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On-Farm Demonstration of Improved Upland Rice Technology in Cluster Based Large Scale Approach at Melo-Koza District of Gofa Zone, Southern Ethiopia

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***Abstract* – Inspite of large area under cultivation, the mean yield of rice per hectare in Ethiopia is very low. Limited access to improved rice varieties and improper use of recommended agronomic practices were some of the contributing factors for low productivity. Therefore, this activity was carried out to increase the productivity of rice through demonstrating early maturing and high yielding upland rice technology in 2023 main cropping season at Melo-Koza district of Southern Ethiopia. 2 kebeles' namely Salayish-1 and Salayish-3 were selected purposively based on potential of rice. A total of 72 farmers were selected based on clustering approach for 40 ha. Awarness creation training and experience sharing field day was carried out and the events were promoted through face book, South Television and FM Radio's to those who couldn't take part with in the program directly. A total of 2,400 Kg of improved seed (NERICA-4) was provided to the farmers by the Arba Minch Agricultural Research Center. Planting was done by seed rate of 60 Kgha-1, spacing of 60 cm b/n rows, 100 Kgha-1 NPS and 100 Kgha-1 UREA fertilizers. Quadrant estimation using grand mean, Likert scale and rank based quotient were used to analyze grain yield, farmers perception and constraints respectively. The mean grain yield of NERICA-4 was 3,681 kg.ha-1, which is greater than the study area average productivity (2,500 kg.ha-1). The major constraing factors identified in rice production in the area include no access to improved seed, high fertilizer price, no access to pesticides and no access to mechanization. Therefore, further expansion and seed supply with its full packages including agronomic practices by the district and Zone office of Agriculture is recommended to enhance rice productivity.**

***Keywords* – Constraints, Cluster, Fogera-1, Gofa, NERICA 4, Rank Based Quotient, Suparica, Upland Rice.**

I. Introduction

Rice ecosystems are classified into rain-fed upland, rain-fed lowland, irrigated lowland ecosystems. Upland rice (*Oryza sativa*) could be a type of rice that performs best in non-flooded and rain-fed situations. Unlike lowland rice, which grows in paddies with standing water, upland rice performs best on inclines slopes, hillsides, and elevated territories. It also grown on naturally depleted soils where the water table continuously stays underneath the rice roots. The rice production under rain fed condition is produced in two agro-ecologies namely *Kolla* and *Woyina Dega* regions, which have particular agronomic and variety requirements. It is cultivated on about 20 million ha-1 around the worldwide at least 3.5 billion people are consuming rice (S. Hegde and V. Hegde, 2013). It accounts for approximately 60% of rice-growing regions in 30% in Latin America, and 10% in Africa. In the world, the biggest volume of upland rice production is concentrated in countries like China, India, Indonesia, Vietnam, Thailand, Bangladesh, Burma, Philippines, Brazil and Japan. The percentage rate of share in percentage of the above top 9 rice producing countries accounts for around 32.9, 24.4, 11.0, 7.0, 6.0, 5.4, 5.3, 2.9 and 1.8 % of the world production, respectively (FAO, 2013).

The major upland rice producing nations in Africa are China, India, Indonesia, Pakistan, Sri Lanka, Thailand

and the United Arab Emirates, Cote d'Ivoire, Guinea, Madagascar, Mali, Nigeria and Tanzania (Africa Rice, 2018a). In Africa, rice too continually expanding as staple food and there has been increasing demand in the past 3 decades from 1999-2022; however, these demands have not been adjusted with the total production. In spite of the huge potential for rice production in Africa, productivity is very low mainly because of inadequate investment in improved technologies and irrigation schemes. The region consumes 30% of the world's production of rice while representing only 10% of its total population (Seck et al. 2013).

