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Pre- Scaling Up of Improved Tef Variety to Potential District of Western Oromia

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Abstract **Original Research Article**

Pre-scaling of Tef variety was carried out at Chaliya and Jimma Arjo districts of East Wollega Zone, Western Oromia. The main objective of this work was to reach farmers with proven improved tef variety, Dursi, to farmers in the study districts. A cluster approach was used to conduct the rescaling up activity. At the onset of the activity, farmers, DAs and district experts of the respective districts were trained on tef production and management at their respective locations. During the course of the work that covered 2021-2023, a total of 83 farmers were reached with technology; 49 hectares of land was covered, and 9.80 quintal improved seed was planted on the farmers' fields. The overall technology gap, extension gap and technology index were 3.4 qt ha^{-1}, 11.6 qt ha^{-1} and 15.45% respectively. Field days were also arranged to create wider awareness and share experiences among farmers on improved tef production and management. Availability of the proven technology; multi-disciplinary research team; key stakeholders; a strong linkage among stakeholders; pre-scaling up strategy with shared vision and supportive research management were among those factors that contributed to successful accomplishment of the work. Feedback from farmers showed that the variety is high yielder, disease tolerant, has preferred seed color, well adapted and has high market demand. Therefore; the variety should further be promoted to wider locations and large number of farmers by respective extension organizations in collaboration with other key stake holders in the study area and beyond.

Keywords: Dursi, Rescaling Up, Tef, Variety, Extension Gap, Technology Gap, Technology Index.

INTRODUCTION

Background and Justification

Teff (Eragrostistef (Zucc.) Trotter) is a warm season annual cereal crop and the major staple food crop grown in Ethiopia. It is the most important cereal, both in terms of production and consumption in Ethiopia. Being the most liked cereal based crops by better off families, more specifically urban residents, teff fetches comparatively better price in the market, making it preferred cash crop to farmers. In its relative term tef is resistant to many biotic and abiotic challenges and can be grown in different agro-ecological conditions, with ranges from lowland to highland areas. It can also be stored for many years without being seriously damaged by common storage insect pests (Bekabil *et al*., 2011).

Teff production keeps its first rank in terms of area coverage among the other cereal crops which accounts about 30% of the land allotted to cereal production followed by maize (23%), sorghum (18%), and wheat (17%) (CSA, 2019). However, it is the lowest in its productivity which is only one third of the average wheat productivity of the nation (CSA, 2019). Today, nearly three million hectares of land are covered annually by teff and more than six million small scale farmers are involved in tef cultivation in the country. Supporting more than 60-75% of Ethiopia's population as staple food teff is believed to serve as a traditional medicine especially for diabetic problems in vast areas of the country. In Ethiopia, teff is mostly utilized in the form of fermented flattened bread nationally termed as injera (Tefera, H., 2006)

Teff is thought to remain a preferred crop of the Ethiopian people and is also gaining reputation as a health foodstuff in the western countries. Studies show that tef is a gluten free crop, which makes it is suitable for patients with celiac disease (Spaenij *et al*., 2005) CSA data over the past few years show that tef 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 (Tefera,2006)

Additionally, it is locally processed in the form of local alcoholic beverages like local beer known as "Tella" and local sprit traditionally called "katikala" or "Areke" and porridge, and its straw is used as dry season animal feed and also used as component of construction material (FAO,2015).

Teff is an economically superior commodity in Ethiopia. Its price often exceeds a market price of maize two to three times, though maize is the largest in terms production in Ethiopia (Assefa, 2019); thus making tef a reliable cash crop for producers (Abraham, 2015) Teff is among the most important cereals on which the livelihood of many farmers is based.

It has the potential to enhance commercialization of smallholder agriculture and tackle food security problems in the country. In Ethiopia, Teff is mainly produced in Amhara and Oromia National Regional State injera (Tefera, H., 2006); and it is estimated to be the most important crop in Ethiopia's agriculture and food economy. Based on the increasing number of health-conscious consumers, worldwide, tef has begun bring in a similar event with quinoa, the nutritious crops indigenous to South America for global prominence (Cheng *et al*., 2017). As a result teff production is getting focus in other parts of the world. Despite the significant importance of the crop to Ethiopia, productivity is considered very low and even dwindling in some cases. This is due to several technical and socio-economic constraints. Weed competition, low or declining soil fertility, diseases, in appropriate use of agronomic practices such as seeding rate, sub-optimal fertilizer application and herbicide use.

