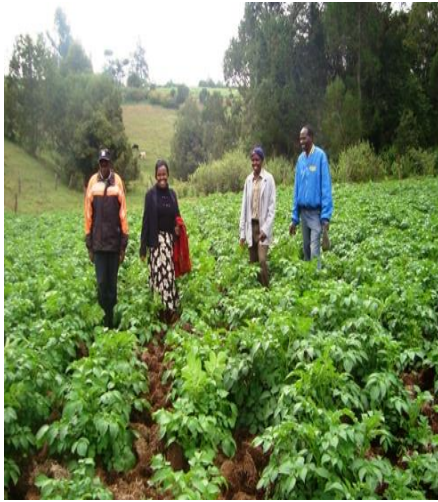
2.4.2 Major challenges in potato production in Nyandarua County

- Disorganised markets and marketing,
- Inadequate supply of quality seed,
- Low level of inputs use,
- Poor infrastructure (markets, collection centres, stores and roads),
- Low adoption of technologies (new varieties and good agricultural practices),
- Poor post-harvest management along the potato value chain,
 - Low private sector involvement in seed production, and
- High input cost

Marketing mix



2.4.3 Products from different quality of potato tubers



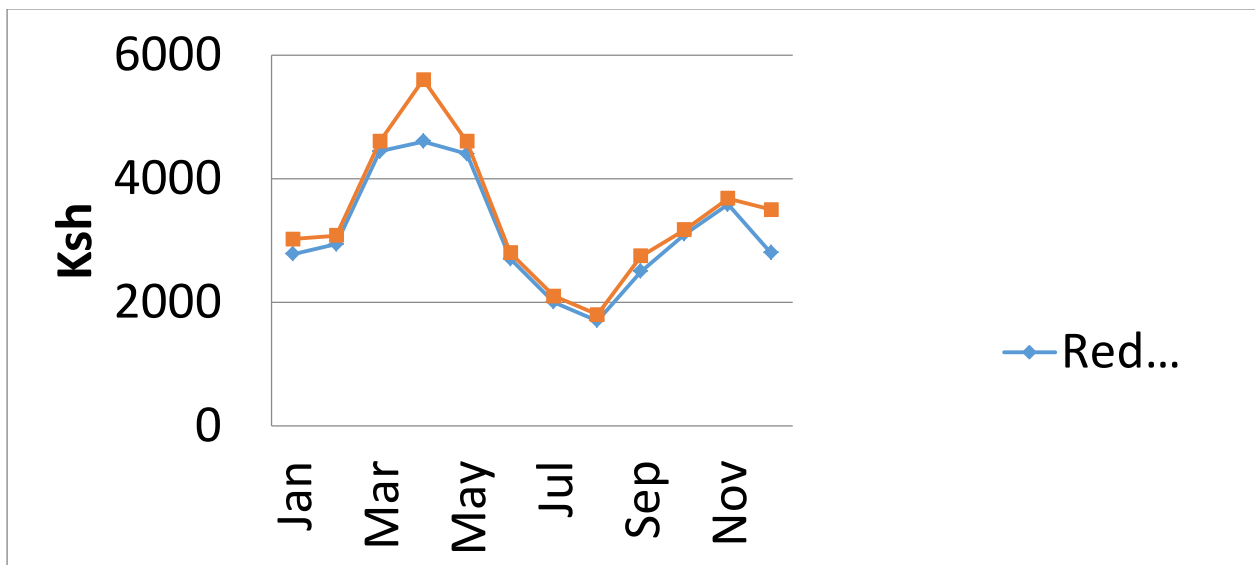
2.4.4 Potato Marketing

- Potato marketing is poorly structured and farmers generally get low returns.
- Potato supply at the local level normally follows the rainfall pattern of the area and is not a direct determinant of the selling or buying prices for potato in the area.
- Potato growers lack the ability to influence selling prices for their potatoes because; high perishability of potatoes,
- lack of adequate storage facilities
- activities of brokers and cartels that bring negative effects into the market

2.4.4.1 Seed/Ware potato awaiting transportation



Annual trends in producer prices



2.4.5 Potato marketing problems

- Poor road infrastructure hence, high cost of transportation
- Poor dissemination of market information.
- Lack of enforcement of standardized grading, packaging and weights
- Multiple taxation, in terms of CESS which is charged at different points for the same product
- Apart from farmers from Bomet there is no contract farming in potato

