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Research Article

Yield Performance of Potato (*Solanum tuberosum* L.) Varieties under Rainy Season at Wogera District, Northwestern Ethiopia

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Abstract

Potato is a very important food and cash crop in Ethiopia which has a favorable agroecology for productivity. However, factor like lack of adapted variety is a critical challenge of crop productivity. A field experiment was conducted at Wogera District, Northwestern Ethiopia to investigate the performance of different varieties of potatoes for yield and its components. The study was conducted at two different locations during 2016/17 namely main cropping season, under rain fed condition using two improved varieties and one local variety. The experiment was laid out in a randomized complete block design with four replications. The result of the study showed significant differences among varieties for all the recorded traits except total number of tubers. The local variety is out performed by improved varieties for the majority of the traits except flowers and maturity. The variety Guassa matured earlier gave 147.2% more marketable tuber number. Moreover this variety provided 121.8% and 90.8% advanced marketable and total tuber yield over the local landrace. Hence, Guassa can be used in the study area in similar agroecology in near future.

Keywords: Potato, agroecology, crop productivity, randomized complete block design, tuber number.

Introduction

Potato (*Solanum tuberosum* L.) is the fourth most important crop and first among root and tuber crops (FAO, 2008). Potato primarily grown for its starchy tuberous root; its flour can be produced for soup, biscuits, bread, and chips. Potato consumed all around the world and is one of the main favorite vegetable in Ethiopia. Potato was introduced to Ethiopia in 1859 (Gebremedhin *et al.*, 2008). Its production has increased considerably through time and has great contribution for millions of Ethiopian. Hence, the crop becomes first among the major crops of Ethiopia. Gondar is amongst the major potato production zones in northwestern part of Ethiopia (Gebremedhin *et al.*, 2001; Adane *et al.*, 2010). Potato is an important food and cash crop in the country especially when the grains get depleted from the store. From the national production, 63.67% is used for human consumption while 20.36% was reserved for planting material (CSA, 2012). As mentioned by Seifu and Betewulign (2017), Potato provides food and income as a cash crop for over 2.3 million households in different part of Ethiopia. According to CSA (2015), about 1.3 million farmers are involved in the production of potato in the country. Nutritionally, Potato produces more energy and protein per unit area and unit of time than most other major food crops; it is fat-free and contains substantial amounts of minerals (Lutaladio and Castaldi, 2009).

The crop is also rich in several micronutrients and vitamins, especially Vitamin C; a single medium sized potato of 150 g provides nearly half of the daily adult requirement (100 mg) (FAO, 2008). Potato is a moderate source of iron, a good source of vitamins B_1, B_3 and B_6 and minerals such as Potassium, Phosphorus and Magnesium. Potatoes also contain dietary antioxidants, which may play a part in preventing diseases related to ageing and dietary fiber (Mulatu *et al.*, 2005). Hence, high production capacity as well as good nutritional quality, regarded potato as high-potential food security crop (Muthoni and Nyamongo, 2009). Though the crop is nutritious and high yielder, Ethiopia has favorable agroecology and wide production area for potato still the national productivity is very low (CSA, 2016). There are various factors that contribute to the low yields of potatoes and lack of well adapted potato variety is among the principal factors limiting production in Ethiopia (Gebremedhin *et al.*, 2008; Adane *et al.*, 2010). In Ethiopia, the variety development study was started in 1975. Since that time, different potato varieties were developed and formally released for production (MOA, 2012). However, there have been many challenges and problems that have been hindering the wider adaptation and use of these improved varieties. The wider adaptation and researchers' criteria may not fit to all agro ecologies and fulfill farmer's preferences.

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Agroecologies varied with respect to soil type, moisture and temperature regimes, fertility condition and the onset, intensity and duration of rain as well as irrigation facilities, where farmers thrive to grow potato (Gebremedhin *et al.*, 2008). Hence, the performance of potato varieties differ from area to area and none of the released varieties has equal potential to perform throughout the country (Bradshaw, 2007). Wogera district is a potential part for potato production and many farmers grow potato for many years. However, many of the farmers use local landraces due to lack of access for well adapted varieties. To do so, there should be identified potato variety. Therefore, this research was initiated to evaluate the different potato varieties for their yield and performance of yield components.

