International Journal of Applied Agricultural Sciences
2022; 8(6): 218-224
http://www.sciencepublishinggroup.com/j/ijaas
doi: 10.11648/j.ijaas.20220806.14
ISSN: 2469-7877 (Print); ISSN: 2469-7885 (Online)

Pre-extension Demonstration and Evaluation of Improved Teff Technology in Selected Districts of West Shewa, East and Horro Guduru Wollega Zones of Western Oromia, Ethiopia

Effa Wolteji*, Berhanu Soboqa, Bayisa Gedafa, Dubiso Gachano

Oromia Agricultural Research Institute, Bako Agricultural Research Center, Bako, Ethiopia

Email address:

effaw03@gmail.com (Effa Wolteji)

*Correspondingauthor

To cite this article:

Effa Wolteji, Berhanu Soboqa, Bayisa Gedafa, Dubiso Gachano. Pre-extension Demonstration and Evaluation of Improved Teff Technology in Selected Districts of West Shewa, East and Horro Guduru Wollega Zonesof Western Oromia. *International Journal of Applied Agricultural Sciences*. Vol. 8, No. 6, 2022, pp. 218-224. doi: 10.11648/j.ijaas.20220806.14

Received: January 17, 2022; **Accepted**: October 12, 2022; **Published**: November 23, 2022

Abstract: This activity was conducted in Dano, Jimma Arjo and Horro districts of Western Oromia with the objective of demonstrating the newly released teff variety Dursi against Kena and Guduru to the farming community in these districts. These districts were purposively selected based on accessibility and potentiality for teff production; and one potential PA from each district were selected based on the aforementioned criteria. After selecting and establishing the FRGs training was provided across the districts. Then after, one variety; Dursi (as newly released variety) as well as Kena and Guduru (as standard checks) were planted on 10 m*10 m adjacent plots on 12 farmers' field. All recommended agronomic practices were equally applied to all the plots and the fields were closely supervised and were managed well. At maturity, the varieties were jointly evaluated with a team composed of researchers, Farmers and DAs. Despite the slight variability in criteria set by farmers at the respective locations yield, disease tolerance, seed color, plant height, pest resistance, tillering capacity, seed size, lodging resistant, early maturity, spike length, were the common selection criteria across all locations. In almost the entire criterion Dursi excel/beat the standard checks and has met the criteria of the farmers. With regard to yield, 18 qt/ha, 15 qt/ha and 13 qt/ha were obtained from Dursi, Guduru and Kena; respectively putting Dursi on the first rank. Besides; Dursi had yield advantage 14.51% and 19.10% than Guduru and Kena; respectively. Furthermore; statistically ANOVA table and mean yield comparison (t-test) results of on farm yield performances showed that as there is highly significant difference at ($p<0.05$) among the varieties demonstrated. In terms of profitability, financial analysis result of the study also showed that using Dursi variety can make farmers' more profitable than Guduru and Kena. As the variety has met the intended criteria of the farmers, the pre-scaling up activity should follow the next season.

Keywords: Teff, FRG Unit, Participatory Evaluation and Selection, Yield Advantage, *Dursi*, *Kena, Guduru*

1. Introduction

Among cereals, teff accounts for the largest share of the cultivated area (28.5% in 2011), followed by maize (20.3%). Teff is second (to maize) in terms of quantity of production. However, because its market price is often two or three times higher than maize, Teff accounts for the largest share of the total value of cereal production. Teff is grown by a total of 6.2 million farmers. Since Teff farm operations such as land preparation, weeding and harvesting are highly labor intensive, with limited availability of suitable mechanical technology, there are no large scale teff farmers in the country. Many farmers grow Teff as cash crop because of its higher and more stable market price [4].

According to the data of the Central Statistical Agency [2] [3] teff production expanded by 72 percent between 2004/05 and 2010/11. This growth was achieved mainly due to 29 percent expansion in area under cultivation and 33 percent

increase in yield levels. The share of Teff in total cultivated areas increased by 2 percent, compared to the decline in barely (25 percent) and wheat (12percent), and rapid expansion in coarse grains (maize, 11 percent, and sorghum, 19 percent). With only 1.3 tons per hectare, teff yield is the lowest among cereal crops. This is mainly due to limited use of improved seeds, inefficient agronomic practices and fragmented farm plots [4].

