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Full Length Research Paper

Performance evaluation of released and farmers' potato (*Solanum tuberosum* L.) varieties in eastern Ethiopia

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A study was conducted at Hirna and Alemaya during 2013 main cropping season. The objective of the study to evaluate the performance of recently released and farmers' potato varieties in eastern Ethiopia. The experimental materials included 16 different varieties of potatowere released by different research centers and Haramaya Universitypotato breeding program for different agro-ecologies of Ethiopia and two dominant farmer's varieties from the study areas was used. The experiment was laid out as a Randomized Complete Block Design with three replications. The results of the study revealed that, the highest leaf area index was recorded for variety Gera (5.25) at Hirnawhile the lowest registered for Bete (1.76) at Haramaya. Marachere (20.47) at Haramaya, Zemen (15.67), Bule (7.73) and Gera (56.85t/ha) all at Hirna, produced highest total tuber number per hill, marketable, unmarketable tubers number per hill and highest total tuber yield per hectare, respectively whereas Moti (6.93),Moti (5.73),Gera (0.53)all at Haramaya and Jarso (17.37) at Hirna produced the lowest total tuber number per hill, marketable, unmarketable tubers number per hill and highest total tuber yield per hectare, respectively. The highest marketable and unmarketable tuber yield ton/ha was recorded for Gera (53.97) and Bule (5.91) both grown at Hirna, respectively,while Jarso(14.09)at Hirna and Zemen (0.3) at Haramaya produced the lowest marketable and unmarketable tuber yield tons/ha, respectively. Marachare (10.13) at Haramaya, Jalenie (6.8) and Gera (8.87) both at Hirna produced the highest small, medium and large sized tuber number per hill, respectively. Gera (1.47), Moti (2.07) both grown at Hirna and Jarso(1) at Haramaya produced the lowest small, medium and large sized tuber number per hill, respectively. The results also revealed that it is an evident that the presence of considerable variations for tuber yield and yield component among varieties and between locations as well as the interaction effect of variety by location significantly influenced most of the studied trait especially for yield character which is considered as the most important economic character. Based on the result of this study under both locations, relatively high yielding potato varieties released by different research institutes than Haramaya University released varieties for eastern Ethiopia in terms of yield and hence, warrant for more location and year evaluation of varieties.

Key words: Farmers, performance, potato, varieties, tubers.

INTRODUCTION

Potato *(Solanum tuberosum* L.) is an important tuber crop grown widely in humid tropics and used as source of carbohydrates for many people in tropical and sub-tropical areas of the world (Crissman et al., 1993). According to FAO, potato is a staple food for more than 600 million people who live in sub-Saharan Africa. The crop particularly has potential for fertile and waste land where other crops could not survived, to help overcome food shortage (Gebremedhin et al., 2013). It is primarily grown for its starchy tuberous root; its flour can be produced for soup, biscuits, bread, and chips. The leaves used as animal feed in the developing countries.

In Ethiopia, potato production could fill the gap in food supply during the hungry months of July to August before the grain crops are being harvested. Potato in Ethiopia is currently planted in around 164,146 ha producing an estimated total tuber yield of 940,087 tons (CSA, 2002). This implies that average yield in the country reaches only 7 t/ha when the potential for small holder is around 25 t/ha. There are many factors that can contribute directly or indirectly for low yield in Ethiopia, lack of

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Table 1. Description of released and local varieties.

No	Varieties	Released year	Breeder/Maintainer	Altitude (m.a.s.l.)
1	Chiro	1998	HU*	1700-2400
2	Zemen	2001	HU	1700-2400
3	Bedasa	2001	HU	1700-2400
4	Jalenie	2002	Holeta	1600-2800
5	Gorrebella	2002	Sheno	2700-3200
6	Guassa	2002	Adet	2000-2800
7	Gera	2003	Sheno	2700-3200
8	Chala	2004	HU	1700-2000
9	Gabisa	2005	HU	1700-2000
10	Bulle	2005	Awassa	1700-2700
11	Marachare	2005	Awassa	1700-2700
12	Ararsa	2006	Sinnana	2400-3350
13	Gudenie	2006	Holeta	1600-2800
14	Bubu	2010	HU	1700-2400
15	Belete	2010	Holeta/East Africa	1600-2800
16	Moti	2011	Sinnana	2400-3350
17	Bete	-	Local cultivar	
18	Jarso	-	Local cultivar	

