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Research Article

Participatory on Farm Evaluation and Demonstration of Improved Potato Varieties (*Solanum tuberosum L.*) in Derashe Special and Bonke Districts of SNNPR, Ethiopia

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ABSTRACT

Potato (*Solanum tuberosum L.*) is the most important food security crop in Ethiopia and it is regularly consumed by millions of people. Despite its sundry importance, potato production and productivity are affected by a couple of biotic and abiotic factors, particularly in the study areas. Thus, participatory on-farm evaluation and demonstration of improved potato varieties were conducted in Derashe special and Bonke districts in Southern Ethiopia. A single plot design (side to side comparison) was adopted and each variety (Horo and Gudane) was planted on the 10 m × 20 m land area. A capacity building training was delivered to selected farmers, extension agents, and other Subject Matter Specialists (SMSs) on potato agronomic practices. A matrix ranking approach was adopted during technology evaluation and varietal preferences by farmers. At plant physiological maturity, a field day was organized and technology was promoted by using different media outlets. The yield performance result revealed that the Horo variety could significantly ($p<0.05$) perform over the Gudane variety (49.9 ± 6.8 tha^{-1} and 33.5 ± 15.2 tha^{-1}, respectively); that is a 49.23% higher yield advantage over Gudane. The Horo variety had a higher net return (242,026 ETB) than Gudane (107,619 ETB) variety. Moreover, the farmers evaluation and preference result showed that improved potato variety (Horo) was ranked as the first choice over Gudane. Therefore, based on the present findings, the Horo variety was recommended for further scaling out and production in the study areas and other similar agroecology.

Keywords: Farmers; Field day; On farm evaluation and demonstration; Potato; Varietal preferences

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the most important crop in terms of economic benefits and food security [1]. It is a nutritionally rich staple crop that contributes carbohydrates, protein, vitamin A and C, zinc, iron, and minerals which alleviate the problem of malnutrition in subsistence farming areas and towards the dietary demands in the fast growing towns and cities [2]. It grows well under a wide variety of conditions (rained or irrigation) and soil pH as low as 5.0 (the best pH range for potato production is 5.5-6.8). Although its production in Eastern Africa has increased considerably over the last decades, the actual farmer's yields per hectare are still far below the achievable yields. In sub-Saharan Africa, its productivity remains below 10 tha^{-1} while the achievable yields with Good Agronomic Practices (GAP) reach as high as 30 tha^{-1} [3].

Potatoes have a high potential to supply cheap and quality food within a relatively short period [4]. It has a promising outlook for enhancing the quality of the basic diet in rural and urban areas of the country. Moreover, due to its shorter vegetative period, farmers easily find an appropriate season for its cultivation under a wide range of weather patterns and less predictable climates. It is important in the farming system in mitigating hunger during food shortage months [5]. It contributes to a more stable food system through maintaining

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nutritional and food security and is a predictable source of income. In order to exploit the potential benefit of the potato crop as food and nutrition security, the Ethiopian Agricultural Research Institute (EIAR) through different national and regional research centers has been conducting several research and development activities.

Ethiopia is the second most populous country in Africa following Nigeria and food insecurity is one of the challenging issues. Potato has been considered as a strategic crop in Ethiopia to ensure food security by providing a high yield and high-quality product per unit input with a shorter crop cycle (*i.e.*, mostly less than 4 months than major cereal crops) [6]. It ranks first in terms of area coverage among Root and Tuber Crops (RTCs) in Ethiopia. The national crop production survey results of the year 2018/19 indicated that from the total land areas of 231,552 ha that is occupied by root crops, 73,678 ha (32%) were occupied by potatoes. Among 45,357,549 quintals produced by root crops, 10,444,364 quintals were obtained from potatoes. However, its productivity remained at 14.2 tha-1 [7].

The FAOSTAT data revealed that potato production in Ethiopia increased from 8 tha^{-1} in 1993 to 13.3 tha^{-1} in 2020, whereas the area of production doubled in the aforementioned periods [8]. Although it's wide popularity and importance, the productivity of potatoes are relatively low. The lower productivity is related to drought, frost, poor agronomic practices, and limited access to high quality and disease resistant seeds [9-11]. Moreover, it is also related to low soil fertility due to inadequate nutrient use, climatic change, inadequate availability of seed particularly at the peak planting period, poor post harvest handling, high production costs, and diseases and insect pests. The study reported that genetic improvement and technology transfer is the most important stepladders in boosting the technology uptake while improving production and productivity. In southern Ethiopia, particularly in Derashe special and Bonke districts, average farmers use local varieties that are susceptible to different biotic and abiotic factors. Therefore, the present study was conducted in the Derashe special and Bonke districts with the objectives of evaluating potato productivity and profitability and farmers' preference for varietal attributes on selected farmer fields.

