

Evaluation of Newly Released Rice Varieties (*Oryza Sativa L.*) Under Smallholder Farmers' Condition Through On-Farm Demonstration in Western Ethiopia

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Abstract: Rice is one of the main important food crops in the world. It is the promising and strategic commodity set under Ethiopian food security strategy program. Although consumers' preference of rice is increasing rapidly, the current production status is unable to meet the existing consumption needs. The evaluation was conducted at Jawe and Pawe districts of Western Ethiopia focusing on the newly released rice varieties under smallholder farmers' condition. A total of 31 hosted farmers were selected purposively based on their experience and willingness to implement the on-farm demonstration under five rice potential kebeles. Four improved varieties of rice (Pawe-1, Nerica-3, Hidasie and Nerica-12) were the materials used for the demonstration under farmers' management practices. The evaluation was done on farmers' field with plot size of 25*25m (625 m²) for each variety. Both qualitative and quantitative data were collected from 51 farmers (20 control group). The collected data were analysed through descriptive and inferential statistics. Farmers' preference ranking also done to choose the best performed variety based on their own selection criteria. The results of the evaluation revealed that all the demonstrated varieties have a significant yield advantage over the control variety and higher than the national average productivity. The highest mean grain yield (3763.08 kg ha⁻¹) was recorded from Pawe-1 variety with yield advantage of 1027.38 kg and the lowest yield (2735.70 kg ha⁻¹) recorded from the local control variety. Marketability, grain yield, seed color, seed size, tillering capacity and maturity date were the major preference traits for farmers. Pawe-1 was the best preferred and promising variety based on farmers' preference criteria followed by Nerica-12 variety. The highest technology gap (1136.85 kg) observed from Nerica-3 variety. Results of the overall evaluation indicated that all the evaluated improved rice varieties performed very well in all testing sites. Therefore, the newly released rice varieties with full recommended packages have to be promoted accordingly for large-scale production to enhance its contribution in the national food security strategy program.

Keywords: Demonstration, Ethiopia, Farmers' Preference, Rice Varieties

1. Introduction

Rice (*Oryza sativa L.*) is a staple food for more than half of 7.7 billion people in the world. World rice production volume reached 745 million tons in paddy by cultivating about 163 million ha lands. Rice is an important economic, political, social and cultural commodity for Asian countries. Asia continent accounts 90% of world's rice production. Asia also has 84% share for world rice consumption followed by

Africa (7%) [1]. The demands of the commodity rapidly increasing and more than 750 million people in Sub-Saharan Africa consume it. The changes in consumers' preference, rapid urbanization and population growth are drivers of rice production [2]. The average productivity of rice for Sub-Saharan Africa (2.22 t ha⁻¹) is lower by half as compared to the global average grain yield of 4.51 t ha⁻¹ [3]. This finding indicates that rice production and consumption increased by 55% and 81% respectively. This implies that rice

consumption and production cannot compatible and needs great effort to boost the production level. More than 200 improved rice varieties released in Africa by considering the productivity performance and disease reaction. Africa Rice significantly contributed to boost rice production in Sub-Saharan Africa. Significant achievements recorded by Africa Rice regarding policy advice, technical information and knowledge and capacity development [4]. This finding suggests that rice value chain also improved due to Africa Rice and this attracts many producers to engage in rice production. Rice cultivation was started in the early 1970s at Fogera and Gambela plains. Although the crop is a recent introduction to Ethiopia, it is put as a strategic commodity to ensure food security and export marketing [5]. It is an emerging crop of Ethiopia and the most important economical crop in Amhara region particularly Fogera district [6]. The crop has become one of the most essential agricultural commodities in Ethiopia like all other African countries [7]. Rice is considered as a millennium crop to ensure the national food security of Ethiopia. An estimated land of 30 million hectare land is suitable for rice production in Ethiopia off which 5.6 million ha is highly suitable and 25 million ha suitable for rice production [8]. Findings of this study suggest that 3.7 million ha land is suitable for irrigated rice.