2.4.5.1 Issues in marketing-Price

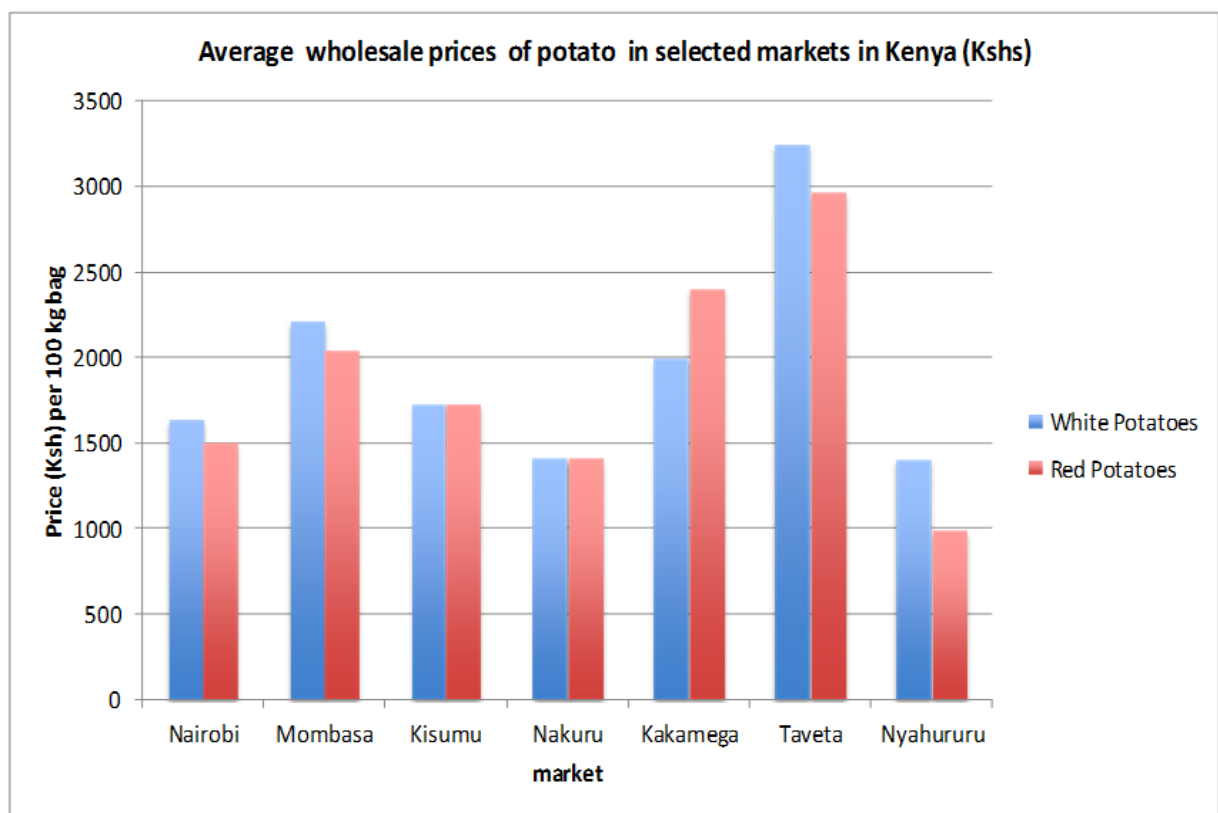
1. Farm gate potato price fluctuations affects potato production planning, stability of incomes and return on investment.

2. Seasonality of production and perishability of potato affects prices,

- storage could be used to stabilize prices but it is hardly used
- Receipt system in potato is difficult to implement due to lack of storage
- Utilization of Market Information Systems & Collection centres stabilizes prices

2.4.5.2 Markets-Place

- Market infrastructure-roads, market structures are not adequate leading to post harvest handling losses.
- Markets are not well managed to avoid unnecessary transaction costs
- Poor markets infrastructure and services leading to unnecessary transaction costs.
- Make sure markets are effective e.g Ukulima and Kongowea markets are not fitted with required equipment to handle potatoes



2.4.6 Processing and Value addition Level

- i. Potatoes are mainly consumed when boiled, fried, or mashed or in stews
- ii. Consumption is growing in urban areas and also in both traditional and non-traditional zones of production
- iii. per capita consumption of potato in Kenya is about 29.6 kg.
- iv. Processing is currently restricted to the production of snack foods such as crisps and chevera and has the following challenges;
 - Inadequate preferred varieties.
 - Inadequate product development associated with entrepreneurial skills.
 - High investment costs , particularly large industrial plants