Source: Haramaya University (HU*) Potato Improvement Programme section (2012).

improved technology, low attention to the crop and high market price of the tuber especially during the time of planting, this are the few to mention. Although, there are many varieties that was released by different research centers for different agro-ecologies in the country, the yield potential is seem unsatisfactory. Besides, the yield potential of the released varieties in different agro-ecological zones have never been assessed and the yield potential of improved and farmers potato varieties in the country level is still unidentified. The detail agronomic, the genetic potential and culinary attributes of varieties have also not been documented for use by scientific research and development program in the country. Therefore, this study was designed to evaluate the performance of released and farmers' potato varieties in a selected districts of Eastern Ethiopia.

MATERIALS AND METHODS

Description of the Study areas

The experiments was conducted at Haramaya and Hirna districts, in East and West Hararghe zones of the Oromia Regional State of Ethiopia during 2013, the main cropping season. Haramaya is located at 42°3'E longitude, 9° 26'N latitude and altitude of 2015 m.a.sl. The mean annual rainfall is 760 mm (Belay et al., 1998). Mean annual temperature 16°C and the soil of the experimental site is alluvial type (Mishra et al., 2004). Hirna is located is located at 9 °12' North latitude, 41 °4' East longitude, and 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°C and the soil of Hirna is vertisol (HURC, 1996).

Experimental materials and design

For this study, 10 varieties of potato released by different research centers for different agro-ecologies of Ethiopia and two local cultivars from each location was used. The name of the varieties, year of released and altitudes presented in Table 1.

The experiment was laid out as a RCBD with three replications. Each plot was 3.60 m x 4.50 m = 16.2 m^2 wide consisting of six rows, which accommodated 12 plants per row and thus 72 plants per plot. The spacing between plots and block were 1 m and 1.5 m, respectively. Well sprouted potato tubers were planted at a spacing of 75 cm between rows and 30 cm between plants. According to Haramaya University (HU) recommendation, 75 kg N and 92 kg P_2O_5 ha^{-1} was applied. Nitrogen was applied as urea split applications (50% + 50% in two installments of 30 and 50 day after planting).

Data collection and measurement

The average of 12 quantitative data from two locations was collected. These are plant height, stem number, leaf area index, total tuber number ,total tuber number, tuber size distribution in number, total tuber yield, marketable tuber yield ,unmarketable tuber yield, tuber dry matter content (%), total tuber yield and specific gravity of tubers (gcm^3) were collected.

Table 2. The interaction effects of variety and location on growth parameters of eighteen potato varieties tested at two locations.

