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Effects of Variety and Tuber Size on Yield and Yield Component of Potato (Solanum tuberosum L.) in Wolaita Zone Southern Ethiopia

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Abstract
Field experiment was conducted to evaluate growth, yield and yield components of different Potato (Solanum tuberosum L.) varaties under three tuber sizes from March 2013 to July 2013 at Wolaita zone Sodo zuria wereda Dalbo kebele southern Ethiopia. The study consisted of four commercially released varieties of Potato named as Gudene, Jalene, Guassa, Digemegn and one local variety as a check and three tuber sizes (large, medium, and small). Factorial experiment was conducted on farmers' field using Randomized Complete Block Design (RCBD) with three replications. Three model and volunteer farmers were involved. Each farmer's field was considered as replication. Data were collected for growth, tuber yield and yield components. Analysis of variances (ANOVA) revealed that varieties differed significantly ($P \leq 0.05$) in plant height, average tuber number per hill, mean tuber diameter, number of marketable potato tuber at net harvestable row, number of unmarketable potato tuber at net harvestable row, number of total potato tuber per net harvestable row at net harvestable row, there was no significant ($P \leq 0.05$) effect for tuber size as well as interaction between variety and tuber size for all observed parameters.In this study, the highest tuber yield of 32.57 t ha^{-1} were obtained from Guasaa followed by Guden (30.09) t ha^{-1} though the difference was statistically not significant but according to the farmers field visit selection criteria, physical stand, disease and pest tolerance, and production of attractive and marketable tubers Gudene variety and use of meduim sized tuber. Therefore, using Gudene variety and use of medium size tube found to be advisable but incase shortage of medium sized planting material occurs large or small sized tubers can be used. However, further testing is required in different locations and on different soils.
Keywords: Potato, Variety, Tuber size, Growth, Yield.

1. Introduction

Potato (Solanum tuberosum L.) is one of the most important food crops in the world. In volume of world crops production, it ranks fourth following wheat, maize, and rice (FAOSTAT data, 2004). Potato is believed to have originated in South America in the vicinity of Lake Titicaca near the present border of Peru and Bolivia (Horton, 1987). It was first introduced to Ethiopia in 1858 by a German Botanist called Schimper (Pankhrust, 1964). Ethiopia is endowed with suitable climatic and edaphic conditions for high quality potato production. However, the total area under potato production is estimated 36,736 ha with total annual production of 385,258metric tones (FAO, 2004). The national average yield is about 10.5 tons/ha, which is very low compared to the world average of 16.4 tons/ha (FAO, 2004). A number of production problems that account for such low yield have been identified. The major ones are the concentration of potato cultivation in the highlands with very little in the lowlands, lack of well adapted cultivars, unavailability and high cost of seed tubers, inappropriate agronomic practices, diseases, insect pests, inadequate storage, transportation and marketing facilities (Tekalign and Hammes, 2005).

The cropping system around the study area is dominated by diversified horticultural crops and there is also a high demand and attractive prices for quality ware potatos. Despite this great potential, farmers do not produce potato due to high temperature of the area. The productivity of potato can be increased by using well-adapted appropriate varities, appropriate planting material, adequate soil moisture and supplying adequate plant nutrients. Generally in Wolaita zone, and particularly sodo zuria wereda where this experiment will be conducted, potato is grown on 80 hectares at different Kebles using rain fed about 220 households are engaged in potato production (MoARD, 2011). However, in area, there is little information on the optimum planting size of potato and use of well adapted cultivar for the maximum yields of potato. Mostly farmers grow local varaties and get the produce with very low yield due to lack of research and technology. Thus, this research was initiated with objectives to evaluate the performance of different potato varieties and to identify optimum size of tuber for planting and marketing of potato in the study area.

