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Up-scaling Innovative Practices to Optimize Teff Yield in Dry-land Areas, Northeast Amhara

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ABSTRACT

The pre-scaling up activity was conducted during July–November from 2020–2022 for three consecutive production years in the potential woredas of Wag-lasta area viz., Lasta, Dahana, Sekota and Sekota zuria, Ethiopia to transfer best performing teff technology to wider community through creating higher demand, on top of establishing sustainable multiplication and stakeholder linkage in the technology supply chain. The improved 'Kora' teff teff technology had been promoted for three consecutive production years involving 182 farmers who had 78 ha of clustered farmland. The required quantitative and qualitative data were collected and analysed using appropritate statistical tools.The performance of improved teff technology presented better performance, and thus had a 90% yield advantage over the local teff production practice in all locations. Among the participating farmers, 90.6% were highly interested to cultivate the new teff technology in the future. However, 72.8% of them described skill gap, complexity of the technology and being pessimist in new technology were the top three challenges experienced by farmers to apply the full technology package in Teff production. Most farmers and stakeholders who attended the field days were rapt, and promised to use the 'Kora' teff technology because it was very adaptive to their moisture deficit areas. The 43.6% of partaking farmers were also diffused 648 kg of improved 'Kora' teff seed for 108 fellow farmers. Therefore, we safely suggest the improved teff technology for further scaling up/out to similar locations through establishing sustainable seed multiplying cooperatives and stakeholder linkages.

KEYWORDS: Clustering approach, teff technology, stakeholder linkage, Wag-lasta area

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1. INTRODUCTION

Teff *[Eragrostis tef (Zucc.) Trotter]*, scientifically known as Eragrostis tef, is one of the world's oldest domesticated grains, originating in the Horn of Africa around 4,000–6,000 years ago. Teff belongs to the grass family, Poaceae, and is sometimes referred to as lovegrass (Hashimoto et al., 2012). Teff is adaptable and can grow in various environments, at altitudes ranging from sea level to 3,200 m. However, it does not tolerate frost (Assefa et al., 2015; Bachewe et al., 2019). Highest yields are obtained when teff is grown between 1,800 to 2,100 m, with an annual rainfall of 450 to 550 mm, and daily temperatures range from 15 to 27°C (Ortiz-Bobea et al., 2021). Yields decrease when annual rainfall falls below 250 mm and when the average temperature during pollination exceeds 22°C (Woodhill et al., 2022). Despite its superficial root system, teff is quite drought-resistant thanks to its ability to regenerate rapidly after a moderate water stress and to produce fruits in a short time span. It is daylight-sensitive and flowers best with 12 hours of daylight. Teff is usually cultivated on pH-neutral soils, but can tolerate acid soil pH below 5 (He and Li, 2020). In Ethiopia, teff is the most significant and traditional staple cereal crop cultivated extensively across diverse climatic and soil conditions. It constitutes approximately 32% of the total cereal production and contributes to over two-thirds of the nutritional intake for the Ethiopian population (Azeb et al., 2017). As a gluten-free cereal, teff is particularly favored by gluten-intolerant consumers. It is highly preferred not only for its superior milling efficiency and baking returns but also for producing high-quality 'Injera' compared to other cereal crops (Bekele et al., 2017). Additionally, teff straw serves as a crucial feed source for livestock, surpassing other cereal straws in Ethiopia (Mihiretu and Abebaw, 2020). Teff is cultivated by 43% of Ethiopian farmers and holds the largest share of crop production in terms of both area and volume (Belachew et al., 2022). Annually, teff covers 3 million hectares of land, yielding 5.2 mt of grain, which accounts for 21% of the production volume in Ethiopia. Among cereal crops, teff is the primary source of income for farmers in Ethiopia due to its high market demand and prices for both grain and biomass yield (Mihretie et al., 2020). In Amhara region, teff is the leading cereal crop interms of coverage and production volume. The regional productivity of 1.5 t ha^{-1} is greater than the 1.4 t ha^{-1} national average ((Bayable et al., 2020). The same holds in Wag-lasta areas, where teff is the second in Wag and first in Lasta in area coverage, with respective productivity of 1.3 and 1.4 t ha^{-1}. Teff straw yield offers multiple applications, primarily serving as fodder for cattle and occasionally as bedding material (Azeb et al., 2017). Despite the benefits and nutritional facts mentioned above, teff productivity is much less than any other cereals both at national and regional levels in Ethiopia (Anonymous, 2022). Likewise, teff still remains the less productive crop than other cereals in the the study areas. To relieve the aformantioned productivity problems in these areas, the Sekota Dry-land Agricultural Research Center conducted a participatory technology evaluation trial and subsequently recommended the improved 'Kora' teff variety, along with its comprehensive production package components (hereafter referred to as Teff technology), for upscaling (Mihiretu and Asresu, 2022). This study was thus aimed to up-scale and diffuse the recommended *teff* technology to the wider community through creating higher demand, on top of establishing sustainable multiplication and stakeholder linkage in the technology supply chain.

