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Performance Evaluation of IrishPotato (Solanum tuberosum L.) Varieties for Tuber Yield in Buno Bedele, Southwestern, Ethiopia

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Abstract
In this study, adaptation trial of improved potato varieties was conducted in Buno Bedele Zone with the objective of recommending best-performing variety. Four potato varieties (Belete, Gudenie Jalanie and Horo) were evaluated for their vegetative growth performance and tuber yield under rain fed conditions. Combined analysis of data revealed that, varieties showed highly significant at (P <0.01) variations for days to maturity, number of tubers per plant, Marketable and tuber yield. The longest days to maturity (95.25 days) was recorded from Gudanie while the shortest days to maturity (87.25 days) was recorded from Horo. Besides, the tested potato varieties showed highly significant (P < 0.01) variations for the number of total tubers per hill. The highest tuber number per hill (22.37) was recorded from Belete variety where as the lowest tuber number per hill (13) was recorded from Jalanie. Variety Belete had also highest (24.24 t/ha) marketable tuber yield followed by Gudanie variety (19.14t/ha) as compared with other Varieties where as, Jalanie variety had the lowest (9.83 t/ha) marketable tuber yield. There was highly significant (p<0.01) difference in total tuber yield among the potato varieties evaluated. The highest total tuber yield (26.24 t/ha) was recorded from Belete variety followed by Gudanie variety (22.06 t/ha). On the other hand, the lowest total tuber yield (11.14 t/ha was recorded from Jalane variety which was found to be at par with Horo variety Belete and Gudenie varities were also relatively resistant to late blight diseaseas compared to other varieties. On the other hand Jalanie and Horo varieties were moderately susceptible and moderately resistant, respectively. The result of the correlation analysis also revealed that tuber number and number of tubers per plant were significantly and positively correlated with marketable and total tuber yield. Likewise marketable tuber yield was also significantly and positively correlated with total tuber yield. Belete and Gudanie were varieties that showed better performance in terms of yield and yield component as well as disease resistance. Therefore, the two varieties are recommended to be demonstrated on farmer's field for further scaling up.
Keywords: Potato, Adaptation, Tuber yield, Marketable tuber yield
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1. Introduction

Potato (*Solanum tuberosum* L.) is originated in the high lands of South America (IPC, 2019).It is fourth and third most important food crop in the world in terms of production and consumption, respectively (FAOSTAT, 2021). Among roots and tuber crops, potato is the first in terms of volume produced and consumed followed by cassava, sweet potato, yams and taro. Potato is grown in more than 150 countries and constitutes a staple food for about one billion people in the world in which about a half is found in the developing counties (IPC, 2020). According to global potato production statistics, about 54% of the production is coming from China, India, Russia, Ukraine, and the United States of America.

Potato was introduced to Ethiopia in the 19th century by a German Botanist Schimper (Pankhrust, 1964). Since then, potato has become an important garden crop in many parts of Ethiopia and it ranks first among root and tuber crops (Alemayehu *et al*., 2020). This is due to the presence of suitable climatic conditions for potato production, high yield potential, nutritional quality, short growing period and wider adaptability (MOANR, 2016)..

However, the national average yield of the crop in Ethiopia is 13.3 t/ha (CSA, 2021), which is lower than world average yield of about 20 t/ha (FAOSTAT, 2019). Moreover the yield of potato in Ethiopia is lower than that of most potato producing countries in Africa like South Africa and Egypt, that have attained yield level of 34.0 and 24.8t/ha, respectively (FAO, 2018). In addition to this, the yield potential of present day of potato exceed 46 t/ha (Arega *et al.,* 2018), indicating considerable yield gap that has to be uncovered through adopting improved production technologies and practices to increase productivity.

The attributes of low production of potato in Ethiopia are due to biotic and biotic factors, of which lack of improved high yielding and disease resistant varieties is the major one. Thus, evaluation and selection of potato verities which best adapt to a potential production area like Gechi and Dega districts of Buno Bedele zone is one of viable strategies to solve production bottle necks related to lack of improved varieties. Therefore, the objective of this study was: To evaluate and select best adapted Potato varieties for tuber yield and tuber yield components for the study areas and other similar agro-ecologies.

2. Materials and Methods

Description of the Study Area

The experiment was conducted at Gechi and Dega districts on different farmers' field during 2020-2021 main cropping seasons.

Gechi District

Gechi district is one of the ten districts in Buno Bedele zone of Oromia National Regional State, Ethiopia which is located 475 km southwest of Addis Ababa and bordered on the south be Dedessa district, on the North by Borecha district and Bedele, and Nunu Kumba district of east Welega zone, on the east and west Bedele district. There are three main agro-climatic zones in the district. Highland,(27%), midland (50%) and 23% lowland. The experimental site receives an average annual rainfall of 1850mm with maximum and minimum temperatures of 21^0c and 18^0c, respectively. There are two distinct seasons: the rainy season starting in late March and ending in October and the dry season occurring from November to early March.

