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Evaluation of Potato (*Solanum tuberosum* L.) Varieties under Irrigation in West Wollega and Kellem Wollega Zones

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ABSTRACT

Background and Objective: Low yields of potatoes have been attributed to several factors including lack of high-yielding improved varieties and poor quality seed, poor disease and pest management, inadequate soil fertility and water stress. The objective of this study was to identify the adaptable, high-yielding, insect pest and disease tolerant varieties of potato in West Wollega and Kelem Wollega zones of Oromia. **Materials and Methods:** Evaluation of potato varieties was done at Sayo and Nedjo sites of Haro Sabu Agricultural Research Center (HSARC) during 2018-2019 under irrigation conditions. Improved potato varieties namely Dagim, Belete, Gudanie, Hundee, Araarsaa, Jalenie and Gera varieties with local check were evaluated using randomized complete block design with three replications. As 195 kg/ha of Diamonium phosphate(DAP) fertilizer was applied at planting while 165 kg/ha Urea was applied in split form (50% at planting and the remaining 50% early before planting). The analysis of variance indicated significant ($p<0.01$ or 0.05) varietal differences for all observed parameters over year and locations. **Results:** The highest number of main stems were recorded from variety Belete at Sayo in 2018 and lowest was from Araarsaa variety at Nedjo in 2019. Highest tuber size was recorded from Belete variety and the lowest was from local variety. The highest and the lowest total tuber yield (TYt/ha) was recorded from Belete and Araarsaa varieties. The tested potato varieties Belete and Gudanie showed better performances on desirable traits such as number of tuber per hill, tuber size and marketable yields which determine total tuber yield. **Conclusion:** Therefore, Gudanie and Belete were identified and selected as the best for different merits to be demonstrated and popularized in the studied areas.

KEYWORDS

ANOVA, improved varieties, marketable yield, number of tuber per hill, tuber size

INTRODUCTION

Potato is a crop of major economic importance worldwide. It is the fourth most important crop after rice, wheat and maize and has historically contributed to food and nutrition security in the world[1]. It is the most important non-grain crop and the fourth most important crop in terms of global production[2]. It is regarded as a high-potential food security crop because of its ability to provide a high yield of high-quality product per unit input with a shorter crop cycle[3]. Potatoes are a precious source of food for many low income people in both urban and rural areas. It can be consumed in different forms, such as boiled, roasted, french fries and chipped[4].

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In Ethiopia, it is the fastest growing staple food crop and source of cash income for small holder having high potential for food security due to its high yield potential and nutritional quality tuber, short growing period (mostly<120 days) and wider adaptability[5] and it is the first among root and tuber crops in both area of production and productivity per unit area[6]. However, the productivity of potato in Oromia Region is very low (112.30 Qt/ha) in comparative to national average (166.87 Qt/ha)[6]. Despite the potential production of potato in the region the productivity of potato is much lower than other regions of the world. These relatively low yields have been attributed to several factors including lack of high yielding improved varieties and poor quality seed, poor disease and pest management, inadequate soil fertility and water stress[7].

In West Wollega and Kellem Wollega zones potato was cultivated under rain fed, irrigation and residual moisture (bone) to ensure food security and food self-sufficiency and income generation. However, due to lack of improved potato varieties, farmers in these areas were using local potato variety that is susceptible to major potato diseases and has low yield potential. Hence, lack of high yielding potato varieties, which are tolerant/resistant to major diseases and insect pests, is becoming the major bottlenecking problem in the study area. Therefore, it is significant to evaluate different improved potato varieties to recommend high tuber yielding and disease tolerant variety/ies for the study area. Thus, the objective of this study was to evaluate the performance of potato varieties and recommend the best performed and disease tolerant varieties for production in the studied areas and similar agrological zones.

MATERIALS AND METHODS

Experimental location and experimental material: The study was conducted at Sayo and Nedjo Districts from Kellem Wollega and Western Wollega zones, respectively under irrigation conditions in 2018 and 2019 cropping seasons from December to March. Seven improved potato varieties namely; Dagim, Belete, Gudanie, Hundee, Araarsaa, Jalenie and Gera (Table 1) were collected from Sinana and Kulumsa Agricultural Research Centers and one local check was evaluated using Randomized Complete Block Design (RCBD) with three replications. The gross plot size for the experiment was 13.5 m^2 (4.5×3 m) with six rows of plants spaced at 75 and 30 cm between rows and plants, respectively and the net plot size was 3×3 m (9 m^2). Inorganic fertilizer DAP-195 kg/ha at planting while UREA-165 kg/ha were applied in split form (50% at planting and the remaining 50% was applied early before flowering at 45 days after planting). Furrow irrigation type was used with three days intervals of watering from land preparation to plant maturity.

