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Research Article

Evaluation of the Performance of Improved Potato (Solanum Tubersom L) Varieties for Mid Altitude Areas of Southern Ethiopia

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Abstract

The experiment was conducted during 2020 and 2021 growing seasons at Wondogenet, Shashemene and Arsis Nigel to evaluate the performance of improved potato varieties with respect to their tuber yield and qualities. Seven improved potato varieties were tested using randomized complete block design with three replications. All necessarily data were collected and analyzed using SAS software. The combined analysis of variance showed a highly significant differences ($p \leq 0.05$) among tested varieties for plant height, tuber diameter, tuber weight per hill, tuber yield per hectare, root dry matter content and specific gravity. As a result, Belete variety gave the highest tuber yield per hectare (35.37 t ha^{-1}) which was followed by Burka variety (31.73 t ha^{-1}) while the lowest (20.41 t ha^{-1}) from Dagim variety. The highest tuber dry matter content (26.52) was obtained from Bolete variety which was statistically similar with Burka (25.85) variety while the lowest (21.18) from variety Dagim. With respect to specific gravity, Belete variety gave the highest (1.15) followed by Burka (1.11) variety but the lowest (1.03) was from Dagim variety. Therefore, among the tested potato varieties, Belete and Burka were recommended fortheir better tuber yield and quality traits for the study areas and similar agroecology

Keywords: Dry matter content; Environment; Genetic variation; Tuber quality; Tuber yield

Introduction

Potato *(Solanum tuberosum* L.*)* belongs to the *Solanaceae* family and genus solanum. The genus *Solanum* is a polymorphous and largely tropical and subtropical genus containing more than 1000 species [1]. 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 [2]. It is playing a major role in national food and nutrition security, alleviation of poverty, generating income, and providing job opportunity in line with production, processing and marketing sub-sectors [3]. Potato has very good nutritional importance and it can produce more energy and protein per unit and area per unit time than most other major cereal food crops; it is fat-free and contains substantial amounts of minerals [4]. 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). It is a high potential food security crop in Ethiopia due to its high yield potential, nutritional quality, short growing period and wider adaptability [5]. In Ethiopia, potato is becoming the most important crop for enhancing food security especially on the highland and mid-altitude areas of the country and it also considered as a source of income generation and double cropping [6].

The major potential areas for potato production are the Central, Southern, Southeastern, Southwestern and Northwestern part the country, where altitude ranges from 1500 to 3000 m and the rainfall between 600 to 1200 mm [7]. Despite, Ethiopia has a suitable environment for potato production, the national average yield of potato in Ethiopia is 13.9 t ha^{-1} [8] which is lower than the world average yield of 20 t ha^{-1} [2]. The low productivity in the country is attributed due to lack of well adapted varieties which is accepted by the farmers, unavailability and high cost of seed tubers, too low or too high planting density, diseases, insect, etc [6,7,9].

The low average yield is attributed to many factors, the major one being lack of well adapted high yielding cultivars, unavailability and high cost of quality seed tubers, inappropriate agronomic practices, diseases, insect pests, inadequate storage, transportation and marketing facilities [10]. The majority of potato growing smallholder farmers uses low yielding and late blight susceptible local varieties due to the limited availability of improved seed potatoes in the country [11]. In many parts of Ethiopia particularly at study areas, farmers grow old varieties, which resulted in farmers for demanding of higher yielder and disease resistant varieties of potato. Thus, evaluation of potato varieties at different potential areas like Wondogenet, Arsinegele and Shashemene is one of the means to solve the aforementioned problems. Therefore, the research was done to evaluate the performance of potato varieties for growth and tuber yield at study areas and to select the best adaptable varieties of potato with respect to yield and quality traits for respective study areas.

Materials and Methods

Description of experimental site

The experiment will be conducted at Wondogenet, A/negele andShashemene in 2020/2021 under rainfed condition. All experimental sites are described in the following table (Table 1).

Table 1: Description of the tested locations.

Locations	Soil type	Temperature (°c)		Soil, pH	Annual, Rainfall	Altitude (m.a.s.l)
		Max	Min			
Wondogenet	Sandy loam	26.72	12.02	6.4	1000	1780
A/negele	Sandy loam	27	10	7.5	500-1150	1840
Shashemene	Sandy loam	28	12	7.65	1500- 2000	1672- 2722

Source: (Wondogenet ARC and respective woreda's office of Agriculure, 2020).

Experimental design and experimental procedures

The experiment consisted of six potato varieties (Dagim, Belete, Burka, Gera, Guassa, Gudane and Jalene), which released by Holetta and Adet Agricultural research center. Thetrial was arranged in randomized complete block design (RCBD) with three replications. Thus, there wasseventreatments in triplicates. The treatments were randomly allotted to each plot. The experimental plot had an area of 8.64 m^2 (3m length x 3.50m width). The space between replications and plots was 1.5 m and 1m, respectively. The space between rows and plants was 75cm and 30cm respectively. Fertilizer was applied at rate of 237 kg NPS/ha and 142 Urea /ha as per recommendation. Urea fertilizer was applied in split that is 50% during time of planting and the rest 50% urea was applied at vegetative stage while all NPS fertilizer was applied at time of planting. Plants in the three middle rows out of the five rows per plot constituted the net plot used as the sampling unit. Ten plants from the middle rows were taken for sampling and for growth parameters and the yield was obtained from the harvestable area of the middle three rows and converted to hectare.