Although the crop becomes a strategic commodity to improve the national food security, producers are facing several challenges regarding rice production. Socio-economic factors, biological, physical, technological and institutional

instruments are the major constraints which limit rice production. Availability of household labor, education level, land size, distance to the nearest market, access to agricultural extension service and seeds were the determinant factors affecting farmers to use improved rice varieties [9]. A clear understanding of farmers' preference traits plays an indispensable role for successful adoption of improved varieties [10].

Metekel and Awe zones are the potential areas of western Ethiopia for rice production. The evaluation was conducted at Pawe and Jawe districts due to their rice potential since these areas can reflect the potentials of Western Ethiopia. The people of the area become familiar with rice foods like injera, bread and kinchie as well as malt preparation for tela besides income source. Use of the newly released improved rice varieties with full recommended packages can take the lion share to improve productivity and production of producers further to meet the national food security objectives. National rice research program with collaborative centers released different improved rice varieties which are promising under up land and low land ecosystems. However, before recommended to apply the released varieties for large-scale production, the performance of the released varieties was evaluated under smallholder farmers' condition. Farmers preferred their own varieties based on their own preference criteria after evaluation. The main objective of this study was to evaluate the yield potentials of the newly released rice varieties through on-farm demonstration and to recommend the preferred variety for large-scale production.