2.4.7 What do we do?

- Potato is an important food crop and its role should inform all strategies and policies of its development.
- The industry should be transformed from subsistence to commercial oriented venture to improve income to 96% of Nyandarua residents --mainstreaming its product value chain.
- Introducing grower empowerment process like associations- is good as bargaining forum
- Production efficiency enhancement thro' technology adoption and ITK is key to potato industry development.
- Breeding for good quality processing varieties and adaptive to diff' ecological zones is important-climate change effects
- Standards in terms of packaging, grading should be followed to make potato products more competitive (Legal Notices; 144 &113,EAC Standards)
- Fragmented agricultural policies (hitherto) managed by different county government
- Streamlining irregular production, seed availability, high cost of inputs, imperfect marketing and inefficient markets & multiple taxation is a bottleneck in making potato agribusinesses more competitive.
- Linking ware producers to markets through contract farming is a prudent way to have farmers benefit from their produce
- Capacity building of farmers on potato crop husbandry: use well-sprouted quality seed of the improved varieties, good agronomic practices, proper pest and disease control measures e.g. late blight and BW, Increases production thus boosting farmers' incomes and enhances household food security.
- Irregular supply due to seasonality mainly because of reliance to rainfed production is a problem –irrigated production is necessary
- Storage of potatoes need be encouraged to stabilize prices
- Collection centres and receipt system should be encourage (hub for ICT)
- Decentralization of seed production and distribution to cut costs of transportation of seed and its availability to ware growers.
- Globalization market needs accountability in terms of food safety, traceability and social responsibility thus farmers should be guided to achieve this.
- Efficiency in supply chain is key to achieving competitive edge in business today streamlining it is fundamental.



ASANTE



2.5 Increasing potato production Opportunities in Nyandarua County: Dr. Maina Machangi Potato Liaison Desk Horticulture Division; Ministry of Agriculture, Livestock and Fisheries

2.5.1 Introduction

- Potato is a very important crop in Kenya.
- It is both a staple food and a cash crop for many rural families and
- Ranks as the second most important food crop in the country after maize. – 1st in Nyandarua
- Grown by over 800,000 households. – 130,000 in Nyandarua
- The subsector employs 2.5 million people
- a short cycle crop with high productivity per unit of land and time,
- it is a major source of food security, income and nutrition
- The ministry and the stakeholders have therefore put concerted efforts to promote it
- Thus increased production of potatoes from an area of 135,924 Ha and a production of 2.6 million MT valued at Ksh. 42 Billion in 2011 to 143,325 Ha (27,520 Ha Nyandarua) in 2012 with a production of 2.9 Million (.8M Nyandarua) MT valued at 50 Billion. – (11 B Nyandarua)

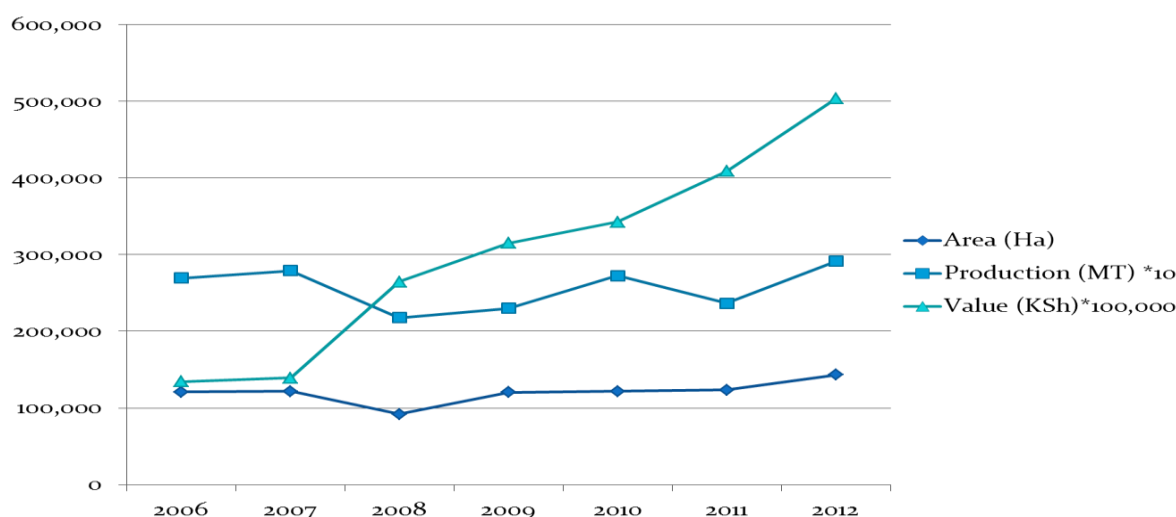


Fig 1: Potato area, production and value trends (2006-2012)

