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On Farm Demonstration of Recently Adapted Irish Potato (Solanum tuberosum) in Highlands of Guji Zone

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Abstract
The activity was conducted in Bore and Ana Sora district in 2015-2017 production season to evaluate productivity and profitability of improved potato variety with standard check (Gudane variety) under farmers' condition and to build farmers' knowledge and skill of production and management of the improved potato variety. From all Irish Potato producing Peasant Associations (PAs), six PAs were selected based on their Irish Potato production potential. From each PA, one FRG having 15 members was established. The selections of participating farmers were carried out by close collaboration with agricultural district offices, DAs, SMSs, opinion leaders, and PA leaders. Training was given for farmers, development agents and experts. Exchange visit also performed to share experience of experimental farmers' management practices conducted by FRG work. Data was collected from 18 experimental farmers by using interaction with FRG members. The collected data was analyzed by descriptive statistics and Net farm income was used to estimate the profitability of Irish potato. Accordingly, the average yield of Belete and Gudane demonstrated was 355 Qt/ha and 269 Qt/ha respectively. The result of samples t-test stated there was significant difference in yield between Belete and Gudane variety. Pairwise ranking showed disease resistance trait was considered to be the most trait preferred by farmers. The production of Belete variety in highlands of Guji Zone was profit with the net farm income of 28182.64 Birr/ha and 14158.34 Birr/ha in Bore and Ana Sora district respectively. Despite Belete variety has higher yield and returns the variety has lower acceptance than Gudane since Gudane was moderately disease resistant, high market demand and good taste. Farmers should use the existing variety (Gudane) in their potato production and used effective chemicals in maintaining disseminated variety. Since potato is relatively early mature crop, chemicals and necessary management practices should also quickly monitored.
Keywords: potato, Farmers Research Group, Pairwise ranking

1. INTRODUCTION

In Ethiopia, agriculture is the most important sector which accounts 46% of GDP, 80% of export value and about 73% of employment (Aklilu, 2015). In addition, agriculture of the country supports 98% of the total calorie supply and 70% of industrial raw material supplies (Assefa, 2014). The sector still remains largely dominated by rain-fed subsistence farming by smallholders (Aklilu, 2015).

Having all these importance, agriculture continues to face a number of constraints. Agricultural production in Ethiopia is characterized by subsistence orientation, low productivity, low level of technology and inputs, lack of infrastructures and market institutions and extremely vulnerable to rainfall variability (Urgessa, 2014). Weak institutions and lack of appropriate and effective agricultural policies and strategies were also hampered the development of agricultural sector (Aklilu, 2015). Bezabih (2010) also mentioned that natural resources degradation and lack of business oriented agricultural production system are key challenges. Despite its important roles agriculture fails to meet the minimum food requirements of the population and eradicate poverty in Ethiopia. But the government of Ethiopia is supporting the interventions of improved technologies that can bring radical change on the farmers' livelihood.

Potato (*Solanum tuberosum* L.) is one of the most important tuber crops in Ethiopia having the potential of improving the livelihood of smallholder farmers. Potato has been considered as a strategic crop by the Ethiopian government aiming at enhancing food security and economic benefits to the country. As the population grows rapidly, increased productivity of potatoes can improve the livelihood of smallholder potato producers and is required to meet the growing demand (Gildemacher, 2012; Habtamu, 2015). It produces considerably more energy and protein than cereals (Haverkort *et al*., 2012). Potato is also the fastest growing staple food crop and source of cash income for smallholder farmers in Ethiopia (Beliyu and Tederose, 2014; Berhanu and Getachew, 2014). Potato has become an increasingly important crop and contributes for food security, employment, nutrition and development in the socio-economic status of producers. Ethiopia has very conducive climatic conditions for production of high quality seed potato. The major potato producing regions of Ethiopia are Oromia, Amhara, SNNPR and Tigray States in that order of production levels (Bezabih *et al.*, 2015).

