Potato Varieties Adapted to Selected Woredas of Gamo Zone and Dirashe Woreda

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ABSTRACT

The study was conducted at three locations (Chosha, Yelagnaw Arguba and Zazie) for two consecutive years. It was carried out to evaluate and select high yielding, potato varieties for study areas and areas with similar agroecologies. The experiment consisted of eight potato varieties (six released varieties and two local checks). The study was conducted using a Randomized Complete Block Design with three sets of repeated measures. The combined analysis of variance showed that there was statistically significant difference among environments, among varieties and significant effect of GEI on phenology and growth parameters, tuber yield and its components. But there was non-significant effect of GEI for days to emergence. The same was true with weight of non-marketable tubers ha^{-1}. This revealed that the environments were diverse, and confirmed differential performances of varieties across locations. The greatest potato harvest was achieved at the Yelagnawarguba site (34.16t ha^{-1}) and the lowest yield was obtained at Chosha (24.53t ha^{-1}). Variety Belete (42.84t ha^{-1}), Horro (35.29t ha^{-1}), Gudanie (34.56t ha^{-1}), Asmara (30.58t ha^{-1}) and Jalenie (30.56t ha^{-1}) gave above average tuber yields (28.73t ha^{-1}), while Araarsaa gave the lowest tuber yield (14.20t ha^{-1}). Thus potato varieties tested for their adaptability were relatively higher except Araarsaa and Hundee. Therefore, these varieties were suggested for expanded cultivation in the study regions and in regions with comparable agroecologies.

Keywords: Potato, *Solanum tuberosum*, tuber yield, yield related traits

INTRODUCTION

Potato (*Solanumtuberosum* L.) is a member of the family Solanaceae. It is considered to be one of the most extensively cultivated and high-yielding horticultural food crops globally. The relative high carbohydrate and low fat content of potato makes it an excellent energy source for human consumption [1]. Potatoes, sweet potatoes, enset, and taro are the most cultivated root and tuber crops in Ethiopia, with potatoes leading in both production area at 66,923ha per year and consumption. Sweet potatoes follow with 54,017ha, while enset and taro are also significant crops with 52,153ha and 48,087ha respectively [2].

Despite potato's greater role in supporting large number of families as important source of food, its national tuber yield of 13.77t/ha [2], is considerably low compared to the world average 19.99 t/ha [3]. This low yield has been attributed mainly to lack of stable, well-adapted, disease and insect pest tolerant varieties [4].

In Ethiopia, over 35 potato varieties have been released since 1987 by agricultural research centers, universities, and privet limiting company [5]. Despite a number of varieties released only few or almost no varieties being produced in Gamo and Derashe. But the areas were known for their suitability in terms of soil type, rain fall, temperature, altitudinal etc to produce potato.

Thus it was paramount important to test the performance of some of improved varieties over locations in Gamo Zone and Derashe woreda of South Ethiopia Regional State (SERS). As a result, this research activity was initiated to evaluate and choose the most productive potato breeds that are resistant to diseases and insect pests, as well as to showcase the most suitable potato varieties for the Gamo Zone and Derashe Woreda in SERS.

MATERIALS AND METHODS

Description of the Study Areas

The experiment was conducted at three locations (Chosha, Yelagnaw Arguba and Zazie) in Bonke, Derashe and Gerese districts of SERS for two consecutive years. Chosha is located at $037^{0}19'57''$ E longitude, $06^{0}07'57''$N latitude and altitude of 2880m.a.s.l. The average yearly precipitation in the region is 1050 mm, with loamy soil texture classification. Yelagnaw Arguba is located at $037^{0}22'$ E longitude, $05^{0}38'$N latitude and altitude of 2122 m.a.s.l. with the mean

annual rainfall of 1100 mm. The experimental site's soil texture is classified as silty loam. Zazie is located at $037^0$18’37’’ E longitude, $05^0$55’42’’N latitude and altitude of 2298 m.a.s.l. The average yearly precipitation is 900mm and the soil texture at the test location is classified as sandy loam.