2.5.2 Challenges

Potato industry has faced a number of challenges that include:

- Low yields,
- high disease incidences,
- lack of suitable varieties
- Limited production, distribution and use of quality seeds
- Low value addition and limited agribusiness activities
- Improper agronomic practices, ineffective and inappropriate disease control measures
- Pre- and post-harvest management problems (harvesting of immature tubers, insufficient or no tuber curing, poor handling of tubers, inappropriate packaging, poor or no storage,

- Inefficient and exploitative marketing practices
- Potato growers lack the ability to influence selling prices for their potatoes for reasons including; high perishability of potatoes, lack of adequate storage facilities and the high influence of brokers and cartels that bring negative effect into the market.
- Over 80% of commercially marketed potatoes go through brokers at both ends of the marketing channel.



2.5.3 Ministry's interventions

- Efforts have been undertaken by National government, stakeholders and development partners to address some of these challenges
- Recent initiatives include introduction of rapid seed multiplication technology (Aeroponics),
- Training on alternative seed production methods (seedplot, Clean and positively selected seeds) and private sector involvement in basic seed production
- The following efforts have been put towards the improvement of the Potato Industry;
- Potato Storage and Seed Multiplication has been improved through rehabilitation of the ADC Molo Potato Cold Stores,
- Construction and equipping of Potato Tissue Culture Laboratories, and
- Construction of at least 200 partly subsidized Diffused Light Stores (DLS) at farm level
- Trained our extension staff, farmers, and seed potato multipliers countrywide. The Ministry recently (April/May 2013) trained 80 crops officers (12 Nyandarua) from 36 major potato growing sub-counties (5 Nyandarua) and 7 Agricultural training Centres (ATCs) (2 Nyandarua) on good seed potato management practices.
- These officers then recruited and trained 10 to 20 potential seed potato growers from each of the 36 counties (No report from Mirangini) who are expected to engage in clean/certified seed potato production to make seed potato available close to the farmers.
- 16 Nyandarua staff from all the 7 districts also trained last year on Seed potato storage through the NACOSTI sponsored seed potato storage project
- In the last 3 years (2011 to 2013), the Ministry has also funded 6-10 ATCs (2 from Nyandarua) to the tune of Ksh. 30 million to carry out seed potato multiplication.

- The Ministry also issued 1,100 bags of 50kg certified seed potato (purchased from ADC Molo at Ksh 2million) to 25 districts (3 in Nyandarua) in the long and short rains 2012 to promote use of certified seed potato by farmers for increased potato yields.
- Through collaboration with International Potato Center - CIP and USAID we have rehabilitated tissue culture laboratory, in KARI Tigoni, and installed Aeroponic facilities in order to increase the availability of potato mini-tubers.
- We have also issued funds to 3 ATCs (1 in Nyandarua) to buy the Minitubers and start producing own basic seed potato

GROWING POTATOES IN MID-AIR: AEROPONICS a technique that has helped increase basic seed potato production in the country. Used in KARI, Suera farm, Kisima farm, Oserian farm, GTIL, ADC and Kephis PQS station in Muguga



Mini tubers from aeroponics



- On provision of a favourable Legal and Policy framework, a draft Potato Strategy and Legal Notice No. 44 on proper packaging of potatoes are in place though they require enforcement by the County Governments.

- The legal notice has recently been revised to adjust the packaging of ware potato to a maximum of 50kg sisal/jute bags and seed potato to 50kg, 25kg and 10kg packages and this is awaiting gazettelement.

2.5.4 Discouraged Practices: Extended Bags



2.5.5 Way forward

With over 90% of Agricultural functions now devolved to the Counties, several of the above activities such as provision of certified seed will be done by the county governments.

The Ministry headquarters will however continue to support the counties where necessary e.g in the provision of basic seed potato to boost certified seed production.