Dega District

Part of the Buno Bedelle Zone, Dega is bordered on the south by Chora, on the west by Supena Sodo, on the north by the West Welega Zone, on the northeast by the the Benishangul-Gumuz Region, and on the east by Bedele.

Table 1. Description of Potato varieties used in the experiment

Varity	Breeder	Released year	Recommended Altitude (masl)
Belete	Holetta research centre	2009	1600-2800
Gudene	Holetta research centre	2009	1600-2801
Jalenie	Holetta research centre	2002	1600-2802
Horo	Bako research centre	2015	2000-2800

Source:MoANR (2016)

Experimental Materials and Design

The experimental test materials consisted of four potato varieties namely Belete, Gudane , Jalene and Horo, which were released by Holeta and Bako research centers (Table 1). The trial was arranged in randomized complete block design (RCBD) with three replications. The treatments were randomly allotted to each plot. The experimental plot had an area of 6.75 m^2 (2.25m width × 3m length). 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 the split of 50% during time of planting and the remaining50% at vegetative stage of growth. 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 basis.

Data Collection and Analysis

To evaluate the yield performance and adaptability of Potato varieties, all the data on yield and yield related parameters were recorded. Days to maturity, plant height (cm), average number of tubers per plant (hill), average tuber weight (g), marketable tuber yield, unmarketable tuber yield and total tuber yield (t/ha) were recorded accordingly. Finally, data were analyzed using SAS Version 9.2 statistical software (SAS., 2012). Correlation analysis among yield and yield contributing parameters was done using SAS version 9.2 statistical software (SAS, 2012).

Data Collected on Plot Basis

Days to Physiological Maturity: was recorded when the haulms (vines) of 90% of the plant population per plot turned yellowish or showed senescence.

Tuber Number per Hill: The total number of tubers harvested from 10 randomly selected plants grown in the net plot area was counted and mean tuber number per plant/hill was computed and used for further analysis purpose (Zelalem *et al*. 2009).

Marketable Tuber Yield (t/ha):tubers which are free of diseases, insect pest damages and above 25g in weight were considered as marketable tubers as indicated by Lung'aho *et al.* (2007). The weight of such tubers harvested from the net plot area was measured using scaled balance and expressed as ton per hectare.

Unmarketable Tuber Yield (t/ha):tubers which were diseased, attacked by insect and less than 25g, misshaped and decayed were considered as unmarketable tuber as indicated by Lung'aho *et al.* (2007). The weight of such tubers harvested from net plot area was measured using scaled balance and expressed as ton per hectare.

Average Tuber Weight (g): It was recorded by dividing total fresh weight of tubers by the total number of fresh tubers per plot. It was obtained by adding small (25 to 39g) and medium (40 to75g) sized potato tubers (which were harvested from the net plot area and used for further analysis.

Total Tuber Yield (t/ha): The total tuber yield was considered as the sum of marketable and unmarketable tuber yield that was used for analysis purpose (Zelalem *et al*. 2009).

3. Results and Discussion

Combined Mean square for varieties were highly significant (P<0.01) for Days to maturity, Number of marketable yield and tuber yield while average tuber weight showed significant (P<0.05) (Table 2). This indicates that the presence of significant variations among varieties and that the varieties had inconsistent performance over years (Table 2).

Table 2: Mean square values on phenological and yield component response variables of potato (*Solanum tuberosum* L.) varieties2020-2021 cropping season

Source	DF	DM	NT	MY	UMY	TY	ATW
Rep	2	2.31	46.63	59.93	83.96	83.96	20.21
Var	3	192.22**	255.11**	509.28**	587.39**	587.39**	1518.5**
Yr	1	481.33**	130.02**	9.35ns	24.34**	24.34^{ns}	6.85**
Loc	1	96.33**	112.24**	179.76*	259.47**	259.47**	292.5^{ns}
Var*Yr	3	16.56^{ns}	11.49^{ns}	21.34^{ns}	19.18^{ns}	19.18^{ns}	564.91*
Var*Loc	3	12.89^{ns}	1.82ns	2.47^{ns}	2.29^{ns}	2.29^{ns}	86.95^{ns}
Error	34	9.11	14.40	18.20	21.58	21.58	232.06
CV		5.28	23.89	27.86	28.03	25.3	21.05
P-Value		P<0.0002	P<0.0001	P<0.0001	P<.0001	P<0.0013	P<0.005

Note: DF=Degree of freedom, DM=Days to Maturity, NT=Number of Tuber, MY=Marketable yield, UMY =Unmarketable Yield, AVTW=Average tuber weight ,TY=tuber yield, CV=Coefficient of variation,*** Very highly significant,** =highly significant.