In Ethiopia, rice is a recently introduced crop and it was introduced to Ethiopia in the 1970s and has been developed with in small areas of the nation (Zenna *et al*, 2008). Rice potential areas in Ethiopia include Gambella, Fogera, and Benshangul Gumuz Regional State (MoA, 2020). The potential upland rain-fed rice production area in Ethiopia is estimated to be about 30 million ha-1 of which a total 5.6 million ha-1 exceedingly reasonable and 25 suitable and 3.7 irrigated (Dawit Alemu, 2015, Tamirat and Jember, 2017). It has been increasing at a quick rate in both area coverage and farmers' involvement, reaching 121,000 tons in 2013 and 171,854 tons in 2019 (MoA, 2020). Ethiopia's rice utilization is quickly growing, mainly through imported rice (Bekele, 2017). This indicates that domestic supply is not fulfilling consumer demand. Imports are increasing at an alarming rate, adding to the pressure on the country's insufficient foreign currency reserves (Merkine, 2022). Imports extended from 22,500 tons to 533,620 tones with foreign currency payments of $12.07 million to $186.2 million between 2008 and 2019 (Assaye and Alemu, 2020). Currently 35 improved rice varieties had been released for the 3 rice ecosystems (15 for rainfed upland, 11 for rainfed lowland and 9 for irrigated). In spite of the fact that, a number of varieties have been released, only a few are adopted by farmers because of lack of extension service, lack of mechanization, lack of grain quality and lack of rice utilization.

Southern Ethiopia is one of the potential regions for rice production, primarily in rain fed upland environments. Currently, the crop is mainly grown in Yeki, Boreda, Guraferda, Ginbo, Shashago, Misha, Debub Ari and the Melo-Koza areas. It plays basic part for smallholder farmers, source of income, as food for domestic utilization (*injera, bread, asambussa, kinche,* and *shorba* (soup) and local drinks (like "*tela*" and "*areke*"). The different by-products of rice (straw, bran and husk) have additional financial benefits and are used in animal feed and house construction material. But the productivity of rice in the area is low as compared to its yield levels under farmers' conditions in other parts of the world. In reaction to this, Arba Minch Agricultural Research Center has been conducted adaptation trails on various rice varieties by giving major emphasis on selection of adaptive varieties in the area. Consequently, several released varieties were evaluated and the best 3 varieties (NERICA-4, Suparica and Fogora-1) were identified and recommended to be demonstrated for better production. Therefore, this activity was designed to popularize improved upland rice technology as well as identifying exploring production constraints.

II. Objectives

1. To increase awareness of farmers on improved upland rice production technology for further popularization.
2. To increase productivity of upland rice in the study area.
3. To investigate farmers perception toward improved upland rice technology.
4. To identify the major constraininng factors for rice production in the study area.

III. Materials and Methods

3.1. *Descriptions of the Large Scale Demonstration Area*

The activity was implemented at Melo-Koza district, among potential rice producing areas of Gofa Zone, Southern Ethiopia in 2023 main cropping season. Geographically, Melo-Koza district located in latitude of 6°30′00″N and longitude 36°40′00″E. The district has 3 agro ecologies, Dega (21.73%), Woyna Dega (52.43%) and Kola (25.84%). The soil of the district is clay-loam (50%), sand-loam (35%) and clay vertisols (15%). The district has 2 rain-seasons, 'Meher' season (July to Oct) and 'Belg' season (Jan to April). The mean annual rainfall of the district is 500 mm. The average annual temperature is 21.3 °C. The major crops grown were Maize, Sorghum, Wheat, Common bean, Teff and Rice.

3.2. *Description of the Variety Demonstrated*

The abbreviation 'NERICA' refers to the ''New Rice for Africa''. This rice variety is the first wide-scale success of crossing of the 2 cultivated species: *Oryza sativa*, known as 'Asian rice', and *O. glaberrima*, often called 'African rice' and found only in Africa. The African rice varieties show strong adaptability to harsh environments, strong ability to compete with weeds, resist local diseases and pests and withstand drought, flood, infertile soils, and iron toxicity. 'NERICA' varieties have on average 25% higher protein than Asian varieties. There are 2 types of the 'NERICA' varieties: upland NERICA's and lowland NERICA's performed best for either rain fed and irrigated ecosystems. In total, there are now 82 NERICA varieties: 18 upland, 60 rainfed lowland and 4 irrigated varieties. Currently, there are 18 NERICA varieties (NERICA-1 to NERICA-18) suited for upland cultivation. NERICA-4, which is tolerant to drought and phosphorus deficiency, is the most widely adopted upland variety, grown in more than 10 Sub Saharan African countries. The short description of NERICA-4 variety indicated hereunder (Table: 1).

Table 1. Descriptions of the NERICA-4 variety.

Name of the Variety	Year of Release	Growing Ecosystem	Days to Maturity	Grain Yield (Kgha-1)		Released Research Center
				Farmers Field	Research Center	
NERICA-4(49WAB-450-IB-P-9/1)	2006	upland	110	3,000	4,800	Pawe /EIAR

Source: SW, 2009.