Nyandarua County government has already forwarded a proposal on seed potato production in the country for support by the Ministry.

Other areas of collaboration will be on issues of policy and capacity building which are still part of the functions of the National government.

3.1 POTATO BREEDING IN KENYA: DEVELOPING VARIETIES WITH HEAT TOLERANCE AND HIGH MARKETABILITY FOR PROCESSING AND DOMESTIC CONSUMPTION

3.1.1 Overview of potato research in Kenya: Gaps and opportunities for research

Introduction

Potato is grown mainly by small scale farmers as a cash and food crop and therefore plays an important role in food and nutrition security (MoA, 2005; 2008)

Potato is grown by about 800 000 farmers, on 158 000 hectares, with an annual production of between 1 to 2 million tons in two growing seasons (Riungu, 2011)

The sector employs 2.5 million people at all levels of the value chain

The sector is valued at KES 46 billion at consumer level and KES 12 billion at farm gate in Kenya.

Traditionally the growing area are characterized by cool temperatures with high rainfalls of at least 1000mm per annum and are situated at altitudes between 1500 and 3500 meters above sea level

But increasing population and consequent diminishing land sizes in these areas, has led to migration to the lower, less agricultural potential areas, where the migrants have moved with their cropping systems including the potato.

Sources of germplasm are mainly imported clonal material or introduced from European or CIP varieties. Most of these (27 varieties) are not well adapted to the Agro-climatic conditions where they are now being grown.

Little resistance to late blight (caused by *Phytophthora infestans*) leading to low productivity of less than 10 tons/ha

There are numerous local varieties grown by farmers with high rate of adoption compared to formally released varieties, **which strategy do we put in place to enhanced improved varieties?**

Potato problems

Why potato production in Kenya is is uncompetitive- low productivity?

- poor quality seed potato (Kinyua et al., 2001);
- high incidences of diseases (Olanya et al., 2001, Kaguongo et al., 2008; Muthoni et al, 2014);
- expensive certified seed (Ng'ang'a et al., 2003);

- imperfect marketing systems and policies (Gildemacher et al., 2007, Barker 2008, GoK, 2009; Nderitu, 2010);
- limited varietal pool for processing (Kabira and Berga, 2003);
- farmers' production inefficiency (Kipkoech et al., 2008, 2013a) ;
- Low use of improved innovations and technologies along potato product value chain (CIP, 2008).

Efforts to boost seed access to farmers

- Use of novel technologies e.g. aeroponics and hydroponics in minitubers production (CIP, 2008),
- Improved own saved seed using positive selection (Gildemacher, et al., 2007),
- Seed plot technique (Kinyua et al., 2005)
- On-farm seed storage using low cost diffused light store (CIP, 1997),
- 3-generation seed system (CIP, 2011),
- Contract farming as a 'supply pull' (Kipkoech et al., 2013b).

Low cost diffused light store



Why then is productivity is low?

Scenario at farm level and along the entire value chain is different due to limited adoption rate of the novel innovations partially due to;

- Technical,
- Economic,
- Organizational and
- Institutional



Challenges in production

- Low yield
- Poor agronomic practices
- Climate change
- High cost of inputs
- Dependency on rain-fed production



Challenges in marketing

- Packaging (Unstandardised)
- Poor road and market infrastructure
- Inadequate marketing information system
- Disorganised marketing system
- Lack of grading and sorting at all level of supply chain
- Cartels in marketing points



Challenges in processing

- Poor quality products
- Few processing varieties
- High cost of processing equipment
- Tedious product certification process



Opportunities in research

- There is increased demand for quality seed and ware potatoes due to awareness, urbanization and changes in population lifestyle- **customise the potato products by doing market differentiation and segmentation?**
- There is energised private sector players' interest in potato production- **how to research tap on the situation?**
- Accessible regional market due to adoption of seed EAS standards- **innovate to fit?**
- Farmers' varieties are currently the most preferred in the market compared to formally released ones, **why?**
- Participatory breeding approach of new potato cultivars is a new way of entering to the market, **Is it?**

- There are many improved varieties introduced to the country to supplement the national seed programme. But few of the introduced varieties made it at farmer's field, the rest failed farmers commercialization test
- **What innovative system approach (ISP) needed to be in place to enhance adoption and diffusion of new technologies and innovations?**
- Globalisation is the driving force in research
- Most of the research on technology and innovation are done within regional bounds, but one of the main challenges of the future is to analyze issues of research and development a broader context
- There is a push by international entrepreneurs to globalize seed production
- Adopt UPOV regulation,
- Consumer concerns (phytosanitary and food safety)
- Efficient product supply chain (make research more responsive to chain actors' demand)

Conclusion

Finally,

'innovation, whether dominantly technical, organizational or institutional, most often require a successful combination of changes in hardware (technological change), software (knowledge and mindset required to make it work), orgware (forms of organization, rules of interaction, and norms) (Leeuwis and Aarts, 2011; Smits, 2002)'.

