

Participatory Variety Selection of Improved Potato (*Solanum tuberosum* L) Varieties in Harari People Regional State and Eastern Hararghe Zone

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Abstract: Participatory varietal selection involves both scientific measurements and farmers evaluations; hence it has emerged as the best method to identify farmers' preferred crop varieties and their popularization. The experiment was conducted during 2019 cropping season at Dire Xayara and Gurawa districts of Harari People Regional State and Eastern Hararghe zone of Oromia Regional State, respectively. The objective of the study was to identify adaptable, high yielding and diseases and pest tolerant potato varieties based on farmer's management, and to evaluate and select potato varieties based on farmer's preference. The treatments arranged in randomized complete block design with three replications. Treatments were consisted of eight potato varieties including standard check. Both agronomic data and farmers preferences toward the varieties were collected and analyzed using Genstat software and matrix ranking respectively. The analysis result showed that there were significant ($p < 0.05$) difference among the varieties in all agronomic parameters except flowering date. Belete Variety gave the highest yield (39.6t/ha) followed by Bubu (29.91t/ha) and Gudanie (28.63t/ha). Matrix ranking of farmers' preference also showed that Belete and Bubu varieties ranked first and second in both districts. Dagim and Horro varieties were not only the low yielding, but also the least preferred varieties by farmers in the study districts. Farmers also liked Marachere for earliness and Gudanie for marketable yield and vegetative performance. However, they indicated that tuber size of Marachere is very small and Gudanie is susceptible to late blight. Therefore based on the findings, Belete and Bubu varieties could be recommended to potato growers in study area and similar agro ecology for further promotion and the two varieties (Marachere and Gudanie) could be used by potato breeders in their breeding program to exploit their merits.

Keywords: Farmers' Preferences, Participatory Variety Selection, Potato, Variety

1. Introduction

Potato (*Solanum tuberosum* L.) is one of the important food crops in the world. It is popularly known as 'The king of vegetables', the fourth most important food crop in the world after rice, wheat and maize in terms of human consumption [14]. In Ethiopia, potato has promising prospecting improving the quality of the basic diet in both rural and urban areas [1]. It holds great promise for improving the livelihoods of millions of smallholder farmers in the highlands of Ethiopia. The potential for high yield, early maturity, and excellent food value give the potato great potential for improving food

security, increasing household income, and reducing poverty [7] It is a short duration crop that can mature within short period of time. It contains practically all essential dietary constituents like carbohydrates, essential nutrients, protein, vitamins, and minerals [25]. Potato production has been considered as the first priority compared to other food crops because of its contribution to food security, income generation and double cropping and its utilization in different forms [16, 20].

In Ethiopia the variety development study was began in 1975 with the objective of developing varieties that are high yielder, widely adaptable and resistant to late blight, which is

most devastating disease [9] and about 36 varieties were formally released for production for wider adaptation [19]. Wider adaptation and researchers' criteria may not fit to all agro ecologies and fulfill farmer's preferences. Agro-ecologies varied with respect to soil type, moisture and temperature regimes, fertility condition and the onset, intensity and duration of rain as well as irrigation facilities, where farmers thrive to grow potato [9]. Heterogeneous environment, large diversity of farmer's needs, lack of adapted varieties to those diverse agro ecologies facing the formal breeding methods and often fails to meet the needs of farmers and to develop cultivars or varieties showing specific or local adaptation [6]. That is why most technologies developed without farmers' participation have failed to address the issues of rural poverty appropriately [23]. Farmers have their own indicators of performance and quality not well anticipated by researchers' criteria [13]. They are relatively consistent in their selection and their selections correspond with their stated criteria [17]. Hence, there is a disproportional development between the large number of technologies generated by the agricultural scientists and the relatively small number of them actually adopted and used by the farmers [3].