MATERIALS AND METHODS

Description of the study area

The participatory on farm evaluation and demonstration of potato varieties were conducted in Derashe special and Bonke districts. The districts were selected based on their potential for potato production and transport accessibility. Derashe is one of the districts in the Southern Nation, Nationalities, and Peoples Region (SNNPR). The district lies at an altitude between 501-2500 m.a.s.l. The annual average precipitation and temperature ranges from 601 mm -1600 mm and 15.1-27.5°C, respectively [12]. Bonke district is located in the Gamo Zone of SNNPR. It lies at a latitude and longitude of 5.96 N and 37.3 E, respectively, and an altitude ranging from 600-4200 m.a.s.l. The annual average precipitation and temperature are 1400 mm and 13.05°C, respectively [13]. Regarding agroecological zones, 46%, 30%, and 24% of the district are highland (Dega), midland (Woina dega), and lowland (Kolla). In both districts, agriculture is the major livelihood activity.

Selection of participant farmers

One kebele and ten host farmers from each district (Chosha kebele from Bonke and Layignawu Arguba from Basketo special district) were selected based on the farmers' willingness to participate and the availability of sufficient farmland for demonstration. In each operational Kebele, a gender inclusive Farmers Research Group (FRGs) was organized. The FRG groups were organized based on the willingness of farmers, wealth status, and gender consideration.

Field design, planting materials and cultural practices

For participatory on farm evaluation and demonstration of improved potato varieties, two varieties of potatoes (Horo and Gudane) were planted side by side. The plot size for each variety was 10 m x 20 m (200 m^2). The seeds were supplied and distributed to the host farmers from Arbaminch Agricultural Research Center. The potato tuber was planted by keeping the inter and intra-row spacing of 75 cm x 30 cm and seed rate of 2000 kg ha^{-1}. The recommended chemical fertilizer of 236 kg ha-1 (NPS) and 144 kg ha^{-1} (urea) was used. Moreover, all the relevant agronomic practices were applied at the requisite time accordingly.

Technology evaluation approaches

Farmers were invited to visit the demonstration plots and evaluate the potato performance at different plant growth stages. Thus, a matrix ranking approach was adopted for the evaluation and ranking of important potato attributes.

Data collection

Data were collected through structured field assessment, checklist, and focused group discussion. At physiological maturity, potatoes were harvested from the entire plots from all host farmers' fields (twenty farmers) and the tuber yield was measured at an optimum moisture level. The yield advantage was calculated as in Equation (1). In addition, preference data was collected using focus group discussion during the evaluation period. The profitability analysis (cost benefit analysis) was calculated as in Equation (2). The cost of potato production includes seeds, fertilizers, pesticides, labor costs, and other transport costs. The net benefit was calculated by taking the cost of production and total gains into consideration.

$$\text{Yield advantage (\%)} = \frac{\text{Yield of improved variety} - \text{Yield of standard check}}{\text{Yield of standard check}} * 100 \quad (1)$$

$$\text{Net benefit} = \text{Total revenue} - \text{Total cost} \quad (2)$$

Data analysis

The collected data was analyzed through an independent t-test to check the statistical differences between varieties using SPSS

version 22.0 and all the illustrations were done using sigma plot version 12.5.

RESULTS AND DISCUSSION

Capacity building on potato production

Training is one of the important tools for creating awareness and promoting agricultural technology [14]. In the present evaluation and demonstration activity, theoretical and practical training was delivered to selected farmers (including experimental/host and non experimental farmers), extension agents, and other Subject Matter Specialists (SMSs) to create awareness and build their capacity on potato production. Moreover, exchange visits were organized at different potato growth stages to enhance farmer to farmer learning on potato production, management, and post harvest handling. At the physiological maturity of the crop, a field day was organized to promote technologies to a larger extent. Also, experiences and scientific knowledge were shared by different researchers and offices of agriculture and natural resources during training provision, mid-term field evaluation, and field day. The number of participants (farmers, development agents, and other stakeholders) in the training, exchange visit, and field day were given in the below (Table 1).

Table 1: Number of participants in capacity building training, exchange visit, and field day.

Activities	Kebele	Farmers		DA		Experts		Total
		M	F	M	F	M	F	
Training	Chosha	22	5	3	-	3	-	33
	Layignawu Arguba	23	5	4	1	2	-	35
Exchange visit	Chosha	20	3	6	1	11	2	43
	Layignawu Arguba	25	5	5	2	14	2	53
Field day	Chosha	20	5	3	2	30	-	60
	Layignawu Arguba	20	3	2	1	30	-	56

Note: DA, M, and F represent development agents, male and female, respectively. The Chosha and Layignawu Arguba kebeles are from Bonke and Derashe special districts, respectively.

Potato yield performance

The result revealed that the tuber yield was significantly ($p<0.05$) influenced by the demonstrated potato varieties across districts. In Layignawu Arguba, the highest tuber yield was recorded in Horo varieties (53.15 ± 4.4 tha^{-1}), but the tuber yield was superb in the Chosha kebele for the Horo variety (46.7 ± 7.3 tha^{-1}) than Gudane variety (19.3 ± 4.37 tha^{-1}). Averaged across the two locations, the mean tuber yield among varieties was significantly and it was 33.5 ± 15.2 and 49.9 ± 6.8 tha^{-1} for Gudane and Horo, respectively. This might be related to the inherited potential of the varieties. More importantly, the potato productivity obtained from the present study was considerably higher than the national and regional averages, implying the high importance of proper field management and the use of appropriate varieties. In line with the present study [15], reported the variations in the magnitude of tuber yield due to varieties and locations.