3.1.2 Potato production constraints in Kenya

- Low soil fertility
- Inadequate supply of certified seeds
- Diseases
- Low and erratic rainfall
- Inability to produce three crop cycles in a year in the highlands
- Migration of the people to lowlands
- Most varieties are late maturing
- Inappropriate varieties

3.1.3 Previous breeding work

- 60's and 70's: Germplasm from Europe. Fourteen commercially grown varieties released through the local National potato programme.
- 1986 to 1997: Adaptive breeding work as a collaborative project between KARI and CIP.
 - Highland stations of Tigonu and Mau Narok
 - Mid-altitude stations of Embu, Kakamega, and NARL
 - low-altitude stations of Mtwapa, Shimba Hills and Katumani
 - Tigonu (for processing) and, Kenya Furaha and Asante (for domestic consumption).

Subsequent collaboration with CIP resulted in release of 7 varieties by 2013.

3.1.4 Justification for empowering local breeding initiatives

- Low adoption of formally released varieties.
 - Low adaptability to climatic conditions
 - Inappropriate qualities.

- Inadequate processing varieties
 - For chipping, crisping, domestic consumption
 - Tigoni-frozen chips
 - Dutch Robyjn-crisping (very susceptible to late blight, not high yielding, has deep eyes)
 - Need to come up with more appropriate varieties
- Use of locally adapted parents
 - Hasten adaptability of a clone to local conditions & hasten the process of variety release.
 - Control over choice of parents and selection procedure

3.1.5 Objectives

3.1.5.1 Overall objective

- To breed high yielding potato varieties with stable yields under hot dryland conditions as well as possessing good processing quality.

3.1.5.2 Specific objective

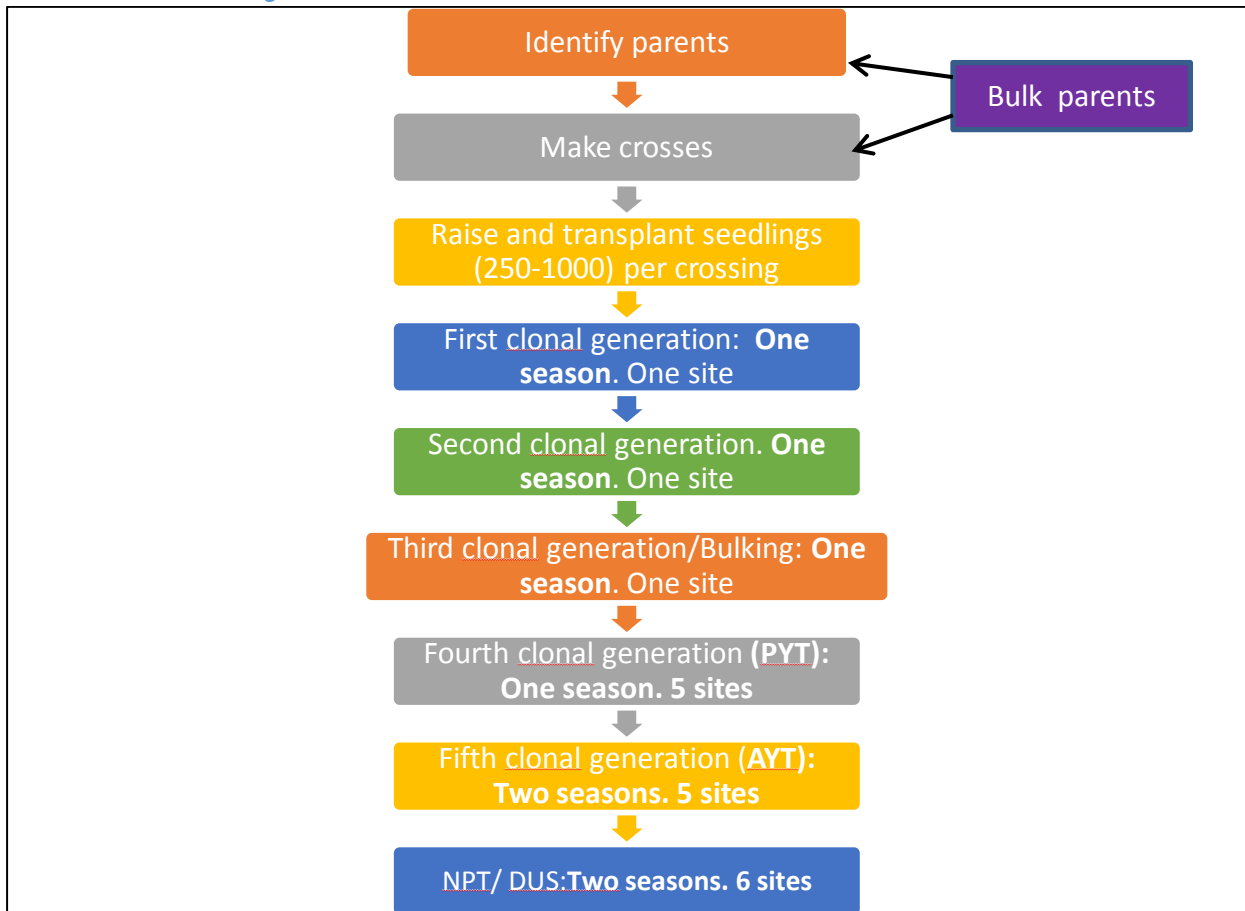
- Produce and distribute disease-free seeds of popular farmers' varieties.
- Breed for heat tolerance under irrigated conditions.
- Develop high yielding, high dry matter potato varieties for chips/crisps.
- Develop early maturing and short dormancy potato varieties for household food security.
- Promote new potato varieties emanating from the national breeding programme