Experimental Materials and Design

The study involved six officially released potato varieties and two local ones. It was set up in a randomized complete block design with three replications. Each unit consisted of a 3m x 3m plot with four rows, spaced 1m apart. The spacing between plots and blocks was 1m and 1.5m, respectively. Well-sprouted potato tubers were planted at a spacing of 75cm between rows and 30cm between plants. In each location, NPS at a rate of 236 kg ha^{-1}, urea at a rate of 144 kg ha^{-1} and MoP (Muriate of Potash) at a rate of 125 kg ha^{-1} were applied. The full rate of NPS and MoP, as well as half of the urea were applied during planting, while the remaining half of the urea was applied at flowering. Cultural practices like weeding, cultivation and ridging were performed as recommended. Data collection was done from the two central rows to minimize border effects.

Table 1: Different types of potato varieties selected for the research

No	Varieties	Source	Year of release
1	Horro (CIP-384321.30)	BARC	2015
2	Belete (CIP-393371.58)	HARC	2009
3	Hundee (CIP-90147.8)	SARC	2006
4	Araarsaa (CIP-90138.12)	SARC	2006
5	Gudanie (CIP-386423.13)	HARC	2006
6	Jalenie (CIP-37792-5)	HARC	2002
7	Kalsa (local check)	Bonke market	-
8	Asmara (local check)	Chencha market	-

[1]BARC= Bako Agricultural Research Center, HARC = Holetta Agricultural Research Center, and SARC = Sinana Agricultural Research Center

Data Collected

The data provided was gathered from the central rows and includes information on Days to emergence, Days to blooming, Days to full mature, Plant height (cm), Number of branches per

plant, Number of marketable tubers per plant, Number of non-marketable tubers per plant, Weight of marketable tubers per plant (kg), Weight of non-marketable tubers per plant (kg), Tuber yield per plot (kg), Tuber yield per hectare (t), Average tuber weight (g), Average tuber length (cm) and Average tuber diameter (cm))were also recorded and analyzed.

Statistical Analysis

The study utilized SAS software version 9.0 to analyze the variance in tuber yield and other traits, examining main and interaction effects. The locations and years were treated as random variables, while the varieties were considered fixed factors. Significant factors were further analyzed through mean comparisons using the Duncan's Multiple Range Test (DMRT) at a significance level of 5%.

RESULTS AND DISCUSSION

Phonological and Growth Parameters

The combined analysis of variance (ANOVA) indicated that both locations and varieties showed statistically significant difference for days to emergence, days to flowering and maturity, plant height and number of branches plant^{-1}. The Variety x Location interaction was also significant for all four traits and non-significant for days to emergence (Table 2).

Table 2: Combined Analysis of variance (ANOVA) for phenological and growth parameters

Source	Df	DTE	DTB	DTM	PH (cm)	NBPP
Location (L)	2	81.40**	1496.27**	59.09**	23507.97**	500.17**
R(L)	6	23.87**	17.70^{NS}	34.53**	28.95^{NS}	1.16^{NS}
Yr(Loc)	3	280.21**	595.31**	1454.57**	3562.73**	224.56**
Variety(G)	7	104.98**	116.13**	368.805**	2868.57**	49.88**
GxL	14	9.12^{NS}	32.29**	42.30**	324.79**	8.02**
Yr*G(Loc)	21	10.65^{NS}	16.36*	11.16^{NS}	73.65**	6.48**
Error	90	7.09	8.92	8.97	31.71	2.85
CV%		12.94	5.19	3.33	7.41	17.08

* = significant at P≤ 0.05, ** = significant at P≤ 0.01, DTE = Days to emergence, DTB = days to blooming, DTM= days to maturity, PH = plant height in centimeter, NBPP =Number of branches plant^{-1}

Days to emergency and flowering were fast at Yelagnaw Arguba while days to maturity was a bit late than the case of Chosha (Table 3), The time required for emergence of seedlings depends on

soil texture and temperature, soil moisture, depth of planting, vigor of the seed and varieties [7]. Regardless of varieties, the longest plants were obtained at Yelagnaw Arguba (89.19cm) and Zazie (88.29cm) but the average plant height was short at Chosha (50.41cm). The highest number of branches per plant was achieved at Yelagnaw Arguba with a value of 12.73, in contrast to 6.38 at Chosha. (Table 3).

