Research Article

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Effect of Site and Variety on Yield of Seed Potato in the North Rift Region of Kenya

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Abstract: Potato is Kenya's second staple food crop, grown by small scale farmers who recycle seed due to unavailability of certified one, resulting in diseases build-up that reduces yields. The subdivision of once seed farms and change of use in the 1980's effectively limit availability of suitable land for seed production against high demand of quality seed. Hence search for alternative sites in the North Rift for seed production are being explored. However, current varieties in commercial production were not evaluated for their performance in this region. The objectives of the study were to identify suitable potato varieties for seed production and for which elevation in the region.Well sprouted seed tubers of six local varieties were planted at Kitale (1901 m), Kapcherop (2386 m) and Kibigos (2887 m) above sea level following recommended management practices. Plant emergence was slowest at Kibigos while fastest at Kitale. Stem density varied with varieties and attained maximum numbers at 56 days after planting. Most of the varieties had 80% of tubers in seed grade 70 days after planting at Kitale. Introduction of potato varieties should be preceded by evaluation for their performance as some varieties seem more suitable while others do well across the sites for seed production. In cooler areas like Kapcherop and Kibigos potato tubers remain younger, emerge slowly compared to warmer areas, but attain maximum emergence 30 days after planting. Some varieties like Dutch Ronjin, have high number of tubers in seed size category while some have more ware size potatoes grown in same elevation for the same growth period.

Keywords: Potato, Variety, Performance, Seed size, North Rift and Region

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1 Introduction

Potato crisps and French fries are fast becoming major potato products in Kenya due to diversifying consumption preferences especially by the youth. Consequently, international hotels like Kentucky Fried Chicken, Chicken Inn have established units in response to anticipated demand trajectory of potato products (Janssens et al. 2013). Potato crop is largely grown by small scale farmers who are over 800,000, produce 2.06 metric tonnes of potato annually value at Ksh. 28.2 billion at consumer end (Anon. 2013). Potato is a highly productive crop per unit area, time and moisture which makes it an attractive food and income enterprise in the Kenya highlands (Gildemacher et al. 2007). However, yields average 7.7 t/ha against potential yield of 40 t/ha (FAO STAT, 2008). The low yields are due to poor quality seed and agricultural practices, low soil fertility and limited use of fertilizers (Kaguongo et al. 2008). It has been established that seed from formal certification system contributes about 1% of potato seed, highly priced and unavailable (Ogola et al. 2012), 3% from semi-informal and the bulk (96%) from informal (Kaguongo et al. 2008).

Seed potato production at independence (1963) was by state farms in the highlands of Rift Valley and Central Provinces. These farms would produce all certified seed derived from the breeders' seed which originated from the public research station at Tigoni. Marketing was entirely by Kenya farmers' Association through its nationwide network. Mid 1980s and 1990s saw change in land policy by the government where these farms were sub divided and allocated to individuals. The new owners even went further and subdivided into small parcels and often changed use to non-agricultural, thus limiting land availability for seed production while demand for ware potatoes was on growth trajectory. To meet the rising demand, ware producers resorted to use of farm saved seeds or road site purchases which status could not be ascertained. This has necessitated the search for new areas to bulk seed potato in the North Rift where potatoes have not been extensively grown. There is limited information on the suitable varieties

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because the current ones were not evaluated in the region. The objectives of the study were to identify suitable potato varieties that can be grown for seed and further consider which varieties and preferred at different elevation.

2 Materials and methods

2.1 Experimental design, Field lay out and Parameters measured

Initial well sprouted tubers of Asante, Dutch Robjin, Kenya Baraka, Kenya Karibu, Tigoni1, and Roslin Tana were planted at Kitale. In the second planting, seed tubers from the Kitale site were planted at Kapcherop, Kibigos and also Kitale. Land preparation was performed by digging using a hoe to a depth of 30 cm, raking out weeds and the plots were levelled.

At all the sites, three blocks were demarcated measuring 8.75 m long (inclusive of 0.5 m in between the plots) by 2.5 m wide along the contour. Plots of 1.25 m^2 were then measured in the blocks which resulted in to six plots per block. Furrows were then made at 75 cm apart and to a depth of 10 cm in each plot. Application of 25 gm diammonium phosphate fertilizer was spread per 1.25 m length of the furrows (rate of 27 kg N and 75 kg P_2O_5 per hectare) and mixed with soil. Randomization of the potato varieties was achieved by using random numbers to assign them to plots in the block and replicated three times. Well sprouted tubers of each variety were planted at the designated plots at a spacing of 75cm between rows and 25 cm within the rows. Each plot had five rows and total of twenty five tubers per plot were planted with their rose ends facing upwards. The tubers were covered by soil to leave a raised ridge. A further two rows of tubers were planted around the experiment to serve as guard rows.