2. MATERIALS AND METHODS

The pre-scaling up activity was conducted during July–November from 2020–2022 for three consecutive production years in the potential woredas of Wag-lasta area viz., Lasta, Dahana, Sekota and Sekota zuria. A total of 182 (48 female) farmers who had a clustered farmland of 78 ha were participated in the pre-scaling up. Researchers and experts from Woreda Office of Agriculture incollaboration had select clusterd farms and farmers, while the Development Agents at kebele level were measured the farmers' field. The participants were given training on basic agronomic practices and the entire extension approach (Anonymous, 2016). The major stakeholders working on agricultural development at different levels were identified in the respective areas to involve and made incessant follow up in the process.

The improved *'Kora' teff* technology was planted in row using a seed rate of 15 kg ha^{-1}, while 50 and 100 kg ha^{-1} rates were applied for Urea and NPS fertilizers, respectively. The Urea fertilizer was applied in split at planting and tillering stages as per the recommendation. All the required management practices were done accordingly, but Karate 5% *E.C* chemical at 0.4 l ha^{-1} was used for shoot fly *(Delia armbourgi)* control (Mihiretu and Abebaw, 2020). Moreover, field days were organized in all locations involving farmers and other concerened stakeholders to creat awareness about the new teff technology in the community. The grain and straw yield data of the pre-scaling up plots and the nearby adjacent farms were collected. Semi-structured checklist was used to collect the farmers' viewpoint and perception on the technology. Approximately 30% of the total participant farmers, were selected through systematic sampling with an estimated sampling interval of 3 (Eq. 1).

$$K=(N/n) \qquad (1)$$

Where, K=Sampling interval, N=Pre-scaling up participants, n=Sample size

The agronomic data of prior participatory evaluation study was taken from published article by Mihiretu and Asresu (2022) to calculate the extension gap (EG).

EG=Dy-Fy ……......………………………….............(2)

Where: Dy=Demonstration yield at frontline farmers, Fy=farmers' yield, EG=Extension gap

The farmers' perception and demand were assessed using descriptive statistics, then calculating the sum (Eq. 3) and average scores[1] (Eq. 4) of different Likert scale items (Mihiretu and Assefa, 2019).

The internal consistency of Likert-type questions was evaluated using Cronbach's alpha test. The primary constraints in the application of teff technology were ranked by severity and converted into percentage positions using Garrett's ranking method (Mihiretu and Abebaw, 2020). Each rank's position (Eq. 5) was transformed into scores and referenced in Garrett's table (Table 5b). A SWOT analysis (strengths, weaknesses, opportunities, threats) was conducted to assess the positive and negative aspects of stakeholders involved in the up-scaling of teff technology (Azeb et al., 2017). The perception data collected during field days were qualitatively analyzed and presented in a thematic narrative.

If the average score is greater than 3.51, the farmers have a good perception of the technology. If the average score is 2.51–3.50, the farmers have no confidence in the technology. If the average score was below 2.50, the farmers do have not a good perception of the technology (Mihiretu and Abebaw, 2020).

$SS=\sum_{i=1}^{5}$ SD, D, NAD, A, SA ……………………..….. (3)

Where, SS=Sum of scores, SD=Strongly disagree, D=Disagree, NAD=Neither agree nor disagree, A=Agree, SA=Strongly agree

Average score=(Sum of score/Sample size)……………. (4)

Percent position=$(100(R_{ij}-0.5))/Nj$ ....…………………. (5)

Where, R_{ij}=Rank given for i[th] constraint by j[th] individual, N_j= number of constraint ranked by j[th] individual

3. RESULTS AND DISCUSSION

3.1. Production performance and yield gaps

The average grain yield of the improved *'Kora'* teff technology was 1140 kg ha^{-1}, but other farmers who used the prevailing production practice were got 600 kg ha^{-1} in similar production years (Table 1). The use of new teff technology hence had 90% yield advantage over the conventional method of teff production. The observed yield increase was might be for the reason that the new teff variety was providentially tolerant to water scarcity and igher temperatures that describe the study areas very well. Similarly, Mihiretu and Asressu (2022) also stated that the yield increase of improved teff technology over the usualpractice might be due to better adaptability and/ or being quite environment-friendly. Table 1 below also illustrated that the yield difference due to extension gap among the frontline demonstration plots and the clustered up-scaling land was on average 4700 kg ha^{-1}. The extension gap result in this study hence designated a need to motivate farmers to adopt the recommended new technology for sustainable and enhanced teff production. Besides, these gaps were an indicators for the farmers' lack of awareness on improved farm technology adoption. The current result was thus similar to the finding by Bekele et al. (2017), who reported that location-specific mediations may have a massive proposition on crop productivity improvement.