There was a notable variation among different varieties in terms of the time taken for emergence, blooming, maturity, plant height, and number of branches per plant. The variety Horro showed the best performance on days to emergence (17.33), blooming (53.67), maturity (82.39) and plant height (98.80cm). However, there was not a statistically significant variation between Horo and Asmara in terms of the number of days required for maturity. The highest number of branches per plant was obtained from potato variety Asmera (12.94) (Table 3).

Results of the current study are in line with the findings of the authors who reported that the existence of significant differences between potato varieties for days to emergence, days to flowering and days to maturity across locations [8]. Other authors also found significant genotypic differences in plant height and number of branches plant^{-1}[9] and [10].

Table 3: Mean days to emergence, blooming and maturity, plant height and number of branches plant^{-1} for three locations and eight potato varieties grown for two consecutive years in Gamo Zone and Derashe Woreda

Locations	DTE	DTB	DTM	PH (cm)	NBPP
Chosha	20.56b	61.13b	88.94a	50.41b	6.38c
YelagnawArguba	19.29a	51.17a	91.08b	89.19a	12.73a
Zazie	21.90c	60.52b	89.52a	88.29a	10.54b
Mean	**20.58**	**57.60**	**89.85**	**75.97**	**9.88**
LSD	1.08	1.21	1.21	2.28	0.68
Varieties					
Horro	17.33a	53.67a	82.39a	98.80a	10.94 b
Belete	20.11bc	58.11cd	94.28de	80.14b	9.67c
Hundee	24.50d	56.39bc	89.67c	64.76d	8.22d
Araarsaa	23.44d	58.72de	90.39c	55.83e	7.50d
Gudanie	21.33c	60.44ef	88.61c	77.84b	9.72c
Jalenie	20.06bc	60.72f	95.39e	78.59b	10.44 bc
Kalsa	19.33b	54.67ab	84.89b	71.68c	9.61c
Asmera	18.56ab	58.11cd	93.17d	80.08b	12.94 a
Mean	**20.58**	**57.60**	**89.85**	**75.97**	**9.88**

LSD	1.76	1.98	1.98	3.73	1.12

Within the same column, means with matching letters are not statistically different at a significance level of 5%.

Tuber Yield and Related Traits

Locations differed significantly in number and weight of marketable tubers kg plant^{-1}, number of non- marketable tubers kg plant^{-1}, total tuber yield plot-^{1} and hectare^{-1}, tuber weight, tuber length and tuber diameter, but did not differ in weight of non-marketable tubers plant^{-1}. The effect of varieties and variety x location interaction were significant for tuber yield and all yield components except weight of non- marketable tubers plant^{-1} and average tuber length (Table 4). The presence of variety x location interaction for tuber yield and related traits would indicate that varieties were inconsistent in performance across the test locations. The existence of variety by location interaction for tuber yield and yield related traits has also reported for potato by various authors [11], [12] and [13].

Table 4: Significance of mean squares of tuber yield, and tuber numbers of eight potato varieties grown for two consecutive years at three locations in Gamo Zone and Derashe Woreda