In Ethiopia, potato is mainly grown at high altitude of 1500-3000 masl by small scale farmers (Abebe *et al*., 2014). Nevertheless the national average productivity of potato is only 8.03 tons/ha which is far lower than the world average productivity of 16.02 tons/ha (Addisu *et al*., 2013). Out of the 216971.05 ha allocated to the root crops during the main season of 2014/2015 in Ethiopia, potatoes occupied 67361.87 ha (31.13%) (CSA, 2015). In the main production season, average potato productivity on research based and farmers level is 29-45 t/h and

22 t/ha respectively (Ali *et al*., 2014). This productivity gap between research based and smallholder farmers could be due to mismanagement practices done by the farmers, lack of improved seed and adverse climate conditions.

As many parts of the country, there are shortage of improved potato varieties in Guji zone and the existing varieties were deteriorating yield potential from year to year due to diseases and adverse environmental conditions. Despite the zone is potential for tuber crop potato the production of crop is characterized by lack of accessibility, shortage of improved technologies, and lack of improved varieties, lack of resistant variety and absence of awareness on the importance of the crop. Therefore, to overcome such problems on farm demonstration of recently adapted Irish Potato was proposed to develop and promote improved Irish Potato technology for sustainable production and productivity there by contributing to food security through increasing Irish Potato yield.

2. MATERIAL AND METHODS

2.1. Description of the Study Areas

Bore district is situated at a distance of 385km from Addis Ababa and 210km from the zone capital city , Negele. Bore district is situated in the Northern part of Guji Zone, Oromia regional state of geographical locations. Astronomically, Bore is located between 5^{o} 57'23" - 6^{o} 26'52" northing latitudes and 38^{o} 25'51" - 38^{o} 56'21" easting longitudes. It has elevation ranging from 1450-2900meters above sea level. The annual rain fall is about 122.7mm (recorded data 1996) and the annual temperature of the district ranges from 10.1up to 20^{0} c. The major soils of Bore district are Nitosols (red basaltic soils) and Orthic Acrosols. The two soils are found on the highland areas, and they are red brown and black brown in colors and on sloping topography and their utilization are good under natural vegetation respectively.

And Ana Sora district is situated at a distance of 410km from Addis Ababa and 180 km from zonal capital city, Negelle. Astronomically, the district is located between 6^{o}20'30" - 5^{o}57'30" northing latitudes and 38^{o}39'30" - 38^{o}57'30" easting longitudes. The district is characterized by two types of climatic zone, namely temperate, Dega (locally known as Bada) which starts in early April up to October and Woina dega (locally known as Bada-dare) which starts late November up to reaches the beginning of March). It is most humid and sub humid moisture condition, which has relatively longer growing season. The annual rainfall nearly about 122.7mm and the annual temperature of the district is nearly about 10.1^{o}c up to 20^{0}c.

The major soils of the district are Nitosoils (red basaltic soils) and Orthic Acrosoils. These two soils are found on the highland areas of the district, and they are red brown and black brown in colors and on sloping topography and their agricultural utilization are good under natural vegetation cover respectively.

2.2. Sampling Procedures

The experiment was conducted at two highland districts of Guji Zone, southern Oromia. Purposively, Bore and Ana Sora districts were selected. From all Irish Potato producing Peasant Associations (PAs), six PAs were selected based on their Irish Potato production potential. From each PA, one Farmers Research Group (FRG) having 15 members was established deliberately. The selections of participating farmers were carried out by close collaboration with agricultural district offices, DAs, SMSs, opinion leaders, and PA leaders. FRG members were selected based on their willingness, wealth status, and gender. Among the FRG members, three trial famers were selected while others grouped under the trial famers.

2.3. Research Designs

The activity was conducted at two high land districts of Guji zone, Bore and Ana Sora districts during 2015-2017. From all Irish Potato producing Kebele, six PAs were selected based on their Irish Potato production potential. Training was given on the general information of improved Irish Potato varieties, recommended agronomic packages and the goal of the experiment for the selected farmers, DAs, and SMSs.

