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Tuber Size Distribution of Potato (*Solanum Tuberosum* L.) as Influenced by Local and Improved Cultivars Grown in Eastern Ethiopia

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Abstract
Potato is an important cash and food security crop in Eastern Ethiopia. Field experiments were conducted at Haramaya and Hirna with the objective of assessing tuber size distribution 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. The highest proportions of small tuber numbers and weight (72.99%), (53.03%), respectively were produced by cultivar Jarso at Haramaya. Chiro had the lowest number of small tubers (27.30%) and weight (14.52%). The maximum weight of large tubers (54.98%) was obtained from Mashenadima, with Jarso giving the minimum (25.63%). Highest medium sized tuber weight (29.63%) was obtained from Jarso and Daddafa gave the lowest 20.95%. The highest proportion of large-sized tubers was obtained from Chiro (48.85%) at Hirna and Minimum by Jarso (4.95%) at Haramaya. Regarding medium tuber numbers, the highest proportion was produced by Gabbisa (26.31%) and Zemen had the lowest proportion (17.04%).
Keywords: potato (*solanum tuberosum* l.), yield Performance, Improved, local, Ethiopia

Introduction

Potato is an important food and cash crop in Eastern and Central Africa, playing a major role in national food security and nutrition, poverty alleviation and income generation, and; provides employment in the production, processing and marketing sub-sectors (Lung'aho *et al*., 2007).

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). Farmers that cultivate local varieties are reported to get yields equivalent to those that cultivate improved varieties. This might be due to good farm management practices, which may be stimulated by the prospect of export market (Adane *et al*., 2010). However, 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 tuber size characteristics among the local and improved potato cultivars grown in the Eastern Ethiopia. Therefore, this study was initiated with the objective of assessing tuber size distribution 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 11. 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.

Tuber size distribution in weight

Analysis of variance of the data revealed that the main effect of cultivar and location significantly influenced large, medium and small size tuber weights. However, the interaction effect was not-significant on large and medium-sized tuber weights

Large size tuber weight

The cultivar Mashenadima (54.98%) produced significantly higher large size tuber weight than the other cultivars followed by Chiro, Batte, Gabbisa and Zemen which is statistically parity with each other and lowers than Mashenadima by about 5, 6, 6 and 8%, respectively. Jarso (25.63%) produced significantly lower large-sized tuber by weight by about 115% than Mashenadima (higher large size tuber weight) (Table 2).

Table 2.The main effect of cultivars and location on medium size tuber number, large size tuber weight, medium size tuber weight and average tuber mass.

	Parameter		
	Medium size tuber number (%)	Large size Tuber weight (%)	Medium size tuber weight (%)
Location			
Haramaya	22.82[a]	41.42[b]	27.59[a]
Hirna	21.21[a]	51.42[a]	23.31[b]
LSD(0.05)	2.09	4.18	2.25
F-test	Ns	**	**
Cultivars			
Badhasa	23.43[ab]	43.99[bc]	28.08[ab]
Batte	21.84[abc]	51.79[ab]	23.54[bc]
Chala	21.56[abc]	43.76[bc]	27.79[ab]
Jarso	20.82[bc]	25.63[d]	29.63[a]
Chiro	24.75[ab]	52.54[ab]	28.01[ab]
Mashenadima	25.32[ab]	54.98[a]	24.42[bc]
Zemen	17.04[c]	51.06[abc]	20.96[c]
Daddafa	17.10[c]	42.43[c]	20.95[c]
Gabbisa	26.31[a]	51.64[ab]	25.70[abc]
LSD(0.05)	4.88	9.09	5.19
F-test	**	**	**
CV (%)	19.01	17.51	20.85

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.

Medium size tubers weight

Jarso (29.63%), Chiro, Badhasa, Chala, Gabbisa resulted in statistically similar medium-sized tuber by weight and the least was obtained for Daddafa (20.95%) and Zemen (Table 8). The medium-sized tuber of both cultivars was lower than that of the Jarso cultivars by about 41%. The results are in conformity with the findings of Wiersema and Cabello (2002) and Tekalign & Hammes (2005), who confirmed that different potato cultivars varied with respect to tuber size distribution.