Many varieties are officially released, but few are adopted by farmers. In contrast, farmers often grow varieties that have not been officially released, a phenomenon known to be associated not only with an inefficient and biased testing system prior to variety release, but also with breeders using different selection criteria from the farmers and particularly G×E interactions in the case of farmers in marginal environments [3]. That is why in many part of Ethiopia farmers grow their own local varieties [8]. Many potato varieties were released at national, but few of potato varieties were tested in eastern Ethiopia by Haramaya University and ISSD project while the left released potato varieties not tested until today in Harari region and Eastern Hararghe zone. In study area that root and tuber crop especially potato took great account in their production and food system but still many farmers' used local varieties. However, Still, Farmers as well as Seed Producer Cooperatives (SPCs) are highly demanding better yielding varieties. Participatory Variety Selection (PVS) can effectively be used to identify farmer-acceptable varieties and thereby overcome the constraints that cause farmers to grow old or obsolete varieties [26]. Therefore, this study was conducted with the objectives to identify adaptable, high yielding and diseases and pest tolerant/resistant potato varieties based on farmer's management, and to evaluate and select potato varieties based on farmer's preference

2. Materials and Methods

2.1. Description of the Study Area

The Experiment was conducted in two locations Harari People Regional State, Dire Xayara district on farmers' land

and Oromia Regional State, Eastern Hararghe zone, Gurawa district in Birbirs village on farmers training center. Dire Xayara district of Harari People Regional State is located at 16km north of Harar town. The altitude of the district ranges from 1,600 to 1,900 meters above sea level. The mean annual rainfall of the district was 880mm. Like some part of Ethiopia, Dire Xayara district was characterized by the bimodal rainfall pattern. The first season was characterized by the short rainy season (Belg), which extends from March to May, while the second season which is the most important main rainy season (Meher) extends from July to October. The dry-spell period was extends from June to July and based on its duration, it may affect crop growth. The minimum and maximum temperature of the area was 13°C and 25°C respectively with the annual average of 19°C [27].

Gurawa district is found in Eastern Hararghe zone of Oromia Regional State. It is located at 76km far away from Harar town. The altitude of district ranges from 500 to 3230 meters above sea level [18, 21, 22]. The mean annual rainfall is 931 mm and has a bimodal distribution. The short rainy season starts in February/March and extends to May, while the long/main rainy season begins in June and stretches to September. The rainfall peaks in the months of July and August. The average annual temperature ranges from 9.40C to 24°C.

2.2. Experimental Materials

Table 1. Eight improved varieties of potato selected for the trial.

No	Varieties	Released year	Breeders/Releasing center
1	Jalenie	2002	Holeta Agricultural Research Center
2	Marachere	2005	Awassa Agricultural Research center
3	Gudanie	2006	Haramaya University
4	Gorobela	2009	Sheno Agricultural Research Center
5	Belete	2011	Holeta Agricultural Research Center
6	Bubu	2011	Haramaya University
7	Dagim	2013	Adet Agricultural Research center
8	Horro	2015	Bako Agricultural Research center

2.3. Treatments and Experimental Design

The experiment was conducted in Dire Xayara district of Harari Regional State and Gurawa district of Eastern Hararghe Zone of Oromia Regional State during 2019 cropping season. The experimental treatments consisted of eight improved potato varieties including standard check (Variety Bubu) were used in the study (Table 1). The experiment was laid out in randomized complete block design with three replications. The area of each plot was 9m² consisting of four rows, which accommodated 10 plants per row and totally 40 plants per plot. The spacing between plots and adjacent replication was 1m and 1.5m, respectively. All treatments were assigned randomly to the experimental plots. The experimental field was prepared following the conventional tillage practice using oxen plow. The medium sized potato tubers (35-45) mm in diameter and well sprouted tubers were planted at the spacing of 75 cm between ridges and 30cm between tubers. Urea fertilizer was applied in split that is 50% during time of planting and the rest 50% was applied near to tie of flowering while all NPS was applied at time of planting.

2.4. Data Collected

2.4.1. Agronomic Data Collected

Data collected were days to 50% flowering, plant height (cm), days to maturity, number of stems per plant, tuber number per plant, tuber diameter (mm), average tuber weight (g), total tuber yield (t/ha), marketable, unmarketable yield (t/ha) and diseases.

2.4.2. Farmers' Varieties Evaluation and Selection Criteria

Potato varieties were evaluated before harvest and at harvest by 14 farmers (8 males and 6 females) at each site. All the farmers were divided into two groups of eight farmers at both sites. Before the evaluation of varieties was carried out, selected farmers at both sites were familiarized with the selection procedure and criteria. At both sites, the first evaluation of varieties was carried out at time of flowering and physiological maturity. The second varieties evaluation cycle of farmers was during harvesting (tuber yield and tuber size uniformity). The selection criteria set by farmers were vegetative performance, earliness to maturity, tuber yield; tuber uniformity, marketable tuber yields, and diseases reaction.. The ranking procedure was explained for farmer participants and then each selection criterion was ranked from 1 to 5 (5=very good, 4=good, 3=average, 2=poor and 1=very poor) for each variety. Ranking was done consensus where differences are resolved through discussion [5].