3.3. *Site and Farmers Selection*

Melo-Koza district from Gofa was purposively selected based on area coverage of rice. 2 representative Keeble's (Salayish-1 and Salayish-3) were selected purposively based on the area coverage of rice. A total of 72 farmers (34 from Salayish-1 and 38 from alayish-3) were selected based on clustering approach and farmers were clustered based on their adjacent lands (Table: 2).

Table 2. No of farmers participated for large scale demonstration of upland rice at Melo-Koza district, 2023.

Zone	District	Kebele	No of Farmers			No of Clusters	Area (ha)
			Male	Female	Total		
Gofa	Melo-Koza	Salayish-1	31	3	34	2	15

Zone	District	Kebele	No of Farmers			No of Clusters	Area (ha)
			Male	Female	Total		
		Salayish-3	36	2	38	3	25
Total		2	67	5	72	5	40

3.4. *Implementation Procedure for the Demonstration*

3.3.1. *Farmer's Research and Extension Groups Establishment*

The selection of Farmers Research Extension Group (FREG) members was based on the farmers' commitment to be members, adjacent farm lands and openness in sharing good experiences with other farmers. FREG's were organized to capacitate farmers through different trainings and experience sharing. As a result, both Kebeles', FREG organized consisting of 10-15 members based on recommendations of Chimdo (2008). For the demonstration, 72 farmers were grouped in to 5 clusters with total area of 40 ha of land. Researchers, extension personel from the district and Kebele Development Agents from office of Agriculture were appointed and developed local bylaws for the demonstration (Table: 2).

3.3.2. *Capacity Building Training*

The training was focused on rice production practices such as land preparation, planting methods, harvesting, type, rate and application of fertilizers for rice crop. Besides this, rice management practices such as weeds, diseases, insect pests; agrochemicals spray (manually) and safety precautions and improved storage were some of the points in the training. A total of 103 farmers (72 participant and 31 copy farmers), 6 Development Agents and 14 other stakeholders attended the awareness creation training (Table: 3).

Table 3. Training on upland rice agronomic practices and concept of cluster approach.

Kebele	Farmers			Development Agents			Others		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Salayish-1	40	9	49	2	1	3	6	-	6
Salayish -3	42	12	54	3	-	3	8	-	8
Total	82	21	103	5	1	6	14	-	14

3.3.3. *Stakeholders Responsibility in the Demonstration*

The stake holders involved and their responsibility in the demonstration was shown here under (Fig. 1).

3.3.4. *Agronomic Recommendations and Inputs Used*

Proper agronomic and improved management practices were the very important to improve the productivity of any crop (Tanaka *et al*, 2013). The total area of the demonstration was 40 ha and a total of 2,400 Kg of improved NERICA-4 seed was supplied by Arba Minch Agricultural Research Center for 72 farmers in 2 Kebele's (Table: 4).

3.5. *Method of Data Collection*

The grain yield data was taken from an area of 2mx2m in the form of quadrat estimation method (from the hi-

-ghest, medium and lowest performed fields per 20 randomly selected farmers) from the 2 kebeles. The grain yield was adjusted to 10% moisture content. Sample field harvests were weighed in Kg and summed to obtain mean production and grain weight was determined after threshing and converted into grain yield on hectare basis. Farmers' perception on the demonstrated technology (agrees and disagrees) data toward the technology was collected from Focus Group Discussion participants using Likert scale question check lists. The constraining factors by farmers in rice production were also collected by checklists.

