

Adaptability of Released Potato (*Solanum tuberosum* L.) Varieties at Masha and Chena, South western Ethiopia.

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Abstract

Background: Rapidly increasing population pressure, widespread environmental degradation, recurrent drought, low productivity of the agricultural sector and limited market access have greatly contributed to critical food shortages in Ethiopia. These in turn have resulted in food insecurity, which is characterized by inability of the people at all times to have a physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life. Therefore; this study was conducted to test the adaptability of improved potato varieties, identify and select the best high yielding and pest and disease resistant/ tolerant variety/ies for target area.

Methodology: Six released potato varieties were brought from Adet agricultural research center and evaluated during 2016 cropping season at two locations (Masha research site and Chena). Six released potato varieties were used for the experiment. The experiment was laid out in randomized complete block design replicated three times.

Results: The mean yield was ranged from 286.3 to 398.48 Quintal/ha for Shenkolla and Belete varieties respectively. Based on the recorded parameters Belete variety performed better than other varieties.

Conclusion: The findings of the study revealed that, the three varieties, Belete, Gera and Gudene were best performed than other varieties and will be recommended for the surrounding farmers for wider production. Further study should be carried out with improved varieties to improve potato production, especially in southwestern Ethiopia.

Keywords: Potato; Adaptability; Tepi; Southwestern Ethiopia

Background

Irish potato (*Solanum tuberosum* L.) is a starchy, tuberous crop of the Solanaceae family [1]. It is a crop of major economic importance worldwide [2]. Ethiopia has possibly the greatest potential for potato production; seventy percent of its arable land mainly in highland areas, above 1500 m.a.s.l., are believed to be suitable for potato. About 70% of the available agricultural land is located in an altitude of 1800-2500 m.a.s.l. and receives an annual

rain fall of more than 600mm which is suitable for potato production. In 2017/18 cropping season, the total area under production is estimated to be 69,610.81 hectares and the production is estimated to be 9,689,696.44 quintals [3] and with an average national yield of 13.9 t ha⁻¹ [4].

According to [5], of the total land areas of about 496, 148.99 hectares covered by root and tuber crops, 296, 578 hectare (~60%)

and of over 7.21 million tons of RTCs produced over 3.67 million tons (~51%) was covered with Potato. Potato has short cropping cycle and higher production per hectare per day when compared to other arable crops and it provides hope for improving the lives of millions of poor farmers in the risk-prone highlands [6]. In Ethiopia, potato is grown in a wide range of agro-ecological zones, throughout the year using different growing practices and is considered a “hunger breaking crop” because it can be grown and harvested when cereals don’t mature for consumption other crops fail. Indeed, potato is the only food crop grown to any large extent in the dry season where rainfall is erratic and unpredictable in the months of March through May [7].

Globally, Potato ranks fourth after wheat, rice and maize crops with an estimated cultivated area of 19 million hectares with production of 332 million metric tons annually [8] and followed by cassava, sweet potato and yam from root and tuber crops [2]. Since the highlands are also home to almost over half of Ethiopian population, the potato could play a key role in ensuring national food security [9]. In Ethiopia, potato ranks first among the major tuber crop in volume of production and consumption followed by Enset, sweet potato, yam and taro [10]. Potato is grown in diverse soil types ranging from vertisol to nitosols in the highlands of Ethiopia.

The national average yield stands at 11.8 t ha⁻¹ [11], which is low compared to the world’s average productivity of 16.4 t ha⁻¹ [13]. However, different biotic and abiotic factors are contributing for the low yield of Potato in Ethiopia. Of the contributing factors to the low yield and yield components of potato, substandard agronomic practices including suboptimum fertilizer amount application, use of substandard quality tubers and shortage of improved and adaptable cultivars are the major [12]. The growing importance of potato as a food crop is prefaced on rising food insecurity in the country. Increasing potato production on a sustainable basis will enable the crop to assert as a national strategic food security crop and help ease the food security challenges of the country. Rapidly increasing population pressure, widespread environmental degradation, recurrent drought, low productivity of the agricultural sector and limited market access have greatly contributed to critical food shortages in Ethiopia. These in turn have resulted in food insecurity, which is characterized by inability of the people at all times to have a physical and economic access to sufficient food to meet their dietary needs for a productive and healthy life.