2.4.3. Data Analysis

Farmers' selection data were analyzed using simple ranking method with given value. Agronomic data were subjected to ANOVA by using Genstat statistical software Version 15th. Means that differed significantly were separated using the LSD (Least Significant Difference) test at 5% level of significance.

3. Results and Discussion

The results of combined analysis of variance (ANOVA) showed that there were significant ($p < 0.05$) differences among the tested varieties for all traits except days to flowering (Table 2). The presence of significant differences among varieties indicates the presence of genetic variability for each of the characters among the tested varieties. Similarly, [2] reported that significant difference among potato varieties for all traits.

3.1. Days to Maturity and Plant Height

Days to Maturity and plant height were significant ($P < 0.05$) differences among varieties, the early maturing was obtained from Horro (88days) while the late maturing was obtained from Gudanie (97.33days) followed by Bubu (94.33days) and Belete (93.33days). The highest plant height (76.92cm) was recorded from Bubu followed by Gudanie (73.67cm) and Belete (63.58cm) while the lowest plant height (44.87cm) was recorded from Dagim. The difference in plant height among the varieties might be associated to genetic differences, which may lead to the variable performances in growth and development. This

study was in agreement with the findings of [10] who indicated that plant height lay between 54.1cm and 77.4cm. The result of current study was contradict with study by [2] who reported that the highest plant height was recorded from Belete and Gudanie which accounts 98cm and 83cm, respectively. This might be variation between the two environments.

3.2. Number of Stems and Tubers per Plant

Analysis of variance revealed that there were significant ($P < 0.05$) differences among varieties for number of stems and tuber numbers per plant (Table 2). The highest number of stems per plant was recorded from Bubu (6.77) while the lowest (2.8) was from Horro variety. On the other hand the highest tuber number per plant was recorded from Marachere (9.8) while the lowest from Horro variety (75.17). This finding was in agreement with the findings of [2] who reported that the number of stems per plant lay between 6 and 10. The difference in number of main stem among the varieties might be due to the inherent genotypic variation in the number of buds per tuber which is in turn influenced by the size of the tubers, physiological age of the seed, storage condition, and number of viable sprouts at planting, sprout damage at the time of planting and growing conditions [4].

3.3. Tuber Diameters and Average Tuber Weight

Based on the analysis of variance, there were significant ($P < 0.05$) differences among the varieties for tuber diameters and average tuber weight (Table 2). Significantly the highest tuber diameter and average tuber weight were recorded from Belete (49.31mm) followed by Bubu (45.49mm) while the lowest tuber diameter (40.6mm) for Gorobela. The highest average tuber weight also recorded for Belete (148.g) followed by Bubu (134.9g) while the lowest were recorded for Dagim (83.3g) and Gorobela (96.1g). This result is in the same range with report of [11] that the highest average tuber weight recorded from Belete (105.24g) followed by Bubu (70.21g) as compared to sixteen improved potato varieties at eastern Ethiopia. According to the study of [15] the highest tuber diameter was recorded from Belete among the tasted varieties at western Ethiopia.

3.4. Marketable, Unmarketable and Total Tuber Yield

Analysis of variance revealed that there were significant differences ($P < 0.05$) among varieties for marketable, unmarketable, and total tuber yield (Table 2). The maximum marketable yield was recorded from Belete (39.32t/ha) followed by Bubu (28.88t/ha) and Gudanie (28.03t/ha) while the lowest was recorded from Dagim (9.36t/ha). The lowest yield in Dagim could be due to its susceptibility to late blight diseases. The highest unmarketable was recorded from Horro (1.33 t/ha) followed by Dagim (1.27 t/ha) while the lowest (0.28t/ha) and (0.78t/ha) from Belete and Marachere respectively. However, this result was in contrast with the study conducted by [12] who reported that the highest loss was recorded from Belete (5.5t/ha) and Marachere (0.52t/ha). This might be the variation between the two environments.