Teff is likely to remain a favorite crop of the Ethiopian population and the crop is also gaining popularity as a health food in the western world. Studies show that teff is a gluten free crop, which makes it is suitable for patients with celiac disease [5]. CSA data over the past few years show that teff ranked first in terms of area coverage (accounting for 28% of the area) and is second to maize in terms of volume of production among cereals, accounting for about 20% of the total produce in the category [1].

However, productivity has remained stagnant or has even declined in some cases until recent years due to several technical and socio-economic constraints. Weed competition, low or declining soil fertility, diseases, inappropriate use of agronomic practices such as seeding rate, sub-optimal fertilizer application and herbicide use are some of the major technical constraints. Limited supply of seeds of improved varieties, high price and unavailability of augmenting technologies like fertilizer and herbicides in required quantity and at required time, and inadequate cash or credit for purchase of inputs are the major socio-economic constraints [8]. With only1.3 tons per hectare, teff yield is the lowest among cereal crops. This is mainly due to limited use of improved seeds, in efficient agronomic practices and fragmented farm plots [4].

In order to increase productivity of this crop, National Agricultural Research System (NARS) has been making great efforts over last ten years to develop and release large number of teff crop varieties and associated production technologies for diversified agro-ecology of Ethiopia. In spite of the availability of several improved teff technologies generated by the research system in Ethiopia over the last four decades, most of the farmers in the Oromia region depend on the local varieties and traditional management practices.

In line with this, even though, most agro-ecologies of West Shewa, East and Horro Guduru Wollega Zones are the potential areas for teff production, the yield obtained by farming community was below the potential. This is due to lack of improved teff varieties, diseases, insect problems and low use of recommended full packages. To this end, actually BARC has recently released new variety; Dursi with potential yield of 22.85 qt/ha on farmers' field and 26% yield advantage than recently released varieties, to reverse the scenario and alleviate the problem of low productivity as well as co-related challenges sustainably [8]. Consequently; this calls for demonstrating, validating and disseminating of the released high yielding, disease tolerant and quality teff varieties that can make producers competitive in the today's competing markets. Therefore, this project is initiated with objectives of demonstrating improved teff technologies so as to familiarize the farming communities with the new teff varieties which in turn will facilitate the adoption process and bridge the productivity gap.

Objectives

1) To demonstrate and evaluate improved teff technologies;
2) To evaluate the productivity and profitability of the technology under farmers' condition;
3) To create awareness on the importance of the improved teff technologies;
4) To collect feedback from the participants for further research design and the way forward.

2. Methodology

2.1. Site and Farmers' Selection

This activity was conducted in selected districts of West Shewa and East Wollega zones of Western Oromia. Selection of the districts was based on potentiality for teff production and accessibility for supervision. Accordingly, Dano, Jimma Arjo and Horro districts were selected based on the aforementioned criteria. One potential PA from each district was selected and in each PA 1FRG unit comprising of 15 farmers was established. Totally 4 hosting farmers from each district were selected and participated on the activity in collaboration with experts and DAs of the respective district office of agriculture and Natural Resource.

2.2. Provision of Training

After sites and farmers were selected both theoretical and practical training was given to farmers, development agents and district experts. Training was provided on the following areas; such as, teff production management, breeding aspect, post harvesting (seed quality). The aim of training was to create awareness of farmers', development agents and district experts on teff technology.

2.3. Input Distribution and Planting

After the plots were properly ploughed and made ready for planting ahead of the planting date, all necessary inputs (seed, fertilizers) were delivered to the farmers. Planting was made on the farmers' field by BARC researchers, TAs as well as FRG farmers.

2.4. Design of the Activity

Three teff varieties released from Bako Agricultural Research Center; one newly released variety namely, Dursi and Guduru and Kena as a standard checks were planted on adjacent plots of 10 m*10 m each. All the necessary recommended agronomic practices; viz 15 kg/h of seed, 100 kg/ha NPS and 100 kg/ha UREA were equally applied for all of the plots. Every field were supervised to check the status and to identify gaps. At

maturity stage, participatory variety evaluation plat form were arranged to be attended by the experimenting farmers, neighboring farmers, researchers from BARC and other stakeholders.

2.5. Data Collected

For this activity all the necessary qualitative and quantitative data were collected; the collected data includes yield data, total number of farmers participated on training, total number of farmers', DAs, experts participated on field visits, farmers' perception on the attribute of the technology, costs and income gained was collected.

