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Evaluation of Quality and Dormancy Period of Improved and Local Potato (*solanum tuberosum* l.) Cultivars Grown in Eastern Ethiopia

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Abstract
Field experiments were conducted at Haramaya and Hirna with the objective of assessing the quality and dormance period of local (farmers') and improved potato cultivars during the main cropping season of 2011. The treatments consisted of five released cultivars (Badhasa, Chala, Chiro, Gabbisa, Zemen) and four local (farmers') potato cultivars (Batte, Daddafa, Jarso, Mashenadima). The experiment was laid out as a Randomized Complete Block Design with three replications. Chala at Haramaya produced the highest specific gravity (1.105) and dry matter content (27.10%) and Daddafa produced lowest (1.061) and (21.05%), respectively at Hirna. Tubers of the local cultivars had generally shorter dormancy whereas tubers of the released cultivars had longer dormancy.
Keywords: potato (*solanum tuberosum* l.), yield Performance, Improved, local, Ethiopia

Introduction

Potato can potentially be grown on about 70% of the 10 million hectares of arable land in Ethiopia (FAO, 2008). The crop is currently being grown by approximately one million farmers. In Ethiopia, potato is grown in four major areas: the Central, the Eastern, the North-Western and the Southern regions, which together constitute approximately 83% of the potato farmers in the country. The Eastern area of potato production in Ethiopia mainly covers the Eastern highlands, especially East Hararghe zone (CSA, 2008/2009). The most important feature of potato production in this region is that the potatoes produced are market-oriented with considerable amounts being exported to Djibouti and Somalia (Adane *et al*., 2010). In this region, potato is mainly grown under irrigation in the dry season (December to April) because of low disease pressure and relatively high prices. The crop is also produced in the belg (February to May) season and the meher (June to October) seasons (Eshetu *et al*., 2005b)

Most potato producing farmers in Eastern Ethiopia grow local potato varieties. However, some farmers accessing the research and extension system of Haramaya University and those targeted by NGO seed programmes grow also improved varieties (Eshetu *et al*., 2005a). In addition to the high yield potential, the local potato cultivars may have other agronomic, culinary, post-harvest...etc values that are well appreciated by the farmers and consumers alike. The comparative performances of the potato cultivars released by Haramaya University and the cultivars developed by the smallholder farmers in the region are not known. In addition, little scientific information has been documented on these cultivars. For these reasons, there is a need to collect, characterize, evaluate and even promote local potato cultivars or genotypes before they become out of production (Balkaya and Ergun, 2008).

However, to date, no systematic studies have been done to investigate and document the similarities and differences on quality and dormancy period of local and improved potato cultivars grown in the Eastern Ethiopia. Therefore, this study was initiated with the objective of evaluating quality and dormancy period of the major local and improved cultivars of potato grown in Eastern Ethiopia.

Materials and Methods

Description of the study area

The study were carried out at Rare, Horticulture section's research field, Haramaya University and Hirna research site of the University under rainfed condition during the 2011 main growing season. Rare research site is located at 9 ^{o}26' N latitude, 42 ^{o}3' E longitudes at an altitude of 1980 m.a.s.l. The mean annual rainfall is 760 mm (Belay *et al*., 1998). Mean annual temprature16 °C (Mishra *et al*., 2004). The mean relative humidity is 50%, varying from 20 to 81%. The soil of the experimental site is alluvial type with organic carbon content of 1.15%, total Nitrogen content of 0.11%, available Phosphorus content of 18.2 mg kg soil^{-1}, exchangeable Potassium content of 0.65 cmol$_c$ kg soil^{-1}, pH of 8.0 and per cent sand, silt and clay content of 62.92, 19.64 and 17.44, respectively (Simret, 2010).

Hirna sub-station is located at 9 ^{o}12' N latitude, 41 ^{o}4' E longitudes at an altitude of 1870 m. a.s.l. The area receives mean annual rainfall of 990 to 1010 mm with an average temperature of 24 ^{o}C (HURC, 1996). The soil of Hirna is vertisol with organic carbon content of 1.75%, total Nitrogen content of 0.18%, available Phosphorus content of 32 mg kg soil^{-1}, exchangeable Potassium content of 0.68 cmol$_c$ kg soil^{-1}, pH of 7.09 and percent sand, silt and clay contents of 27, 28 and 45, respectively (Nebret, 2011).