Shortage of improved seeds, escalating price and lack of complementary technologies such as fertilizer and herbicides in required amount and at and untimely arrival, and scarcity of cash or credit for purchase of inputs are the major socio-economic constraints (Kenea *et al*., 20060. For decades, the National Agricultural Research System (NARS) has been making tremendous efforts over last ten years to develop and release large number of improved teff varieties and related production packages for diversified agro ecology of Ethiopia. More specifically, Bako Agricultural Research Center (BARC) has been endeavoring to release improved teff varieties to agro-ecologies under its mandates. As part of this effort, Bako Agricultural Research Center (BARC) released an improved teff variety known as Dursi, having 10 % yield advantage over its predecessor, and exhibiting better agronomic characteristic. This variety was demonstrated on farmers' fields a year ahead of the current activity and won the attention of the farming community both in qualitative and quantitative parameters farmers regard as vitally important. On top of this, the potentiality of western Oromia for teff production, increased demand for improved varieties and availability of the options, it is due time to disseminate the variety to farmers in potential agro ecologies of teff production under BARC's mandate.

Objectives

- ➢ To promote verified improved teff variety to small scale farmers in the district;
- ➢ To disseminate the selected variety and build sustained seed system ;
- ➢ To strengthen linkages with target beneficiaries and stakeholders so as to enhance

MATERIALS AND METHODS

Operation Sites and Participant Actors

The pre-scaling activity was conducted in selected districts of West Shewa and east Wollega zone of western Oromia. Cost sharing approach was the main strategy to disseminate the technology. Accordingly, the activity was carried out in Jimma Arjo and Chaliya districts producing district known for their potentiality in tef production. In each district two potential PAs were identified with the help of DAS and district experts. The variety used for this activity was advanced from previous pre-extension demonstration activity that employed improved tef variety, Dursi. The variety was tested through FRGs a year ahead of the current activity. The current activity followed a cluster approach, where adjoining fields of different sizes were used. The minimum acreage of land was 0.25 ha per farmer. As the activity followed a cost sharing approach, improved seed and technical back up was from researchers whereas the share of the farmers was labour and fertilizer.

Stakeholders Training and Seed Distribution

Following identification of sites and selection of farmers, both theoretical and practical training were given to farmers, Development agents and district experts. Training was provided on such topics as tef production management, breeding and post-harvest management (seed quality). The aim of training was to create awareness of farmers, Development agent and district experts on tef technology. Finally; after the plots were properly ploughed and made ready for planting ahead of the planting date, all necessary inputs (seed) were delivered to the farmers. Planting was made on the farmers' field by BARC researchers, DAs as well as Farmers Extension Groups.

Variety Dissemination

As opposed to pre-extension demonstration, pre-scaling up involves many farmers and covers large areas. Consequently disseminating the variety along with the necessary inputs like fertilizer was not within the economic reach the team. Cognizant of this, farmers who are capable of purchasing inorganic fertilizer on their own were identified and used. To this end, Development Agents took part in site and farmer selection, giving guidance during planting, field supervision and facilitating field visits. Duri, the already tested and verified tef variety was planted on the selected farmers' fields adhering to all recommended agronomic practices. During the activity period that extended from 2021 to 2023, a total of 9.80 quintal improved seed was planted covering a total area of 49 hectare. A total of 83 farmers were reached during the course of the activity. Fertilizers and labour required for production were covered by the farmers themselves as per our agreement on cost sharing.

Data Collection and Analysis

For this activity all the necessary qualitative data (farmers' perception on the attribute of the technology) and quantitative data (yield data, total number of farmers, DAs, experts participated on training and field visits) were collected and analyzed. Simple descriptive statistical tools such as mean, graph, frequencies and percentages were used to summarize the data.

Technology Gap, Extension Gap and Technology Index

Technology gap is the difference between potential yield of the variety and demonstration yield a variety under consideration. Extension gap is denotes the difference between demonstration yield and that of farmers' practice. As per the current work, technology gap represents the difference between the potential yield of the new variety (Dursi) and the yield recorded per hectare for the same variety on this specific work. At the same time technology index is the difference between potential yield and demonstrated yield divided by potential yield and multiplied by hundred. Technology gap, among others, might stem from difference in fertility, acidity, precipitation and other natural Phenomena. Analysis of technology gap, extension gap and technology index was done based on the formula developed by (Samui *et al*., 2000). Further; according to Dhaka et.al, 2010 its contribution is to narrow down the gap between the yields of different varieties and to provide location specific recommendations. The yield gaps can be further disaggregated into technology to describe the feasibility of the variety under farmers' fields.