3.1.6 Methodology

- Crossing: Short rains 2012 –Done
- Seedling crop: Long rains 2013- Done
- First clonal crop: Short rains 2013- Done
 - From the first clonal crop, about 2000 samples were selected based on number of tubers per hill, tuber size, tuber shape, tuber skin colour, tuber eye depth and well as early sprouting as an indicator of early maturity.
 - Other data collected: days to 50% flowering, days to maturity, number of tubers per plant i.e. ware (>55 mm in diameter) and seed (<55 mm in diameter), weight of different tuber sizes i.e. ware (>55 mm in diameter) and seed (<55 mm in diameter), tuber shape, tuber skin colour, number of eyes per tuber, tuber eye depth and tuber skin type.
- Second clonal crop-KARI-Tigoni (Long rains 2013).
- Participatory selection, during flowering and at harvesting.
 - Scientists, processors, farmers etc
 - Cooking and processing evaluation
- Third, fourth, fifth clonal generations-Multilocational trials
- Sixth, seventh, eighth clonal generations- NPT/DUS- KEPHIS.

- Alongside this process, further crossing, evaluation and selection will be conducted continuously and in a cyclic manner to improve on candidate clones and to create more variability.

3.1.6.1 Potato breeding scheme



3.1.7 Tentative work plan

Season	Short rains 2014)	(Long rains 2015)	(Short rains 2015)	(Long rains 2016)	(Short rains 2016)	(Long rains 2017)
Activity						
	Participatory selection of promising clones at various sites (Multilocal and on-farm trials) including hot and dry conditions	Participatory selection at various sites (Multilocal and on-farm trials) including hot and dry conditions	Raising of the seedling crop	Submission of the best clones to NPT/DUS (KEPHIS)	NPT/DUS (KEPHIS)	NPT/DUS (KEPHIS)
		Additional crossing and back-crossing to improve on selected clones. Further crossing to generate variation.	Participatory selection at various sites (Multilocal and on-farm trials) including hot and dry conditions	Participatory selection at KARI-Tigoni	Participatory selection at various sites (Multilocal and on-farm trials) including hot and dry conditions	Participatory selection at various sites (Multilocal and on-farm trials) including hot and dry conditions
Financial year	2014-2015	2014-2015	2015-2016	2015-2016	2016-2017	2016-2017

	2014		2015		2016		2017		2018	
	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR
Output 1. Farmers' popular potato varieties collected, characterized and, disease - free seeds of acceptable varieties multiplied and distributed										
Collect farmers potato varieties in 13 major potato producing counties										
Clean the collected varieties through heat treatment to remove viruses, nematodes and bacterial wilt										
Bulk the clean materials at KARI-Tigoni										
Evaluate the varieties for field performance, tuber storability, cooking and processing quality and other tuber characteristics for one season at KARI-Tigoni.										
Bulk for NPT/DUS										
NPT/DUS trials for two seasons (KEPHIS)										
Bulk for release										
Conserve the germplasm in situ and ex situ using laboratory, green house and fields.										