2.6. Data Analysis

The data were analyzed using descriptive statistics such as mean, frequency distribution, tables and percentages. Also quantitative data collected were subjected to SPSS software to analyse mean, standard deviation, t- test and ANOVA table. Besides; score ranking techniques was used to evaluate and select best bet variety/ies and/or technology/gies and to rank their criteria and parameters according to real situation of the area. Further, gross margin analysis is very useful in a situation where fixed capital forms a negligible portion of production. Thus; it is the difference between gross income and the total variable cost [10]. Furthermore; according to [11] technology gap and technology index were also calculated using the following formula.

$$\text{Technology gap} = \text{Potential yield qt/ha} - \text{Demonstration yield qt/ha}$$

$$\text{Technology index} = \frac{\text{Potential yield} - \text{Demonstration yield}}{\text{Potential yield}} \times 100$$

3. Result and Discussion

3.1. Participatory Variety Evaluation and Selection

At maturity, the varieties were evaluated based on the farmers' selection criteria. At this juncture, the farmers were assisted to jot their own evaluation criteria, which then be ordered using pair-wise ranking technique. Each variety was then be evaluated against the criteria ordered based on the weight attached to each parameter. At the end of the evaluation process, result of the evaluation was displayed to the evaluators, and discussion was made on the way ahead. The variety/ie selected, accordingly, will be proposed for further scaling up. To this end; FRG farmer sscored each variety for individual traits considered important by them and ranking of varieties were done on a scale of 1-5, *1 being very poor and 5 being the highest score representing superiority.*

Teff yield, disease tolerance, lodging tolerance, seed size, seed color, number of spikes per head and spike length were considered as the most selection criteria for each teff varieties. Based on over all mean score the best preferred variety/ies was/were evaluated and ranked. Accordingly; in all the districts, based on over all mean score and rank, Dursi variety was selected firstly in all of its traits then followed by Guduru and Kena lastly. This underlines the importance of testing of improved varieties in farmer's fields across districts. Scoring of farmers selection criteria was based on a ranking scale from 1- 5, with1as the most important to 5 as the least important.

Table 1. *Total and mean score and ranks given to the varieties in the study areas.*

Variety	Dano			JimmaArjo			Horro			OverallRank
	Totalscore	Meanscore	Rank	Totalscore	Meanscore	Rank	Totalscore	Meanscore	Rank	
Dursi	49	4.45	1st	48	4.36	1st	48	4.36	1st	1st
Kena	37	3.36	3rd	42	3.82	3rd	43	3.91	3rd	3rd
Guduru	46	4.18	2nd	43	3.91	2nd	44	4.00	2nd	2nd

NB: 1-11farmers' selection criteria set;1=Lodging tolerant, 2=early maturity, 3=Disease tolerant, 4= Insect-pest 5=seed color, 6=seed size, 7=Thillering capacity, 8=spike length, 9=Marketability, 10=Yield and11=Number of spike per head.

3.1.1. Varietal Total and Mean Score Ranking

According to (table1) above ranking and scoring of teff varieties across the districts was done; accordingly, the highest score was recorded for Dursi variety; 4.39, then by Guduru variety; 4.03, and the least score was recorded for Kena; 3.71. Consequently; Dursi variety was ranked as first followed by Guduru variety and finally the least ranked variety was Kena. Besides; except seed size and its late maturing nature of the variety farmers selected Dursi variety as a best because its ability to tolerate disease, seed color, number of spikes per head, number of thiller per plant and marketability. Furthermore, secondly selected Guduru variety share almost similar in the entire trait acquired with Dursi variety except seed color and seed size. The least ranked and selected variety Kena, was mainly selected as least against the parameters mentioned above. Generally; comparable yield could be obtained from the three varieties but their differences mainly from the others related traits discussed above for selection of the best variety that suits the need of the farmers and most preferred by the farmers' at large.

3.1.2. Varietal Traits Pair-Wise Ranking

At maturity farmers were invited toe valuate and rank the most important criteria/ traits that enable them to select best variety from all the demonstrated varieties. At out set they were helped to jot down their selection criteria at random. Then the farmers' evaluated the varieties traits against the ordered criteria. Pair-wise ranking technique was used to order the criteria on the basis of the weight attached. Accordingly; yield, disease tolerant, lodging tolerant, seed color, tillering capacity, early maturity, spike length, number

of spike per head, seed size and plant height were considered as most important traits for teff selection (table 2). Then after, farmers ranked these criteria in accordance with their importance, real situation existing and weight attached in their area by the community.