Data collection and statistical analysis: Data collected for days to 90% maturity, number of main stems, number of tubers per hill, tuber size in centimeter, total tuber yield in tone per hectare, the weight of marketable yield and weight of marketable yield were analyzed using 18th edition Gen Stat software. Fisher's protected Least Significant Difference (LSD) test was used to compare treatment mean differences at the probability level of 0.05.

Table 1: Description of evaluated potato varieties

Variety name	Year of release GC	Maintaining center
Dagim (CIP-396004.337)	2013	Adet ARC/ARARI
Belete (CIP-393371.58)	2009	Holeta ARC/EIAR
Gudanie (CIP-386423.13)	2006	Holeta ARC/EIAR
Hundeee (CIP-90147.8)	2006	Sinana ARC/OARI
Araarsaa (CIP-90138.12)	2006	Sinana ARC/OARI
Gera (KP-90134.2)	2003	Sheno ARC/ARARI
Jalenie (CIP-37792-5)	2002	Holeta ARC/EIAR
Local	-	-

RESULTS AND DISCUSSION

Analysis of variance: The analysis of variance revealed the main effect of variety, location and year had a highly significant ($p<0.01$) effect on days to maturity and the main effect of variety had a significant ($p<0.05$) effect on total tuber yield (ton/ha) and weight of marketable and unmarketable yield. Likewise, the interaction effect variety and location revealed significant differences ($p<0.05$) in number of main stems, number of tubers per hill and weight of marketable yield. On the other hand, all the interactions only revealed a significant effect ($p<0.05$) number of main stems (Table 2).

Days to maturity: The interaction effect variety and year revealed a highly significant effect ($p<0.01$) on days to maturity (Table 2), where Belete variety was earlier than others in 2018 and later matured in 2019 (Table 3). This might be due to the varietal effect and environmental conditions such as light and soils which influence crop maturity[8]. This result was related to Fekadu *et al.*[9], who reported different maturity dates for different potato varieties in Siltie Zone of Southern Ethiopia. Similarly, Hunde *et al.*[10] reported significant differences among potato genotypes on days to maturity. Likewise, Alemayehu *et al.*[11], stated that significant difference in flowering and maturity days among varieties in which the longest days required to attain 50% flowering and 70% maturity were recorded on Belete (66.3 and 115.6 days) and Gudenie (65.7 and 113.3 days) varieties.

Number of main stem per plant: The interaction effect of variety, location and year showed significant differences ($p<0.05$) on number of main stems per plant (Table 2). The highest number of main stems was recorded from variety Belete at Sayo location in 2018 and lowest was from Araarsaa variety at Nedjo in 2019 (Table 4). The differences might be due to varietal effect and plant canopy which determine the main stem to different locations. Similarly, the difference in number of main stems among the varieties might be due to the genotypic variation in the number of buds per tuber which might be determined by the size of the tubers and number of viable sprouts at planting. The result was consistent with Damtew *et al.*[12], who reported that the number of stems per plant is influenced by variety.

Number of tuber per hill: The interaction effect of variety and location as well as variety and year revealed a significant ($p<0.05$) effect on number of tuber per hill; whereas the interaction effect of location and year showed highly significant ($p<0.01$) (Table 2). The highest (16.44) and the lowest (6.75) number of tuber per hill was obtained from Belete in 2018 and Hundee varieties in 2019, respectively (Table 5). On the other hand, the highest and the lowest number of tuber per hill was recorded Gudanie (16.1) at Nedjo site and Gera (8.44) varieties at Sayo site, respectively (Table 6). These differences might be due to soil fertility dissimilarity between locations since soil fertility varies based on pH, soil porosity and soil particle make-up. On the other hand, the number and size of tubers depend on the varietal character and edaphic factors. Correspondingly, Zewdu *et al.*[13] reported that the highest number of tuber per hill from Gudanie variety. Similarly, Abewoy *et al.*[12] stated that the maximum tuber number per hill (16.73) and the

Table 2: Analysis of Variance (ANOVA) for performance evaluation of potato varieties