Das to Maturity: the longest days to maturity (95.25 days) was recorded from Gudanie while the shortest days to maturity (87.25days) was recorded from Horo. This might be due to the fact that maturity period is dependent on the varieties and climatic conditions. This is in agreement with the report of Taye *et al.,* (2021) who noted that the maturity period is varietal characteristic which of course can be influenced by planting date, climatic conditions and adopted cultivation practices. Haile *et al*. (2015) also reported that the vegetation period for potato varied from 90 to 124 days.

Number of Tuber Per Hill : Potato varieties had showed highly significant (P < 0.01) variation on total number of tubers per hill (Table 3). The highest tuber number per hill (22.37) was recorded from Belete variety and the lowest tuber number per hill (13) was recorded from Jalanie. The variation may be attributed to the differences in genetic potential among potato varieties. Bekele (2018) reported stolen and tuberilization processes is affected by genetic makeup and environmental factor. Habtamu *et al.* (2016) as well as Berhanu and Tewodros (2016) also reported a significant variation between varieties, growing environment and their interaction in potato for number of tuber per hill in Eastern Ethiopia. Seifu and Betewulign (2017) similarly reported a significant difference in tuber numbers per hill in Southern Ethiopia.

Marketable Tuber Yield (t/ha): The cultivar has very highly significant (P < 0.01) effect on mean marketable yield of potato (Table 3). Belete cultivar had the highest (24.24 t/ha) number of marketable tuber yield followed by Gudanie variety that had 19.14t/ha of marketable tuber yield. On the other hand, variety Jalanie had the lowest (9.83 t/ha) marketable tuber yield. The research reported that marketable tuber yield significantly varied among varieties (Elfinesh, 2008; Kumar *et al*., 2007). Similarly, other authors reported significant differences in marketable and total tuber yield among potato varieties (Ebrahim *et al*.,2018); Habtamu*et al*.,2016;Alemayehu *et al*.,2018).

Unmarketable Yield (t/ha): Variety Belete gave the highest unmarketable yield (2.46 t/ha) followed by Gudanie (2.14 t/ha) which might be due to the higher number of tubers produced by these varieties. However, the lowest unmarketable yield (1.06 t/ha) was recorded from variety Jalanie and it is statistically at par with Horo (1.46 t/ha) (Table 3). Variation among Varieties for non-marketable yield could be attributed to their genetic make-up which influenced tuber size. The result in the present work is in line with the findings of Haile *et al*. (2015), who reported the effects of genotype that significantly influence unmarketable tuber yield.

Average Tuber Weight (g): In potatoes, weight of tubers has an important role in yield. In the present study, the average tuber weight (g/tuber) showed highly significant (p<0.01) variations among the test varieties (Table 3).The maximum average tuber weight (88.41 g) was recorded from variety Belete. However, Jalanie gave the lowest average tuber weight (62.55 g) (Table 3). The variation may be attributed to the inherent genetic variation on tuber bulking among potato varieties. The duration and rate of tuber bulking vary among varieties and depend on environmental conditions (Levy, 2007).

Disease Incidence

Potato late blight was the major disease observed on potato during the experimental period. Accordingly, variety

Jalanie showed moderately susceptible (40ms) and Horo moderately resistant (30 ms (Table 3) reactions to the disease. However, variety Belete and Gudanie showed best level of resistance (5r) to late blight as compared to other varieties (Table 3). Similarly, Haile et al. (2015) observed significantly lower late blight incidence in all planting dates for variety Guidene. This variation in response to disease is probably due to genetic variations varieties.

Table 3. Combined mean of yield Component of potato varieties over two years at Gechi and Dega districts

Varieties	DM	NT	MY (t/ha)	UMY (t/ha)	AVTW (t/g)	Disease (LB)
Belete	94.08 ^{a}	22.37^{a}	24.24^{a}	2.46^{a}	88.41^{a}	5r
Gudanie	95.25^{a}	21.34^{a}	19.14^{b}	2.14^{a}	71.55^{a}	5r
Jalanie	87.25 b	13 ^{b}	9.83^{c}	1.06^{b}	67.43^{b}	40ms
Horro	88.42^{b}	15.07^{b}	12.50^{c}	1.46^{b}	62.55^{b}	30mr
LSD (0.05)	3.38	3.53	3.77	0.51	12.8	
CV (%)	5.28	23.89	27.86	23.51	21.47	
P-Value	P<0.0002	P<0.0001	P<0.0001	P<0.0001	P<0.0013	

Days to Maturity, NT=Number of Tuber, MY=Marketable yield, UMY=Unmarketable Yield, AVTW=Average tuber weight ,TY=tuber yield, CV=Coefficient of variation,*** Very highly significant,** =highly significant, LSD=Least significant difference , CV = Coefficient of Variation, LB= Late blight , r=resistance, ms=moderately susceptible and mr=Moderately resistant