To this end; disease tolerant, high yielder, lodging tolerant, number of spike per head, seed color, spike length and seed size were the first five best selected and ranked criteria that researchers should seriously consider for future design and way forward to develop farmer preferred variety/ies. Apparently; from the listed criteria/trait early maturity (earliness) get less attention and not included as important trait for selection of variety/ies. This is mainly because in Western Oromia the intensity and distribution of rain fall may not be a problem. During the course what have been learnt was that the farmers' selection criteria are beyond yield and most of the farmers gave priority for qualitative traits such as tolerance to disease-pest, lodging tolerant and seed color (marketability) of the variety.

Table 2. *Pair-wise matrix ranking for teff varieties.*

SelectionParameters	1	2	3	4	5	6	7	8	9	10	Frequency	Rank
1		2	1	1	1	1	1	1	1	1	8	2nd
2			2	2	2	2	2	2	2	2	9	1st
3				3	3	3	3	3	3	3	7	3rd
4					4	4	7	8	9	4	4	6th
5						5	7	8	9	10	3	7th
6							7	8	9	10	0	10th
7								8	7	7	5	5th
8									8	8	6	4th
9										9	5	5th
10											2	8th

FarmersSelectionCriteria:1=Yield;2=DiseaseTolerant;3=LodgingTolerant;4=SeedColor;5=TilleringCapacity;6=EarlyMaturity;7=SpikeLength;8=Numberofspikeperhead;9=SeedSizeand10=PlantHeight.

Table 3. *Varietal ranking based on farmers' selection criteria.*

No	Varieties	Rank	Reasons
1	Guduru	2nd	High yielder, disease tolerant, medium maturing, good size, high thiller
2	Dursi	1st	High yielder, very good color, disease tolerant, relatively late maturing, good seed size, very high thiller
3	Kena	3rd	Good yielder, good seed color, less disease tolerant, medium maturing, medium size, good tillering capacity

3.2. On-Farm Performance of the Varieties

In spite of the inevitable variability in performance between and even within locations, yield performances of the varieties were still promising. The variability in yield performance might have stemmed from difference in the status of soil fertility, difference in management (usage of recommended cultural practices) and others. To this end; for the three districts; Dano, Jimma Arjo and Horro, the combined mean analysis result of on farm yield performance of the varieties demonstrated is summarized in (table 4). Accordingly; a mean yield of 17.52 ± 0.78 qt/ha, 14.71 ± 0.81 qt/ha and 15.30 ± 0.80 qt/ha for Dursi, Kena and Guduru varieties; respectively was recorded. Similar and consistent results were also reported by [6, 7, 9]; respectively. From the above result one can deduce that almost on farm mean yield performances for all the three varieties is similar.

Table 4. *Mean yield of teff varieties across the districts.*

Variety	N	Mean	SD	Min	Max
Dursi	12	17.52±0.78	2.71	14.78	23.03
Kena	12	14.71±0.81	2.81	11.31	20.86
Guduru	12	15.30±0.80	2.77	10.19	20.27

Moreover, ANOVA table result summarized and presented in (table 5) below showed that as there is statistically significant difference on mean yield performance among the varieties demonstrated; Dursi, Kena and Guduru at ($p<0.05$).

Table 5. *Analysis of variance table for yield.*

Source	DF	SS	MS	F	P
Farmer	3	44.171	14.7235	1.99	0.1379
District	2	1.18	0.5902	0.08	0.9234
Variety	2	52.658	26.3289	3.56	0.0418
Error	28	206.883	7.3887		
Total	35	304.891			
GrandMean	15.841				
CV	17.16				

Further, mean yield comparison (t-test) result summarized and presented in (table 6) below also verified that as there is significant difference on mean yield performances between the varieties demonstrated; Dursi, Kena and Guduruat ($p<0.05$).