2. MATERIALS AND METHODS 2.1. Description of the study area

A field experiment was carried out at Dalbo kebele in sodo zuria Woreda found in wolaita Zone of Southern Ethiopia which is 340 km from A A, SW direction located at 8° 71' 8'' North and 43° 89' 85'' East latitude and

longitude, respectively. The mean annual temperature and rainfall of the study area is 22°C and 1100 mm, respectively. The altitude of the trial site is 1350 m.a.s.l.

2.2. Treatments and experimental design

The treatments consisted of four commercially released varieties of Potato named as Gudene, Jalene, Guassa, Digemegn and one local variety as a check and three tuber sizes (large, medium, and small). Each varieties was grouped in to three based on their tuber sizes (smaller sizes, medium sizes, and larger sizes). Tuber size categorization was based on weight i.e. Size categories of tubers into small (< 39 g); medium (39-75 g), and large (>75 g) according to (Lung'aho *et al*., 2007). Factorial experiment was conducted on farmers' field using Randomized Complete Block Design (RCBD) with three replications using five potato varaties (four improved and one local) and three tuber sizes as large, medium and small. Three model and volunteer farmers were involved. Each farmer's field was considered as replication. Test varieties were planted in collaboration with the three volunteer farmers in the study area. Data were collected on Days to flowering, Days to maturity, Plant height, Average tuber number per hill, Marketable and unmarketable tuber numbers, Total tuber number per plot, Marketable tuber yield, Unmarketable tuber yield, Total tuber yield, Tuber dry matter yield, Tuber diameter (mm). Data were subjected to analysis of variance (ANOVA) procedure using (SAS, 2003) and the mean were separated using least significant difference (LSD) test

3. RESULTS AND DISCUSSION

The experiment was started with four commercial varieties of Potato (Jalene, Gudene, Guassa and Digemegn) and local variety but local variety totally failed to grow and give yield due to disease development while improved variety could resist the occurrence of disease and give yield. The local variety was then excluded from the analysis.

3.1. Crop Phenology

3.1.1. Days to 50 % flowering

Differences in days to 50 % flowering among varieties as well as tuber sizes were not significant. All most all varaties and all tuber size bear 50% flowing nearly equally and also no significant differences were found for the variety and tuber sizes interaction effect on days to 50 % flowering (Table 3).

3.1.2. Days to 50 % maturity

Differences in mean number of days for achieving 50 % maturity were not significant ($P \leq 0.05$) among varieties (Table 3). However, the mean number of days to 50 % maturity was slightly higher for Guassa 133.33 than other varaties (Table 1).Tuber size had no significant (P £ 0.05) effect on mean number of days for achieving 50 % maturity and also interaction effects of variety and tuber size in days to 50 % maturity were non-significant (P £ 0.05) (Table 3).

3.2. Vegetative growth

3.2.1. Plant height

Variety had significant ($P \leq 0.05$) effect on mean plant height of potato (Table 3). It was observed that mean plant height of variety Gudene was significantly higher Guasa where as mean plant height of Jalene and Digemegn variety were statically similar (Table 1). Tuber size had no significant ($P \leq 0.05$) effect on mean plant height and also interaction effects of variety and tuber size on mean plant height were non-significant ($P \leq 0.05$) (Table 3).

3.3. Tuber characteristics

3.3.1. Average tuber number per hill

There was significant ($P \leq 0.05$) difference amongst varieties in mean tuber number per hill (Table 3). Jalene scored the highest mean tuber number per hill (15.40) which was, however, not significantly different from the mean tuber number per hill (12.7), (11.76) Gudene and Guassa respectively but significantly higher than the lowest mean tuber number per hill (10.79) which was recorded for Digemegn (Table 2). But the effect of tuber size on mean tuber number per hill was not significant ($P \leq 0.05$) (Table 3). Interaction effects of variety and tuber size on mean tuber number per hill were not-significant ($P \leq 0.05$) (Table 3).