Materials and methods

Study area: The study was conducted on farmers' field nearby Ambagiworgis and Kossoye area of Wogera district during 2016 main cropping season. Wogera District is located between 37.36°E and 12.46°N longitude and at an altitude of 2900 m.s.l in the northern highlands of Ethiopia, 781 km from Addis Ababa and 41 km from Gondar city. The rainfall pattern is bimodal, with a short rainy season from March to May, followed by a long rainy season from June to September. It has an average annual rainfall of 700 mm and the mean annual temperature is 12.7°C as mentioned by Eshetu *et al.* (2017).

Experimental materials and designs: Three potato varieties (two improved and one local variety) were arranged in a randomized complete block design with 4 replications on two locations (Table 1). The study area has a clay loom soil which was plowed 3 times using Oxen. Medium sized (35-45 mm diameter) and Sprouted tubers were planted by hand in rows 75 cm apart and with 30 cm between plants within rows. Blocks were separated by 1.5 m and 1 m between plots within the block. There were 4 rows/plots for each treatment. Data were collected from the middle two rows; the outermost rows and terminal plants were borders. Urea and DAP fertilizer were used as source of nitrogen and phosphorous respectively. The entire rate of phosphorus and half the rate of nitrogen was applied at the time of planting and the remaining half of nitrogen was applied 45 days after planting. Earthening up and weeding were carried out 3 times by hand during the growing period.

Collection of data: Data on phenological and yield component traits were recorded from five sample plants per plot from the following traits

Days to 50% emergence: Recorded by counting the number of days from planting to 50% of the plants emerged in each plot

Days to 50% flowering: Recorded by counting the number of days from emergence to a stage when 50% of the plants in the plot produce flowers

Days to 70% maturity: Counted by the number of days from emergence to a stage when 70% of the haulms (vines) turned yellow and leaves show senescence

Plant heights (cm): Measured from the soil surface to the top most growth point of the main shoot apex when 50% of the plants produce flowers

Number of stems/plant: Recorded the stems that emerged independently above the soil as single stems at 50% flowering.

Total tuber number (count/plant): Recorded by counting the actual number of tubers at harvest.

Number marketable tubers: Recorded by counting the number of healthy and more than 50g tubers per plant (Tekalign, 2005).

Number unmarketable tubers: Recorded by counting the number of diseased and less than 50g tubers per plant

Marketable tuber yields (ton/ha): Measured by the weight of tubers with a size greater than or equal to 50g and converted in hectare base (Zelalem *et al.*, 2009).

Total tuber yield (ton/ha): Measured the weight of all tubers (marketable and unmarketable tuber yields) at time of harvest.

Data analysis: Collected data were checked for constant variance ANOVA and normality and subjected to analysis of variance using SAS Version 9.2 statistical software (SAS, 2008). Treatment means that showed significant difference were compared using Least Significant Difference (LSD) test at 5% significant level.

Results and discussion

The Combined Analysis of variance (ANOVA) for different recorded traits showed a significant influence of the variety among which days to 50% emergence, days to 70% maturity, unmarketable and marketable tuber number, marketable and total tuber yield exhibited high significance ($P<0.01$) influence while a significant difference ($P<0.05$) was noted for days to 50% flowering, number of stems per plant and plant height (Table 2). However, the result revealed that total number of tubers was not significantly influenced by the varieties. These significant variations among tested potato varieties indicate the presence of variability for selection of varieties based on those yield and yield related traits. There was no significant location influence on the studied traits except days to emergence which showed presence of environment influence. Also, the interaction of location and variety did not significantly affect all the traits.

Days to emergence: According to Khalafalla (2001), numbers of days to emergence, flowering and maturity are important for potato producers for land use and marketing plan.

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Table 1. Characteristics of varieties used.

S.No.	Genotype Name	Year of release	Released by	Favorable Environment		Time to maturity	Yield Performance (t/ha)	
				Altitude (m)	Rainfall (mm)		Farmer field	Research Site
1.	Guasa (CIP-384321.9)	2002	ADARC	2000-2800	1000-1500	110-115	22-25	24.4-33
2.	Belete (CIP-393371.58)	2009	HARC	1600-2800	750-1000	110-120	28-33.8	47
3.	Local variety			1600-3100	980-1398			

ADARC = Adet Agricultural Research Center, HARC = Holetta Agricultural Research Center, (MOA, 2012).