		Mean squares						
Source of variation	df	DM	NMS	NTPH	TS (cm)	MY (ton/ha)	UMY (kg/ha)	TY (ton/ha)
Replication	2	20.57	5.48	9.56	42.69	35.2	5278	36.01
Variety	7	95.14**	3.39	60.914**	72.08*	510.09**	284680**	498.2**
Location	1	137.76**	0.27	14.714	4.78	212.96*	14416	216.48*
Year	1	1464.84**	96.25**	206.85**	1141.84**	32.04	172819**	36.92
Variety×location	7	1.784	6.48*	17.098*	29.39	80.14	211173**	78.69
Variety×year	7	68.82**	5.098*	18.923*	56.21	43.32	143372**	40.89
Location×year	1	137.76**	34.79**	119.44**	30.28	2.83	2119579**	9.85
Variety×location×year	7	1.784	6.514*	9.448	18.52	70.08	367739	79.35
Error	62	3.637	2.023	7.756	26.77	37.94	7742	37.95

**Highly significant ($p<0.01$), *Significant effect ($p<0.05$), DM: Days to maturity, NMS: Number of main stem, NTPH: Number of tuber per hill, TS: Tuber size in centimeter, TY ton/ha: Total tuber yield in tone per hectare, MY: Weight of marketable yield (ton/ha) and UMY: Weight of unmarketable yield (kg/ha)

Table 3: Interaction effect of variety and year on days to maturity

	Year	
Variety	2018	2019
Dagim	103.3^{g}	110.3^{a}
Belete	97.7^{h}	109.8^{ab}
Hundee	104.3^{fg}	109.2^{abc}
Gudanie	107.7^{bcde}	108.2^{abcd}
Jalenie	93.7^{j}	107.7^{bcde}
Gera	95.3^{ij}	107^{cde}
Local	97^{hi}	106.3^{def}
Araarsaa	102.7^{g}	105.7^{ef}
LSD (0.05)	2.201	
CV (%)	1.8	

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance, LSD (0.05): Least significant difference at 5% level and CV: Coefficient of variation

Table 4: Interaction effect of variety, location and year on number of main stems

		Year	
Variety	Location	2018	2019
Belete	Sayo	9.667^{a}	3.583^{f-m}
	Nedjo	5.111^{c-j}	2.861^{j-m}
Araarsaa	Sayo	3.222^{h-m}	3.417^{g-m}
	Nedjo	8.222^{ab}	1.417^{m}
Local	Sayo	5^{c-j}	4.833^{c-k}
	Nedjo	7.111^{bc}	3.917^{e-l}
Jalenie	Sayo	3.889^{e-l}	3.667^{f-m}
	Nedjo	6.778^{bcd}	3.625^{f-m}
Hundee	Sayo	4^{e-l}	3.083^{i-m}
	Nedjo	6.111^{b-e}	2.528^{klm}
Dagim	Sayo	5.444^{c-h}	4.583^{d-l}
	Nedjo	5.778^{c-f}	2.5^{lm}
Gudanie	Sayo	5.222^{c-i}	5.667^{c-g}
	Nedjo	5^{c-ij}	2.917^{i-m}
Gera	Sayo	3.444^{g-m}	4.667^{d-l}
	Nedjo	4.556^{d-l}	3.25^{h-m}
LSD (0.05)	2.3		
CV (%)	31.4		

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance, LSD (0.05): Least significant difference at 5% level and CV: Coefficient of variation

Table 5: Interaction effect of variety and year on number of tuber per hill

	Year	
Variety	2018	2019
Belete	16.44^{a}	11.62^{def}
Gudanie	15^{abc}	16.17^{ab}
Local	15.28^{abc}	12.23^{cdef}
Gera	13.22^{bcd}	10.08^{defg}
Hundee	13.11^{bcd}	6.75^{h}
Jalenie	12.56^{cde}	7.69^{gh}
Dagim	11.44^{def}	9.17^{fgh}
raarsaa	9.89^{efgh}	9.75^{efgh}
LSD (0.05)	2.3	
CV (%)	31.4	

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance, LSD (0.05): Least significant difference at 5% level and CV: Coefficient of variation

minimum number per hill (13.17) we rerecorded from Gudanie and Guassa varieties, respectively. Degebasa[14] also reported a significant variation between varieties, growing environment and their interaction in potato for average tuber number per hill.