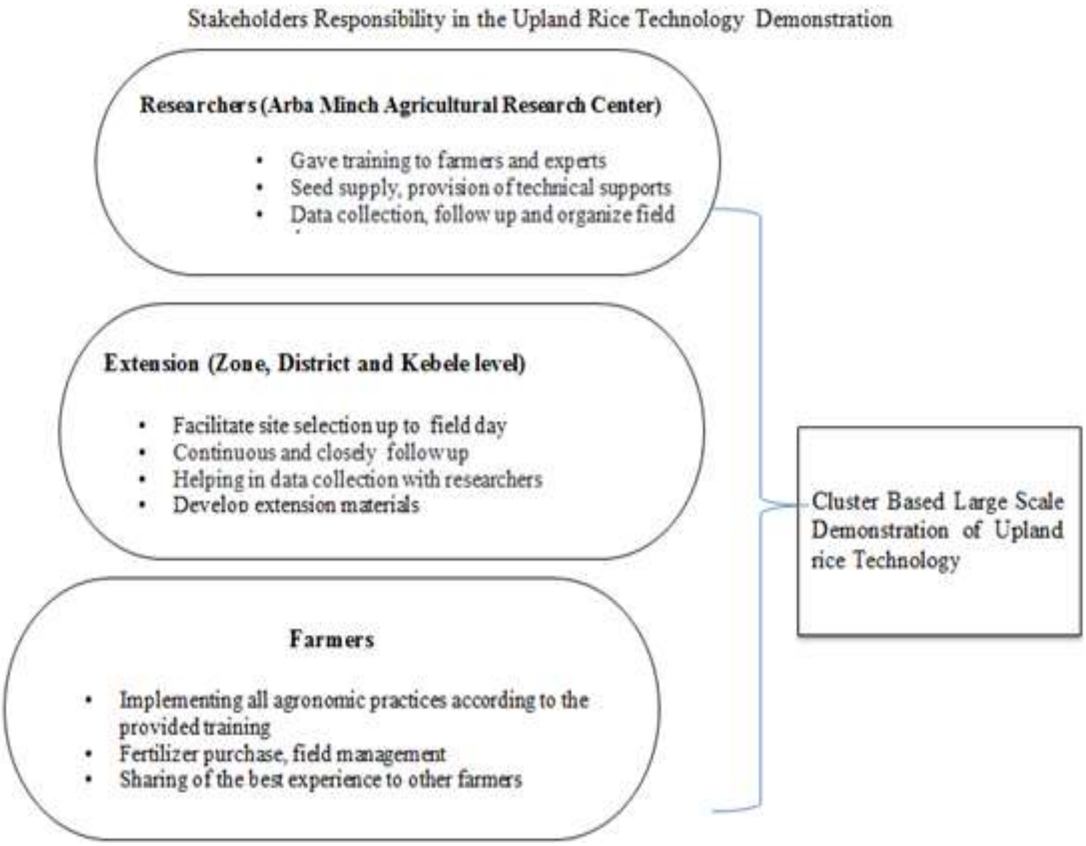

Fig. 1. List of stake holders' responsibility shared during the demonstration.

Table 4. Agronomic recommendations used for rice production at Melo-Koza, 2023.

No	Items / Practices	Recommendations used
1	Crop type	Upland rice
2	Variety Demonstrated	NERICA-4
3	Number of farmers participated	72 by considering farmers as a replication
4	Total Land size covered (ha)	40
5	Seed rate (Kgha-1)	60 as per the recommendation
6	Spacing (cm)	25cm b/n rows by drilling the seeds in the rows
7	Fertilizer rate (Kgha-1)	NPS : 100(during planting) and UREA : 100 (1/3 at planting and 2/3 at panicle initiation stage)
8	Weeding frequency	2-3 times(3rd and 6th weeks after germination uniformly to all fields)
9	Harvesting	Done manually using hand sickle

3.6. *Method of Data Analysis*

Statistical Package for Social Science Version-27 data processing and analysis tool was used for quantitative data analysis. The data was reported using mean, minimum, maximum, percentage, standard deviation and presented using tables and graphs. Farmers perception was analyzed by Likert scales using mean score. Preference ranking was used to identify the major upland rice production constraints in the study area. Major constraints in rice production was identified and calculated by Rank Based Quotient (RBQ) based on the ranking done by 20 sample respondents. Formula suggested by Sabarathnman and S, Vennila (1996) was used for quantifying and ranking of major constraints faced farmers in the study area.

$$\text{Rank Based Qoutient (RBQ)} = \sum \text{fi}\,\frac{n+1-ith}{N*n)} \quad (1)$$

Where: 'i' is the ith rank.

'fi' is the number of respondents giving particular point at ith rank.

N': is the total number of respondents from the target population.

'n' the number of ranked items (constraints).

The qualitative data's collected from the demonstration was analyzed qualitatively.

3.7. *Ethical Issues*

Before the work, a support letter from Arba Minch Agricultural Research Center was given to the Gofa Zone office of Agriculture for their permission and support. After getting permission, the study design was explained to the administrative bodies of the office of the Agriculture of the Melo-Koza district. Furthermore, the study kebele's selection was purposively undertaken. Then, a supporting letter from the district office of Agriculture head was also presented to the sample kebele administrators and Development Agents by informing the purpose of the research for being there. All the respondents have been informed of the objective of the study in general and the purpose of the demonstration in particular. Respondents were also informed about the data obtained from them will be kept confidential and all respondents who participated in the demonstration were fully acknowledged, trained and participated in the demonstration.