Table 2. Mean square values of yield and yield components of potato varieties for combined analysis of variance over location.

Source of variation	DEM	DFL	DTM	NSt	PH	UMTN	MTN	TTN	MTY	TTY
Replication	5.5**	34.7**	67.77**	7.6**	27.51ns	38.61**	39.51**	9.52*	311.5**	312.37**
Location (L)	4.16*	0.38ns	1.5ns	0.35ns	35.04ns	0.46ns	4.35ns	7.6ns	24.4ns	16ns
Variety (V)	8.16**	8.16*	28.46**	2.24*	162.5*	24.42**	24.72**	0.18ns	303.8**	235.87**
V×L	1.79ns	1.12ns	7.87ns	0.26ns	51.26ns	0.06ns	1.55ns	1.48ns	5.44ns	8.83ns
CV%	4.9	2.25	2.95	15.48	11.36	22.6	18.67	12.54	21.32	17.86

ns = not significant, ** significant at 0.01%, * = significant at 0.05%, DEM = Days to emergence, DFL = Days to flowering, DTM = Days to maturity, PH = Plant height (cm), NSt = Numbers of stems /plant, UMTN = number of unmarketable tubers/plant, number of marketable tubers/plant, TTN= Total number of tuber/ plant, MTY= marketable tuber yield (t/ha), TTY = total tuber yield (t/ha).

Table 3. Means of phenological traits as affected by the varieties over location.

Variety	DEM	DFL	DTM	NSt	PH
Belete	17.12b	62.25b	119.37b	5.85a	58.81a
Local	19.75a	66.75a	124.5a	3.32b	50.56b
Guassa	17.87b	61.87b	116.62c	5.08a	55.75ab
Mean	18.25	63.6	120.16	4.75	55.04
LSD (5%)	0.95	1.15	2.49	0.78	6.66

LSD = Least significant difference, DEM = Days to emergence, DFL = Days to flowering, DTM = Days to maturity, PH = Plant height (cm), NSt = Numbers of stems /plant, UMTN = number of unmarketable tubers/plant, number of marketable tubers/plant, TTN= Total number of tuber/ plant, marketable tubers yield (t/ha), TTY = total tuber yield (t/ha).

Table 4. Means of variety over yield and yield characters of potato varieties combined over location.

Variety	UMTN	MTN	MTY	TTY
Belete	3.85b	9.06a	29.46a	33.3a
Local	9.1a	3.58b	14.45b	18.76b
Guassa	3.54b	8.85a	32.06a	35.8a
Mean	5.52	7.16	25.32	29.31
LSD (5%)	1.33	1.43	5.7	5.58

UMTN = number of unmarketable tubers/plant, number of marketable tubers/plant, TTN= Total number of tuber/ plant, marketable tubers yield (t/ha), TTY = total tuber yield (t/ha) .

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The result of current study revealed that there was no significant difference for days to emergence and days to flowering between Belete and Gussa varieties (Table 3). Both varieties emerged earlier than the local variety. Local variety took extended time for emergence and flowering which was significantly different from the two varieties. The local variety reached to 50% emergence at 2.63 and 1.88 days after Belete and Guassa varieties emerged, respectively. Similarly, it was flowered at 4.88 and 4.5 days later to Guassa and Belete varieties, respectively. This may be due to the genetic difference among variety inheritance as Bradshaw (2007) stated that the days require for flowering is highly dependent on gene factor. On the other hand, the three experimental materials significantly differ for days to 70% maturity (Table 3). Guassa variety reached to 70% maturity at 2.75 days prior to Belete variety. The local variety showed 6.75 % and 4.3% in extended time to reach to 70% maturity as compared to Guassa and Belete varieties, respectively. The result is inconformity with Ebrahim *et al.* (2018) who reported a significant difference in days to emergence and flowering among potato varieties and local landrace took longest time to emerge from the soil and to reach physiological maturity. Also, Dash *et al.* (2018) reported that potato varieties significantly differ in their time of emergence. Alemayehu *et al.* (2018) reported a significant variation on days to 50% flowering as well as days to 70% maturity and also reported that the local variety showed early flowering and maturity characteristics.