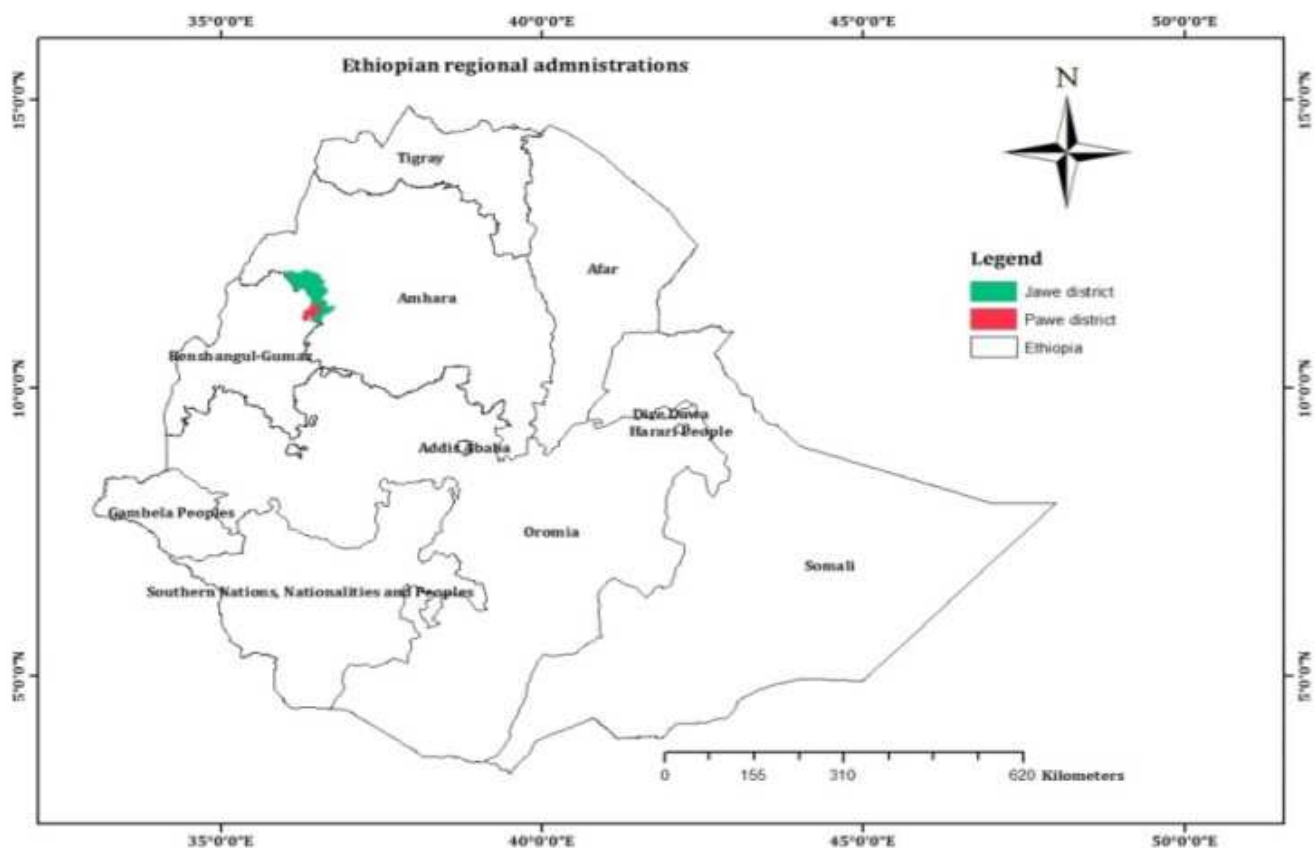


Figure 1. Map of the study area (Pawe & Jawe).

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted under Pawe and Jawe districts of Metekel and Awi zones respectively. Pawe and Jawe districts are the most potential areas of western Ethiopia in rice production. Pawe and Jawe districts are located 567 and 602 km away from Addis Ababa respectively. Pawe is geographically located at 36°27'21.88''- 36°28'22.95'' longitude and 11°20'04.93''- 11°17'50.43'' latitude. Similarly, Jawe is located at 36°29'17.58'' longitude and 11°33'22.68'' latitude. Pawe and Jawe have the respective total population of 64,431 (51.68% male) and 122,259 (53.08% male) as the data obtained from their district agriculture offices. Both districts experience mixed farming system both crop production and livestock rearing. The total area of Pawe and Jawe districts is 64,300 and 515,400 hectares respectively. Cereals (maize, rice, finger millet & sorghum) and pulses (soybean & ground nut) are the dominant crops in Western Ethiopia. The areas have suitable agro ecologies with great potentials for rice production. Pawe district receives an average annual rainfall and temperature of 1582 mm/year and 32.7°C respectively over the last thirty years with altitude of 1120 m.a.s.l. On the other hand, Jawe has an average annual rainfall of 1250 mm/year and its altitude ranges from 700 to 1500 m.a.s.l. The study areas have a long rainy season starting from May to end of October.

2.2. Farmer Selection and Field Establishment

The on-farm demonstration was conducted under Pawe and Jawe districts of western Ethiopia due to their potentials of rice production. Similarly, the five kebeles under the two districts were selected purposively based on their rice potential and performance. Three kebeles namely village 14, village 17 and village 24 were selected purposively from Pawe. Simida and Jaimela kebeles were selected and used in Jawe district. A total 31 hosted farmers were selected purposively by considering their willingness and performance to implement the demonstration with close guidance of development agents and experts.

Additionally, 20 farmers who were producing rice by using locally available seeds were used as a control in the same kebeles. The fields of each participant farmer were considered as a replication. Full technology packages of rice were provided to farmers. Both theoretical and practical trainings organized accordingly before the activities get started. Each hosted farmer prepared 25m*25m (625m²) plot of land for each variety and planted accordingly. All the demonstrated four varieties were planted side by side and evaluated properly. The varieties planted in a 25cm row spacing with recommended seed rate of 80 kg ha⁻¹. Based on agronomic recommendations, 100 kg ha⁻¹ NPS fertilizer and 150 kg ha⁻¹ UREA was applied. Weeding, insect and pest control and other farming operations were implemented. Researchers and experts were monitored and evaluated each

activity accordingly as the schedule with development agents and hosted farmers at different stages of the crop. Feedbacks were collected directly in the field and homestead of the hosted farmers.

2.3. Planting Materials

The evaluation was done by using the four improved rice varieties (Pawe-1, Nerica-3, Nerica-12 and Hidasie) in the overall processes of this on-farm experimentation. NPS and UREA fertilizers also used to implement the demonstration.

2.4. Data Collection and Analysis

Both qualitative and quantitative data were collected by the researchers from the field and in the homestead of each hosted farmer. Similarly, data were collected from the control group in the same locations for comparison. Data of yield and yield components of each crop variety recorded carefully to compare the yield to the control group. Farmer's perception and preference on the demonstrated varieties were recorded during the evaluation process and directly on the spot. Finally, the collected data were analyzed through descriptive and inferential statistics by using SPSS (version 26) software package. Farmers' preference ranking also conducted based on their selection criteria.