Weeds were controlled by tilling using a hoe at 30 and 40 days after planting each time raising the soils (earthing) until the canopy closed, thus, limiting any weed growth. Control of leaf diseases was done by first spraying with Dithane M 45® (protective fungicide) followed by Ridomil® (curative) when symptoms of late blight was noticed. Six sprays were done at 7-10 days interval depending on the weather condition and late blight pressure. In overcast days with high rainfall, humidity and cold nights, spraying was done after seven days whereas, when weather was sunny and no rains, it was sprayed at ten days interval. Various parameters were measured at specific days during the experimentation period

On the 14th day after planting the number of emerged tubers were taken by counting the plants per plot and followed at 14 days interval till 42 day after planting. Stem density was done at 56 days after planting by counting total stems per metre square at random from any position within the inner three rows. This was followed by dehaulming at 75 days after planting when the leaves turned yellow and tubers left in the soil for three weeks to harden and hence reduce damage during harvesting. Finally, potatoes were harvested by lifting the tubers from the three inner rows and counting them per plant before seed grading into chats (less than 28 mm), size I (28-45 mm), size II (46-60 mm) and ware (> 60 mm) in diameter. Total tuber weight per plot was taken followed by those tubers in seed size grade 28-60 mm. The per cent by weight of tubers in seed size category compared to total tuber yield was also computed.

2.2 Data analysis

Collected data were entered in the Excel and analysed according to Sheffe's statistical procedure (Ott, 1988) using SAS 9.3 Software. The results on Analysis of Variance, Coefficients of Variations (C.V. %) and standard error (S.E) were tabulated. Means were separated using minimum critical differences (MCD).

Ethical approval: The conducted research is not related to either human or animal use.

3 Results and discussions

In the first 14 days after planting (DAP), all the varieties had attained 80% emergence at Kitale while it had reached 50% emergence at Kapcherop and only 8% at Kibigos. However, 14 days later, all varieties were over 85% emergences, except Roslin Tana at Kapcherop and Kibigos. At 42 DAP, in Kibigos all varieties had 95% emergence while at Kitale's (86%) and Kapcherop's (92%) (Table1).

Table 1: Influence of site on seed potato emergence (%)

	Days after planting		
Site	**14**	**28**	**42**
Kitale	81a	85a	86b
Kapcherop	48b	85a	92a
Kibigos	8c	92a	95a
C.V. %	21	9	10
S.E.	0.6	0.5	0.6
MCD	17.17	7.35	5.76

* Values with same letter along each column are not statistically different at $p \leq 0.05$ according to Sheffe's test.

MCD refers to minimum critical difference

Plant emergence and establishment is influenced by many factor such as soil temperature, soil moisture and variety, among others. Cool temperatures in high altitudes affect the time it takes for potatoes to emerge compared to warmer soil conditions in lower altitudes. This was demonstrated at Kitale (1,901 m) where all potato varieties emerged fastest followed by those at Kapcherop (2387 m) and slowly in Kibigos (2,886 m) in the first 14 days since planted. However, two weeks later, those planted in cooler soils emerged rapidly and attained the highest per cent plants per plot compared to those at other elevations. This could have been associated with warmer conditions at Kitale compared to cooler days at the other sites resulting in tuber breaking dormancy early and advance sprouting as some were at branching physiological stage by the time of planting. The rapid emergence later at Kibigos and eventually attaining the highest plants could have been that tubers were more vigorous while those at Kitale had lost some vigour.

Dutch Robjin was statistically different from the rest of varieties in the number of stems/plant while Tigoni1 and Kenya Karibu were similar ($p \leq 0.05$). Asante and Roslin Tana were also similar but the least was Kenya Baraka.

In terms of tuber yield per unit area, Kenya Karibu and Roslin Tana were statistically similar ($p \leq 0.05$) but differed from Asante, Dutch Robjin, Kenya Baraka and Tigoni1. Consequently, when the percent proportion of tubers in seed size grades were compared, Dutch Robjin, Asante and Tigoni1 were statistically different from the other varieties ($p \leq 0.05$). Roslin Tana had the least tubers in seed size categories along with Kenya Baraka (Table 2).

When site and tuber yield of varieties were compared, at Kitale, Kenya Karibu was significantly different from other varieties ($p \leq 0.05$). At the same site Asante and Roslin Tana were similar in respect to tuber yield expressed per hectare while Tigoni1 was the least .At Kapcherop, Roslin Tana outperformed all the varieties followed by Kenya Karibu but at Kibigos, Roslin Tana had the highest tuber yield followed closely by Kenya Karibu. When all the sites were compared, Kenya Baraka performed the least at all the sites while Roslin Tana had the highest tuber yield per hectare (Table 3).

In tandem with plant emergence, those tubers grown at lower altitudes favoured by warmer conditions passed dormancy break and reach branching stage earlier than those at higher altitudes. When sites were compared, plants grown at Kitale had the highest number of stems per plant. When mean stem densities were compared for varieties at the various sites, Dutch Robjin and Tigoni1 had the highest number of stems per plant and the least was Kenya Baraka while the rest were in between. This concurs with the findings by Alvin et al., (2010) that stem density largely determines the plant population per unit area. Similar finding had been found by Firmann et al., (2004) when he stated that after potato plant emergence, main stems arising from the seed tuber assume independent existence from the plant resulting in a collection of competing stems.