Number of stem and plant height: The current study revealed that the type of variety affected the number of stem per plant. The highest number of stems was found from variety Belete (5.85) followed by Guassa (5.08) while less number of stems was recorded from local landraces (3.32). On the other hand, a significant plant height variation was exhibited between the land races and the two potato varieties (Table 3). Though there was no statistical difference between the improved varieties, Belete variety was the tallest (58.81 cm) compared to the three varieties while the shortest plant height was measured from the land race/ local variety. The number of stem and the height of a plant are related to the number of branch and the number of leaves which contributes to leaf area of a plant. According to Paul (2007), the number of first order stem have role for an increase in leaf insertion number and position of the leaf on the plant which is important for rate of leaf area increment. Leaf area of a plant has relationship with the photosynthesis potential of a crop. Likewise, White (2007) stated increase in absorption of solar radiation can ensures a higher photosynthesis potential and then promotes the synthesis and accumulation of reserve carbohydrates in the potato tuber which has a positive effect on the final tuber yield.

In line with the current result, similar achievements were reported by Abu-Zinada and Mousa (2015) who had reported a significant difference on plant height and number of stem per plant in potato varieties. Ebrahim *et al*. (2018) reported significant difference on stem number among potato varieties and local landraces exhibited the lowest number of stem per plant. Also, Alemayehu *et al*. (2018) reported a significant variation and shortest plant height from local landraces as compared to 7 potato varieties.

Number of tubers: The current result showed that the number of marketable as well as unmarketable tubers was affected by the variety (Table 4). More number of unmarketable tubers was found from local landraces (9.1) while more number of marketable tubers was found from the improved potato varieties. The number of unmarketable tuber of local landrace was 136% and 157% higher than Belete and Guassa, respectively. On the other hand, the highest number of marketable tuber, which has direct economic value for the benefit of the farmers as well as the consumer, was obtained from Belete variety which was 153% higher than the local landrace followed Guassa that gave 147.2% higher. In line with the current study Alemayehu *et al*. (2018) reported a significant variation on the number of marketable and unmarketable tuber and lesser number of marketable tubers in line with highest unmarketable tuber number was recorded from local landrace. Similarly, Tibebu (2016) reported a significant influence of potato varieties on number of marketable and unmarketable tuber yield.

Yield: Marketable tuber yield has great economic value for the farmers and it was affected by the variety used (Table 4). The highest marketable tubers were found from Guassa variety while the lowest was from local variety. The current result showed the possibility of marketable tuber yield increment by 121.8% and 103.8 % via use of Guassa and Belete variety, respectively. The more number of marketable tubers contributed to more marketable tuber yield. Similarly, the total tuber yield of potato was affected by the variety used. The lowest total tuber yield was recorded from local landraces (18.76) which was lesser by 90.8% from the highest performed variety, Guassa and 77.5% from Belete variety. The result is in agreement with Dash *et al.* (2018), who had previously reported a significant difference in marketable and total tuber yield among potato varieties. Similarly, Ebrahim *et al*. (2018) reported significant difference of marketable and total tuber yield among potato varieties and local landraces exhibited the lowest marketable and total tuber yield. Likewise, Habtamu *et al*. (2016) and Alemayehu *et al*. (2018) reported a significant variation on the marketable and total tuber yield among potato varieties and lowest marketable yield was recorded from local landrace.

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Conclusion

The two improved varieties performed better over the studied areas, they had showed early emergence, flowering and maturation than the local landrace. Also they had good vegetative growth (height and stem number), higher number of marketable tuber in line with lesser number of unmarketable tubers. Moreover, these varieties provided high amount of marketable tuber yield which is a key need of producers. Though there was no significant variation in between Belete and Guassa in their yielding ability, Guassa had shorter time to mature and yield more in shorter period of time as compared to Belete as well as local landrace. Hence, to maximize productivity of potato in the study and similar agroecological area, it is better to consider the characters of the variety having high market and yield advantage in conjugation with time. Therefore, Guasa variety also matured early with high yield and can be used in the study area under similar environments.

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