Data collection and analysis

Data on plant height, tuber number/plant, tube length, tuber diameter, tuber weight/plant, tuber yield/ha, tuber dry matter content and specific gravity were collected. Collected data were subjected to analysis of variance using SAS package (SAS 9.4). Least significance differences (LSD) were made to compare the treatments following the procedures of Gomez and Gomez (1984).

Results and Discussion

The combined mean analysis of variance revealed significant (P≤0.01) difference among potato varieties for plant height, tuber diameter, tuber weight/plant and tuber yield per hectare but no significance differences have been observed for tuber length and tuber number. Guassa variety was the tallest (108.27cm) which was statistically similar with Belete (103.87cm) variety and the shortest (79.00 cm) was Dagim. The differences in plant height among the tested varieties probably caused by genetic makeup and growing environments [12]. The result is in harmony with Berhanu and Tewodros [13] who found a significant effect of environments, cultivar and their interaction on plant height in Eastern Ethiopia. Zerihun [14] also observed substantial variability in plant height among potato genotypes and growing environments in northern Ethiopia. The maximum average stem number (6.93) was recorded from Gudanevariety that was statistically similar with Jalene (6.72) variety followed by variety Belete (5.45) while the lowest (3.22) was from variety Dagim. The difference in number of number main stem among the varieties might be due to the inherent genotypic variation in the number of buds per tuber which is influenced by the size of the tubers, physiological age of the seed and number of viable sprouts at planting. The result is consistent with Habtamu *et al*. [15] who reported that thenumber of stems per plant is influenced by variety.

Maximum tuber number per hill (16.73) was recorded from Guidance variety which was statistically similar with Burka (14.00) and Jalene (13.88) varieties followed by Guassa (13.17) variety. But the lowest was obtained from Dagim (6.11) variety. Abebe *et al*. [16] also reported a significant variation between varieties, growing environment and their interaction in potato for average tuber number per hill. Similarly, Lemma *et al.* [17] reported a significant difference in tuber numbers per hill among twenty potato varieties in the central highlands of Ethiopia. The maximum tuber length (10.58cm) was obtained from Belete variety which was statistically similar with the value recordedfrom. Burka (8.94 cm) variety followed by Gudane and Guassa varieties while the lowest (6.72cm) was from Dagim variety (Table 2). The differences among varieties

for agronomic and yield traits, indicated the presence of variability, which could be attributed to the genetic potential of the varieties used among the evaluated varieties and for the traits under consideration. This result is in agreement with similar findings in potato varieties tested in different areas [18]. Similarly, Abebe *et al*. [19] observed significance differences amongpotato genotypes for different growth and yield traits.

Table 2: Combined mean values for different traits of tested potato varieties at Wondogenet, A/Negele and Shashemene in 2020/2021 main cropping season.

Varieties	Plant Height (cm)	Average Stem Number/Hill	Tuber Number/Hill	Tuber Length (cm)	Tuber Diameter (cm)
Dagim	79.00^{d}	3.22^{c}	6.11^{d}	6.72^{c}	5.81
Belete	103.87^{ab}	5.45^{b}	10.67^{bc}	10.58^{a}	6.07
Burka	94.00^{bc}	5.52^{ab}	14.00^{ab}	8.94^{ab}	6.37
Gera	84.47^{cd}	4.13^{bc}	9.18^{c}	7.12^{bc}	5.75
Guassa	108.27^{a}	5.20^{b}	13.17^{b}	7.64^{bc}	6.06
Guadane	87.53^{cd}	6.93^{a}	16.73^{a}	8.45^{b}	5.22
Jalene	92.67^{bcd}	6.72^{ab}	13.88^{ab}	7.27^{bc}	5.75
CV	8.69	10.63	13.87	13.28	7.06
LSD (0.05)	13.96	1.41	3.03	1.66	NS
VAR	<.0001	<.0001	<.0001	<.0001	0.08
LOC	<.0001	NS	<.0001	<.0001	NS
VAR*LOC	<.0001	NS	NS	NS	NS

Means followed by the same letters within the same column are statistically non- significant at p<0.05 according to the least significant difference (LSD) test. NS= non-significant, Var= Variety, Loc= location, Var*Loc= Interaction of variety with location, CV= Coefficient of Variation.