3. Results and Discussion

3.1. Capacity Building Training

Trainings were provided to hosted farmers and development agents regarding rice production and management techniques to increase their skill of practical application. The training included both the theoretical and practical sessions. Thirty one hosted farmers 12 development agents were took the training accordingly before the activities get started and during implementation directly in the field.

3.2. Varieties Yield Performance

The grain yield data were collected both from 31 hosted farmers and other 20 farmers who produced rice by using locally available variety seeds as a control. As the results depicted in Table 1, the maximum mean grain yield was recorded from Pawe-1 variety (3849.96 kg ha⁻¹) at Pawe district followed by Nerica-12 (3424.00 kg ha⁻¹). Mean grain yield of 3410.09 and 3250.29 kg ha⁻¹ was recorded from Hidasie and Nerica-3 varieties respectively. The least mean grain yield of rice observed (2768.25 kg ha⁻¹) from the local check variety with high degree of farmers' variability at SD of 211.24. The finding of the on farm experimentation indicates that all the improved demonstrated varieties dominated the locally available control variety regarding grain yield.

Table 1. Mean grain yield of the demonstration at Pawe district.

Variety	Minimum	Maximum	Mean	Std. Deviation
Pawe-1	3631.00	4212.30	3849.96	150.45
Nerica-3	2956.20	3589.54	3250.29	211.35
Nerica-12	3245.50	3645.00	3424.00	121.24
Hidasie	3245.50	3566.89	3410.09	104.76
Local seed	2465.00	3021.00	2768.25	211.24

Source: Own computation from data, 2020.

The results of the demonstration showed that the maximum grain yield recorded from Nerica-3 (3755.00 kg ha⁻¹) variety followed by Pawe-1 (3688.00 kg ha⁻¹) in Jawe district. The study results depicted in Table 2 showed that all the demonstrated improved varieties had significant yield increment over the control local variety. The maximum mean grain yield observed from Nerica-3 variety (3600.17 kg ha⁻¹) followed by Pawe-1 (3580.64 kg ha⁻¹) at Jawe unlike Pawe district. Mean grain yield of Nerica-12 and Hidasie varieties in the demonstration was 3368.08 and 3356.33 kg ha⁻¹ respectively. The least (2686.88 kg ha⁻¹) mean grain yield observed from the local check variety.

Table 2. Mean grain yield of rice demonstration at Jawe district.

Variety	Minimum	Maximum	Mean	Std. Deviation
Pawe-1	3451.26	3688.00	3580.64	80.59
Nerica-3	3366.66	3755.00	3600.17	131.46
Nerica-12	3000.00	3589.54	3368.08	174.94
Hidasie	3214.00	3521.02	3356.33	82.63
Local seed	2400.00	2987.00	2686.88	225.87

Source: Own computation from data, 2020.

The combined data of the experiments over the two locations showed that all the demonstrated improved rice varieties well performed and dominated the local varieties. The combined results depicted in Table 3 indicates that the maximum mean grain yield observed from Pawe-1 variety (3763.08 kg ha⁻¹) implies that the variety is the best preferred by the farmers due to its high grain yield as compared to others. Nerica-12 variety was the 2nd high yielder next to Pawe-1. Hidasie and Nerica-3 varieties brought the respective mean grain yield of 3392.75 and 3363.15 kg ha⁻¹. Producers received 2735.70 kg ha⁻¹ from the locally available

seeds which is the least as compared to the improved varieties used by hosted farmers. Overall findings of this evaluation revealed that significant mean difference observed between improved seed users and local seed users regarding grain yield.

Table 3. Combined mean grain yield of the demonstration.

Variety	Minimum	Maximum	Mean	Std. Deviation
Pawe-1	3451.26	4212.30	3763.08	182.80
Nerica-3	2956.20	3755.00	3363.15	250.21
Nerica-12	3000.00	3645.00	3405.96	140.31
Hidasie	3214.00	3566.89	3392.75	100.08
Local seed	2400.00	3021.00	2735.70	215.18

Source: Own computation from data, 2020.