Lower values of technology index imply more feasibility of the varieties. Extension gap is the difference between the yield (qt ha^{-1}) of the new variety and the yield per hectare from farmers experience up on producing using their own seed, fertilizer and cultural practice. As per the current work, extension gap refers to the difference between the average yield recorded from the disseminated variety, Dursi, accompanied by recommended seed, fertilizer rate and recommended cultural practices and the farmers' seed and own local practice. As the current activity was not conducted side by side with farmers' practice, other approach was followed to capture the yield per hectare obtained from farmers' local practice. To this end, farmers were individually interviewed, that was followed by (focus group discussion (FGD) for triangulation. The result obtained from these two approaches was used as representative farmers' yield that in turn helped us calculate extension gap. The technology gap, extension gap and technology index were calculated using the formula indicated as illustrated below:

(1). Technology gap (qt) = Potential yield qt ha^{-1} – Demonstration yield (1)

(2). Technology index (%) = $\frac{\text{Potential yield - Demonstration yield}}{\text{Potential yield}} * 100$ (2)

(3). Extension gap (q ha^{-1}) =Demonstration yield (q ha^{-1}) - Farmers yield (q ha^{-1}) (3)

Communication Methods (Dissemination Strategies)

Field day and field visit, training and print media such as leaflets, pamphlets and production. Manuals were used for further creating awareness and for enhancing users' knowledge and skill in rice production.

Monitoring and Evaluation

Researchers, Development agents (DAs) and farmers periodically conduct monitoring and evaluation to supervise the overall management, performance of the variety and others to fill gap observed starting from site selection through harvesting. At the end based on its performance the variety was jointly evaluated with FEGs, researchers, extension agents and other relevant stakeholders.

RESULTS AND DISCUSSION

Training of Stakeholders

Gender & occupation disaggregated number of trainees was summarized and depicted in Table 1 below. As can be seen from the table, a total of 62 participants (47 farmers, 11 DAs and 4 district experts participated on the training that was held at the onset of the rescaling up activity. The training was given on the overall teff production and management activities.

Table 1: Stakeholders training by gender and occupation

	Training participants									**Grand Total**
Training topic	**Farmers**			**DAs**			**Experts**			
Tef production & management	M	F	Total	M	F	Total	M	F	Total	
	40	7	**47**	8	3	**11**	4	0	**4**	62

Field Days

Field days were jointly organized and arranged with district level agriculture and natural resource offices so as create opportunities for all relevant stakeholders', to create awareness on the importance and availability of the technology, to learn from the technologies promotion activities and also to evaluate the performance of varieties, to enhance farmers' knowledge on tef production and management and to give/collect feedback from all relevant stakeholders. For the last three years (2021-2023) a total of 68 farmers, 8 development agents and 4 district experts were invited and attended on the field day event. Below (Table 2) summarize gender disaggregated number of participants participated on the field day events organized.

Table 2: Field day participants by gender and occupation

Field day	Participants by gender & occupation										
	Farmers			DAs			Experts			Grand total	
	M	F	Total	M	F	Total	M	F	Total		80
	60	8	**68**	6	2	**8**	4	-	**4**		

Amount of Seed Distributed and Number of Participant Farmers over Years

Figure 1 summarizes total number of farmers reached, amount of seed distributed and area covered. Overall, a total of 85 farmers were reached, 8.80 quintals of seed was planted and a total area of 33 hectare was covered with the variety during the activity period. Location disaggregated result of the current work reveals that 43 farmers were reached, 5.80 quintal seed was planted and 24 hectare of land was covered at Chaliya, while the values are 42 farmers, 4.0 qt and 24 hectare in the above order for Jimma Arjo. The values are summarized and depicted in fig.1 below.