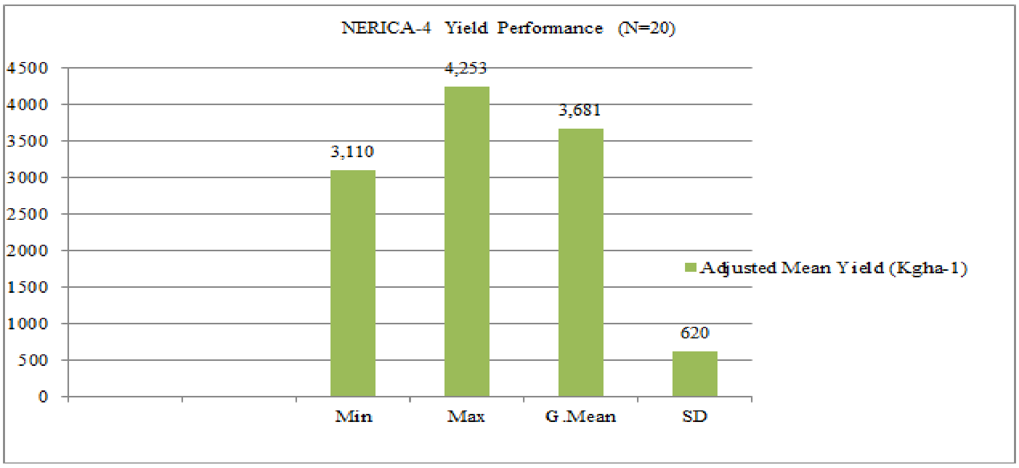

Fig. 2. Adjusted mean yield of NERICA-4variety at Melo-Koza district in 2023.

Note: G.mean refers to grand mean.

IV. Results and Discussion

4.1. *Adjusted Grain Yield Performance of NERICA-4 at Farmers Field*

Based on the results of the demonstration, mean grain yield of NERICA-4 upland rice variety in Melo-Koza district was 3,681Kgha-1. The variety gave better yield as compared to Ethiopia National mean productivity of rice (2,800Kgha-1) and is quite low compared to the Global average productivity of 4,400 to Kgha-1(CSA, 2022) and 6,000 Kgha-1 on research centers (Dessie *etal*, 2018). Similar yield performance was obtained by Hailegebriel et al., (2017) which was conducted in Tselemt district of Tigray regional state. This is a sign that realized yields at farmers' field still have huge potential for improvement in the study area.

4.2. *Farmers Perception Toward Upland Rice Technology in Cluster Approach*

For farmer's perception analysis, 12 positive and 3 negative questions with Likert scale values was prepared. Farmers were asked to give a score. Based on data collected from 20 Focus Group Discussants, on average, all farmers agree that the variety has good germination performance, high grain yield, large seed size, takes short time to maturity, highest number of panicle per spike, good for injera making, a good ability to resist disease (Blast) (Table: 5). The results suggest that farmers give weight to the qualitative attributes on top of considering yield is very important issue in technology transfer.

Note: * For +ve perception values were agree = 1, disagree = -1, do not know = 0

**For -ve perception values were agree = -1, disagree = 1 do not know = 0

Table 5. Farmers perception on NERICA-4 upland rice technology at Melo-Koza district (N = 20).

		NERICA-4 Rice Variety at Melo-Koza		
		Farmers Level of Perception		
No.	**Perceptions**	**Agree**	**Disagree**	**Do not know**
	Positive perception*			
1	Good germination performance	1		
2	With stand variable rainfall	1		
3	Takes short time to mature	1		
4	High tillering capacity		-1	
5	Highest number of panicle per spike	1		
6	Large seed size	1		
7	High grain yielding potential	1		
8	High biomass			0
9	Good grain color	1		
10	Good injera making quality	1		
11	Premium price in the market	1		
12	Good ability to resist disease (Blast)	1		

	Negative perception**			
1	Sensetive to water loadging		-1	
2	High shattering during harvesting	1		
3	Easily attacked by pests	1		

4.3. *Feedback of Rice Production Constraint in the study area*

Based on the ranks given, rank based quotient was calculated to identify major production constraints. The analysis of the data collected from 20 Focus Group Discussants reveled that, little access to improved rice varieties followed by high fertilizer price, no access and use of pesticides, poor access and use of mechanization equipments like weeder, harvestor and thresher for rice producers, poor market channel and shortage of land were the major constraints to upland rice production in the study area (Table 6). The current demonstration employed traditional method that there is reportedly considerable post-harvest loses in addition to the other constraints mentioned in the current production area. Understanding and addressing limitation to production in the region could have positive impact on upland rice production and productivity improvement.