Source of variation	Df	NMTPP	NNMTP	WMTPP (kg)	WNMTPP (kg)	TYPP (kg)	TYPH (t)	ATW (g)	ATL (cm)	ATD (cm)
Location (L)	2	125.52^{**}	18.55^{**}	1.82^{**}	0.0001^{NS}	236.58^{**}	11683.197^{**}	58034.18^{**}	18.37^{**}	5.60^{**}
R(L)	6	5.16^{NS}	0.26^{NS}	0.04^{NS}	0.001^{NS}	4.77^{NS}	235.788^{NS}	731.79^{NS}	2.18^{NS}	0.10^{NS}
Yr(Loc)	3	126.03^{**}	55.84^{**}	7.00^{**}	0.03^{**}	472.21^{**}	23319.159^{**}	129076.85^{**}	126.64^{**}	32.62^{**}
Variety(G)	7	131.58^{**}	247.65^{**}	1.67^{**}	0.04^{**}	325.45^{**}	16071.580^{**}	59314.67^{**}	26.58^{**}	4.96^{**}
GxL	14	10.63^{**}	11.79^{**}	0.12^{**}	0.002^{NS}	29.22^{**}	1442.940^{**}	2523.424^{**}	2.09^{NS}	0.48^{**}
Yr*G(Loc)	21	9.54^{**}	18.94^{**}	0.10^{**}	0.009^{**}	13.43^{**}	663.298^{**}	3363.60^{**}	1.45^{NS}	0.24^{**}
Error	90	2.70	2.45	0.03	0.002	4.11	202.932	657.98	1.32	0.11
CV%		18.47	38.79	18.49	61.65	15.68	1.568	16.77	12.38	5.96
Mean		**8.90**	**4.03**	**0.87**	**0.07**	**12.93**	**28.730**	**152.93**	**9.28**	**5.59**

* = significant at P≤ 0.05,** = significant at P≤ 0.01, NMTPP = Number of marketable tubers plant^{-1}, NNMTPP = Number of non-marketable tubers plant^{-1}, WMTPP = Weight of marketable tubers plant^{-1}, WNMTPP = Weight of non-marketable tubers plant^{-1} (kg), TYPP = Tuber yield plot^{-1}(kg), TYPH = Tuber yield hectare^{-1} (t), ATW = Average tuber weight in gram, ATL = Average tuber length in centimeter, ATD = Average tuber diameter in centimeter

There were considerable variations in number and weight of marketable tubers plant^{-1}, tuber yield per plot and per hectare, and tuber length, weight and diameter (Table 5). The number of marketable tubers plant^{-1} ranged from 7.23 at Chosha to 10.46 at Yelagnaw Arguba. Similarly, the highest weight of marketable tubers plant^{-1} was obtained at Yelagnaw Arguba (1.07 kg) followed by Zazie (0.87 kg) and the lowest tuber weight (0.68 kg) was obtained at Chosha.

Average tuber weight ranged from 115.89g at Chosha to 184.86g at Yelagnaw Arguba. The highest average tuber length and diameter were obtained at Yelagnaw Arguba (9.99cm and 5.99cm) respectively.

High number of marketable tubers plant^{-1} were obtained from, Asmera (13.89) followed by Horro (10.00),Kalsa (9.61) Gudanie (9.44) and Belete (9.28) but fewer marketable tubers plant^{-1} were obtained from Jalenie (7.17), Hundee (7.11), and Araarsaa (4.67). Weight of marketable tubers plant^{-1} of varieties ranged from 0.42kg (Araarsaa) to 1.33kg (Belete). Weight of Marketable tubers plant^{-1} was also high for Horro (1.09kg), Jalenie (1.05kg) and Gudanie (1.025 kg) but low for Hundee (0.58 kg), Kalsa (0.66 kg) and Asmera (0.80 kg).The variation in number of tubers plant^{-1}and tuber weight plant^{-1} has also been reported in previous studies in potato [9] and [14]. Asmara had the highest number (13.00) and weight (0.18 kg) of non-marketable tubers plant^{-1} while the lowest number (1.72) and weight (0.03kg) of non-marketable tubers plant^{-1} were observed on Horro followed by Belete 1.833 and 0.04, respectively. The highest average tuber weight plant^{-1} was obtained from Belete (254.49g) followed by Jalenie (217.24g) and the lowest from Asmera (97.22g), Kalsa (102.82g) and Hundee (107.31g). Tuber length ranged from 7.75cm (Asmera) to 11.11cm (Belete) and tuber diameter ranged from 5.01cm (Asmera) to 6.40cm (Jalenie) (Table 5).