One improved variety (Belete) of Irish Potato was evaluated along with standard check (Gudane) in a single experimental design, a plot size of 10m*10m, for each treatment with space of 75cm and 30cm between row and tuber respectively. 18 quintal/ha seed rate, 100Kg/ha Urea split at the first two earthing up and 200Kg/ha DAP at planting time was used. Land preparation, planting, earthing up, weeding and harvesting were done according to the roles and responsibilities assigned between farmers, researchers and Development Agents (DAs). Farmers' ideas on the technologies and yield data was collected.

2.4. Farmers' evaluation of potato varieties

Farmers were set their own selection criteria for potato varieties based on their selection criteria of yield per area, early maturity, market demand, disease resistance, sweetness, number of tubers per plant and tuber size. During varietal selection, the 6 FRG member farmers (18 members) and six non FRG members with a total of 24

household heads (male =18 and female =6) were participated. The evaluation was conducted after harvesting. Pairwise ranking was used to rank the preference of traits of potato by farmers and selection of potato varieties.

2.5. Method of Data Collection

Regular interaction with farmers, key informant and Focus Group Discussions (FGDs) were used to collect the data.

2.6. Data Analysis Methods

Simple descriptive Statistics and qualitative analysis of farmers' feedback were used to analysis data. Yield data and profitability analysis and farmers' perception on demonstrated potato were used in this analysis. Pairwise ranking was conducted for trait and varieties selection.

2.7. Research Implementation

Intensive orientation and training were given to update the farmers' knowledge and skills related to agronomic practice, protection, weed management and post-harvest management on potato during the last two span of the activity. 6 FRGs was established. 180 FRG members (131 males and 49 females), 8 development agents (DAs), and 5 subject matter specialists (SMSs) were trained. Follow up was done during the span of the activity. Exchange visit was arranged among experimental FRGs to evaluate the performance of the crop and the management practices done by the FRGs. In addition, this exchange visit helps to share experience of FRG members on potato production.

3. RESULTS AND DISCUSSION

3.1. Yield obtained over two years

In production per plot, Belete variety was best performed than standard variety (Gudane). The average yield for Belete demonstrated was 355 Qt/ha while it was 269 Qt/ha Gudane variety which was lower than the previously demonstrated Gudane (367 Qt/ha) and the productivity of earlier demonstrated Gudane in Bore district was 413 Qt/ha (BOARC, 2013). When the yield was compared based on locations, Belete had better performance in Bore district (Enshido Alayo kebele) than those of in Ana Sora district (Raya Boda kebele).

Yield obtained over two years

Table 1. The yield of demonstrated potato per FRG of kebeles and districts

Variety	Yield of Bore district from 10*10m plot size in quintals				Yield of Ana Sora district from 10*10 plot size in quintals				Average yield of two the districts in qt/ha (n=18)	Std. Dev.	CV (%)
	Kebeles			Ave.	Kebeles			Ave.			
	Enshido Alayo	Ano Kerensa	Kombolcha Wate		Irba Buliyo	Raya Boda	Bube Korsa				
Belete	4.5	4.13	3.16	3.93	3.33	2.50	3.67	3.17	355	93.82	3.78
Gudane	3.67	2.83	2.33	2.94	2.33	2	3	2.44	269	68.90	3.90

n= sample size

The yield difference across location may came from management practices performed by experimental farmers. Belete and Gudane did not showed their maximum yield potential due sudden break-out of bacterial wilt. Belete was more affected by bacterial wilt starting from vegetative stage to flowering stage. But Gudane was not much affected by wilt bacteria except lower yield may be due to the mother seed deterioration. In addition to wilt bacteria, frost also affected Belete during vegetative stage in study area.

Based on the results of independent t-test ($p = .004 < .05$), it was concluded that there was significant difference in yield between Belete and Gudane variety in the study area.