Varieties	Plant height(cm)		Stem no (per hill)		Leaf area index		Marketable tuber number		Unmarketable tuber number	
	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna
Ararsa	42.63^{m}	53.67^{l}	4.07^{f-m}	4.68^{f-j}	2.52^{h-k}	2.76^{h-k}	6.87^{mno}	7.07^{l-o}	1.00^{nop}	1.53^{l-o}
Bedasa	56.33^{kl}	72.50^{b-e}	5.33^{ef}	7.33^{cd}	3.07^{g-ie}	4.21^{a-e}	13.53^{abc}	13.33^{a-d}	3.93^{def}	5.53^{b}
Belete	42.20^{m}	57.50^{jkl}	2.87^{m}	3.45^{g-m}	3.30^{d-i}	5.11^{ab}	7.87^{j-o}	9.20^{g-m}	2.47^{h-k}	2.53^{h-e}
Bete	66.80^{e-h}	65.50^{e-h}	5.13^{e-h}	4.24^{f-l}	1.76^{kl}	1.86^{kl}	10.20^{e-k}	8.87^{i-n}	4.80^{a-d}	5.13^{bc}
Bubu	64.73^{g-i}	73.33^{bcd}	8.60^{ab}	8.83^{a}	3.37^{d-h}	4.69^{abc}	9.27^{g-m}	9.40^{g-m}	2.53^{h-k}	2.80^{ghi}
Bulle	53.57^{l}	59.83^{ijk}	4.87$^{e-ı}$	4.24^{f-l}	2.45^{h-k}	1.84^{kl}	10.00^{e-k}	6.07^{no}	3.40^{e-h}	7.73^{a}
Chiro	53.97^{l}	99.17^{a}	5.40^{ef}	4.83^{f-j}	2.83^{h-k}	4.69^{abc}	8.33^{i-o}	11.30^{b-i}	1.80^{k-n}	2.40^{i-l}
Gabisa	53.73^{l}	71.05^{c-f}	5.20^{e-g}	6.21^{de}	3.20$^{e-ı}$	4.37^{a-d}	12.53^{b-f}	12.13^{b-g}	2.93^{ghı}	3.40^{e-h}
Gera	61.13^{ijk}	68.83^{d-f}	4.20^{f-m}	3.75^{h-m}	3.40^{d-h}	5.25^{a}	11.07^{b-i}	15.67^{a}	0.53^{p}	2.87^{ghi}
Gorrebella	52.87^{l}	71.33^{b-e}	4.93^{e-i}	4.50^{f-k}	2.31^{h-l}	3.20^{e-i}	8.67^{h-o}	10.67^{c-g}	1.67^{k-n}	3.60^{efg}
Guassa	41.98^{m}	60.17^{ijk}	3.80^{g-m}	5.10^{e-h}	2.56^{h-k}	4.32^{a-d}	8.56^{h-o}	10.70$^{c-ı}$	3.04$^{f-ı}$	4.20^{cde}
Gudenie	66.87^{e-h}	75.33^{bc}	7.50^{bc}	7.68^{abc}	2.82^{h-k}	4.14^{b-f}	9.93^{e-l}	9.67d^{f-m}	2.13^{k-m}	2.67^{g-j}
Chala	56.13^{kl}	71.00^{c-f}	6.20^{de}	4.55^{f-k}	2.69^{h-k}	4.10^{b-f}	12.87^{a-e}	10.40$^{d-ı}$	4.80^{bcd}	4.00^{de}
Jalenie	39.67^{mn}	60.67^{ijk}	4.27^{f-l}	4.27^{f-l}	2.45^{h-k}	4.17^{b-f}	11.60^{b-h}	11.50^{b-h}	3.00$^{f-ı}$	7.60^{a}
Jarso	36.27^{n}	67.97^{d-h}	2.93^{lm}	3.73^{h-m}	1.36^{l}	2.20^{i-l}	7.27^{k-o}	7.33^{l-o}	4.20^{cde}	5.40^{b}
Marachare	60.13^{ijk}	62.67^{hij}	3.60^{l-m}	3.29^{klm}	3.17$^{e-ı}$	4.95^{abc}	15.60^{a}	13.80^{ab}	4.87^{bcd}	5.07^{bc}
Moti	42.50^{m}	77.00^{b}	3.80^{g-m}	5.05^{e-h}	1.94^{jkl}	4.01^{c-g}	5.73^{o}	9.80^{f-m}	1.20^{m-p}	2.73^{g-j}
Zemen	57.33^{jkl}	73.40^{bcd}	6.73^{cd}	4.76^{f-j}	3.01^{g-j}	4.01^{c-g}	11.4^{b-h}	15.67^{a}	0.67^{op}	2.33^{i-l}
F-test	**		**		**		**		**	
CV (%)	11.07		14.05		17.15		14.8		15.5	

Means followed by the same letter within a column and row are not significantly different at 5 % level of significance according to (DMRT). ** = significant at 1% probability level.

Statistical analysis

A significance test was adopted by analysis of variance (ANOVA) for Randomized Complete Block Design. The ANOVA was carried out using the General Linear Model of the SAS procedure of version 9.1 (SAS, 2007). For factors showing significant effects, mean comparisons were made using the Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Plant height

The main effects as well as the interaction of variety and location were found to be highly significant (P < 0.01) for plant height. The highest plant height was recorded for variety Chiro (99.17 cm) grown under Hirna condition while the shorter plant height was recorded in local varieties Jarso (36.27 cm) at Haramaya (Table 2). Height is a quantitative trait controlled by many genes, therefore, it is highly influenced by environmental factors like nutrient status of the soil, available soil moisture and intercepted radiation (Singh and Singh, 1973). This suggestion is consistent with that of Elfinesh`s (2008) finding, who reported varietal difference across locations in plant height.