Consequently, there is evidence of a reduced capacity to cope with expected setbacks in their economic or natural environments. The vast majority of the Ethiopian population depends mainly on cereal crops as food source. The food potential of horticultural crops, particularly that of root and tuber crops, has not yet been fully exploited and utilized despite their significant contributions towards food security, income generation, provision of food energy and resource base conservation [13].

On top of this, the root and tuber crops can also serve as source of cash income for low-income farm households and raw material for processed products for both rural and urban consumption. No country in sub-Saharan Africa has experienced a faster growth in Potato area than Ethiopia. The area under Potato cultivation is increasing at an average annual rate of 15%. As in most developing countries, the growth in production of Potato was brought about by an expansion in acreage rather than productivity.

Three decades ago, Ethiopia’s national potato area was estimated at 30000 hectares [14], reaching 50000 hectares by the mid 1980’s, and 160000 hectares by 2001 [14]. Yet, during this same period average yields have only increased by 3 tons per hectare, from 5 tons per hectare in 1975 to 8 tons at present. These low yields are the consequence of multiple factors, including the use of unproductive, highly susceptible varieties subject to rapid degeneration by viruses, and limited use of sustainable integrated crop management (ICM) practices in potato cropping systems. National potato research programs in sub-Saharan Africa have continuously focused on selection of high-yielding varieties with resistance to late blight (LB) disease [15].

Potato holds a huge (largely ignored) promise for improving the livelihoods of hundreds-of-thousands of smallholder farmers in Ethiopia’s risk-prone highlands. Potato has high potential for improving food security, increasing household income and poverty reduction. Despite these; the major problems include shortage of good quality seed tubers; lack of adaptable and disease-resistant varieties; inappropriate agronomic practices; poor storage, transport, and marketing conditions; declining soil fertility; and inadequate extension services [14].

Recently, the government of Ethiopia declared that Irish potato to be a national strategic food security crop [9]. This main policy pronouncement, qualified Irish potato for government-initiated farmer support initiatives supervised by Agricultural Research Centers through on farmer’s plot seed multiplication and small scale semi-modern irrigation building. The growing importance of potato as a food crop is prefaced on rising food insecurity in the country. Increasing potato production on a sustainable basis will enable the crop to assert as a national strategic food security crop and help ease the food security challenges of the country.

Ethiopia is one of the principal potatoes producing countries in Africa and probably displays a unique position for having the highest potential area for cultivating potatoes. It is endowed with suitable climatic and edaphic condition for the production of high yield of potatoes. The crop is grown mainly during the rainy season and where irrigation is available and frost is not limiting, year-round production is also possible. The high lands are the most populated area of the country containing the majority of agricultural work force required for the sector. With the continuing increase in population and decline in the size of farm holdings, the

major labor force has to move to labor intensive cropping system to sustain rural development and food production.

A number of production problems that account for the small area cropped with potato and the low national yield have been identified. The major ones are the concentration of potato cultivation in the highlands, unavailability and high cost of seed tubers, non-optimal agronomic practices, the prevalence of diseases and insect pests, and inadequate storage, transportation and marketing facilities [3]. Southwest Ethiopia is one of the region's high land areas that demands intervention efforts in line with improving potato productivity there by to have an input for the betterment of farmers of the area. Providing varieties which out yield the local variety is of paramount importance to increase accessibility of balanced food and household income.

To advance improvement of crop productivity in different localities, continual identification of the best and suitable crop technologies appeared to be essential. This can be achieved, through adaptability tests and generation of new technologies. Keeping this in view, the present study was conducted at Tepi Agricultural Research Center to test the performance of released Potato varieties for their adaptability in Tepi area.