The results indicated in Table 4, showed that 31 hosted farmers were improved variety seed users and 20 farmers were local seed users who considered as a control group. The combined analysis showed that the mean grain yield of 3481.24 kg ha⁻¹ was recorded from hosted farmers' farm plots. On the other hand, 2735.70 kg ha⁻¹ mean grain yield obtained from the local seed users. Grain yield variability was high among local seed users as compared to their counter parts. The result of t-test ($t = -15.97$, $p < 0.01$) implies that significant mean difference observed between improved variety seed users and non-users regarding grain yield at ($p < 0.01$). The negative sign of t-value (-15.97) implies that farmers who use local variety seeds produce less output than improved seed users. The findings of Sime, G. and J. B. Aune also confirmed that agricultural technologies including improved varieties significantly increased agricultural productivity [11]. The result is similar to Anang, B. T. who found that the productivity of improved rice variety adopters significantly higher than non-adopters [12]. This finding suggests that significant yield increment observed for farmers who produce rice through application of improved varieties. The finding by Bello, L. O. et al. also showed that adoption of improved rice variety significantly and positively affected the productivity [13]. The results of propensity score matching (PSM) revealed that 452 kg ha⁻¹ of additional rice grain yield obtained due to application of improved rice varieties.

Table 4. Statistical test of (t-test) improved and local seed users.

Variable	Grain yield in kg per ha		Mean	SD	t-value	Sig. value
	Category	Frequency				
Improved seed	Non-users	20	2735.70	215.18	-15.97	0.000
	Users	31	3481.24	118.06		

Source: Own computation from data, 2020.

3.3. Yield Advantage

The combined average yield of rice varieties across locations showed that Pawe-1 variety was the highest yielder among the demonstrated improved varieties. The results of the evaluation revealed that 3763.08 kg ha⁻¹ mean grain yield was recorded from Pawe-1 variety and 763.08 kg ha⁻¹ is more

as compared to its mean grain yield at research field (on-station). The mean grain yield at on-station of this variety was 3000 kg ha⁻¹ which is lower than the demonstrated yield through on-farm experimentation. This lower on-station yield of the variety might be due to fertility and termite problems of on-station farm plots due to over cultivation for more than 30 years. All the demonstrated improved varieties have

significant yield advantage over the control. Pawe-1 variety had 1027.38 kg yield advantage over the control variety. The results also showed that the respective yield advantage of 670.26, 657.05 and 627.45 kg was observed from Nerica-12, Hidasie and Nerica-3 varieties. The lowest mean grain yield (3363.15 kg ha⁻¹) was recorded from Nerica-3 variety. The maximum technology gap (1136.85 kg ha⁻¹) was recorded from Nerica-3 variety and the lowest recorded from Nerica-12 variety which is 694.04 kg. This gap might be resulted due to low soil fertility, change in weather condition and informal rain fall distribution. The yield difference between the varieties is the potential of the variety itself not by other

external factors within that particular season and locations. The results of the overall evaluation revealed that the demonstrated improved rice varieties accepted by smallholder farmers in terms of their productivity since yield is the main parameter for farmers to select the varieties in the study area. The finding agrees with Nascente, A. S. and R. Kromocardi who found that use of improved rice varieties with appropriate recommended fertilizer rate significantly increased the mean grain yield of rice producers [14]. According to the findings of this study, farmers lost 1000 kg ha⁻¹ of rice yield due to application of local variety seeds.

Table 5. Yield increments over control in kg per hectare.

Variety	Demo yield	Yield on-station	Control yield	Yield increment over control	Technology gap
Pawe-1	3763.08	3000.00	2735.70	1027.38	-763.08
Nerica-3	3363.15	4500.00	2735.70	627.45	1136.85
Nerica-12	3405.96	4100.00	2735.70	670.26	694.04
Hidasie	3392.75	4200.00	2735.70	657.05	807.25

Source: Own computation from data, 2020.