Stem Number

The interaction effect of variety and growing environment was highly significant (P < 0.01) for main stem number. Likewise, main stem number per hill was highly significantly (P < 0.01) influenced by variety but not location which was statistically non significant for this parameter The highest number of stem was recorded for Bubu under both growing environment while the lowest stem number was produced by Belete at Haramaya. Therefore, the stem number of Bubu exceeded that of Belete by about 208% (Table 2). This result is consistent with that of Morena et al. (1994) who showed that the number of stems per plant is influenced by variety.

Leaf area index

Genotype and location are highly significantly (P < 0.01) interacted to influence leaf area index. Likewise, the main effect genotype and location highly significantly (P< 0.01) influenced leaf area index. Significant and highest leaf area index was recorded for Gera (5.25) grown at Hirna, while significantly lowest leaf area was registered for Bete (1.76) and Jarso (1.36) both grown at Haramaya. Thus, the leaf area index of Gera obviously exceeded that of Bete, and Jarso by about 198 and 286%, respectively (Table 2). This result gives information that growing environment has effect on leaf area index of potato varieties. This result is similar with those of Allen

Table 3. The interaction effect of variety and location on tuber size distribution number per hill and marketable yield of eighteen potato varieties tested at two locations.

Varieties	Total tuber number		Small size tuber number(< 39 g)		Medium size tuber no.(39-75 g)		Large size tuber no.(>75 g)		Marketable tuber yield(≥20 g)	
	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna
Ararsa	7.87^{n}	8.60^{mn}	2.13^{mn}	1.47^{n}	2.53^{ijk}	2.20^{k}	3.20^{i-l}	4.93^{c-f}	24.24^{kl}	37.54^{g-i}
Bedasa	17.47^{bc}	18.87^{ab}	7.80^{bcd}	8.00^{bc}	4.80^{cd}	6.40^{ab}	4.87^{c-g}	4.47^{e-g}	37.92^{ghı}	40.05^{d-g}
Belete	10.33^{klm}	11.73^{i-l}	2.27^{mn}	2.87^{lmn}	2.67^{h-k}	3.30^{f-k}	5.40^{b-e}	5.60^{b-e}	44.39^{bc}	50.94^{a}
Bete	15.00^{de}	14.00$^{d-ı}$	8.00^{bc}	7.13^{b-e}	5.40^{bc}	4.80^{cd}	1.60^{mn}	2.07^{lmn}	22.40^{l}	23.21^{l}
Bubu	11.80^{i-l}	12.20^{o-l}	4.20^{i-l}	3.13^{lm}	2.60^{h-k}	3.10^{g-k}	5.00^{c-f}	5.93^{bc}	35.62^{hij}	42.87^{b-f}
Bulle	13.40^{d-j}	13.80^{d-i}	6.87^{c-g}	8.47^{bc}	3.73^{d-i}	3.10^{g-k}	2.80^{jkl}	2.27^{lmn}	27.11^{k}	18.37^{m}
Chiro	10.13^{lm}	13.70$^{d-ı}$	3.67^{g-m}	3.60^{l-m}	3.27^{f-k}	3.87^{d-h}	3.20^{i-l}	6.27^{b}	26.96^{k}	44.96^{b}
Gabisa	15.47^{cd}	15.53^{cd}	5.87^{f-h}	6.33^{d-h}	4.60^{cde}	3.47^{e-i}	5.00^{c-f}	5.73^{bcd}	39.26^{fgh}	43.69^{bcd}
Gera	11.60^{jkl}	18.53^{ab}	1.53^{n}	5.47^{ghi}	4.47^{c-f}	4.20^{c-g}	5.60^{b-e}	8.87^{a}	39.08^{gh}	53.97^{a}
Gorrebella	10.33^{klm}	14.27^{d-h}	3.27^{lkm}	4.80^{h-k}	3.00^{g-k}	4.93^{cd}	4.07^{f-i}	4.53^{e-g}	33.22^{j}	33.67^{j}
Guassa	11.60^{jkl}	14.87^{de}	5.03^{hij}	5.60^{f-i}	3.50^{e-i}	3.73^{d-i}	3.07^{i-l}	5.53^{b-e}	25.96 ^{kl}	37.84^{ghi}
Gudenie	12.07^{h-l}	12.33^{f-l}	4.27^{i-l}	2.87^{lmn}	4.20^{c-g}	4.93^{cd}	3.60^{h-k}	4.53^{e-h}	32.95^{j}	36.03^{hij}
Chala	17.67^{b}	14.40^{d-g}	7.27^{b-e}	4.20^{i-l}	4.67^{cd}	4.80^{cd}	5.73^{bcd}	5.40^{b-e}	32.71^{j}	38.07^{ghi}
Jalenie	14.60^{def}	19.07^{a}	7.00^{f}	8.53^{b}	5.20^{c}	6.80^{a}	2.40^{lmn}	3.73^{g-h}	27.02^{k}	35.41^{hij}
Jarso	11.47^{jkl}	12.73^{e-j}	7.20^{b-e}	8.20^{bc}	3.33^{f-i}	3.20^{f-k}	1.00^{o}	1.33^{no}	16.3^{mn}	14.09^{n}
Marachare	20.47^{a}	18.87^{ab}	10.13^{a}	7.53^{bcd}	6.33^{ab}	4.80^{cd}	4.00^{f-i}	6.53^{b}	43.11 $^{b-e}$	50.54^{a}
Moti	6.93^{n}	12.47^{f-l}	2.33^{mn}	4.87^{hıj}	2.07^{k}	2.67^{h-k}	2.53^{klm}	4.93^{c-f}	25.48^{kl}	40.96^{c-f}
Zemen	12.07^{h-l}	18.00^{b}	2.93^{lmn}	8.40^{bc}	3.73^{d-i}	3.80^{d-i}	5.40^{b-e}	5.80^{bc}	34.34^{ij}	39.38^{fgh}
F-test	**		**		**		**		**	
CV (%)	8.68		15.41		16.13		14.17		19	