3.3.2. Tuber dry matter content

The analysis for tuber dry matter content revealed no significant for variety as well as for tuber size. However, the highest mean tuber dry matter content (51.25) was recorded for Guassa variety at small tuber size where as the lowest (35.49) was recorded variety Jalene (Table 2). Interaction effects of variety and tuber size on mean bulb dry matter percentage were not-significant ($P \leq 0.05$) (Table 3).

3.3.3. Mean Tuber diameter

There was significant ($P \leq 0.05$) difference amongst varieties in mean tuber diameter (Table 3). Guassa scored the highest mean bulb diameter (53.77mm) which was, however, not significantly different from the mean tuber diameter of Digemegn. The lowest mean bulb diameter of 6.11mm was recorded for Jalene (Table 2). Mean tuber

diameter per plant was not significantly ($P \leq 0.05$) affected by tuber size (Table 3). However; the highest mean tube diameter of 3.77mm was recorded at large tuber size while the minimum tuber diameter 48.97mm was observed at medium size tuber (Table 2). Interaction effects of variety and tuber size on mean tuber diameter were non-significant ($P \leq 0.05$) (Table 3).

3.3.4. Number of marketable potato tuber at net harvestable row

Differences in mean number of marketable tuber between varieties were significant ($P \leq 0.05$) (Table 3). Jalene scored the highest mean number of 294.67 marketable tuber which was, however, not significantly different from the mean number of marketable tuber of Gudene (272.78) and Guassa (260.22). The lowest mean number of marketable tuber of 210.67 was recorded for Digemegn (Table 2). Tuber size and interaction effects of variety and tuber size had no significant ($P \leq 0.05$) effect on mean number of marketable tuber (Table 3).

3.3.5. Number of unmarketable potato tuber at net harvestable row

There was significant ($P \leq 0.05$) difference amongst varieties in mean number of unmarketable tuber (Table 3). Jalene scored the highest mean number of unmarketable tuber (167.44) which was, however, not significantly different from the mean number of unmarketable tuber of Gudene (109.89) and Guassa (92.56) but significantly higher than the lowest mean number of unmarketable tuber (115.56) which was recorded for Digemegn (Table 2). The effect of tuber size and interaction effects of variety and tuber size on mean number of unmarketable tuber was not significant ($P \leq 0.05$) (Table 3).

3.3.6. Number of total potato tuber per net harvestable row at net harvestable row

Variety had significant ($P \leq 0.05$) effect on total number of potato tuber (Table 3). It was bserved that total number of potato tuber of variety Jalene (462.11) was significantly higher variety Guassa (352.78) and digemegn (326.22) where as total number of potato tuber of variety Jalene and Gudene were statically similar (Table 2).Tuber size had no significant ($P \leq 0.05$) effect on total number of potato tuber and also interaction effects of variety and tuber size on total number of potato tuber were non-significant ($P \leq 0.05$) (Table 3).

3.4. Tuber Yield characteristics

3.4.1. Weight of marketable potato tuber

Variey had no significant ($P \leq 0.05$) effect on weight of marketable potato tuber (Table 4). However, the lowest weight of marketable potato tuber yield of 24.77 t ha^{-1} was obtained from Jalene whereas the highest 30.26 t ha^{-1} was obtained from Guassa (Table 2). The effect of tuber size on weight of marketable potato tuber was not significant ($P \leq 0.05$) (Table 4). However, the highest weight of marketable potato tuber (29.46) was recorded at large tuber size while the minimum was observed (25.10) at small tuber size (Table 2). Interaction effects of variety and tuber size on weight of marketable potato tuber were non-significant ($P \leq 0.05$) (Table 4).

3.4.2. Weight of unmarketable potato tuber

Variey had no significant ($P \leq 0.05$) effect on weight of unmarketable potato tuber (Table 4). However, the lowest weight of unmarketable potato tuber yield of 2.32 t ha^{-1} was obtained from Guassa whereas the highest 4.03 t ha^{-1} was obtained from Jalene (Table 2). The effect of tuber size on weight of unmarketable potato tuber was not significant ($P \leq 0.05$) (Table 4). However, the highest weight of unmarketable potato tuber (3.15) was recorded at large tuber size while the minimum was observed (2.67) at medium tuber size (Table 2). Interaction effects of variety and tuber size on weight of unmarketable potato tuber were non-significant ($P \leq 0.05$) (Table 4).