Material and Methods

Description of experimental site

The experiment was conducted at Masha and Chena districts during 2015/2016 cropping seasons by Tepi Agricultural Research Centre. Tepi located in south western Ethiopia in SNNP Regional State at an elevation of 1200 meter above sea level and it is situated at Latitude of 7° 10, 54.5' and with a Longitude of 35° 25,04.3-28.2' E of Ethiopia. The research station receives an annual average rainfall of 1559 mm with maximum and minimum temperatures of 29.7 °c and 15.5 °c, respectively. The soil of experimental site is reddish brown sandy clay loam classified as nitosol with PH range of 5.6 to 6.0.

Experimental materials and design

The experiment was based on six released potato varieties which were obtained from Adet Agricultural Research center. Description of the experimental materials with their yield potential is shown in (Table 1) below. Randomized complete block design with three replications was used to conduct the experiment. Seed tubers were planted 75cm*30cm spacing between rows and between plants respectively.

Table 1: Description of six potato varieties with their agro-ecological adaptations.

Variety	Altitude (m)	Yield qt/ha		Year of Release
		RM	FM	
Belete	1600-2800	472	280-338	2009
Gudene	1600-2800	290	210	2006
Gera	2200-3200	259	-	2003
Jalene	1600-2800	403	291	2002
Guassa	2000-2800	244-330	220-225	2002
Shonkolla	1700-2700	315	291	2005

RM = under researchers 'management, FM = under farmers 'management.

Source: Ministry of Agriculture Crop variety registration bulletin (1987-2010).

Table 2: The Combined Mean Values of measured traits of tomato varieties at Masha and Chena.

Treatments	Stem Number per Plant	Stem Height	Marketable Yield per Plot	Total Yield per Plot	Total Yield Qt/ha	Av. Tuber Number	Av. Tuber Weight	Tuber Width	Tuber Length	Tuber Eye Number
Belete	3.33 ^b	47.6 ^{ab}	35.79 ^a	35.86 ^a	398.48 ^a	9.22 ^a	178.33 ^a	5.32 ^a	8.51 ^a	11.1 ^a
Guasa	3.5 ^{ab}	42.16 ^{bc}	28.31 ^{cd}	30.02 ^b	333.56 ^b	6.61 ^a	83.33 ^c	4.54 ^b	6.68 ^b	6.56 ^b
Shenkola	2.56 ^b	37 ^{cd}	25.71 ^d	25.76 ^c	286.3 ^c	6.38 ^a	120 ^{bc}	4.74 ^b	6.25 ^b	6.58 ^b
Jalene	4.3 ^a	36.63 ^d	28.51 ^{bc}	28.57 ^{bc}	317.46 ^{bc}	9.13 ^a	116.67 ^{bc}	4.56 ^b	6.8 ^b	6.69 ^b
Gudene	4.4 ^a	46.13 ^{ab}	31.13 ^b	31.18 ^b	346.44 ^b	8.58 ^a	118.33 ^{bc}	4.58 ^b	6.93 ^b	6.76 ^b
Gera	2.93 ^a	50.13 ^a	34.83 ^a	34.88 ^a	387.57 ^a	8.75 ^a	141.67 ^{ab}	5.17 ^a	6.94 ^b	7.63 ^b
CV	22.6	10.52	7.24	9.27	9.27	32.91	36.13	6.31	13.32	15.65
LSD	0.94	5.45	2.66	3.44	38.3	3.19	54.68	0.36	1.12	1.41

Data collected

Data were collected on ten traits of potato varieties. Marketable and total tuber yield kg/plot, Stem number/plant at 50 % flowering,

Stem height at 50 % flowering, Stand count at harvest, Average tuber weight, Average. Tuber number/hill, Tuber eye number etc. Some important metrological data including mean monthly rain fall

(mm), mean maximum and minimum monthly temperature, mean % relative humidity and soil type were recorded.

Statistical analysis

All necessary data were recorded and being subjected to analysis. Analysis of variance was performed using the ANOVA procedure of SAS Statistical Software. Effects were considered significant in all statistical if the P-values were < 0.05. Means were separated using least significant difference test.