With respect to influence of site on proportion of tubers in seed size category of the various potato varieties, at Kitale, all varieties showed over 70% of tubers in seed size categories compared to about 70% at Kapcherop while at Kibigos averaged 65%. In terms of individual varieties, Dutch Robjin had the highest tubers in seed sizes categories across all the sites followed by Tigoni1. At Kitale, varieties Dutch Robjin, Asante, Kenya Karibu and Tigoni1 attained over 80% while the rest were below

Table 2: Influence of variety on the stems/ plant, tuber yield and per cent seed tuber

Variety	Stems/plant	Tuber yield (t/ha)	Percent seed grade
Asante	5bc	22bc	63ab
Dutch Robjin	8a	16cd	80a
Kenya Baraka	4c	12d	60bc
Kenya Karibu	6b	27ab	71ab
Roslyn Tana	5bc	28a	52c
Tigoni 1	6b	18cd	70ab
C.V %	13	18	14
S.E	0.74	3.7	9.4
MCD	1.23	6.17	15.77

* Values with same letter along each column are not statistically different at $p \leq 0.05$ according to Sheffe'stest.

Table 3: Interactions between the site and variety on tuber yield (t/ha)

Varieties	Kitale	Kapcherop	Kibigos
Asante	21b	22c	22bc
Dutch Robjin	17c	22c	11d
Kenya Baraka	10d	17d	8d
Kenya Karibu	28a	27ab	27abc
Roslin Tana	23b	28a	32a
Tigoni 1	15c	23bc	16cd
C.V. %	18	18	18
S.E.	1.2	1.2	1.2
MCD	2.17	4.13	6.77

* Values with same letter along each column are not statistically different at $p \leq 0.05$ according to Sheffe's test.

75%. At Kapcherop, only Dutch Robjin and Kenya Karibu reached 60% with Kenya Baraka hardly managed 40%. Even at Kibigos, Dutch Robjin and Tigoni 1 averaged above 75% with the former reaching over 80%. Most varieties had the highest percentage in seed size category at Kitale site followed by Kibigos and Kapcherop in descending order, respectively. Kenya Karibu, Dutch Robjin, Asante and Tigoni1 were similar at Kitale but significantly differed from Roslin Tana and Kenya Baraka with respect to percent of tubers in seed size category. This was the same as at Kibigos and Kapcherop (Dutch Robjin and Tigoni 1). The least varieties were Roslin Tana and Kenya Baraka (Kapcherop and Kibigos) (Table 4).

It appears that potato productivity is affected by the variety and the site; among others. When variety parameters were compared per site, most performed better at Kapcherop than at Kibigos or Kitale. In the study, Kenya Karibu and Roslin Tana out performed Dutch Robjin and Tigoni. It suggests that Kapcherop would be considered most suitable for tuber yield compared to the other sites. These findings agree with earlier studies done in Kenya by Lung'aho et al. (2006), who reported tuber yield of 29.79 t /ha for variety Kenya Karibu. In terms of which area will be suitable for seed, tubers when graded indicated that, Kitale is better compared to Kapcherop. This could have been due to less net photosynthates yield (daily photosynthesis- respiration), initial physiological stage of the tubers planted at Kitale (already at advance sprouting stage compared to those at other sites (normal or apical dominance) could have accounted for lower tuber yields of which most were in seed sizes category at Kitale. Dutch Robjin, Kenya Karibu and Tigoni1 had high stem density which may have competed resulting in small but many tubers (Struik and Wiersema, 2012).

4 Conclusions and recommendations

Plant emergence is slow at higher altitudes but later have a better stand at plant establishment and higher tuber yield. However, different varieties vary at rate of emergence in spite of being at similar tuber size and physiological stage. Potatoes grown at lower altitudes break dormancy earlier, emerge faster, produce more stems per tuber and yield small tubers than those produced at higher elevation when planted at similar spacing. In this respect, therefore, it is imperative that before introducing commercial seed potato production, variety performance evaluation should be done to identify suitable varieties for those sites.

Conflict of interest: Authors state no conflict of interest.

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Table 4: Proportion of tuber yield in seed size category at the experimental sites

	Percent of tubers in seed size grade		
Varieties	**Kitale**	**Kapcherop**	**Kibigos**
Asante	82abc	44b	64b
Dutch Robjin	89a	66a	85a
Kenya Baraka	74bc	39b	66b
Kenya Karibu	86abc	61a	66b
Roslin Tana	69c	43b	50c
Tigoni 1	80ab	54ab	75a
C.V. %	14	14	14
S.E.	3.2	3.2	3.2
MCD	13.32	12.18	12.18

* Values with same letter along each column are not statistically different at p ≤0.05 according to Sheffe's test.

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