3.4.3. Total weight of potato tuber

Variey had no significant ($P \leq 0.05$) effect on total weight of potato tuber (Table 4). However, the lowest weight of marketable potato tuber yield of 28.01 t ha^{-1} was obtained from Digemegn whereas the highest 32.57 t ha^{-1} was obtained from Guassa (Table 2). The effect of tuber size on total weight of potato tuber was not significant ($P \leq 0.05$) (Table 4). However, the highest weight of total weight of potato tuber (32.61) was recorded at large tuber size while the minimum was observed (28.13) at small tuber size (Table 2). Interaction effects of variety and tuber size on total weight of potato tuber were not-significant ($P \leq 0.05$) (Table 4).

4. CONCLUSIONS

The growth and yield parameters studied in this paper indicated that varieties had significant differences in plant height, average tuber number per hill, mean tuber diameter, number of marketable potato tuber at net harvestable row, number of unmarketable potato tuber at net harvestable row, number of total potato tuber per net harvestable row at net harvestable row. Amongst varieties Guden performed best by good physical stand, tolerating disease and pest incidence, producing more attractive and marketable tubers and selected by farmers better in selection criteria than other improved varieties; however there is no significant difference in weight of marketable potato tuber, weight of unmarketable potato tuber, total weight of potato tuber between improved varaties. Guassa and Digemegn were susceptible for disease and higher number of unmarketable tubers and poor stand in the field as compared to Gudene. Tuber sizes on the performance of different Potato varieties suggested that tuber sizes no significant effect on all of parameters; however most of previous works recommended that medium size tuber. In this study, using Gudene variety and use of medium size tube found to be advisable but incase shortage of medium

sized planting material occurs large or small sized tubers can be used.

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Table 1. Mean plant height (cm)**,** Days to 50% flowering, and Days to 50% maturity of potato as affected by Varieties, and Tuber size in Wolaita zone at Dalbo, in 2012

Treatments	DTFL	DTMT	PH
Variety			
Jalene	48.78a	111.33a	71.22a
Gudene	47.89a	111.56a	72.11a
Guassa	17.18a	113.33a	70.11a
Digemegn	48.11a	111.22a	71.33a
LSD 0.05	Ns	Ns	Ns
Tuber Size			
Large	47.58a	112.25a	70.92a
Medium	47.83a	112.25a	71.33a
Small	49.33a	111.0a	71.33a
LSD 0.05	Ns	Ns	Ns
CV%	5.32	3.15	2.85

PH=Plant height, DTFL=Days to 50% flowering, DTMT= Days to 50% maturity

Note: Means with the same letters within the columns are not significantly differ at $P < 0.05$

Table 2. Mean Weight total tuber, un marketable tuber and marketable tuber in t/ha, Average tuber number per hill, Tuber dry matter Content, Tuber diameter, number of marketable, un marketable and total tuber number Potato in net harvestable plot, of potato as affected by Varieties, and Tuber size in Wolaita zone at Dalbo, in 2012

Treatments	WTT	WUMKT	WMkT	AvTN	TDMC	TubD	NMkT	NUMKT	NTT
Variety									
Jalene	28.81a	4.03a	24.77a	15.40a	7.93a	46.11b	294.67a	167.44a	462.11a
Gudene	30.09a	2.40b	27.69a	12.76ab	50.81a	46.91b	272.78a	109.89b	382.67ab
Guassa	32.57a	2.32b	30.26a	11.76b	51.25a	53.77a	260.22ab	92.56b	352.78b
Digemegn	28.01a	3.04ab	24.97a	10.87b	50.75a	52.31ab	210.67b	115.56ab	326.22b
LSD	NS	1.49	NS	2.419	NS	6.27	57.92	55.69	83
Tuber Size									
Large	32.61a	3.15a	29.46a	13.14a	48.44a	50.64a	261.08a	133.08a	394.17a
Medium	28.88a	2.67a	26.25a	12.56a	50.57a	48.79a	268.5a	108.33a	376.83a
Small	28.13a	3.03a	25.10a	12.39	51.56a	49.71a	249.17a	122.67a	371.83a
LSD	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV%	30.46	31.47	34.31	22.51	7.89	12.9	22.82	36.93	22.51