Table 5: Mean values of nine tuber yield and related traits of eight potato varieties grown at three locations for two consecutive years in Gamo Zone and Derashe Woreda

Locations	NMTPP	NNMTPP	WMTPP (Kg)	WNMTPP (Kg)	TYPP(Kg)	TYPH(t)	ATW(g)	ATL(cm)	ATD (cm)
Chosha	7.23c	3.63a	0.68c	0.069a	11.04c	24.53c	115.89c	8.85b	5.40b
YelagnawArguba	10.46a	4.75b	1.07a	0.071a	15.37a	34.16a	184.86a	9.99a	5.99a
Zazie	9.00b	3.73a	0.87b	0.071a	12.37b	27.49b	158.05b	9.01b	5.39b
mean	**8.90**	**4.03**	**0.87**	**0.07**	**12.93**	**28.73**	**152.93**	**9.28**	**5.59**
LSD	0.67	0.63	0.065	0.02	0.82	1.83	10.40	0.47	0.14
Varieties									
Horro	10.00b	1.72a	1.09b	0.03a	15.88b	35.29b	165.90c	10.02b	5.62b
Belete	9.28b	1.833a	1.33a	0.04ab	19.28a	42.84a	254.49a	11.11a	6.33a
Hundee	7.11c	3.67c	0.58d	0.06bc	8.48e	18.85e	107.31e	8.31cd	5.21c
Araarsaa	4.67d	3.22bc	0.42e	0.05abc	6.39f	14.20f	125.52d	8.91c	5.57b
Gudanie	9.44b	2.61ab	1.025b	0.06bc	15.55b	34.56b	152.95c	9.75b	5.50b
Jalenie	7.17c	2.33ab	1.05b	0.059bc	13.75c	30.56c	217.24b	10.39ab	6.40a
Kalsa	9.61b	3.89c	0.66d	0.08c	10.33d	22.96d	102.82e	8.02d	5.10c
Asmera	13.89a	13.00d	0.80c	0.18d	13.76c	30.58c	97.22e	7.75d	5.01c
mean	**4.03**	**0.87**	**8.90**	**0.07**	**12.93**	**28.73**	**152.93**	**9.28**	**5.59**
LSD	1.09	1.04	0.11	0.03	1.34	2.98	16.99	0.76	0.22

Means in the same column followed by the same letters are not significantly different at 5% level of significance, NMTPP = Number of marketable tubers plant^{-1} in kilogram, TYPP (kg) = Tuber yield plot^{-1} in kilogram, ATD (cm) = Average tuber diameter in centimeter

Mean Performance of Varieties in Tuber Yield

The performance of varieties varied with locations. At Chosa Horo and Belete; at Zazie Horo, Belete, Gudeni, Jaleni and Asmera, and at Yelegnaw Arguba Belete gave the highest values (Table 6).

All the high yielding varieties except Asmara (Belete, Horro, Gudanie and Jalenie) had above average tuber weight, length and diameter (Table 5). Asmara had many small tubers (13 tubers plant^{-1}), while the other four varieties had 1.72 to 2.61non marketable tubers plant^{-1}. However, only 51.65% of Asmara's tubers were marketable; while others consisted of 75.47 (Jalenie) to 85.3% (Horro) marketable tubers. Significant genotypic, environmental and G x E effects on tuber yield have been reported by various authors [11], [12] and [13]. Differential performance of potato varieties across environments has also been reported by [15], [16] and [17].

