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Pre-Extension Demonstration of Irish Potato (*Solanum Tuberosum* L.) in Midlands of Guji Zone, Oromia, Ethiopia

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A B S T R A C T

Potato is an interesting root crop used for food security due to its early maturity and compatibility with double cropping for farmers in the midlands of the Guji zone. However, using verified tuber seed is challenging for potato production. Therefore, verifying improved potato variety in the form of demonstration prior to large extension is necessary on the specified agroecology. This study was conducted to increase farmers' knowledge and abilities in potato cultivation, measure productivity and profitability, and assess farmers' preferences for potato farming. Adola Rede and Arda Jila Mea Boko districts were purposefully chosen. Twelve farmers were selected and planted Gudane and Zemen varieties on a 10x10m area with 70 and 30 cm inter and intra row spacing, respectively. Training was employed to help farmers enhance their knowledge and skills. Interviews were conducted to gather information about yield, production costs, and farmer preferences. The data was analyzed using descriptive statistics, t-tests, and net benefit. The demonstration results revealed that the Gudane variety yielded 20.8 t/ha, while the Zemen variety yielded 17.09 t. There was a significant difference in mean yield between Gudane and Zemen variety production at 0.001 levels. Production of Gudane and Zemen varieties returned 117083.33 birr/ha and 87416.67 birr/ha, respectively. Farmers preferred Gudane variety due to its higher yield and tolerant to disease than Zemen variety. Thus, Gudane variety was recommended for large extension production at midland districts of Guji zone

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INTRODUCTION

Potato (Solanum tuberosum L.) is a global food crop and a popular vegetable crop (FAOSTAT, 2022; Kadakoğlu and Karli, 2022; Tilahun, 2018). It is the leading root and tuber crop in production, followed by cassava, sweet potato, and yams (Getachew et al., 2023; Komlaga et al., 2021). Potatoes are grown at high elevations in tropical nations such Egypt, Sudan, Kenya, and Ethiopia (Chandio et al., 2022; Scott, 2021). Potato prefers altitudes of 1500-4200 meters and temperatures of 18-20°C for optimal growth and output (Aloo, 2021). Potatoes may grow in a deep, well-drained, friable environment with a pH range of 5 to 6.5 (Mugo et al., 2021). Ethiopia has the largest potential for potato production, with 70% of its arable land considered to be To be suitable for potato (Shamil and Dereje, 2021). The outstanding climatic and edaphic conditions for cultivation and productivity contribute significantly to Ethiopia's high potato output potential (Chen, 2023).

Over a billion people eat potatoes practically every day (Sultana et al., 2023). Hundreds of millions of people in poor countries rely on potatoes for survival. It is a critical crop for nations like Ethiopia, where low protein and calorie supply are major nutritional issues (Tekle and Tesfu, 2023; Erokhin et al., 2021). It also creates job opportunities in the manufacturing, processing, and marketing sectors (Hedberg and Lounsbury, 2021). The Ethiopian government has identified potato as a strategic crop with the goal of improving food security and economic advantages for the country (Beriso, 2023). The potato's large yield, early maturity, and outstanding food value make it ideal for enhancing food security, raising household income, and reducingpoverty (Getachew *et al.,* 2023; Chen, 2023; Burgos, 2020; Kolech *et al.,* 2019). Currently, potato is consumed as cooked and chips at household and restaurant level.

Potato exports have increased significantly in recent years, both in volume and value. Ethiopia exported about 71,000 tons of potatoes to regional markets. Djibouti is Ethiopia's major market outlet, absorbing 80 to 90% of its potato exports, with Somalia coming in second at 8 to 15%. Other regional markets such as Sudan, Yemen, and Saudi Arabia import minor amounts of potatoes from Ethiopia. (Brasesco *et al.,* 2019).

Ethiopia's annual potato production climbed from 349,000 tons in 1993 to roughly 743,153 tons in 2018 (Herforth et al., 2020). However, typical potato yields in Africa range from 6 to 12 tons ha-1, compared to 35-45 tons ha-1 in Europe and North America (CIP, 2017), and in Ethiopia, they are 13.14 tons ha-1 (CSA, 2020), significantly below the crop's potential (FAO, 2019; Lulu et al., 2023). The main reasons for Ethiopia's low potato production and productivity are a scarcity of seed tubers from better potato types and illnesses. (Tekle and Tesfu, 2023; Lulu *et al.,* 2023; Lemessa *et al.,* 2019; Gelaye *et al.,* 2022). Hence, substituting local varieties by the improved potato varieties which are disease tolerant are needed to feed the increasing human population and maintain food security within short period of time.