WTT=Weight of total potato tuber, WUMKT=Weight of unmarketable potato tuber, WMkT=Weight of marketable potato tuber AvTN=Average tuber number per hill, TDMC=Tuber dry matter content, TubD=Tuber diameter (mm), NMkT=Number of marketable potato tuber, NUMKT=Number of unmarketable potato tuber, and NTT=Number of total potato tuber per net harvestable row

Note: Means with the same letters within the columns are not significantly differ at $P < 0.05$

Table 3: Mean square values for Days to 50% flowering, Days to 50% maturity, Plant height, Average tuber number per hill, Tuber dry matter content, Tuber diameter (mm), Number of marketable potato tuber, Number of unmarketable potato tuber, and Number of total potato tuber per net harvestable row, at Dalbo in 2013.

		Mean squares								
Source	DF	DTFL	DTMT	PH	AvTN	TDMC	TubD	NMkT	NUMKT	NTT
Replication(R)	2	14.58 ^{ns}	16.33 ^{ns}	0.36^{ns}	14.83^{ns}	20.17^{ns}	101.65	13681.3 ^{ns}	1757.69 ^{ns}	13373.36^{ns}
Variety (V)	3	1.28 ^{ns}	9.22 ^{ns}	6.10*	34.56**	20.81**	132.14*	11394.54*	9356.25*	31136.63*
Tuber size (T)	2	10.75 ^{ns}	6.25 ^{ns}	0.69^{ns}	1.83 ^{ns}	30.42 ^{ns}	8.38	1141.58 ^{ns}	1853.03 ^{ns}	1648.44 ^{ns}
Interaction	6	4.89 ^{ns}	7.91 ^{ns}	2.43^{ns}	10.27 ^{ns}	31.017^{ns}	15.33^{ns}	6054.32^{ns}	973.58^{ns}	9236.96^{ns}
Error	22	6.58	3.52	4.11	8.16	15.68	41.22	3510.15	3244.3	7350.66

*, **, *** indicate significance at $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively, 'ns' not significant.

DTFL=Days to 50% flowering, DTMT= Days to 50% maturity, PH=Plant height, AvTN=Average tuber number per hill, and TDMC=Tuber dry matter content, TubD=Tuber diameter (mm), NMkT=Number of marketable potato tuber, NUMKT=Number of unmarketable potato tuber, and NTT=Number of total potato tuber per net harvestable row

Table 4: Mean square values for Weight of total potato tuber, Weight of unmarketable potato tuber, and Weight of marketable potato tuber, at Dalbo in 2013

		Mean square		
Source	DF	WMkT	WUMKT	WTT
Replication(R)	2	83.49 ^{ns}	1.31 ^{ns}	66.86 ^{ns}
Variety (V)	3	60.37 ^{ns}	5.63 **	35.87 ^{ns}
Tuber size (T)	2	61.65 ^{ns}	0.76 ^{ns}	69.14 ^{ns}
Interaction	6	32.62 ^{ns}	1.11 ^{ns}	30.99 ^{ns}
Error	22	85.33	2.32	82.81

*, **, *** indicate significance at $P < 0.05$, $P < 0.01$, $P < 0.001$, respectively, 'ns' not significant.
WTT=Weight of total potato tuber, WUMKT=Weight of unmarketable potato tuber, and WMkT=Weight of marketable potato tuber