Table 2. Independent t-test output

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	T	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Yield/ha	Equal variances assumed	2.74	.107	3.12	34	.004	85.60	27.44	29.8	141.31
	Equal variances not assumed			3.118	31.20	.004	85.60	27.44	29.6	141.50

df= n-1, degree of freedom

3.2. Profitability Analysis

Production costs and returns of demonstration of potato was collected from experimental farmers. Production cost and return was taken from the area of demonstration (100m^2) but it was converted to hectare in order to calculate the profitability of potato. Production costs included were variable and fixed costs. Variables costs includes cost of land preparation, cost of seeds, cost of fertilizers, planting, weeding, harvesting, cost of transport and cost of sacks. Since potato (Belete) variety was perishable the cost of loss was included in analyzing profitability of Belete. Fixed cost was cost of land. In the study area potato can be produced twice a year. After potato was harvested other secondary crops such as wheat, barley and faba bean can be produced. Therefore, cost of land was included for only one season of production (2388.89 Birr/ha for Bore district and 2444.44 Birr/ha for Ana Sora district). Average farm gate price was 150 Birr/Qt. The price of potato after harvest was low but gradually it increases specially during planting time. Thus, both potato varieties have the same price during harvesting time. The demonstration of potato in the highland Guji is profitable for farmers with return of Belete 28182.64 Birr/ha and 14158.34 Birr/ha in Bore and Ana Sora district respectively. From the table below, Belete was more profitable than Gudane but experimental farmers were not interested on Belete since it was not sweet as Gudane and not used for *Datah* (local name of cooked potato sold near road for consumption).

Table 3. Profitability analysis

Location	Variety		Location	Variety	
Bore district			Ana Sora district		
	Belete	Gudane		Belete	Gudane
Yield/ha (Q)	393	294	Yield/ha (Q)	317	244
Price (P) per quintal	150	150	Price (P)	150	150
Total Revenue (TR)= TR= QxP	58950	44100	TR= QxP	47550	36600
Variable costs			**Variable costs**		
Cost of land preparation	2160	2160	Cost of land preparation	1890	1890
Seed cost	12110	12110	Seed cost	12400	12400
Fertilizer cost	3325.78	3325.78	Fertilizer cost	3557.22	3557.22
Planting	475.56	475.56	Planting	511.11	511.11
Weeding	382.35	382.35	Weeding	811.11	811.11
Harvesting	486.67	486.67	Harvesting	833.33	833.33
Cost of transport, sacks	438.11	438.11	Transport, sacks	500	500
Others (loss)	9000	0	Others (loss)	10500	0
Total variable costs (TVC)	28378.47	19378.47	**TVC**	31002.77	20502.77
Fixed costs			**Fixed costs**		
Cost of land	2388.89	2388.89	Cost of land	2444.44	2444.44
Total fixed costs (TFC)	2388.89	2388.89	**TFC**	2444.44	2444.44
Total Cost (TC) = TVC+TFC	30767.36	21767.67	**TC = TVC+TFC**	33447.21	22947.21
Gross Margin (GM) = TR-TVC	30571.53	24721.53	**GM = TR-TVC**	16547.23	16097.23
Profit= GM-TFC	28182.64	22332.64	**Profit= GM-TFC**	14158.34	13652.79

3.3. Farmers' Preference Criteria

Farmers have their own criteria to select certain new or improved technologies characteristics from their farm experiences. Thus, number of tubers per plant, tuber size, market demand, disease resistance and early maturity

were some of crop attributes identified and used to evaluate the potato varieties demonstrated and selection criteria by the selected farmers in the study area. In pair wise ranking each trait with compared in turn with the other traits. The number of time a trait had been found to be more important was measured by counting the number of times trait number appeared in the matrix. The trait number to appear most times said to be the most important trait. In this case trait "disease resistance" appears more times (six times) in the matrix than any other traits. Therefore, disease resistance trait was considered to be the most trait. This was confirmed with the participating farmers who agreed that this was the case.