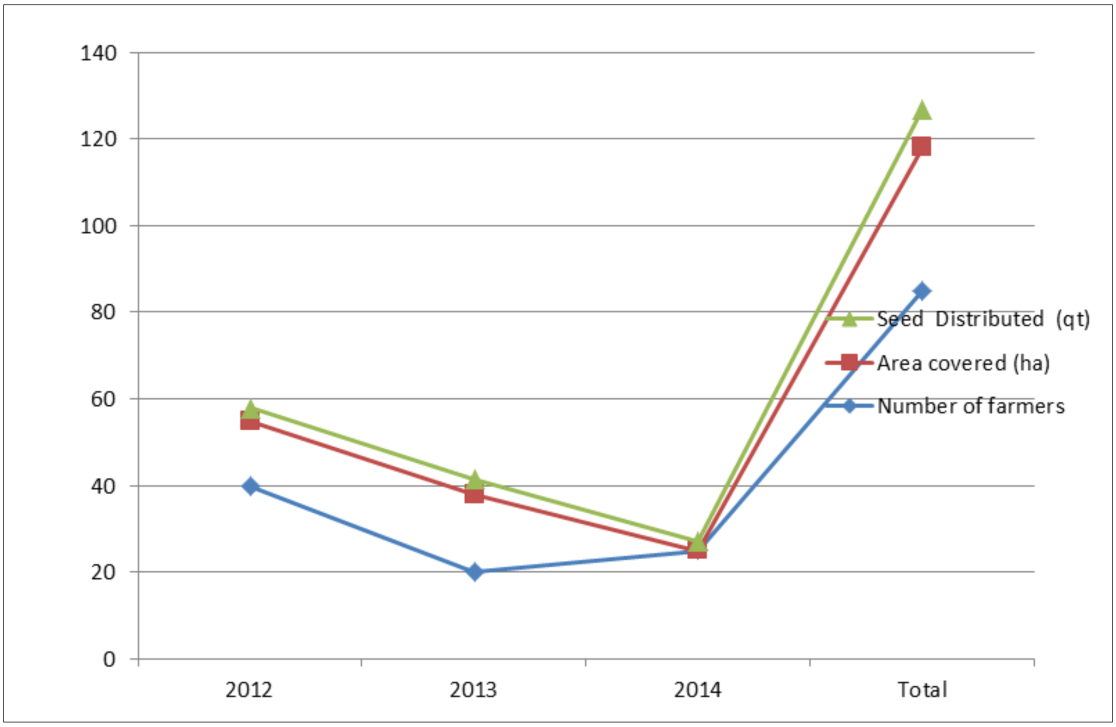

Figure 1: Seed distributed and area covered by year and location

On-Farm Grain Yield Performance

The grain yield performance of the variety is summarized and represented by figure 2. The result discloses that the highest mean yield was recorded during 2021 production season and relatively the lowest mean yield was recorded during 2023 production season. Overall, however, participant farmers and other stakeholders who participated on the pre-scaling up activity and other events such as field days rated the variety as a high yielder, very good in color (marketability), disease tolerance, and lodging tolerance, very good stand. Hence; taking these facts into account large scale dissemination (scaling-up) should be sustained through Ministry of agriculture of the respective districts, so that much more number of farmers are reached and more areas are covered.