Many Guji's highland and midland regions are well-known for producing potatoes. The crop is very interesting in the areas as it can be harvested early for household consumption; generate high yield and high return for farmer. Now a day potato is roasted on road side for human consumption and generating

income for women. Potato is highly demanded by rural farmers and urban dwellers. Interestingly, potato gets attention from agricultural research centers as different Potato cultivars were released for various agro-ecologies in Ethiopia, although many varieties did not reach the Guji zone's midlands. Guji's midlands are ideal for producing potatoes. Furthermore, because to its early maturity, the crop is used for double cropping, which can boost productivity and income for farmers. In spite of its importance obtaining improved tuber seed of potato is challenging for farmers. Hence, it is important to demonstrate the improved potato varieties on farmers' land and ensure the availability of potato varieties for production. Potato cultivars were released for various agro-ecologies in Ethiopia, although many varieties did not reach the Guji zone's midlands. Guji's midlands are ideal for producing potatoes. Furthermore, because to its early maturity, the crop is used for double cropping, which can boost productivity and income of Guji zone.

LITERATURE REVIEW

The Ethiopian government and research institutions have invested a significant amount of money and time in upgrading potato technology and quality in order to enhance smallholder production (Basha et al., 2017). Considering potato as a strategic crop aimed at improving food security and economic benefits to the country, the Ethiopian government has collaborated with the International Potato Center (CIP) partner to introduce many new cultivars over the last three decades to promote adoption of improved potato varieties, despite the fact that most Ethiopian farmers continue to grow older local cultivars (Kolech et al. 2015). The National Potato Research Program of Ethiopia, in conjunction with CIP and other stakeholders, has published more than 29 enhanced potato cultivars to increase productivity (Haverkort *et al.*, 2012). Therefore, released variety of potato need to be demonstrated and tested on few farmers land to extend the recognition of variety on farmers' circumstance. Agricultural Research System of Ethiopia in general and Oromia in particular focused on the circular link the so called research-extension-farmer linkage pillar where demonstration of agricultural research variety/technology was the unit of study that interlink the research, extension and farmer.

In Ethiopia the role agricultural extension is mainly technology promotion which can increase farmers and pastorals agricultural production. Technology can be improved or new variety or new methods of production used to improve production for producers. Hence, promoting agricultural technologies expected to improve household consumption and help the farmers and pastorals market participation. In line with different variety release Oromia Agricultural Research Institute has devoted to promote agricultural technologies through Pre extension demonstration, scaling up and large scale demonstration in its mandate areas **(**Amare *et al.,* 2023; Korji *et al.,* 2023; Kebede and Bobo, 2023; Kebede *et al*., 2024).

METHODOLOGY

Kebeles and Farmers Selection Procedure

Adola Rede and Arda Jila Mea. Boko districts were chosen specifically because they have the potential for potato cultivation. Two kebeles were chosen from each district for demonstration purposes. Each kebele developed a farmer research group with 15 farmers as members. Each kebele has three experimental farmers. In total, there were 12 experimental farmers for this demonstration while the remaining farmers research member were shared knowledge on potato production.

Research Materials and Methods

Zemen and Gudane types were displayed on a 10m x 10m space. The recommended 18 qt/ha tuber seed was planted with inter and intra raw spacings of 75cm and 25cm, respectively. During the demonstration, the recommended 200kg/ha NPS at planting and 100kg/ha UREA at earthing up were used. Training and a short field day were held to promote potato variety in the selected districts.

Methods of Data Collection and Analysis

Data were acquired using observation, measurement, and interview approaches. Yield and production costs were obtained. The total variable costs (seed, fertilizer, land preparation, planting, weeding, and harvesting) and fixed costs were collected per hectare. The farm gate price was determined at the time of production. The yield performance of potato varieties was assessed using descriptive statistics and an independent t-test. The profitability of displayed cultivars was calculated using net benefit. The total revenue (TR) was calculated by multiplying the demonstration's yield (Q) by the farm gate price. The net benefit (NB) was computed by subtracting the total cost (sum of total variable cost (TVC) and fixed cost) (FC) from total revenue. Farmers' preference on potato traits were analyzed by matric ranking while direct ranking was used to rank and select the best potato variety.

$$TR = Q * P \quad \text{.....1}$$

$$NB = TR - TVC - TFC \quad \text{.....2}$$

RESULTS AND DISCUSSION

Capacity Building on Potato Production

In component of technology promotion, training was important to enhance knowledge and skills of farmers in line with the recommended packages. Such training can sustain technology promotion as farmers independently produce the variety in their farm at the termination of research activity. Training and field day can increase farmers' knowledge and skill (Kebede et al., 2023; Kebede et al., 2021; Kebede et al., 2018).