Small size tuber weight

Higher small-sized tuber weight was obtained for cultivar Jarso (53.03%) at Haramaya, which was significantly different from the small-sized tuber weight of the other cultivars, followed by Daddafa at both locations. Jarso at Hirna Badhasa, and Zemen at Haramaya, which produced statistically similar small sized tuber weights. The least proportion of small-sized tuber weight was obtained from cultivar Chiro (14.52%) and Meshenadima (19.94%) at Hirna. The results are in conformity with the findings of Wiersema and. Cabello (2002) and Tekalign and Hammes (2005) who confirmed that different potato cultivars varied with respect to tuber size distributions.

Tuber size distribution in number

The main effects as well as interaction effect of cultivar and location significantly ($P < 0.01$) influenced large tuber numbers, medium tuber numbers and small tuber numbers. But the main effect of location on medium tuber number was not significant.

Large size tuber number

The highest proportions of large-sized tuber were produced by Chiro (48.85%), Zemen (45.24%), followed by Gabbisa, Badhasa and Mashenadima at Hirna. Jarso (4.95%) at Haramaya produced the least proportion of large-sized tubers (Table 3). Almost all cultivars produced the lowest proportion of large-sized tubers at Haramaya than at Hirna. Cultivars which produce more number of large-sized tubers are considered to be the best for market. The difference in the number of large-sized tubers produced by the cultivars is most likely due to certain genetic factors, as well as environment where the cultivars grown may have favoured cultivars like Chiro to flourish better than the other cultivars. Corroborating this suggestion, Sanchez (1996) also reported that among eight cultivars received from Holland, the variety “Walse” gave maximum number of large tubers and reasoned that the production of large tubers is genetically controlled.

Medium size tuber number

The cultivar Gabbisa (26.31%) followed by Mashenadima, Chiro Badhasa, Batte and Chala produced medium-sized tubers, which were in statistical parity (Table 3). Jarso (20.82%) followed by Daddafa and Zemen

produced the least proportion of medium-sized tubers. Medium size tuber is useful for planting material. There are the genetic as well as environmental factors that cause difference in the size of tuber. Related to the result, Struick *et al*. (1990) obtained that the number of active stem per plant is a variable linked to the differences in tuber size distribution.

Small size tuber number

Jarso (72.99%) produced significantly higher small size tuber number than the rest of the cultivars followed by Daddafa, Badhasa, Zemen, Batte and Chiro at Haramaya and Daddafa at Hirna (Table 3). In addition, Mashenadima (39.45%) at Hirna produced least proportion of small size tuber number. Differences in small size tuber number between cultivars are because of genetic as well as environmental factors. According to the farmers' choice it is not a good character of cultivar to produce small tubers because it is of no benefit to the farmer as the market value of small tubers is very low. These results are in confirmation with the findings of Sanchez (1996) who reported significant differences in the number of small-sized tubers between potato varieties.

Table 3. The interaction effect of cultivar and location on large size tuber number, small size tuber number and small size tuber weight

		Parameter		
Location	Cultivar	Large size tuber number (%)	Small size tuber number (%)	Small size tuber weight (%)
Haramaya	Badhasa	18.41^{hi}	60.86^{bc}	34.40^{bcd}
	Batte	24.66^{f-i}	55.60^{bc}	26.19^{d-g}
	Chala	16.36^{i}	59.30^{bc}	29.28^{c-f}
	Jarso	4.95^{j}	72.99^{a}	53.03^{a}
	Chiro	21.78^{f-i}	52.57^{cd}	24.38^{efg}
	Mashenadima	28.57^{d-g}	46.24^{de}	21.25^{fgh}
	Zemen	20.96^{ghi}	57.60^{bc}	31.27^{b-e}
	Daddafa	20.29^{ghi}	62.20^{b}	34.57^{bcd}
	Gabbisa	25.16^{fgh}	46.08^{def}	24.43^{efg}
Hirna	Badhasa	36.80^{cd}	37.08^{f}	21.46^{fgh}
	Batte	29.69^{c-f}	46.37^{de}	23.16^{e-h}
	Chala	23.48^{f-i}	57.74^{bc}	27.62^{d-g}
	Jarso	27.69^{efg}	52.74^{cd}	36.45^{bc}
	Chiro	48.85^{a}	27.30^{g}	14.52^{h}
	Mashenadima	35.11^{cde}	39.45^{ef}	19.94^{gh}
	Zemen	45.24^{ab}	42.11^{ef}	24.69^{efg}
	Daddafa	24.48^{f-i}	58.84^{bc}	38.68^{b}
	Gabbisa	37.80^{bc}	38.34^{ef}	20.89^{fgh}
LSD(0.05)		8.37	9.08	8.75
F-test		**	**	**
CV (%)		18.53	10.78	18.75

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

Conclusion

Analysis of variance of the data revealed significant differences in most of the parameters studied. There were a number of differences in tuber size distribution among and within the cultivars released by the Haramaya University and those developed through selection by farmers.