Table 6. *Mean yield comparison (t-test) for the varieties.*

Varietiest-test	Mean	StdError	Pvalue
Dursi*Kena	2.81	0.85	0.0069
Dursi*Guduru	2.22	1.00	0.0468

3.3. Yield Advantage

Calculating yield advantage of the varieties helps: to show the extra benefit in percentage that the farmers' obtained from producing improved variety. Besides; to recommend based on the relative yield advantage over other varieties. Accordingly; Dursi had yield advantage of 19.10% and

14.51% over Kena and Guduru; respectively and could be calculated using the underlying formula. Similarly [6, 7] authors reported consistent results on yield advantage of this variety.

$$\text{Yield advantage} = +\frac{Yield\ of\ new\ variety - Yield\ of\ standard\ check}{Yield\ of\ standard\ check} * 100$$

Yieldadvantageof Dursi over Kena=19.10%

Yield advantage of Dursi over Guduru=14.51%

Table 7. *Yield advantage of newly released teff varieties over the standard check.*

Demonstrated Varieties	Yield obtained (qt/ha)	Yield advantage over the standard checks (Kena and Guduru) in%
Dursi	17.52	19.1
Kena	14..71	14.51
Guduru	15.30	

3.4. Technology Gap and Technology Index

Technology gap indicates that the gap in the demonstration yield over potential yield. Theo bserved technology gap is attributed to dissimilarities in fertility, acidity, rainfall and other natural calamities. The yield gaps can be further categorized into technology index which is used to show the feasibility of the variety at the farmer's field. The lower the values of technology index the more the feasibility of the varieties. To this end, the technology gap and index of demonstrated varieties (Dursi, Kena and Guduru) were calculated using the underlying formulas and presented in below table 8.

Technology gap= Potential yield qt/ha–Demonstration yield

$$\text{Technology index (\%)} = \frac{Technology\ gap\ \left(\frac{qt}{ha}\right)}{Potential\ yield\ \left(\frac{qt}{ha}\right)} * 100$$

Table 8. *Technology gap and index for teff varieties across the districts.*

Parameter	Teff Varieties		
	Dursi	Kena	Guduru
Yield gap (qt/ha)	5.33	3.29	1.3
Technology index (%)	23.32	18.28	10

As calculated in the above (table 8) the yield gapis 5.33 qt/ha, 3.29 qt/ha and 1.30 qt/ha for Dursi, Kena and Guduru varieties; respectively. This indicates that the lowest gap was observed on Guduru variety which in turns hows the demonstration yield is very close to the potential yield. Further; in terms of technology index 23.32%, 18.28% and 10% for Dursi, Kena and Guduru varieties; respectively. As the varieties have an average technology index of 17.20% and this dictates the varieties are feasible to the farmers in the study area and other similar agro-ecologies.

3.5. Financial Analysis

In terms of profitability and returns could be gained from each of the varieties, financial analysis result of the study was summarized and presented in below (table 9). Accordingly; on average 31,557.33 Birr, 25,320.66 Birr and 23,547.33 Birr per hectare were gained from Dursi, Guduru and Kena varieties; respectively and the highest profit were gained from using Dursi then by Guduru and finally from Kena varieties per production season in the areas where the activity was carried out. This means a total of 31,557.33 Birr profit can be obtained from a hectare of land investment on Dursi variety and from the others too. Further, as the study result also revealed the highest returns to investment was gained from Dursi then by Guduru and finally from Kena varieties which were 2344%, 187% and 174%; respectively. Therefore; from this result can be concluded that as Dursi variety is high yielder than Guduru and Kena varieties, using improved variety seed of Dursi was economically profitable than Guduru and Kena varieties.

Table 9. *Financial analysis for teff across the districts.*

Financialanalysis											
Location:Jimma Arjo				Location:Dano				Location:Horro			
Parameters	Variety			Parameters	Variety			Parameters	Kena	Dursi	Guduru
	Kena	Dursi	Guduru		Kena	Dursi	Guduru				
Yieldqt/ha (Y)	14.29	18.55	14.09	Yieldqt/ha (Y)	15.47	16.35	16.46	Yieldqt/ha (Y)	14.23	17.64	15.34
Price (P) per quintal	2800	2800	2800	Price (P) per quintal	2800	2800	2800	Price (P) per quintal	2800	2800	2800
Total Revenue (TR)=TR=Y*P	40012	51940	39452	Total Revenue (TR)=TR=Y*P	43316	45780	46088	Total Revenue (TR)=TR=Y*P	39844	49392	42952
Variablecosts				Variablecosts				Variablecosts			
Seedcost	3360	3360	3360	Seedcost	3360	3360	3360	Seedcost	3360	3360	3360
Fertilizercost	3150	3150	3150	Fertilizercost	3150	3150	3150	Fertilizercost	3150	3150	3150
Laborcost	7000	7000	7000	Laborcost	7000	7000	7000	Laborcost	7000	7000	7000
TotalVariable Costs (TVC)	13510	13510	13510	TotalVariable Costs (TVC)	13510	13510	13510	TotalVariable Costs (TVC)	13510	13510	13510
Fixedcosts				Fixedcosts				Fixedcosts			