The maximum total yield was recorded from Belete (39.6t/ha) followed by Bubu (29.9t/ha) and Gudanie (28.63t/ha) while the lowest recorded from Dagim (10.63t/ha). In line with this study, [24] also reported that the

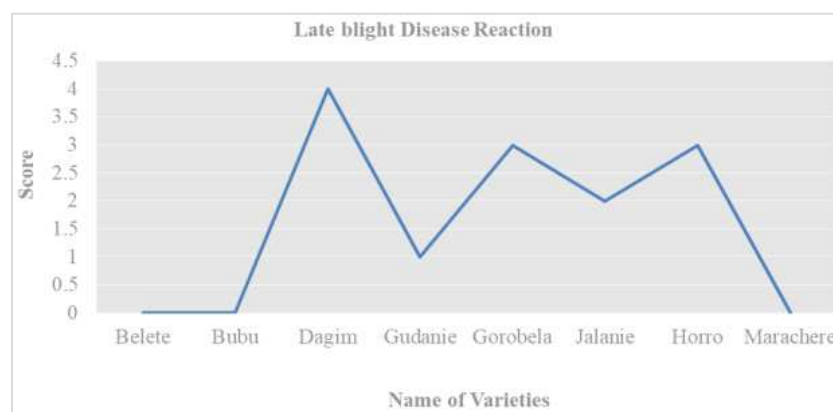
highest outstanding marketable and total yield was recorded from Belete (43.99t/ha) followed by Bubu (35.31t/ha) as compared to six potato varieties in northern Ethiopia.

Table 2. Combined mean performance of parameters for Potato PVS at Dire Dawa and Gurawa districts in 2019 cropping season.

Varieties	DF	DM	PH(cm)	NSP	TNP	TD(mm)	ATW(g)	UMY(t/ ha)	MY(t /ha)	Y(t /ha)
Belete	48.8	93.33 ^{abc}	63.58 ^{ab}	4.367 ^b	8.33 ^a	49.31 ^a	148.6 ^a	0.28 ^c	39.32 ^a	39.6 ^a
Bubu	46.3	94.33 ^{ab}	76.92 ^a	6.767 ^a	8.33 ^a	45.49 ^{ab}	134.9 ^{ab}	1.01 ^{ab}	28.88 ^b	29.91 ^b
Gudanie	46.2	97.33 ^a	73.67 ^a	6.267 ^a	8.17 ^a	43.97 ^{ab}	116.1 ^{abc}	1.03 ^{ab}	28.03 ^b	28.63 ^b
Marachere	45.3	92.67 ^{abc}	43.13 ^c	4.53 ^b	9.8 ^a	42.12 ^{ab}	119.1 ^{abc}	0.78 ^b	24.9 ^{bc}	25.51 ^{bc}
Jalenie	48.8	94.17 ^{ab}	56.85 ^{bc}	3.6 ^{bc}	8 ^a	44.75 ^{ab}	110.3 ^{abc}	1.16 ^{ab}	20.61 ^c	21.63 ^c
Gorobela	47.3	89.83 ^{bc}	55.47 ^{bc}	3.4 ^{bc}	5 ^b	41.51 ^{ab}	96.1 ^{bc}	1.14 ^{ab}	12.53 ^d	13.67 ^d
Dagim	46.8	89 ^{bc}	44.87 ^c	3.8 ^{bc}	3.83 ^b	43.77 ^{ab}	83.3 ^c	1.27 ^a	9.36 ^d	10.63 ^d
Horro	46.8	88 ^{bc}	56.23 ^{bc}	2.8 ^{5c}	5.17 ^b	40.60 ^b	111 ^{bc}	1.33 ^a	10.17 ^d	11.44 ^d
LSD (5%)	12.5	5.34	7.69	1.275	2.2	1.17	32.8	0.99	5.06	5.03
CV	22.9	5	22.6	24.5	26.8	14	24.4	34.5	19.9	19

Keys: DF =Days to flowering, DM= Days to maturity, PH=plant height (cm), NSP=Number of stems per plant, TNP=Tubers number per plant, TD(mm) =Tuber diameters, ATW(g)= Average tuber weight, UMY(T/ha) =Unmarketable yield, MY(t/ha)=Marketable yield and TY(t/ha)= Total yield. Means followed by different letters within columns are significantly different by Duncan's new multiple range test (P = 0.05).