Means followed by the same letter within a column and row are not significantly different at 5 % level of significance according to (DMRT). ** = significant at 1% probability level.

et al. (1992) who stated that leaf area index can vary widely according to growing conditions and variety.

Yield components

Number of marketable, unmarketable and total tubers

Analysis of variance revealed that the main effect of variety and growing environment as well as variety x growing environment significantly influenced marketable, unmarketable and total tuber number. Marachare (20.47) produced highest and significantly different total tuber number per hill at Haramaya, while Moti (6.93) produced the lowest and significantly different total tuber number per hill. At Hirna Jalenie (19.07) produced highest and significantly different total tuber number per hill while Ararsa (8.6) recorded significantly different and lowest values for the same trait. At Hirna, the highest marketable tuber number per hill was recorded for Zemen (15.67) and Gera (15.67) whereas significantly different and the lowest value produced by Bulle (6.07). In the same way, at Haramaya, Marachare (15.6) gave significantly highest marketable tubers per hill over the other varieties while the lowest produced by Moti
(5.73) .Significantly different and the highest number of u nmarketable tubers per hill recorded for Bulle (7.73) and Jalenie (7.6) both grown at Hirna while the lowest produced by Gera (0.53) under Haramaya condition (Table 2).

Tuber size distribution in number

Small sized tuber number

Variety by location interactions was found to be highly significant with respect to number of small sized tubers. Similarly, there was highly significant ($P < 0.01$) variation in number of small sized tubers among the tested varieties and between location. At Haramaya, the data in Table 4 indicate that the highest and significantly different small sized tuber number per hill was recorded for Marachare (10.13) while significantly different lowest small sized tuber number was registered for Gera (1.47) at Hirna. Allen (1978) showed that the number of tubers set by plants was determined by stem density, variety, crop management and season. Former and Snnewald (1995) reported that the competition among tuber initials reduced the final tuber number. 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. Gebremedhin et al. (2013) also observed a significant difference in tuber number between the improved cultivar Al-624 and the local check.

Medium sized tuber number

The main effect of variety was highly significantly ($P < 0.01$) which influenced the medium sized tuber number potato plants, but the main effect of growing environment did not significantly affect this trait. Furthermore, locations by variety interaction effects were highly significant in

affecting medium sized tuber number. Jolene (6.8) produced highest and significantly different medium sized tuber number per hill at Hirna, while Ararsa (2.2) produced the lowest and significantly different medium sized tuber number per hill. At Haramaya, Marachare (6.33) produced highest and significantly different medium sized tuber number per hill while Moti (2.07) recorded significantly different and lowest values for the same trait (Table 3). There are 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.