Financialanalysis											
Location:Jimma Arjo				**Location:Dano**				**Location:Horro**			
Parameters	**Variety**			**Parameters**	**Variety**			**Parameters**	**Kena**	**Dursi**	**Guduru**
	Kena	**Dursi**	**Guduru**		**Kena**	**Dursi**	**Guduru**				
Costofland	2000	2000	2000	Costofland	2000	2000	2000	Costofland	2000	2000	2000
Totalfixedcosts (TFC)	2000	2000	2000	Totalfixedcosts (TFC)	2000	2000	2000	Totalfixedcosts (TFC)	2000	2000	2000
Totalcost (TC)=TVC+TFC	15510	15510	15510	Totalcost (TC)=TVC+TFC	15510	15510	15510	Totalcost (TC)=TVC+TFC	15510	15510	15510
GrossMargin (GM)=TR-TVC	24502	36430	23942	GrossMargin (GM)=TR-TVC	27806	30360	30578	GrossMargin (GM)=TR-TVC	24334	33882	27442
Profit=GM-TFC	22502	34430	21942	Profit=GM-TFC	25806	28360	28578	Profit=GM-TFC	22334	31882	25442

3.6. Training of Farmers, Experts and DAs

Below table 7 summarizes stakeholders' participated on the training across the districts.

Table 10. *Stakeholders training participants across the demonstration districts.*

Participants	**Districts**			**Total**
	JimmaArjo	**Dano**	**Horro**	
Experts	3	3	3	9
DAsandsupervisors	4	4	4	12
Farmers	15	15	15	45
Total	22	22	22	66

3.7. Field Visit

Field visit was also arranged across the districts so as to evaluate/select best performing varieties, to enhance farmers' knowledge on teff production and management and to collect feedback from all relevant stakeholders' for further way forward. On the field visit event organized a total of 114 participants; 90 (75 male and 15 female) farmers, 16 (14 male and 2 female) DAs and Supervisors and 12 (11 male and 1 female) agricultural experts were participated across the districts.

3.8. Farmers' Perception on Teff Technology

The farmers' have appreciated the selected teff technology for the following merits; perceived better yielder than the commercial varieties, perceived better resistance to disease, perceived better seed color and marketability.

4. Conclusion and Recommendation

This pre-extension demonstration of improved teff technologies wasc arried out in selected districts Western Oromia; namely, Jimma Arjo, Horro and Dano. One newly released teff variety; Dursi, was planted along with standard checks; Kena and Guduru, on 10 m*10 m adjacent plots of land and on a total of 12 hosting farmers in the districts. At maturity stage participatory variety evaluation and selection was arranged and held so as to evaluate, rank and select best suiting variety/ies in accordance with their real situation. Accordingly; Dursi variety was selected first in all of the traits and then by Guduru and Kena one after the other. Dursi variety suits the farmers' selection criteria and ranked as high yielder and other traits listed. Even the standard checks; Guduru and Kena can be best options as it can give better yield than the varieties farmers' have been using. To this end; the demonstrated improved variety was much better in yield performances than the standard checks used and varieties on the hands of the farmers'.

Moreover; Dursi variety demonstrated was far better in financial profitability, yield advantage of about 19.10% and 14.51% than Kena and Guduru; respectively suiting farmers' need. Further; statistical analysis of mean yield performance comparison between the varieties (t-test) and ANOVA table results of the varieties on yield showed that there exists highly significant difference at ($p<0.05$). Eventually; farmers' evaluated, preferred and selected Dursi first then Guduru and finally Kena one after the other. But as farmers' evaluated though low yielder as compared to Dursi, Guduru and Kena varieties, can excel in yield than commercial varieties the farmers' have been using. Therefore; this entails scaling up/out activity will be the next activity to be carried out for the coming years for Dursi variety as a prior on more number of farmers and on wider areas where the activity was carried out and on other similar agro-ecologies.

Generally, through this participatory demonstration and evaluation process, farmers became aware of the importance and quality of technologies as compared to the local one. The demand for the variety was also created. Demonstration result showed that the Dursi variety was recorded high yielder than Guduru and Kena at all location. It also was preferred by participant farmers for its better agronomic performance. Based on these facts, Dursi variety was recommended for further scaleup and scaleout for demo districts and other similar areas.

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