Table 6. Rank based upland rice production constraints (N = 20).

No	Major Constraints	Ranks						RBQ	Ranks
		1	2	3	4	5	6		
1	High fertilizer price	8	7	3	2	0	0	74.82	2
2	No access and use of pesticides	5	8	4	3	0	0	72.96	3
3	Little access to improved rice varieties	14	3	2	1	0	0	78.02	1
4	Shortage of land	8	10	1	1		0	56.67	6
5	Poor access and use of mechanization equipments like weeders, harvestor and threshers for rice producers	6	7	2	2	1	0	71.11	4
6	Poor market channel	3	7	6	2	2	0	67.78	5

4.4. *Field Day*

Experiences were shared among participant farmers, researchers, Development Agents, and other stakeholders through group discussion on the specific improved practices during the farmers' days. A total of 86 and 154 participants from Salayish-1 and Salayish-3 respectively attended the field day events and the technology was promoted through face book, South Television and local F.M Radio's to those who couldn't participated in the program directly (Table: 7 and Fig. 3).

Table 7. Number of participants for the field day events.

S No	Participants	Salayish -1			Salayish-3		
		Male	Female	Total	Male	Female	Total
1	Farmer	63	5	68	83	22	105
2	Development agents	6	-	6	11	3	15

3	Subject Mater specialists	4	-	4	5	-	5
4	Other invited gusts	8	-	8	20	-	20
Total		81	5	86	129	25	154

Fig. 3. Sample field day photo at Melo-Koza district.

4.5. *Awareness Created*

After the demonstration, all participant farmers were informed of the recommended seeding and fertilizer rates. Surprisingly 90%, 100%, 48%, 100%, and 87% of participant farmers were aware of the spacing, seed rate, fertilizer rate, fertilizer application and agro-chemical application use respectively after the implementation demonstration in the study area (Table 8).

Table: 8. Farmers aware of the recommended practices of improved upland rice (N = 72).

No	Recommended Technology	Number of Farmers Aware			
		Male	Female	Total	Percent
1	Spacing	60	5	65	90
2	Seed rate	67	5	72	100
3	Fertilizer rate	31	4	35	48
4	Fertilizer application	67	5	72	100
5	Agro-Chemical application	60	3	63	87

V. Conclusion and Recommendations

Cluster Based Large Scale Demonstration of improved upland rice technology (Nerika-4) with its full packages was demonstrated at Melo-Koza District at 2 kebeles on40 ha-1. Training was provided to farmers, development agents and other experts on agronomic practices of the commodity. When the crop reaches to its maturity stage, field day was also organized and farmers, Development Agents, District and Zone office of

Agriculture heads and researchers were attended the event in order to facilitate the diffusion of technologies. The crop performed well in almost all farmers field. Mean yield of 3,681Kgha-1 was recorded in the area which is relatively good compared to national upland rice productivity. This is a sign that realized yields at farmers' field still have huge potential for improvement in the study area. Farmers also positively perceive on early maturity, escape from moisture stress and high yielding. Little access to improved rice varieties followed by high fertilizer price, no access and use of pesticides, poor access and use of mechanization equipments like weeders, harvestor and threshers for rice producers, poor market channel and shortage of land were the major constraints to upland rice production in the study area. Farmers have decided to continuously grow the variety and decided to share the available seed to other follower farmers who eagerly follow the demonstration activities. Therefore, it is recommended that the office of Agriculture of the district needs to focus on focus on improvement of production constraints address the technology to wider areas of the community to benefit quite a significant number of farmers.

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Authors Contribution

L.L Design, formulation and supervision of experiment, and writing of manuscript ME and A.B: Performing the field level data collection and analysis of data.

Importance of the Study

This study contributes by filling the knowledge gap on issues of rice production packages, specific factors contributing to it and the farmer's perception related to the current rice production practices of the study area. The information generated from this study may help in designing more rice production and management interventions in the study area and in other similar agro-ecologies of the country. Besides this, the study might serve as a reference source for researchers who are interested to further investigate the issue of rice.

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