Large sized tuber number

Large sized tuber number was found to be significantly influenced by the interaction effect of variety and location. Also large sized tuber number per hill was found to be highly significantly ($P < 0.01$) influenced by varieties and growing environments. Gera (8.87) produced highest and significantly different large sized tuber number per hill at Hirna, while Jarso (1) produced the lowest and significantly different large sized tuber number per hill grown at Haramaya condition (Table 3). This study result is in agreement with Beukema and Zaag (1990) who observed that the variation larger sized tuber number variation among cultivars could be genetic. 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.

Total tuber yield

Highly significant ($P < 0.01$) variation in total tuber yield was observed among the tested varieties and between locations. The total tuber yield ranged from 17.37 (ton ha^{-1}) to 56.85 (ton ha^{-1}) produced by Jarso and Gera, respectively, both grown at Hirna. Significantly highest total tuber yield was recorded for Belete (48.3 ton ha-1) grown at Haramaya, while significantly lowest yield was registered for Jarso (18.14 ton ha-1). In comparison, total tuber yield produced at Hirna was higher than Haramaya for all the varieties except Jarso. For instance, at Hirna varieties Gera, Marachare, Belete, and Gabisa gave total tuber yield of 30.7, 16.7, 11.2 and 10.1% more yield than the respective yield at Haramaya. The result of this study is in agreement with Elfinesh, (2008); Asmamawu, (2007) and Tekalign, (2003) who reported that yield differences among genotypes were attributed both by the inherent yield potential of genotypes and growing environment as well as the interaction of genotype x environment.

Marketable tuber yield

The main as well as the interaction effect of variety and location significantly ($P < 0.01$) influenced marketable tuber yield. At Hirna significantly highest marketable tuber yields were recorded for Gera (53.97 ton ha^{-1}) while significantly lowest yield was registered for Jarso (14.09 ton ha^{-1}) (Table 3). Under Haramaya condition varieties Belete and Marach are recorded significantly as the highest marketable tuber yield that were in a statistical parity while the lowest marketable yield was produced by variety Jarso. Hence, marketable tuber yield of variety Belete exceeded that of varieties Gabisa, Gera, Bedasa and Jarso by about 5.13, 5.31, 6.47 and 27.09 ton ha^{-1}, respectively (Table 3). Meyling and Bodlaender (1981) reported that inter varietal differences in tuber yield of the four late maturing cultivars were due largely to differences in the distribution of dry matter.

Unmarketable tuber yield

Significantly highest unmarketable tuber yield was recorded for Bulle (5.91ton ha^{-1}) grown at Hirna, while significantly lowest yield was registered for Zemen (0.3 ton ha^{-1}) which were in statistical parity grown at Haramaya (Table 4). Variation observed for unmarketable tuber yield could be varietal differences. Moreover, unmarketable tuber yield might be controlled more importantly by manipulating other factors such as disease incidence, harvesting practice, etc. (Berga et al., 1994).

Tuber quality attributes

Tuber specific gravity

The main effect variety was highly significantly ($P < 0.01$) influenced the specific gravity potato plants, but the main effect growing environment didn’t significantly affect this trait. Similarly, the specific gravity of tubers was found to be significantly influenced by the interaction effect of variety and location. The higher specific gravity was recorded for variety Belete, at both location while except variety Gudenie, the other varieties were observed statistically with the lowest specific gravity (Tables 4). The probable reason for such variation in specific gravity among the tested varieties could be attributed to variation in dry matter (total solid) contents of tubers. 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. According to Kabira and Berga (2003), potatoes which have specific gravity value more than 1.080 are suitable for processing while tubers with specific gravity values less than 1.070 are generally unacceptable for processing. Hence, all varieties except

Table 4. The interaction effect of variety and location on total tuber yield (ton ha^{-1}), specific gravity and dry matter yield of eighteen potato varieties tested at two locations.