Description of Experimental Material

Five potato cultivars, which were released by Haramaya University at different times and four locally available potato cultivars were used for the experiment (Table 1).

Table 1. Potato cultivars used in the study, year of release and their sources.

Variety	**Year of release**	**Source of planting material**
Chiro	1998	HUPIP
Zemen	2001	HUPIP
Badhasa	2001	HUPIP
Gabbisa	2005	HUPIP
Chala	2005	HUPIP
Source (MoARD, 2010)		
Batte	Local	RHSPC
Mashenadima	Local	RHSPC
Jarso	Local	RHSPC
Daddafa	Local	RHSPC

Key: HUPIP = Haramaya University Potato Improvement Programme
RHSPC = Rare Hora Seed Producers' Cooperative

Treatments and Experimental Design

The treatments are nine consisting of five improved cultivars (Chala, Chiro, Badhasa, Gabbisa and Zemen) and four local cultivars (Batte, Mashenadima, Jarso and Daddafa). The experiment was laid out as a Randomized Complete Block Design (RCBD) and replicated three times. Each plot was 3.60 m x 4.50 m = 16.2 m^2 wide consisting of six rows, which accommodated twelve plants per row and thus 72 plants per plot. The spacing between plots and adjacent replication were 1 m and 1.5 m, respectively. There was a total of 669.3 m^2 area for experimental site.

Experimental Procedures

The experimental field was cultivated by a tractor to a depth of 25-30 cm and levelled and ridges were made by hand. Medium sized (39-75 g) Lung'aho *et al*., (2007) and well sprouted tubers were planted at the sides of ridges at the spacing of 75 cm between ridges and 30 cm between tubers. Planting depth was maintained at 5 cm (Mahmood *et al.,* 2001). Phosphorus fertilizer at the rate of 92 kg P_2O_5 ha^{-1} in the form of Diammonium Phosphate (200 kg ha^{-1}) was used and the whole rate was applied at planting. 75 kg Nitrogen ha^{-1} was applied in the form of urea in two splits, half rate after full emergence (two weeks after planting) and half rate at the initiation of tubers (start of flowering). Potato plants were treated with Mancozeb 80% WP at the rate of 1.5 kg ha^{-1}diluted at the rate of 40 g per 20 litre water once a week to control late blight disease.

Plant Data Collection and Analysis

Post harvest observations and measurement were taken from randomly selected plants from each plot for all characters studied. Data were subjected to analysis of variance (ANOVA) using the General Linear Model of the SAS statistical package (SAS, 2007) version 9.1. All significant pairs of treatment means were compared using the Least Significant Difference Test (LSD) at 5% and 1% level of significance.

Result and Discussion

Specific gravity and dry matter content

The main effect of cultivar and location as well as the interaction effect of cultivar and location significantly ($P < 0.01$) influenced specific gravity and tuber dry matter content.

The tuber specific gravity values of Chala (1.105), Badhasa (1.098) and Gabbisa (1.097) produced at Haramaya and that of Mashendima (1.097 and 1.091) produced at Hirna and Haramaya, respectively, were significantly higher than the tuber specific gravity values of the other cultivars grown at both locations. Most cultivars had higher tuber specific gravity values for tubers produced at Haramaya than those produced at Hirna (Table 2). The differences in tuber specific gravity among the cultivars and between locations may be attributed to genetic differences as well as environmental disparity. This suggestion is consistent with that of Booth and Lovell (1972), who reported that environmental as well as genetic differences may explain variations in partitioning of assimilates to the tubers, thereby affecting tuber specific gravity.