Table 6: Mean tuber yield (t ha^{-1}) of eight potato varieties grown at three locations for two consecutive years in Gamo Zone and Derashe Woreda

	Locations			
Varieties	Chosha	Zazie	Yelagnaw Arguba	**Mean**
Horro	32.83ab	30.98a	42.08b	**35.29b**
Belete	36.25a	35.66a	56.61a	**42.84a**
Hundee	15.02c	19.86bc	21.60de	**18.82c**
Araarsaa	11.96c	12.69c	18.22e	**14.2c**
Gudanie	28.05b	28.94ab	46.7b	**34.56b**
Jalenie	29.16b	34.03a	28.49cd	**30.56b**
Kalsa	18.65c	24.17b	26.06d	**29.96b**
Asmera	24.64bc	33.63a	33.49c	**30.59b**
Mean	**24.54**	**27.5**	**34.16**	**28.73**
LSD	6.84	8.30	7.10	7.41

Means in the same column followed by the same letters are not significantly different at 5% level of significance

SUMMERY AND CONCLUSION

Eight different types of potatoes (six released between 2002 and 2015 and two local types) were tested at three different locations in SERS, which varied in soil type, rainfall (ranging from 900 to 1100 mm per year), and altitude (2122 to 2880 meters above sea level). The Randomized Complete Block Design (RCBD) with three replications was used for two years consecutively. The main purpose of the experiment was to identify the best-performing potato varieties in terms of high yield, resistance to diseases and insect pests, and adaptability in Gamo Zone and Derashe Woreda of SERS. These areas had previously relied solely on local varieties for potato cultivation.

Results of the combined analysis of variance across the different locations revealed significant differences among the varieties and locations for most phenological and growth parameters related to tuber yield and its components. The V x L interactions was also highly significant for most traits, indicating the need to assess the stability of varieties across locations.

The presence of significant V x L interaction indicates inconsistency of performance of varieties over the testing locations and the necessity of looking for stable varieties that possess high performance across environments.

Better performance of the potato varieties were observed at Yelagnaw Arguba where mean tuber yield of 34.16 t ha^{-1} were obtained. Plants matured later, grew taller, and had many branches and tubers (especially marketable), and higher weight of marketable tubers $plant^{-1}$, and produced bigger (longer, heavier and wider) tubers at this location. Below average mean tuber yields ha^{-1} were recorded at Chosha (24.54 t ha^{-1}) and Zazie (27.50 t ha^{-1}), where general performance was poor.

In the present study four varieties released in different years, Belete (2009), Horro (2015), Gudanie (2006) and Jalenie (2002) and two of the local checks (Asmara and Kalsa) gave above average tuber yields of 42.84, 35.29, 34.56, 30.56, 30.59 and 29.96 t ha^{-1}. All the released varieties except Horro were released by Holeta agricultural research center, which is under EIAR (a Federal Research Institute). Horro was released by Bako agricultural research center under OARI (regional research institute). It is interesting to note that Jalenie, released before 16 years, is still performing well under diverse environments in southern Ethiopia. Two of the varieties released in 2006 by Sinana agricultural research center under OARI, Hundee and Araarsaa gave below average tuber yields of 14.20 and 18.82 t ha^{-1}. Poor performance of the varieties released

relatively recently (in 2006) by a regional research center and better performance of varieties released long ago by a federal research center might point to the limited access of regional research to diverse testing environments and the vice versa for the federal research centers. Varieties released by regional research centers might be adapted to a very narrow environmental range and may not withstand the fast worsening climatic conditions over many production seasons and may become quickly obsolete and come out of production.

It was also interesting to note that both local checks under production by farmers were characterized by many smaller tubers plant^{-1} although percentage of marketable tubers was low (51.65 and 71.185%).

Under subsistence agriculture the farmer's major emphasis may not be on marketable yield but on total productivity (both marketable and unmarketable tubers) to feed the family. One of these farmers' varieties, Asmara, however, was among the high yielding varieties released by conventional research.

The existence of high variability in phenology, growth, tuber yield and yield components among the six highest yielding varieties is believed to give opportunity for making crosses among them and further improve tuber yield.

RECOMMENDATIONS

Based on the findings of this study the following recommendations were made.

1. Varieties Belete, Horro and Gudanie were recommended for PED to farmers for large scale production for the study areas and areas with similar agroecologies.
2. Even if Asmara was inferior to other varieties except farmers' variety, it can be used by potato breeders as it possessed a number of small tubers per plant that potentially be improved if crossed with varieties such as Jalenie which had bigger but small number of tubers per plant.

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