Total Tuber Yield (t/ha):the test varieties showed highly significant($p<0.001$) differences for total tuber yield(Table 4). The highest total tuber yield (26.24 t/ha) was recorded from Belete Variety followed by Gudanie Variety (22.06 t/ha). On the other hand, the lowest total tuber yield (11.14 t /ha was recorded from Jalanie Variety which is also not significantly different from total tuber yield (14.01 t/ha) obtained from Horo variety (Table 4). This result is in line with the findings of Taye *et al*. (2021), who also found significant differences in total tuber yield among potato varieties. Similarly, Makdes (2019) also concluded that improved potato varieties were higher in total tuber yield. Similar tuber yield variation results were reported on potato by different scholars in Ethiopia (Wassu, 2016; Seifu and Betewulign 2017).

Table 4. Combined mean Tuber yield (t/ha) of Potato varieties tested at Gechi and Dega districts for two years

Varieties	**Gechi**			**Dega**	
	Year 1	Year 2	Combined	Year 1	Over all
Belete	24.83^{a}	19.18^{a}	22.09 ^{a}	27.65^{a}	26.24^{a}
Gudane	20.9^{a}	16.10^{a}	18.39 ^{a}	23.21^{a}	22.06^{b}
Jalane	9.69^{c}	10.29^{b}	9.98 ^{b}	12.59^{b}	11.14^{c}
Horro	15.19^{b}	10.61^{b}	12.97^{b}	12.35^{b}	14.01^{c}
LSD (0.05)	7.38	4.15	3.85	6.71	4.18
CV (%)	34.46	14.79	20.03	17.7	27.64
P-value	P<0.0024	P<0.0048	P<0.0001	P<0.0134	P<0.005

LSD=least significant difference at 5%, CV (%) = coefficient of variation in percent

Correlation Among Tuber Yield and Tuber Yield Contributing Parameters of Potato Varieties

In the present study correlation analysis among tuber yield and tuber yield contributing parameters was done and revealed positive and negative associations among the studied yield and yield contributing parameters of potato varieties evaluated in the study (Table 5). Accordingly, Days to maturity was highly significantly and positively correlated (R = 0.67***) with marketable tuber yield and also highly significantly and positively correlated (R = 0.72***) with total tuber yield. In similar manner, number of tubers per plant was significantly and positively correlated (R = 0.85***) with marketable tuber yield and also highly significantly and positively correlated (R = 0.86***) with total tuber yield. Likewise marketable tuber yield was also highly significantly and positively correlated (R = 0.97**) with total tuber yield.

Table 5.Correlation Days to maturity, Number of tuber per hill, marketable tuber yield, unmarketable tuber yield and total tuber yield in potato varieties

	DM	NT	MY	UMY	TY	AVTW
DM	1					
NT	0.62***	1				
MY	0.67***	0.85***	1			
UMY	0.70***	0.83***	0.94***	1		
TY	0.72***	0.86***	0.97***	0.96***	1	
AVTW	0.49*	0.41*	0.78***	0.67***	0.70***	1

Note: DM=Days to maturity, NT= Number of Tuber, MY=Marketable Yield, UMY=Un marketable Yield, TY=Tuber Yield ,AVTW =Average Tuber weight , *Significant, **Highly significant and *** Very highly Significant at 5%, 1%, and 0.1%, respectively.

4. Conclusion and Recommendation

The current results showed that the most important yield and yield contributing parameters: Days to Maturity, Number of tuber per hill, Marketable tuber yield and total tuber yield and Average tuber weight were significantly varied among the potato varieties evaluated. Accordingly, the longest days maturity (95.25cm) recoded from Gudenie while number of tuber per hill (22.37), marketable tuber yield (24.24 t/ha) and total tuber yield (26.24 t/ha) were recorded from variety Belete. The result of the correlation analysis also showed that Days to maturity was highly significantly and positively correlated with marketable tuber yield (R = 0.67***) and total tuber yield (R = 0.72***). In the same way, number of tuber per hill is significantly and positively correlated with marketable tubers yield (R = 0.85***) and total tuber yield (R = 0.86***). Likewise marketable tuber yield is also highly significantly and positively correlated (R = 0.97***) with total tuber yield. This indicated that potato producers targeting tuber production should use the number of tubers per hill and marketable tuber yield as selection criteria. Generally, yield is an important agronomic index that shows the adaptability of a variety to its growing environment and hence variety Belete and Gudane can be identified as the highest tuber yielding and adaptable varieties to the study area under rain fed condition. Most of the agronomic parameters were positively and significantly correlated with tuber yield. Thus, these two varieties were selected to be demonstrated on farmer's field for further scaling up.

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