The cultivars also differed in tuber dry matter content across the two locations. Thus, Chala (27.10%), Badhasa (26.77%), Gabbisa (26.68%) at Haramaya and Mashenadima (26.58 and 26.39%) produced at Hirna and Haramaya, respectively, had the highest tuber dry matter content. However, at Hirna, only Jarso and Mashenadima had superior tuber dry matter contents compared to the other cultivars. The lowest dry matter content values were recorded for Daddafa, Batte and Chiro at Hirna. This indicates that the cultivars significantly differed in the production of tuber dry matter contents across the two locations, with more tuber dry matter contents being produced at Haramaya than at Hirna.
These results are in accord with the suggestions of Beukema and Van der Zaag (1979) who reported that potato tuber dry matter content and specific gravity are influenced by a large number of factors the most important ones being cultivar and environmental conditions.
Consistent with the results of this study, Burton (1966) reported that genetic differences among varieties play a role in their ability to produce high solids when grown on the same area. Dry matter content is subjected to the influence of both the environment and genotypes (Miller *et al.*, 1975; Tai and Coleman, 1999). Similar results were reported by Barrios *et al.* (1961) where the same variety grown in different locations resulted in different specific gravity.
Table 2. The interaction effect of cultivars and location on specific gravity and tuber dry matter contents of potato cultivars.

Location	Cultivars	Specific gravity	Tuber dry matter Content (%)
Haramaya	Badhasa	1.098^{ab}	26.77^{ab}
	Batte	1.086^{b-e}	25.47^{a-f}
	Chala	1.105^{a}	27.10^{a}
	Jarso	1.079^{c-g}	24.42^{d-g0}
	Chiro	1.073^{e-i}	23.21^{g-j}
	Mashenadima	1.091^{bc}	26.39^{abc}
	Zemen	1.075^{d-h}	24.16^{e-h}
	Daddafa	1.088^{bcd}	26.09^{a-d}
	Gabbisa	1.097^{ab}	26.68^{ab}
Hirna	Badhasa	1.074^{e-i}	23.75^{f-i}
	Batte	1.067^{ghi}	22.02^{ijk}
	Chala	1.082^{c-f}	25.05^{b-f}
	Jarso	1.087^{bcd}	25.72^{a-e}
	Chiro	1.070^{f-i}	22.56^{h-k}
	Mashenadima	1.097^{ab}	26.58^{ab}
	Zemen	1.064^{hi}	21.71^{jk}
	Daddafa	1.061^{i}	21.05^{k}
	Gabbisa	1.079^{c-g}	24.76^{c-g}
LSD(0.05)		0.01	1.77
F-test		**	**
CV (%)		0.74	4.34

Treatment means followed by the same letter within a column are not significantly different. ** = significant at 1% probability level.

Consistent with this idea, Hogy and Fangmeier (2009) stated that potatoes with high specific gravity may be suitable for processing such as the making of chips and French fries. This is because such potatoes have high yield of processed product and do not suck to much oil during preparation, thereby resulting in less cost of oil for chip production. high specific gravity of potatoes are better suited for baking, frying, mashing and chipping; low specific gravity for boiling and canning. Therefore, among those cultivars under this study, it is possible to select further potatoes best suited for processing as well as for boiling or canning.

Dormancy Period

The main effect significantly (P < 0.01) influenced the dormancy period of the tubers. The effect of location as well as its interaction effect of cultivar and location did not affect tuber dormancy Badhasa had the longest period of tuber dormancy, followed by Zemen and Chiro. Tubers of Badhasa required almost three and a half months to break dormancy and sprout. Tubers of Zemen and Chiro took about three months and a quarter to reach the time of tuber dormancy breakage. The cultivar which broke its tuber dormancy in a short time after harvest (15 days) was Daddafa. This was closely followed by Gabbisa, which required only 40 days for breaking its dormancy. The tuber dormancy of the other cultivars ranged between 40 and 60 days. In general, the farmers' cultivars had shorter tuber dormancy compared to the improved cultivars released by the University. The improved cultivars had relatively longer tuber dormancy. The variations in tuber dormancy among the cultivars may be attributed to genetic differences. This is consistent with the findings of Sonnewald (2001) and Suttle (2004) who reported that the length of tuber dormancy depends on the genetic background of the cultivars.
It is stated in most literature that tuber potato dormancy normally ranges between 80 to 90 days (Lung'aho *et al.*, 2007). However, the tuber dormancy of most of the farmers' cultivars was found to be very short. On the other hand, the tuber dormancy of most released cultivars was long. This shows that breeders developing high-yielding potato cultivars at the University may have been selecting against the trait of short tuber dormancy since they would find it detrimental to prolonged shelf-life whether the tuber are used as ware potato or as seed potato.