There was a highly significant (P< 0.01) variation among the tested varieties with respect to tuber yield, dry matter content and specific gravity among the evaluated varieties as indicated in (Table 3). The over locations results showed highly significant (P< 0.01) variation for the tested varieties however the interaction effects p<0.01 of varieties and locations were non-significant. The highest tuber weight per plant (1.29 kg) was harvested from Belete varietywhich was statistically similar with Burka (1.15 kg) variety but Dagim variety was gave the lowest (0.55 kg) which was statistically similar with Gera (0.75) variety. According to Kirkman [20], number and size of potato tubers are an economically important characteristic in processing, marketing demand, human consumption, and for seed for planting. Belete variety gave the highest tuber yield per hectare (35.37 tha^{-1}) which followed by Burka (31.73 tha^{-1}) variety while the lowest (20.41 tha^{-1}) was recorded from Dagim variety. The presence of highly significant differences among potato varieties for tuber yield might be the due to the presence of genetic differences used in the development of these varieties. Lemma *et al*. [17] also reported that potato varieties had a significance difference with respect to tuber and tuber related traits. Moreover, Habtamu *et al*. [15] and Abebe *et al*. [19] also reported a similar result in which significance differences among potato varieties with respect to tuber weight was found probably due to genetic variability presented. This result agreed with the study result reported by Abebe *et al*. [16] who found that potato varieties gave different tuber yield across different environments. Similarly, Lemma *et al*. [17] observed significant differences with respect to tuber yield due to genotype and environment.

The highest tuber dry matter content (26.52) obtained from Belete which was statistically similar with Burka (25.85) variety followed by Gudane (23.35) variety and Dagim variety gave the lowest (21.18) dry matter content (Table 3). The differences with respect to tuber dry matter content is might be due genetic variations presented among tested varieties. The present study was in agreement with different scholars, who reported that there was a genetic difference among potato varieties tuber yield, dry matter content [16,17,21]. Similarly, Habtamu *et al.* [15] reported that tuber dry matter content is strongly governed by growing environment, cultivars and their interaction. Moreover, Berhanu and Tewodros [13] also found that tuber dry matter content was highly influenced by varieties. The tested potato varieties had significant difference with respect to specific gravity. The highest specific gravity (1.15) recorded from Belete variety which followed by Burka variety but the lowest (1.03) was from Dagim variety. The differences might be due to genetic and environmental variations.

Chemeda *et al*. [22]and Tesfaye *et al*. [23] found that tuber specific gravity is influenced by genetic and environmental variations. Moreover, Berhanu and Tewodros [13] reported a statistically significant effect of varieties on tuber specific gravity. Furthermore, Wassu [24] also reported that tuber specific gravity was affected by genotypes and environments. Tuber specific gravity is important for estimation of dry matter and starch content in potato tuber [25] (Table 3).

Table 3: Combined mean values for different traits of tested potato varieties at Wondogenet, A/Negele and Shashemene in 2020/2021 main cropping season.

Varieties	Tuber Weight//Plant (kg plant^{-1})	Tuber Yield Per Hectare (t ha^{-1})	Tuber Dry Matter Content (%)	Specific Gravity (g/cm^3)
Dagim	0.55^{d}	20.41^{d}	21.18^{d}	1.03^{d}
Belete	1.29^{a}	35.37^{a}	26.52^{a}	1.15^{a}
Burka	1.15^{ab}	31.73^{b}	25.85^{a}	1.11b
Gera	1.12^{ab}	24.93^{c}	22.21^{c}	1.06^{c}
Guassa	1.33^{a}	26.15^{c}	22.63^{bc}	1.07^{c}
Gudane	1.11^{b}	29.33^{b}	23.35^{b}	1.09^{bc}
Jalene	0.83^{c}	26.11^{c}	22.65^{bc}	1.09^{bc}
CV	13.18	7.91	5.47	1.2
LSD	0.24	2.49	0.85	0.02
VAR	<.0001	<.0001	<.0001	<.0001
LOC	<.0001	<.0001	NS	NS
VAR*LOC	NS	NS	NS	NS

Means followed by the same letters within the same column are statistically non- significant atp<0.05 according to the least significant difference (LSD) test. NS= non-significant, Var=Variety, Loc= location, Var*Loc= Interaction of variety with location, CV= Coefficient of Variation.

Conclusion

Enhancing the productivity of this crop may be a key tool in fulfilling the nutritional requirements of the rising global population including Ethiopia. In order to respond to an increasing demand of this crop, potato variety evaluation was conducted with the objective of selecting the best performed and adapted variety with respect to tuber yield and quality traits. The combined analysis of variance showed a highly significant differences (p≤0.05) among tested varieties for plant height, tuber diameter, tuber weight per hill, tuber yield per hectare, root dry matter content and specific gravity. As a result, Belete variety gave the highest tuber yield per hectare (35.37 t ha^{-1}) which wasfollowed by Burka variety (31.73 t ha^{-1}) while the lowest (20.41 t ha^{-1}) from Dagim variety. The highest tuber dry matter content (26.52) was obtained from Belete variety which was statistically similar with Burka (25.85) variety while the lowest (21.18) from variety Dagim. With respect to specific gravity, Belete variety gave the highest (1.15) followed by Burka (1.11) variety but the lowest (1.03) was from Dagim variety. Thus, it could be concluded that genotypic and environmental variations had a considerable influence on potato production. Therefore, among the tested potato varieties, Belete and Burka were recommended forbetter tuber yield and quality attributesacross the study areas

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Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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