Table 4. Pairwise ranking of farmers' (n=24) selection traits for potato varieties

Selection criteria	**Early maturity**	**Yield/ Area**	**Number of tubers/plant**	**Tuber size**	**Market demand**	**Disease resistance**	**Sweetness**	**Total score**	**Rank**
Early maturity								0	7
Yield/ area	Yield/ area							3	4
Number of tubers/ plant	Number of tubers/plant	Yield/ area						2	5
Tuber size	Tuber size	Yield/ area	Number of tubers/plant					1	6
Market demand	Market demand	Market demand	Market demand	Market demand				5	2
Disease resistance	Disease resistance	Disease resistance	Disease resistance	Disease resistance	Disease resistance			6	1
Sweetness	Sweetness	Sweetness	Sweetness	Sweetness	Market demand	Disease resistance		4	3

n= number of farmers selecting potato traits

Source: Farmers' preference result

Gudane was lower yield than Belete but farmers prefer to produce Gudane in the study area as it was not seriously affected by bacteria wilt, sweeter than Belete and has higher market demand. Farmers did not prefer to produce Belete due it's to low reaction to bacteria wilt and even being left in the land it further initiates the spread of disease to the whole land so farmers were not choose. In addition, Belete variety was also easily affected during post-harvest (especially in storage).

Table 5. Direct matrix ranking of potato varieties by farmers (n=24)

Selection criteria	Early maturity	Yield/area	Number of tubers/plant	Tuber size	Market demand	Disease resistance	Sweetness	Total score	Rank
Relative weight	2	3	2	2	3	3	3	-	-
Belete	**6**(3)	**12**(4)	**8**(4)	**8**(4)	**9**(3)	**6**(2)	**9**(3)	58	2
Gudane	**6**(3)	**9**(3)	**6**(3)	**6**(3)	**15**(5)	**9**(3)	**15**(5)	66	1

Source: Farmers' preference result

Note: numbers in parenthesis indicated the performance rating value of each variety given from 1-5 (5= excellent, 4=very good, 3= good, 2= poor and 1=very poor) and numbers written in the bold indicate total score of a variety as per each selection criteria, which was obtained by multiplying the relative weight of each selection criteria with that of the performance rating number in the parenthesis. The relative weight criteria (3= very important, 2 = important, 1= somewhat important).

3.4. Farmer's perception

Farmers more prefer to plant Gudane than Belete due to adapted to agro-ecology and moderately resistant disease. Even though Gudane productivity (269Qt/ha) was less than that of Belete (355Qt/ha) with a yield difference of 86Qt/ha farmers were still favoring Gudane rather than Belete since Belete was first affected on the land by wilt bacteria and secondly it also easily affected in storage. The crop could not wait good market price and could not stayed for planting time. But selling at harvesting time was low price for outputs of farmer so less returns. As discussed with key farmers, when Belete was stored in a sack or stored in the home it easily perishable and has bad smell. So farmer's perception on producing Belete was negatively high.

4. CONCLUSIONS

Improved variety, Belete and standard check, Gudane was not showed their maximum potential of productivity because of the sudden break out of wilt bacteria in both years. Belete variety had higher yield than Gudane but farmers prefer to produce Gudane due to moderately resistance to disease. The production of Belete variety in highlands of Guji Zone was profit with the net farm income of 28182.64 Birr/ha and 14158.34 Birr/ha in Bore and Ana Sora district respectively. Despite Belete variety has higher yield and returns the variety has lower acceptance than Gudane since Gudane was moderately disease resistant, high market demand and good taste.

Disease resistance was the most trait of potato variety in the study area. Effective chemical that control potato disease (bacteria wilt and blight light) must be introduced to potato producers.

5. RECOMMENDATIONS

Until other new varieties released farmers should use the existing variety (Gudane) in their potato production and used effective chemicals in maintaining disseminated variety. Since potato is relatively early mature crop, chemicals and necessary management practices should also quickly monitored. Like provision of potato seed the other inputs (for instance, chemicals that control disease) should be provided on right time at fair price for local farmers. Disease resistant trait was the most trait of potato in the study area therefore disease resistant variety of potato should be introduced to farmers.

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