Table 3. Effect of cultivar and location on dormancy period of potato tuber.

	Dormancy period (days)
Location	
Haramaya	62.11[a]
Hirna	62.11[a]
LSD(0.05)	0.38
F-test	ns
Cultivars	
Badhasa	108.03[a]
Batte	51.10[e]
Chala	50.47[e]
Jarso	41.90[f]
Chiro	98.40[c]
Mashenadima	52.33[d]
Zemen	101.23[b]
Daddafa	15.03[h]
Gabbisa	40.50[g]
LSD(0.05)	0.82
F-test	**
CV (%)	1.05

Treatment means followed by the same letter within a column are not significantly different. ** = significant at 1% probability level. ns = non significant at 5% probability level.

However, the fact that farmers value and cultivate their own cultivars side with the improved potato cultivars of the University indicates that there is a merit that breeders did not see in the farmers' cultivars as well as in the pool of genotypes at their disposal.

This clearly indicates that tubers with short dormancy are desired by farmers since they best fit to their cropping calendar for irrigated cultivation during dry seasons whereas the improved cultivars fit into the cropping cycle of the rainy season. This is consistent with the suggestion of Fuglie (2007) that variations in tuber dormancy are important to fit potato varieties into cropping calendars of farmers.

In addition to genetic factor both pre- and post-harvest environmental factors can affect tuber dormancy duration. Unusually cold or hot weather during tuber development in the field often results in pro-tracted or shortened (respectively) dormancy (Burton, 1989). Depending on the cultivar, extremely hot (>35 ^{o}C) field temperatures can result in the immediate termination of tuber dormancy, a physiological disorder known as heat sprouting (Van den Berg *et al*., 1990).

Post-harvest environmental conditions can have a dramatic quantitative effect on tuber dormancy. Between 3 and 25 ^{o}C, the length of tuber dormancy is inversely proportional to temperature (Burton, 1989). Prolonged exposure to temperatures ≤2 or ≥30 ^{o}C abruptly terminates tuber dormancy, and sprouting commences upon return to moderate temperatures (Wurr and Allen, 1976). The presence or absence of light during post-harvest storage has little effect on dormancy duration but dramatically affects the morphology of emerging sprouts (Burton, 1989).

Furthermore, Rappaport and Wolf (1969) and Hemberg (1985) stated that depending on the intended purpose, accelerated (i.e. seed tubers) or delayed (i.e. ware potato, industrial processing) sprouting of the harvested tubers is favourable. Thus, prolonged tuber dormancy may be a problem for dry season cultivation of potato in Eastern Ethiopia since the tubers do not sprout according to the cropping calendar of irrigated cultivation. Farmers would always want to replant the tubers as soon as they harvest the crop for double or triple production in the dry seasons using irrigation so as to exploit mainly the local export markets. Therefore, they have apparently selected their own cultivars such as Daddafa and other for such a purpose. In fact, short tuber dormancy may pose a problem to shelf-life but has its own unique advantage to smallholder farmers in the region as stated above. On the other hand, prolonged dormancy could be an advantage for farmers cultivating the cultivars during the rainy season since this would delay sprout aging during the long 7-8 month storage and avoid diminutive yields that may arise plated from aged and senile tubers.

Conclusion

The cultivars also differed in tuber quality attributes such as specific gravity and tuber dry matter content, indicating that they could be used for different purposes suited to consumers' needs. Thus, cultivars Chala and Gabbisa in this experiment which recorded having higher dry matter content and specific gravity may be selected for processing whereas moderate specific gravity and dry matter content could be used for normal table purposes.

The cultivars also differed in length of tuber dormancy significantly, with the released cultivars generally having tubers with longer dormancy than the within 15 days. This clearly indicates that tubers with shorter dormancy are desired by farmers local (farmers') cultivars. In particular, one farmers' cultivar named Daddafa broken its dormancy since they best fit to their cropping calendar for irrigated cultivation during dry seasons whereas the improved cultivars fit into the farmers' cropping cycle in the rainy season. This would explain why farmers value and cultivate their own cultivars side by side with the released potato cultivars of the University. Thus, farmers saw a special merit of short tuber dormancy in their cultivars, against which breeders of the University or elsewhere in the country may have been selecting.

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