3.4. Farmers' Preference

Farmers were engaged in the evaluation of rice varieties during field day events and choose their own variety based on their own selection criteria. A total of 63 farmers were participated in the evaluation. Majority (36.51%) of farmers were selected Pawe-1 variety by considering different perspectives based on their own selection criteria. Off the total participants, 30.16% and 17.46% of farmers selected Nerica-12 and Nerica-3 varieties respectively and requested seed for large-scale production. Only 15.87% of farmers preferred Hidasie variety by their own observation. Although yield is the main selection trait of the variety for most of the farmers, they gave their own variety score for each trait and finally the varieties selected based on the cumulative score points. The result is consistent with Burman, et al. who found that grain yield was an important trait for farmers to select their own variety including other preference traits [15]. The finding by Singh, Y. et al. also indicates that high yielder and environmentally adaptive rice variety was the most preferred variety by farmers besides other traits [16].

The evaluated improved varieties were ranked by farmers accordingly based on their own preference criteria with close guides of researchers and experts. Farmers who were engaged in the evaluation have been selected by considering their experience and knowledge on rice farming and marketing in the study area. Marketability, grain yield, seed

color, seed size, maturity date and tillering capacity were the major important traits set by farmers to choose the demonstrated improved varieties. Accordingly, Pawe-1 was the best preferred variety by farmers based on its total score of 23 point followed by Nerica-12 variety. Nerica-3 was the 3rd preferred variety next to Pawe-1 and Nerica-12 varieties. Hidasie was the last choice of farmers as depicted in Table 6. According to farmers' evaluation, Pawe-1 variety highly scored in all preference traits and it can be considered as a promising variety to be widely produced by rice producer farmers in the study area. The finding agrees with Melesse, M. B. et al. who confirmed grain yield is the main preference trait for farmers besides disease and drought resistance [17]. The finding by Jin, S. et al. indicates that grain yield, maturity date, pest and disease resistance and seed longevity were the main preference traits for rice producers [18]. Maturity date, high yielding, longer and slender grains were the main preference traits for farmers [19]. The result is in line with Ishikawa, H. et al. who investigated and confirmed that maturity, seed color and seed size of cowpea were the most important farmers' preference traits including good and acceptable grain yield [20]. The findings by Atnaf, M. et al. suggest that good performance of rice in grain yield, biomass yield, good palatability, good disease reaction and phenotypic acceptability were the major farmers' preference traits including good physical qualities and uniform panicle length [21].

Table 6. Farmers' preference traits of improved varieties.

Variety (N = 63)	No. of farmers choose the variety	Farmers' preference traits					Tillering capacity	Total score	Rank
		Marketable	Grain yield	Seed color	Seed size	Maturity date			
Pawe-1	23 (36.51)	4	4	4	3	4	4	23	1 st
Nerica-3	11 (17.46)	3	2	3	3	2	3	16	3 rd
Nerica-12	19 (30.16)	4	3	4	3	2	1	17	2 nd
Hidasie	10 (15.87)	2	2	1	4	2	3	14	4 th

NB: 1 = Poor, 2 = Good, 3 = Very good, 4 = Excellent.

4. Conclusion and Recommendations

Overall evaluation of on-farm experimentation concluding that the newly released rice varieties performed very well in all testing locations although yield variability observed among the varieties. All the demonstrated newly released rice varieties have significant yield advantage over the control local variety and higher than the national average rice productivity in all hosted farmers' field plots. Marketability, grain yield, seed color, seed size, maturity date and tillering capacity are the major important traits for farmers to choose the variety in the study area. Overall combined evaluation of on-farm demonstration showed that Pawe-1 variety is the best preferred and promising variety followed by Nerica-12 based on farmers' preference traits. The results of on-farm demonstration revealed that production and productivity of rice producers can be enhanced and significantly contributed to meet the national food security objectives through application of improved rice varieties with other recommended agronomic practices and packages. Although Pawe-1 is the best preferred and promising variety for rice producers, all the demonstrated improved varieties have yield increment over the control. Therefore, the district and zone agricultural offices have to promote the newly released rice varieties accordingly for large-scale production to enhance the contribution of rice to the journey of the national food security strategy program. Most breeding programs in the past focused on grain yield increment and other traits have to be considered in future breeding programs besides grain yield since consumer preferences and market demand varies over time. Emphasis has been given by agricultural experts and other stake holders regarding agronomic practices and full recommended packages while promoting the proven rice technologies.

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