For this demonstration training was given on theoretical and practical session. Hence selected experimental farmers were trained on agronomic potato production, postharvest (storage) of potato and principles of on farm research. Other non-experimental farmers were trained with selected experimental farmers in order to enhance their knowledge and skills and motivate farmers for the next potato production season. Accordingly, 96 farmers, 17 During the potato demonstration, 14 subject matter professionals and development agents received

training (Table 1). A mini field day was held during the vegetative stage of the shown potato. This event was created to promote potato variety in the neighborhood. Various stakeholders attended the small field day and recognized the performance of shown potato varieties on farms. Following the small field day, participants reviewed how improved potatoes were communicated to possible kebeles for increased output, as well as the role of agricultural research centers, farmers, and the district agricultural office in furthering the promotion of potato varieties in the Guji zone's midlands.

Table 1. Capacity Building on Potato Demonstration and Production

Capacity building methods	SMS			DAs			Farmers		
	M	F	T	M	F	T	M	F	T
Training	12	2	14	14	3	17	85	11	96
Mini field day	6	-	6	5	1	6	27	9	36

SMS= subject matter specialist, DAs= development agents, M= male, F= female, T= total

Yield Performance of Potato Varieties

From the demonstrated varieties the higher yield was obtained from Gudane variety with 20.8 t/ha than Zemen variety which was 17.09 t/ha at midland of Guji zone. This result was lower than the study of Korji and Kebede (2017) who harvested 26.6t/ha from Gudane variety. In addition, the result of Tilahun (2018) showed that from Gudane 40.72 t/ha and Teshome *et al.,* (2023) reported 23.59 t/ha of Zemen was harvested. The finding of this study was higher than the results of Dembi *et al.,* (2020) and ESS (2022) where Gudane variety can gave 14.9 t/ha at highlands of Guji zone and the national yield of potato was 16.68 t/ha respectively. This showed that Gudane variety has a potential to increase production for farmers at different locations. The result of participatory variety selection also indicated that at midland of Guji zone Gudane and Zemen gave 39.25 and 43.95 t/ha respectively (Amdie and Teshome, 2021). However, there was high variation with participatory variety selection and the current results as the former was intensively conducted on research and on farms managed by researchers while the latter was managed by farmers. This indicated that researcher manage and farmers manage can affect the yield of potato. More yields of Gudane were obtained from Arda Jila Mea Boko district than Adola Rede district. At Arda Jila Mea Boko Gudane variety gave 22.37 t/ha compared to 16.92 t/ha at Adola Rede dstrict. This showed that Arda Jila Mea Boko district was more suitable for Gudane variety (Table 2).

Table 2. Yield Performance of Demonstrated Potato Varieties

Districts		Yield of Zemen variety (t/ha)	Yield of Gudane variety (t/ha)
Adola Rede	Mean	17.27	19.23
	N	6	6
	Std. Deviation	1.38	1.48
Arda Jila Mea Boko	Mean	16.92	22.37
	N	6	6
	Std. Deviation	3.04	1.94
Total	Mean	17.09	20.80
	N	12	12
	Std. Deviation	2.26	2.32

Independent t test was used to explain the mean difference between demonstrated potato varieties. There was 3.7 t/ha mean difference between Gudane and Zemen variety. Based on the results of independent t-test ($p = .001 < .05$), There was a substantial variation in yield between the Gudane and Zemen varieties in the study locations (Table 3).

Table 3. Independent Samples Test

Yield of potato varieties		t-test for Equality of Means						
		T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
							Lower	Upper
Yield (t/ha)	**Equal variances assumed**	3.969	22	.001	3.708	0.934	1.77	5.65
	Equal variances not assumed	3.969	21.98	.001	3.708	0.934	17.704	5.65

Profitability of Potato Production

The total revenue obtained from Zemen and Gudane was 136733 and 166400 birr/ha, respectively. During study the selling of tuber seed was 1500 birr/ha and 18 quintals of potato were required for one hectare so that the seed cost for one hectare was 27000 birr for each variety production and farm gate price was 800 birr/ha. Zemen and Gudane had equal price during plantation and selling price. Total variable cost (cost of tuber seed, fertilizer, land preparation, sowing, weeding and harvesting) for each variety was 42316 birr/ha while 7000 birr/ha was the fixed cost of potato production at the study areas. Gudane returned 117083 birr/ha and 87416 birr/ha was obtained from Zemen variety. The result of net benefit showed that higher profit was obtained by Gudane variety production than Zemen variety production (Table 4). The result of this

demonstration showed that production of Gudane and Zemen was profitable for farmers at midland districts of Guji zone.