Varieties	Unmarketable tuber yield(<20 g)		Total tuber yield		Specific Gravity		Dry matter percentage	
	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna	Haramaya	Hirna
Ararsa	0.98^{pq}	1.84^{k-o}	25.22^{lm}	39.38^{fgh}	1.0888^{a-h}	1.0756^{ijk}	26.24^{d-g}	19.97^{m}
Bedasa	1.92^{k-n}	3.45^{def}	39.85^{fgh}	43.50^{cde}	1.0832^{b-j}	1.0766^{h-k}	27.30^{cde}	21.11^{j-m}
Belete	3.91^{cd}	3.44^{def}	48.30^{b}	54.39^{a}	1.0942^{ab}	1.0969^{a}	32.77^{a}	30.29^{abc}
Bete	3.26^{e-f}	2.89^{c-h}	25.66^{lm}	26.11^{j-m}	1.0563^{l}	1.0692^{k}	24.19^{e-k}	15.65^{n}
Bubu	1.19^{nop}	3.49^{de}	36.80^{hi}	46.36^{bc}	1.0865^{a-j}	1.0868^{a-j}	32.33^{a}	24.62^{e-h}
Bulle	2.25^{h-l}	5.91^{a}	29.36^{j}	24.27^{m}	1.0832^{b-j}	1.0803^{d-k}	29.03^{bcd}	21.33^{j-m}
Chiro	1.90^{k-o}	2.36^{h-l}	28.86^{jk}	47.32^{b}	1.0934^{abc}	1.0928^{a-d}	26.39^{d-g}	21.93^{i-m}
Gabisa	2.31^{h-l}	2.56^{g-k}	41.57^{efg}	46.25^{bc}	1.0886^{a-h}	1.0878$^{a-ı}$	26.08^{d-g}	23.50^{f-l}
Gera	0.33^{q}	2.88^{e-h}	39.41^{efg}	56.85^{a}	1.092^{a-e}	1.0919^{a-e}	26.92^{de}	23.33^{g-l}
Gorrebella	1.30^{m-p}	2.78^{e-i}	34.52^{i}	36.45^{hi}	1.0892^{a-h}	1.0893^{a-f}	30.71^{ab}	25.16^{e-h}
Guassa	2.59^{g-l}	3.89^{cd}	28.55^{j-l}	41.73^{efg}	1.0884^{a-h}	1.0922^{a-e}	28.65^{bcd}	22.78^{h-m}
Gudenie	1.15^{o-p}	2.78^{e-i}	34.10^{i}	38.81^{gh}	1.082^{b-j}	1.0829^{b-j}	28.74^{bcd}	24.25^{e-j}
Chala	3.88^{cd}	4.59^{bc}	36.59^{hı}	42.66^{def}	1.0689^{k}	1.0789^{e-k}	25.99^{d-g}	21.20^{j-m}
Jalenie	1.48^{mno}	5.17^{b}	28.50^{j-l}	40.59^{efg}	1.0773^{g-k}	1.0747^{jk}	28.63^{bcd}	21.41^{j-m}
Jarso	2.04^{i-l}	3.28^{d-g}	18.34^{n}	17.37^{n}	1.055^{l}	1.068^{e-k}	19.78^{m}	15.01^{n}
Marachare	2.70^{f-j}	4.44^{c}	45.81^{bcd}	54.98^{a}	1.0846^{a-j}	1.0849^{a-j}	26.69^{def}	20.97^{klm}
Moti	0.86^{pq}	1.99^{j-m}	26.34^{j-m}	42.96^{c-f}	1.0818^{b-j}	1.0809^{c-k}	25.31^{d-g}	21.65^{i-m}
Zemen	0.30^{q}	1.74^{l-o}	34.64^{i}	41.11^{efg}	1.0911^{a-f}	1.0884^{a-f}	30.38^{abc}	20.85^{lm}
F-test	**		**		**		**	
CV (%)	15.38		21		0.692		6.803	

Means followed by the same letter within a column and row are not significantly different at 5 % level of significance according to (DMRT). ** = significant at 1% probability level.

Chala, Jarso, Bete and Jalenie under both locations produced tubers with acceptable specific gravity values and are considered suitable for processing. .

Dry matter percent

Percent dry matter of tubers at the time of harvest was significantly ($P < 0.05$) influenced by the interaction effect of variety and location. Also the main effect of variety and location had highly significant ($P < 0.01$) influence on dry matter percent of potatoes. Varieties Belete, Bubu and Gorrebella produced relatively high percent dry matter at both locations than the others. This might be attributed to varieties inherent differences in the production of total tuber dry matter. Similarly, there was a variation in dry matter content among varieties grown in the same location. Burton (1966) reported genetic differences among varieties in their ability to produce high solids when grown on the same test plot. The report of Tekalign and Hammes (2005a) also indicated that cultivars differed significantly with respect to total dry matter production.