Reference

Adane Hirpa, M.P.M. Meuwissen, A Tesfaye., W.J.M. Lommen, A.O. Lansink, A. Tsegaye and P.C. Struik, 2010. Analysis of Seed Potato Systems in Ethiopia. *American Potato Research Journal*. 87: 537-552.

Balkaya, A. and A. Ergun, 2008. Diversity and use of pinto bean (*Phaseolus vulgaris* L.) populations from Samsun, Turkey. *New Zealand Crop Sci*ence *Journal.* 36: 189-197.

Belay, S.C., W. Wortman and G. Hoogen boom, 1998. Haricot bean agro-ecology in Ethiopia: definition using agro-climatic and crop growth stimulation models. *African Crop Science Journal.* 6: 9-18.

Eshetu Mulatu, O. Ibrahim and E. Bekele, 2005. Improving potato seed tuber quality and producers livelihoods in Hararghe, Eastern Ethiopia. *New Seeds Journal.* 7(3): 31-56.

FAOSTAT, 2010. Agricultural data. Provisional 2009 Production and Production Indices Data. Crop primary. Food and Agriculture Organization of the United Nations, Rome, Italy.

Gebremedhin woldegeorgis, E. Gebre and B. Lemaga, 2008. Potato variety development. pp. 15-32. In Root and

tuber crops. *Ethiopian Institute of Agricultural Research.*
HURC (Haramaya University Research Centre), 1996. Proceedings of the 13th annual Research and extension review meeting. pp. 26-28.
Lung'aho, C., B. Lemaga, M. Nyongesa, P. Gildermacher, P. Kinyale, P. Demo and J. Kabira, 2007. Commercial seed potato production in eastern and central Africa. Kenya Agricultural Institute, Kenya. 140p.
Mahmood, M.M., A. Hussain and K. Farooq, 2001."Aallo Ki Kasht" 9 p. National Potato Programme, NARC. 59p.
Mishra B.B., H.G. Kidan, K. Kibret, M. Assen and B. Eshetu, 2004. Soil and land resource inventory at Alemaya University research farm with reference to land evaluation for sustainable agricultural management and production: Synthesis of working papers, *Soil Science Bulletin*. Alemaya University, Ethiopia.
Mondal, M.A.A., 2003. Improvement of potato (*Solanum tuberosum* L.) through hybridization and *in vitro* culture technique.A. Ph.D. Dissertation presented to Rajshahi University, Rajshahi, Bangladesh. 270p.
MoARD (Ministry of Agriculture and Rural development), 2010. Animal and Plant Health Regulatory Directorate. Crop Variety Register. Crop Development Department, Issue No.13 June 2010, Addis Ababa, Ethiopia.138p.
Nebret Tadesse, 2011. The effect of Nitrogen and Sulfer on yield and yield component of common bean in Eastern Ethiopia. Unpublished M.Sc. Thesis presented to the school of graduate studies of Haramaya University.13p.
Sanchez, S., 1996. Effect of seedling tuber size on growth and yield of potato by TPS. *Indian Potato Association Journal*. 22: 362-500.
SAS (Statistical Analysis Software), 2007. Stat. Jahrbuch tuber Ernahrung, Landwirtschaft und Forsten In German, Landwirtschaftsverlag Munster-Hiltrup, Germany, 2008.
Simret Burga, 2010. Influence of inorganic nitrogen and potassium fertilizers on seed tuber yield and size distribution of potato (*Solanum tuberosum* L.). An. M. Sc Thesis Presented to the School of Graduate Studies of Haramaya University, Ethiopia. 65p.
Struick, P.C., A.J. Haverkort, D. Vreugdenhil, C.B. Bus and R. Dankert, 1990.Manipulation of tuber-size distribution of a potato crop. *Potato Research*. 33: 417-432.
Tekalign Tsegaw and P.S. Hammes, 2005. Growth and productivity of potato as influenced by cultivar and reproductive growth: II. Growth analysis, tuber yield and quality. *Scientia Horticulture Journal*. 105(1): 29-44.
Wiersema, S.G. and R. Cabello, 2002. Effect of potato mini tubers on the yield and production. Department of Physiology, Int. Potato Center, Lima, Peru. http://www.springerlink. com/content/lru3208p21604732.

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