3.5. Disease Reaction Score



0=highly disease resistant, 1=disease resistant, 2=moderate disease resistant, 3=susceptible, 4=highly susceptible, 5=Very susceptible.

Figure 1. Mean of disease score per varieties.

From this graph the varieties Dagim, Gorobela and Horro were highly susceptible to late blight disease whereas Belete, Bubu and Marachere varieties have resistant reaction against the disease (Figure 1).

3.6. Farmers' Preference

Table 3. Matrix ranking of potato varieties based on criteria selected by farmers (n=28).

Evaluation criteria	Gurawa							
	Belete	Bubu	Marachere	Gudanie	Jalenie	Gorobela	Horro	Dagim
Vegetative performance	5	5	5	5	4	4	4	4
Maturity	3	3	4	4	4	4	4	4
Tuber Uniformity	5	4	4	4	3	3	3	2
Marketable yield	5	5	4	4	3	3	2	2
Unmarketable yield	5	4	3	3	3	2	2	2
Total yield	5	4	3	3	3	2	2	1
Disease resistance	5	5	5	3	1	1	1	2
Over all mean	4.7	4.3	4	3.7	3	2.7	2.5	2.4
Over all rank	1	2	3	4	5	6	7	8

Table 3. Continued.

Evaluation criteria	Dire Xayara							
	Belete	Bubu	Marachere	Gudanie	Jalenie	Gorobela	Horro	Dagim
Vegetative performance	5	5	5	5	4	4	4	4
Maturity	3	3	4	4	4	4	4	4
Tuber Uniformity	5	5	4	4	3	3	3	3
Marketable yield	4	4	3	3	2	1	1	1
Unmarketable yield	4	4	3	2	2	1	1	1
Total yield	5	4	4	4	3	2	1	1
Disease resistance	5	5	5	3	1	2	2	2
Over all mean	4.4	4.3	4	3.5	2.7	2.3	2.2	2.2
Over all rank	1	2	3	4	5	6	7	7

Rank: Degree of satisfaction 5=very good, 4=good, 3=average, 2=poor and 1=very poor

Farmers' perception on the performance of potato varieties were tested at study area and analyzed using matrix ranking. As a result the majority of participant farmers in the districts have good interest to grow potato. From eight potato varieties evaluated only variety Belete performed well over the standard check (Bubu). The tested varieties showed similar performance in the two districts. Through evaluation and discussion, farmers ranked the varieties based on their preferences and degree of satisfaction by giving the values 1-5. Generally, matrix ranking result showed that overall mean of the ranks for all performance indicators at Gurawa district were higher for Belete (4.7), Bubu (4.2) and Marachere (4). On the other hand, the overall mean of the ranks for all performance indicators at Dire Xayara district were higher for Belete (4.4), Bubu (4.3) and Marachere (4) Table 3. Participatory evaluation of potato varieties conducted before harvest and at harvest stage of crop by 14 farmers (8 males and 6 females) at each site. The farmers agreed that vegetative performance, earliness to maturity, tuber uniformity, marketable tuber yields, unmarketable tuber yields, total yield and diseases reaction are important parameters. Among these traits, tuber yield, disease reaction, tuber uniformity and early maturity were selected as the top three important selection criteria. Accordingly, Belete and Bubu were selected as the best two preferred potato varieties by the farmers due to their higher yield and tolerance to diseases and tuber uniformity. Farmers also liked Marachere for its early maturing and moderate disease resistance and Gudanie for marketable yield and vegetative performance.

4. Conclusion and Recommendation

PVS helps farmers to get familiar with adoption of new varieties and helps researchers in decision making. The result of this study indicated that Belete and Bubu were higher yielding and the most preferred potato varieties by farmers at both district. Dagim and Horro were not only the low yielding varieties but also the least preferred varieties by farmers in the study districts. Therefore, based on these findings, Belete and Bubu could be recommended to potato growers in Dire Xayara and Gurawa Districts for further promotion. Though, Farmers also liked Marachere for its earliness and Gudanie for marketable yield and vegetative

performance. Therefore, we recommend these two varieties should be improved by breeders so that farmers can utilize in the future.

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