	2014		2015		2016		2017		2018	
	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR
Output 2. Potato varieties with heat tolerance developed										
Bulk the selected parents (select the parents from germplasm currently being screened by National irrigation board at Bura and Perkerra irrigation schemes.)										
Cross the selected parents										
Raise the seedling crop and transplant in the field at KARI Tigoni. Keep one tuber per plant.										
Evaluate the first clonal generation crop (FCG) under irrigation at Bura and Perkerra irrigation schemes. Conduct participatory selection of the best plants for one season										
Evaluate the selected plants in SCG under irrigation at Bura and Perkerra irrigation schemes. Conduct participatory selection of the best clones for one season										
Bulk the selected clones at KARI Tigoni										
Evaluate the selected clones in PYT at Bura, Perkerra, Mwea and Kano irrigation schemes for one season. Conduct participatory selection of the best clones										
Evaluate the selected clones in AYT at Bura, Perkerra, Mwea and Kano irrigation schemes for two seasons. Conduct participatory selection of the best clones										
Conduct NPT/DUS trials for two seasons (KEPHIS)										
Bulk for release										

	2014		2015		2016		2017		2018	
	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR
Output 3. Potato varieties with high yields and high dry matter developed for chips/crisps										
Screen potential parents for high yields and high dry matter content at KARI-Tigoni. Select										
Cross the selected parents										
Raise the seedling crop and transplant them in the field at KARI-Tigoni. Keep one tuber per plant										
Evaluate the FCG at KARI-Tigoni. Select the best plants.										
Evaluate the selected clones in SCG at KARI-Tigoni. Conduct participatory cooking and processing quality assessment. Select the best clones.										
Bulk the selected clones at KARI-Tigoni										
Evaluate the selected clones in preliminary yield trials (PYT) (minimum 5 sites) at KARI-Tigoni, Kibirichia, Molo, Narok and Timau for one season. Conduct participatory selection.										
Evaluate the selected clones in advanced yield trials (AYT) (minimum 5 sites) at KARI-Tigoni, Kibirichia, Molo, Narok and Timau for two seasons. Conduct participatory selection.										
Conduct NPT/DUS trials for two seasons (KEPHIS)										
Bulk for release										

	2014		2015		2016		2017		2018	
	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR
Output 4: Early maturing, short dormancy good quality potato varieties developed										
Screen potential parents for high yields and high dry matter content at KARI-Tigoni. Select										
Cross the selected parents										
Raise the seedling crop and transplant them in the field at KARI-Tigoni. Keep one tuber per plant										
Evaluate the FCG at KARI-Tigoni. Select the best plants.										
Evaluate the selected clones in SCG at KARI-Tigoni. Conduct participatory cooking and processing quality assessment. Select the best clones.										
Bulk the selected clones at KARI-Tigoni										
Evaluate the selected clones in preliminary yield trials (PYT) (minimum 5 sites) at KARI-Tigoni, Kibirichia, Molo, Narok and Timau for one season. Conduct participatory selection.										
Evaluate the selected clones in advanced yield trials (AYT) (minimum 5 sites) at KARI-Tigoni, Kibirichia, Molo, Narok and Timau for two seasons. Conduct participatory selection.										
Conduct NPT/DUS trials for two seasons (KEPHIS)										
Bulk for release										

	2014		2015		2016		2017		2018	
	LR	SR	LR	SR	LR	SR	LR	SR	LR	SR
Output 5. New potato varieties emanating from the national breeding programme promoted										
Bulking of pre-basic and basic seed										
Develop a new potato varieties catalogue										
Recruitment of seed multipliers in various counties										
Linking of seed multipliers to ware potato growers										
Link ware potato growers to the market										
Awareness creation on new potato varieties through mass media, e-platforms, SMS platforms, shows, field demonstrations etc.										
Monitoring and evaluation on marketing of new potato varieties										