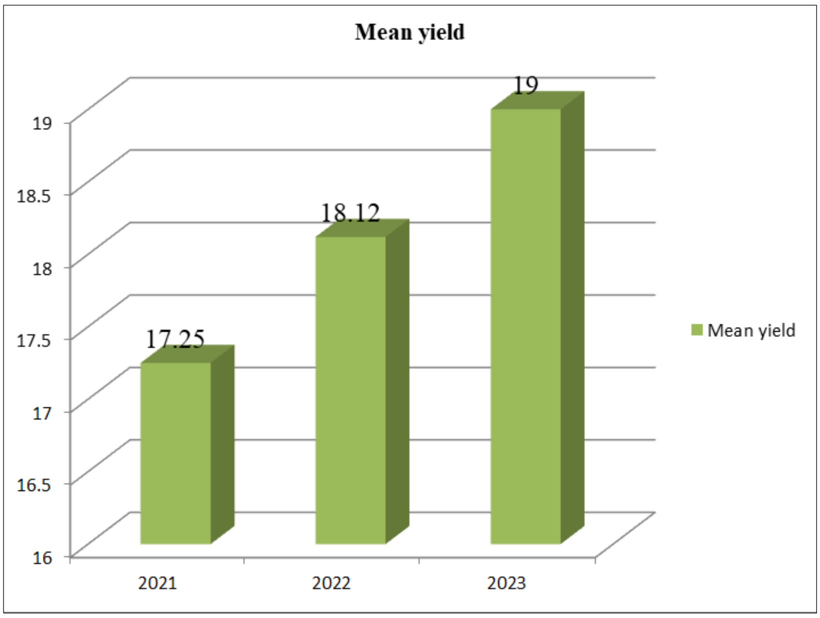

Figure 2: Grain yield performance by year and location

Yield Potential and Yield Gap Analysis

The overall mean grain yield of the variety across years and locations was 18.6 qt ha^{-1}. Disaggregated to the respective locations, the mean grain yield was 19.6 qt ha^{-1} and 17 qt ha^{-1} for Chaliya and Jimma Arjo locations, respectively. The overall yield increment (advantage) over the farmers' practice was 165% while it was 180% and 151.4% for Chaliya and Jima Arjo locations, respectively. This difference is due to the utilization of best-fit variety (Dursi) and periodic supervision and management to correct procedural and managerial gaps that recurrently appears on farmers' fields. The result of the current study plainly reveals superiority of the technology over the farmers' practice and the benefit that farmers can fetch if they resort to the new variety (Dursi) at the expense of farmers' practice. Conversely, farmers produce less and earn less if they choose to produce local variety with local practice sacrificing the new variety (Dursi). Hence, large scale demonstration (scaling up) of the varieties should get more emphasis in the targeted environment and similar areas that share similar agro ecology with the current activity locations.

Table 5: Yield advantage of the new variety over farmers' practice

Location	Potential yield ($qtha^{-1}$)	Demonstration yield ($qtha^{-1}$)	Farmers practice ($qtha^{-1}$)	% Yield increases over farmers practices
Chaliya	22	19.6	7	180
Jimma Arjo	22	17.6	7	151.4

NB. Percentage of yield increase over farmers practice = (demonstration yield – farmers practice)/farmers practice × 100

Technology Gap and Technology Index

The estimation of technology gap, extension gap and the technology index was done using the formula the formulae given by (Samui *et al.*, 2000, Sagar and Chandra Ganesh, 2004). The formulae were indicated under the methodology part.

Technology gap = Potential yield – Demonstration yield
Extension gap = Demonstration yield – Farmers yield

$$\text{Technology index} = \frac{(\text{Potential yield - Demonstration yield})}{\text{Potential yield})} * 100$$

Yield gap was analyzed based on the actual implementation of improved tef technologies and the trend of farmers practices to grow tef in the district. Based on this, the yield gap of the disseminated variety has been explained in terms of technology and extension gaps. Technology Gap (TG) analysis indicates the extent to which technologies have not been adopted. This information is essential to identify the weakness of technology transfer program, to remove bottlenecks and accelerate adoption of improved technologies (Neha P. 2018).

The Average of technology gap (TG) calculation and overall gaps in contrast to the recommended technology practices were calculated. Hence, the overall technology gap was calculated using the formula given under the methodology part and the result was 3.4 ha^{-1}. On the other hand, the result of extension gap (EG) was 11.6 % and the result indicated that it needs emphasis to strengthen the extension approach using various methods like farmer training, experience sharing, enhancing awareness through information dissemination networks and other relevant methods. It is also believed that advanced improved tef technology production package with acceptable grain quality will subsequently change the extension gap. Hence, dissemination of newly released improved field pea technologies including production packages will have a significant impact on food security and income of the beneficiaries.

Similarly, the overall technology index was 15.45% indicating feasibility of the technology under farmers' condition. Location disaggregated analysis of technology gap, extension gap and technology index reveals that the technology gap is relatively higher (5 ha^{-1}) for Jimma Arjo compared to that of Chaliya (2.4 ha^{-1}) implying relatively better adoption of the technology by the latter category. The trend of technology gap that ranged from 2.4 to 5 qt ha^{-1}) reflects the farmer's cooperation in carrying out such popularization with encouraging results in subsequent years. As to the extension gap, the value is relatively higher for Chaliya (12.6 ha^{-1}) than that of Jimma Arjo 10(ha^{-1}). The value of technology index reveals higher value (22.7%) for Jimma Arjo as compared to that of Chaliya (10.9 %). As higher value denotes lower feasibility, it can be learned that the technology is more feasible for the farmers at Chaliya than those at Jimma Arjo.