Table 6: Interaction effect of variety and location on number of tuber per hill

	Location	
Variety	Sayo	Nedjo
Gudanie	11.97[b]	16.1[a]
Belete	15.79[a]	15.38[a]
Jalenie	11.86[b]	15.65[a]
Hundee	11.92[b]	11.39[bc]
Local	10.01[bc]	9.85[bc]
Dagim	10.89[bc]	9.35[bc]
Araarsaa	11.18[bc]	9.43[bc]
Gera	8.44[c]	11.9[bc]
LSD (0.05)	3.2	
CV (%)	23.4	

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance, LSD (0.05): Least significant difference at 5% level and CV: Coefficient of variation

Table 7: Main effect of variety and year on tuber size of potato varieties

Variety	Tuber size (cm)
Belete	27.95[a]
Dagim	25.64[ab]
Gera	24.93[ab]
Araarsaa	24.71[ab]
Hundee	24.21[ab]
Jalenie	22.52[bc]
Gudanie	22.35[bc]
Local	19.83[c]
LSD (0.05)	4.223
Year	
2018	27.47[a]
2019	20.57[b]
LSD (0.05)	4.22
CV (%)	21.5

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance, LSD (0.05): Least significant difference at 5% level and CV: Coefficient of variation

Tuber size: The main effect of variety and year revealed significant ($p<0.05$) and highly significant ($p<0.01$) effects on tuber size (cm) (Table 2). The highest (27.95 cm) and the lowest (19.83 cm) tuber size were recorded from Belete and local varieties, respectively (Table 7). The significant variations among varieties across growing environments (locations) and year for tuber size might be attributed to inherent potential of such varieties which were highly influenced by growing conditions and interaction of genotype and environment. This result was comparable with the work of Fekadu *et al.*[9], who reported significant tuber diameter among different potato varieties in Siltie Zone of Southern Ethiopia. Likewise in line with this result, Zeleke *et al.*[15] reported the biggest tuber size obtained from Belete variety, which was higher by 12.5 and 39.70% over Gudane and local varieties, respectively.

Marketable yield (ton/ha): The main effect of effect of variety and location showed a significant ($p<0.01$) effect on weight of marketable yield whereas the main effect of year and all the interactions had no significant effect on marketable yield (Table 2). The highest (41.93 ton/ha) and the lowest (20.87 ton/ha) marketable yield was recorded from Belete and Araarsaa varieties, respectively (Table 8). Similarly, the highest (33.86 ton/ha) and the lowest (30.88 ton/ha) marketable yield were obtained from Sayo and Nedjo sites, respectively (Table 8). The differences among varieties and locations might be due to potential adaptability of varieties to different locations. On the other hand desirable yield component traits such as number of tuber per hill and tuber size greatly determine market quality and are key for variety adoption and play a great role in affecting marketable tuber yield. Likewise, Gebreselassie *et al.*[16] reported that Belete variety produced the highest marketable yield per hectare in the eastern parts of Ethiopia.

Table 8: Main effect of variety location and year on Marketable tuber yield (ton/ha), unmarketable yield (kg/ha) and total tuber yield (ton/ha)

Variety	Marketable tuber yield (ton/ha)	Unmarketable tuber yield (kg/ha)	Total tuber (ton/ha)
Belete	41.93^{a}	246.9^{c}	42.17^{a}
Gudanie	38.34^{ab}	135.4^{de}	38.48^{ab}
Jalenie	33.93^{bc}	163.5^{d}	34.1^{bc}
Gera	33.88^{bc}	107de	33.99^{bc}
Local	32.46^{c}	72^{e}	32.53^{c}
Hundee	30.78^{cd}	503.8^{a}	31.28^{cd}
Dagim	26.8^{d}	368.5^{b}	27.17^{d}
Araarsaa	20.87^{e}	372.3^{b}	21.24^{e}
LSD (5%)	5.027	71.807	5.08
Location			
Sayo	33.86^{a}	258.43^{a}	34.12^{a}
Nedjo	30.88^{b}	233.92^{b}	31.12^{b}
LSD (5%)	5.027	35.904	2.514
Year			
2018	31.80	203.74^{b}	32.00
2019	32.95	288.60^{a}	33.24
LSD (5%)	NS	35.904	NS
CV (%)	19	35.7	18.9

Means in columns and rows followed by the same letter(s) are not significantly different at 5% level of significance, LSD (0.05): Least significant difference at 5% level and CV: Coefficient of variation