Table 4. Analysis of Profitability of Demonstrated Potato Varieties

Parameters	N	Minimum	Maximum	Mean	Std. Dev
Yield of variety Zemen (qt/ha)	12	120	200	170.92	22.569
Yield of Gudane variety (qt/ha)	12	180	250	208.00	23.203
Farm gate price (birr/qt)	12	800	800	800.00	.000
Total revenue of Zemen (birr/ha)	12	96000	160000	136733.33	18055.134
Total revenue of Gudane (birr/ha)	12	144000	200000	166400.00	18562.132
Cost of tuber seed birr/ha	12	27000	27000	27000.00	.000
Fertilizer cost birr/ha	12	5400	6000	5800.00	295.420
Land preparation birr/ha	12	4000	6000	5300.00	738.549
Sowing cost birr/ha	12	1000	1300	1045.83	98.761
Weeding cost birr/ha	12	1000	1200	1150.00	90.453
Harvesting cost birr/ha	12	1800	2200	2020.83	103.261
Total variable cost of Zemen (birr/ha)	12	40400	43500	42316.67	1078.369
Total variable cost of Gudane (birr/ha)	12	40400	43500	42316.67	1078.369
Fixed cost of land (birr/ha)	12	5000	8000	7000.00	1477.098
Net benefit of Zemen (birr/ha)	12	50600	108800	87416.67	16837.220
Net benefit of Gudane (birr/ha)	12	92800	148800	117083.33	19543.731

Farmers' Preference on Demonstrated Potato Varieties

Farmers' feedback during the demonstration stage is crucial before large-scale manufacture of crops mainly to empower farmers in improvement of the variety and minimize the drawbacks associated with variety. During this demonstration farmers gave more attention to yield. As a result Gudane variety was more preferred than Zemen variety. There was the incidence of wilt bacteria during the demonstration. Gudane variety was moderate tolerant in wilt incidence than Zemen variety. This was similar to the study of Tilahun (2018) as Gudane variety was lowest disease incidence compared to other varieties. In addition, Zemen variety tubers were easily perishable under the ground and affected by wilt bacteria during demonstration. Moreover, Gudane variety produced more tubers per plant than Zemen variety. Based on different traits Gudane variety was ranked first by experimental farmers at the study areas (Table 5). However, maturity and seed size was similar for both varieties.

Table 5. Rank of Demonstrated Potato Varieties

Variety	Rank	Reason for trait selection
Gudane	1st	Higher yield, moderately tolerate disease, normal tubers under the ground, more sweetness and more number of tubers per plant
Zemen	2nd	Less yield, susceptible to disease, not normal seed under the ground, less number of tubers

Pair wise ranking was used to identify farmers' preference on potato traits. Thus, sweetness, disease tolerance and yield were the top three trait rank given by experimental farmers (Table 6). This study was similar to the results of Korji and Kebede (2017) who found disease and sweetness traits were the most traits preferred at highland areas of Guji zone.

Table 6. Pair Wise Ranking of Potato Traits by Farmers

Potato traits	Yield	Disease tolerance	Sweetness	tubers /plant	Frequency	Rank
Yield					1	3
Disease tolerance	Disease tolerance				2	2
Sweetness	Sweetness	Sweetness			3	1
tubers/plant	Yield	Disease tolerance	Sweetness		0	4

Over the last 60 years, research improvements have resulted in a huge rise in potato yield while simultaneously combating severe illnesses. Maintaining potato yield stability has remained a global concern due to slow genetic erosion, loss of genetic purity, and seed degeneration caused by pathogen buildup in seed. (Devaux *et al* 2020; Thomas *et al*., 2017). Therefore, developing and releasing disease tolerant potato variety for farmers is expected from agricultural research center.

CONCLUSIONS AND RECOMMENDATIONS

Gudane and Zemen varieties were demonstrated before large extension production at Guji zone's middle districts. The demonstration demonstrated that the Gudane variety produced a larger yield (20.8 t/ha) than the Zemen variety (17.92 t/ha). Production of Gudane variety generated a net profit of 117083.33 birr/ha compared to Zemen variety (87416.67 birr/ha). In the study areas, farmers preferred potato variety for traits of higher yield, tolerant to disease and more sweetness. Therefore, agricultural research should focus on disease tolerance trait in releasing potato varieties for target areas. Based on farmers' preference Gudane variety was ranked first for production. Production of Gudane variety for large extension was verified by the demonstration on experimental farmers' land. Therefore, large- scale production The Gudane cultivar was suggested for potato production in midland districts of Guji zone.

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