Table 6: Technology gap, extension gap and technology index by district

Location	Technology gap (qt ha^{-1})	Extension gap (qt ha^{-1})	Technology index (%)
Overall	3.4	11.6	15.45
Chaliya	2.4	12.6	10.9
Jimma Arjo	5	10	22.7

Impact/Change of Intervention

Institutional Linkage

Achieving sustainable and incremental economic development is not at ease without strong institutional linkages among relevant stakeholders engaged in transforming the agricultural sector and improving the livelihood of the resource poor farmers. Among other reasons, unilaterality, lack coordination and synergy among the intervention made by different institutions is crucial. But these days approach of developing partnership and institutional linkage in agricultural technology/commodity promotion proved successful and therefore is viewed as a win-win working model by stakeholders involved across the value chain from technology generation via production to marketing of value added products. Furthermore; the successful accomplishment of this innovative work together with the active involvement of all relevant and responsible stakeholders has brought about significant and positive attitudinal change towards partnership and collaboration, thus built mutual trust and self-confidence among themselves in expanding their cooperation in other similar joint initiatives.

Outcome of the Activity (Achievements)

Even though most of the outcomes of the current work do not lend themselves to direct calibration and explanation, the following benefits could be seen as an outcome of the activity. A few among them include: farmers have got improved tef variety of their own preference; mutual trust among farmers, researchers, DAs and other stakeholders was fostered, 85 farmers were reached through direct intervention; and many were reached via other routes(sale, exchange, gift);

Success Factors

Success cannot be guaranteed without well-coordinated and orchestrated effort of all stakeholders involved in a given development agenda. Right procedures and committed folks are behind any success stories. The following points are among other factors that contributed to the successful completion this activity: availability of the proven technology; multi-disciplinary research team; identification of the key stakeholders; a strong linkage among stakeholders; scaling up strategy with shared vision and supportive research management have played a pivotal role.

Farmers' Perception of the Technology

During feedback assessment farmers were revealed the advantages and disadvantages of the technology as well as their views/perception towards the technology. Accordingly; the farmers strongly liked and listed the merits of the technology over the commercial varieties in terms of yield, color, disease tolerance, market price, spike length, number of spikes per plant. Besides; the farmers also appreciated the group approach (FREG) in due of its quickness in sharing knowledge, responsibility sharing, ownership, team spirit and easiness in solving problems and easy operation.

Exit Mechanism

The mandate and scope of Bako Agricultural Research center is technology generation, adaptation and demand creation through demonstration and pre-scaling activities on limited farmers' fields. To this end, actually promoting scaling out/up of the already demonstrated, verified, proved and selected technologies is the mandate of respective district agricultural and natural resource office. Therefore; the wider scope dissemination or scaling up/out of the technology should be handled/over taken and implemented by agricultural and natural resource offices as well as other relevant and mandated stakeholders' involved in this area. To this effect, BARC and the respective agriculture and natural resource offices discussed, agreed and signed an exit strategy on how the technology is to be promoted sustainably and on wider scale.

SUMMARY, CONCLUSION AND RECOMMENDATION

The current activity was conducted in Chaliya and Jimma Arjo districts of Western Oromia aiming at disseminating demonstrated and selected improved tef variety in the afore mentioned districts. The variety used for this activity was advanced from past demonstration activity held a year ahead of the current work. Cluster based rescaling approach was used to undertake the activity where a farmer contributes a minimum of 0.25 hectare to form the cluster. Model farmers who are capable of purchasing inorganic fertilizer on their own were selected to host the rescaling up activity. The variety for the current activity portrayed a remarkably higher yield advantage (as high as 180%) over that of farmers' practice. Thus; by using this improved variety with its full package, farmers can earn more benefit than conventional and local varieties. As the variety is preferred by farmers' and other stakeholders' promotion and dissemination of the technology should continue sustainably on wider scope. The farmers and other stakeholders participated on field days witnessed superiority of the variety with regard also to other economically important traits of their interest. Sustainability of wider dissemination should thus be guaranteed through commitment of the respective bureaus of agriculture and natural resources development involving other relevant stakeholders operating in this sphere. To realize a relay type of extension system and ensure sustainability of the seed system, an exit strategy was designed where memorandum of understanding was signed and the activity was handed over to the respective bureaus of agriculture.

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Conflict of Interest: The authors would like to assert that there is no conflict of interest.

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