Unmarketable yield (kg/ha): Except the main effect of location and interaction effect of variety, location and year; all the main effect and interaction effects revealed significant ($p<0.01$) on unmarketable tuber yield. The interaction effect of variety and year revealed a significant ($p<0.05$) effect on the unmarketable yield. The lowest (503.8 kg/ha) and the highest (72 kg/ha) unmarketable tuber yields were recorded from Hundee and Local varieties, respectively (Table 8). The variation in unmarketable yield of the genotypes might be attributed to variability in varieties and inherent ability of potato genotypes to produce unmarketable tubers per plant. Moreover, unmarketable tuber yield might be controlled more importantly by intensively manipulating the growing environment associated with factors such as disease incidence, agronomic practices and harvesting practices[17]. In line with this result, Bekele and Ebrahim[18] reported significant difference in varieties on unmarketable yield at Maokomo; in which the lowest (0.37 kg/plot) and the highest (1.82 kg/plot) unmarketable tuber yield were obtained from Belete and Shonkola varieties, respectively. Similarly, the current result was in line with the findings of Gebreselassie *et al*.[16], who reported that the interaction effects of growing environment and genotype; significantly influence unmarketable tuber yield.

Total tuber yield (TYt/ha): The main effect of variety revealed a highly significant ($p<0.01$) effect and the main effect of location showed significant ($p<0.05$) differences on total tuber yield (TYt/ha). The highest (42.17) and the lowest (21.24) total tuber yield was recorded from Belete and Araarsaa varieties, respectively (Table 8). On the other hand the highest (34.12 ton/ha) and the lowest (31.12 ton) total tuber yield was recorded at Sayo and Nedjo sites, respectively (Table 8). The significance difference among varieties and between locations might be due to the ability to adaptableness of different varieties of the same crop to different environments. Moreover the highest value of vital yield related traits (number of tuber per hill and weight of marketable yield) of Belete and Gudanie varieties play a great role in determining the tuber yield of these varieties. Singh and Singh[19] also indicated that yield per unit area is the end product of components of several yield contributing characters which are highly influenced by the environment. The result of this study is in agreement with Kiffo[17] in which significantly highest total tuber yield was recorded for Belete (48.3 ton/ha), while significantly lowest yield was registered for Jarso (18.14 ton/ha) at Haramaya and Hirna. Similarly, in line with current result, Alo and Geremew[20] reported that highest and the lowest tuber yield was recorded from Belete and Shonkolla varieties, respectively in Southern Ethiopia. Accordingly, Zeleke *et al*.[8] reported a significant variation between potato varieties for

their average tuber weight, total tuber number per hill, marketable and total tuber yield in which the highest tuber yield (48.55 ton/ha) obtained from Gudanie variety and the lowest (5.29 ton/ha) was recorded from CIP-395077.12 genotype. In addition to this Shiferaw *et al.*[21] reported the highest yield (55.12 ton/ha) was recorded from Gudanie variety at BuleHora District of Borena Zone. Similarly, Korji and Kebede[22] also reported that Gudanie variety yielded 26.69 ton/ha on farm evaluation at Guji highlands of Oromia region.

CONCLUSION

The experiment was done to evaluate the performance evaluation potato varieties under irrigation in Kellem and West Wollega zonesat Sayo and Nedjo locations for two consecutive years. Seven improved varieties were evaluated with a local variety using RCBD with three replications. The result of the study revealed that Belete and Gudanie showed better performances on more important such as number of tuber per hill, tuber size, marketable yields and unmarketable yields which determine total tuber yield in ton/ha. The highest (42.17 ton/ha) and the lowest (21.24 ton/ha) total tuber yield was recorded from Belete and Araarsaa varieties. Among evaluated potato varieties Belete and Gudanie showed better performances on marketable yields and total tuber yield. Thus, Gudanie and Belete were selected and approved for demonstration and large scale production in the studied areas and similar agro ecologies.

SIGNIFICANCE STATEMENT

Lack of high yielding improved varieties and use of local cultivar which are susceptible to major potato diseases are major factors decreasing potential yields of potato in Kellem Wollega and West Wollega zones. The objective of the study was to identify and recommend the adaptable, high-yielding, insect pest and disease tolerant varieties. Gudanie and Belete were selected for their higher tuber yield and major disease tolerant. Thus they are approved for demonstration and large scale production.

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