All varieties except Jarso grown under Haramaya conditions exhibited percent tuber dry matter of greater than 20% which is acceptable range for processing. Kabira and Berga (2003) justified that potato tubers containing high dry matter of 20 - 24% produce fried products with high yields, less oil absorption and having better texture than those with lower solids. High dry matter has a direct effect on chips and French fries yield as the weight of the processed product depends directly on the amount of dry matter present per quantitative weight of fresh potatoes (Burton et al., 1992).

Summary and conclusion

The present results confirmed the existence of variations among nationally and regionally released potato varieties for yields and other related agronomic traits at Hirna and Haramaya condition. This justifies that different varieties had different genetic potential across locations. The research findings indicate no superior genotype for all tested characteristics. However, superior genotypes for each grouping of traits could further be analyzed and used in breeding programs to develop other superior genotypes. From mean analysis Gera, Marachare and Belete varieties produced significantly higher total and marketable tuber yield at both locations compared to other varieties. However, there was a change of tuber yield rank order of varieties across locations. This could also be considered as the most specific adapted genotypes and thus can be recommended for the test in similar environment.

Present study also reveals that both locations had fairly high tuber yielding and yield component for superior potato varieties. While in terms of yield, varieties that released by different research organization and

institutions had top to Haramaya University released varieties at eastern Ethiopia condition. Nevertheless attributes like acceptability also markedly influence the preferences for varieties than yield alone. Thus, further investigation may address the acceptability issue for varieties included in present study by assessing farmers perception toward marketing condition either in terms of preference or additional cost it can incur through transportation. In addition, further similar works have to be done over locations for at least one more times in order to identify superior genotypes either wide or specific adaptation, predicating performance of genotype and environment as well as confirms the result obtained in this experiment.

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Appendix

Appendix Table 1.Mean squares of growth parameters from analysis of variance of eighteen potato genotypes grown at two locations of east and west Hararghe.

Source of variation	DF	Mean squares						
		PHF	MSN	LAI	STN	MDTN	LTN	MTN
Replication	2	3.3	0.55	0.15	1.27	0.75	0.29	1.78
Location(A)	1	7157.5**	0.09ns	39.17**	7.84**	1.31ns	33.56**	10.53*
Varieties(B)	17	392.33**	12.38**	3.65**	27.75**	7.12**	13.49**	33.18**
AxB	17	204.64**	1.61**	0.77**	6.72**	1.29**	2.15**	8.39**
Error	70	9.50	0.49	0.32	0.68	0.42	0.38	2.36
CV (%)		5.07	14.05	17.15	15.41	16.13	14.17	14.8

*, **=indicate significant difference at 5% and 1 % level of significance, respectively; ns = non-significant; CV = coefficient of variation; PHF = plant height at 50% flowering; DTF=days to 50% flowering; DTM= days to 50% maturity, MSN=main stem number, LAI= Leaf Area Index**.** STN = small tuber number; MDTN = medium tuber number, LTN = large tuber number. MTN = marketable tuber.

Appendix Table 2. Mean squares of eight quantitative traits from analysis of variance of eighteen potato genotypes grown at two locations of east and west Hararghe.

Source of variation	DF	Mean squares							
		UMTN	TTN	MTY	UTY	TTY	TDMP	SG	HI
Replication	2	0.13	2.77	3.14	0.10	2.31	0.0933	0.00001	0.0096
Location(A)	1	42.41**	94.85**	1074.53**	52.64**	1602.83**	852.39**	0.0001^{ns}	0.0169**
Varieties(B)	17	12.61**	50.94**	441.17**	5.45**	437.68**	56.369**	0.0005**	0.0192**
AxB	17	2.94**	11.51**	68.69**	1.97**	66.4**	5.92*	0.0001**	0.0008^{ns}
Error	70	0.27	1.42	4.27	0.16	3.67	2.834	0.00004	0.0019
CV (%)		15.5	8.68	5.95	15.38	5.13	6.803	0.583	5.332

*, ** = indicate significant difference at 5% and 1% level of significance, respectively; ns= non-significant; CV = coefficient of variation; UMTN = unmarketable tuber number, TTN = total tuber number; number; MTY=marketable tuber Yield; UTY= unmarketable tuber yield, TTY=total tuber yield; TDMP =tuber dry matter percentage; SG=specific gravity; HI=harvest