Results and Discussion

All varieties showed significant difference for stem number per plant, stem height, marketable yield per plot, total yield per plot, total yield quintal/ha, average tuber number/hill, average tuber weight, tuber width, tuber length and tuber eye number. Belete, Gera and Gudene gave highest yield followed by Guassa, Jalene and Shenkolla respectively. Gudene had highest stem number per plant followed by Jalene. Belete had highest marketable yield per plot, total yield per plot, total yield quintal/ha, average tuber weight, tuber width, tuber length and tuber eye number followed by Gera. Belete had highest average tuber number followed by Jalene. Gera had highest stem height followed by Belete. Yield per hectare showed significant difference among the varieties. The highest yield was obtained by Belete and the least yield was recorded by Shenkolla. This result is in agreement with the result which reported by [16] which stated that Belete variety was high yielder than other varieties at Haramaya location. Although, in contrary with the result reported by same authors at Hirna location which stated Gera variety was high yielder than Belete (Table 2).

Summary

The vast majority of the Ethiopian population depends mainly on cereal crops as food source. The food potential of horticultural crops, particularly that of root and tuber crops, has not yet been fully exploited and utilized despite their significant contributions towards food security, income generation, provision of food energy and resource base conservation [13]. Six released potato varieties were tasted at Tepi ARC in randomized complete block design with three replications during 2008 cropping season at two locations. The experiment was carried out to test the adaptability of improved potato varieties and identify and select the best high yielding, pest and disease resistant/tolerant variety/ies for the target area. The mean yield mean average tuber number and mean tuber length was ranged from 286.3 to 398.48 q/ha, 6.38 to 9.22 and 6.25 to 8.51 for Shenkolla and Belete respectively. Based on mean yield, Belete, Gera and Gudene gave highest yield. The mean average tuber weight ranged from 83.33 gm to 178.33 for Guassa and Belete respectively. The mean tuber width ranged from 4.56 for Jalene to 5.32 for Belete. The mean tuber eye number was ranged from 6.56 to 11.1 for Guassa and Belete respectively [17-20].

All varieties showed significant difference for stem number per plant, stem height, marketable yield per plot, total yield per plot,

total yield quintal/ha, average tuber number/hill, average tuber weight, tuber width, tuber length and tuber eye number. Belete, Gera and Gudene gave highest yield followed by Guassa, Jalene and Shenkolla respectively. Gudene have highest stem number per plant followed by Jalene. Belete have highest marketable yield per plot, total yield per plot, total yield quintal/ha, average tuber weight, tuber width, tuber length and tuber eye number followed by Gera. Belete had highest average tuber number followed by Jalene. Gera have highest stem height followed by Belete. Yield per hectare showed significant difference among the varieties. The highest yield was obtained by Belete and the least yield was recorded by Shenkolla. In general, Belete, Gera and Gudene were well adapted than other varieties and have to be multiplied and disseminated to users. Further study should be carried out with improved varieties to improve potato production, especially in Southwestern parts of Ethiopia [21,22].

Conclusion

Potato holds a huge (largely ignored) promise for improving the livelihoods of hundreds-of-thousands of smallholder farmers in Ethiopia's risk-prone highlands. Potato has high potential for improving food security, increasing household income and poverty reduction. Despite these; a set of constraints along the potato production has to be considered simultaneously, to ensure higher yields, better income, and a significant contribution of potato farming to food security, nutritional security and improved livelihoods in the country. The best adapted varieties like Belete, Gera and Gudene should have to be multiplied and disseminated to the area. Potato varieties that have high yielding, good resistance to late blight and low degeneration rate as well as good table and processing qualities have to be released and disseminated to boost potato production and productivity.

Authors' Contributions

SA initiated and executed the field experiment, managed and followed the field, collected data and wrote the manuscript. DG managed and followed the field and collected data.

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Availability of Data and Materials

All data generated from the study and reported in the manuscript are included in the article. Further data sets are available from the corresponding author upon request.

Consent for Publication

Not applicable.

Ethics Approval and Consent to Participate

It is not applicable to this study.

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Conflict of Interest

The authors declare that they have no competing interests.

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