Yield advantage

The result showed that the improved variety (Horo) had a positive yield response over the standard check (Gudane) across both locations, but with varied magnitude. The highest yield response was observed at Chosha (142%) due to the potential of the Horo variety to resist drought and unfavorable conditions over the Gudane variety. At Layignawu Arguba, the magnitude of yield response was considerably lower (11.63%) as compared to Chosha. Overall, the Horo variety had a 49.23% yield advantage over the Gudane variety (Table 2).

Table 2: Yield advantage and yield increase of the demonstrated potato varieties in Layignawu Arguba and Chosha kebeles.

Location (n=20)	Tuber yield (kg ha^{-1})		Yield increase (kg)	Yield advantage (%)
	Gudane	Horo	Horo	Horo
Chosha	19300	46700	27400	142
Layignaw Arguba	47610	53150	5540	11.63
Mean	33455	49925	16470	49.23

Varietal evaluation and preference

One of the most important parts of the present study was evaluating farmers varietal preferences. It is apparent that actively participating farmers in the technology evaluation and demonstration process is one of the most important steps to enhance technology dissemination and thereby adoption [16]. It was reported that the mismatch between the goals of potato breeders and the farmer's needs and preferences are the major factors for the low adoption and dissemination of improved potato varieties [17], which there by affects its production and productivity. This is because farmers prefer multiple traits in their potatoes and they may not prefer an improved variety that performs best for some specific traits and poor for others. Overall, farmers prefer the technology/variety which is better in terms of productivity and other criteria over the local variety.

Accordingly, farmers were participated in the evaluation of these varieties at different times and selected the best trait according to their importance, which included seed emergence, resistance to lodging, disease resistance, early maturity potential/earliness, tuber size, tuber yield, test, cooking time, rotting, marketability in parallel, a Focus Group Discussion (FGD) was adopted to collect feedback on the tested potato varieties. The rating performance was scored from 5 to 1 *i.e.*, 5 being the highest score representing excellent, 4 for very good, 3 for satisfactory, 2 for poor, and 1 for very poor. A total of 45 stakeholders have participated (20 from Chosha and 25 from Layignawu Arguba) in the evaluation and they ranked potato variety based on the aforementioned criteria. The result revealed that farmers preferred and selected the Horo variety over the Gudane in both locations (Table 3). Thus, the above criteria are very important for breeders to reshuffle their plans and incorporate the need of farmers during technology generation in order to enhance technology uptake and ensure food security.

Table 3: Preference ranking analysis of the demonstrated potato varieties in Layignawu Arguba and Chosha kebeles.

Variety	Chosha (n=20)			Layignawu Arguba (n=25)		
	Total score	Mean score	Rank	Total score	Mean score	Rank
Gudane	23.8	2.36	2	35.6	3.56	2
Horo	48.6	4.86	1	49.8	4.98	1

Profitability analysis

The profitability analysis was conducted by summing all the production costs incurred and incomes obtained. The farm gate price during potato production season was 9 ETB for one kilogram. The profitability analysis revealed that an average net return of 107, 619 ETB and 242, 026 ETB per hectare were obtained from Gudane and Horo varieties, respectively (Table 4).

Table 4: Profitability analysis of potato varieties.

Items	Description	Gudane	Horo
Marketable yield (kg ha^{-1})		17,500	36,562.50
Adjusted yield (-10%)		15,750	32,906
Total gain in ETB (A)		1,41,750	2,96,156
Seed cost (ETB)		20,000	40,000
Fertilizers costs (kg)	NPS	2,832	2,832

	Urea	1,629	1,629
	Potassium	1,250	1,250
Chemical cost (kg)	Ridomil gold	26,211	46,211
Land preparation cost	per hectare	3,000	3,000
Labor cost (ETB)	Planting	600	600
	Weeding	1,200	1,200
	Fertilizer application	720	720
	Harvesting and transporting	2,400	2,400
Total cost in ETB (B)		34,131	54,131
Net benefit (C) = A-B		1,07,619	2,42,026

Note: ETB represents Ethiopian Birr.

CONCLUSION

Participatory on farm evaluation and demonstration of improved potato varieties were conducted in Derashe special and Bonke districts on 20 host farmers fields with the objectives of evaluating their productivity and profitability, and farmers preference for varietal attributes. As a result, the Horo variety could significantly lift tuber yield over the Gudane variety and had a yield advantage of 49.23%. Based on ten important criteria, farmers evaluated and preferred the Horo variety as their first choice over Gudane. Therefore, the Horo variety was recommended for production in the study areas and other similar agro ecologies. Moreover, it is necessary to actively involve farmers in technology generation, evaluation, and demonstration processes to exploit their indigenous knowledge and selection criteria to develop farmer preferred varieties.

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CONFLICT OF INTEREST

None

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