Table 1: Productivity and extension gap of the new teff technology

Teff	Range yield index (kg ha^{-1})	Mean yield (kg ha^{-1})	SD	Yield index (%) (kg ha^{-1})	Extension gap
Grain	780 –1450	1140	1.787	90	470
Straw	1900 –2650	2170	6.233	24	996

3.2. Perception and demand for teff technology

Most of the farmers had a positive view and good perception about the new technology in most parameters used for teff comparasion. The average score of 4.61 implied that farmers perceived and accepted the new technology with full confidence. The Cronbach's alpha coefficient (α=0.83) also demonstrated that the questions used for comparasion were consistent and reliable. About 90.6% of farmers were highly interested to adapt the new teff technology in the future, and most of them (82.4%) convinced their neighbour farmers to use the technology (Table 2). Besides, field days involving farmers, agricultural experts, NGOs and journalists were held and their opinion about the visited teff technology was summarized as follows:

The 'Kora' teff technology was very adaptive to our moisture deficit area and could give reasonable yield under low moisture than the existing teff varieties under use. Clustering as an approach was also appreciated for creating competition in farm management among farmers, as well as having "eye-catching" power to impress individuals.

3.3. New technology application and its constraints

Among other factors, applicability was playing a significant role in new technology adoption, hence with experts' strict follow up 79.5% of farmers applied the full technology package. Despite the better package application, 72.8% of farmers were identified constraints in package application

Table 2: The perception level of participant farmers' towards new teff technology using five point Likert items

Parameters	SD	D	NAD	A	SA	SS	MS
The germination performance of the new is variety good	-	-	-	47.2	52.8	249	4.53
The vegetative performance of the variety is good	-	-	-	26.5	73.5	254	4.74
Seed setting performance of the variety is good	-	-	16.1	27.1	56.8	238	4.23
The seed colour of the variety is good	-	-	-	53.5	46.5	269	4.87
The new teff variety is early maturing	-	-	-	24.5	75.5	257	4.76
The variety is adaptable to marginal dry-land areas	-	-	2.5	12.0	85.5	262	4.82
The productivity of the new variety is good	-	-	10	44.8	45.2	243	4.45
The straw palatability of the new variety is good	-	9.8	13.6	20.0	56.6	264	4.78
The food quality of the new variety is good	-	-	12.9	28.4	58.7	245	4.49
The improved production package is easy to apply		-	20.5	38.0	41.5	218	4.02
Absence of constraints during package application	13.4	59.4	19.2	8.0	-	164	3.54
Higher interest to use the new technology in the future	-	-	9.4	34.4	56.2	278	4.52
Cheered to suggest fellow farmers to use the technology	-	-	17.6	25.8	56.6	284	4.78
							Average score=4.61
							Cronbach's 'α' coefficient=0.83

Note: Values are in percentage points (%); SD: Strongly disagree; D: Disagree; NAD: Neither agree nor disagree; A: Agree; SA: Strongly agree; SS: Sum of scores; MS: Mean of scores

and ranked them according to their severity (Table 2). The percent position of each rank was converted into scores using Garrett's table (Table 3a). The mean scores of all constraints were arranged to make the final ranks, thus attributes with the highest mean score were considered as the most influencing factor. The results in table 3 showed that skill gap, the complexity of the technology and being pessimist in new technology were the top three challenges experienced by farmers to apply the full technology package in Teff production.

Table 3: Constraint in the new teff technology package application

Constraints	Rank						Total sample	Total score	Total mean	Rank
	1	2	3	4	5	6				
The technology is totally complex	40	26	53	20	17	26	182	572	95.3	2
Row sowing is time taking	63	53	33	7	26	-		427	71.1	5
No experience (Technical skill gap)	-	26	60	40	33	23		579	96.6	1
Labour shortage	83	53	20	10	17	-		371	61.9	6
Higher cost of production	56	53	30	33	10	-		433	72.1	4
Being pessimist on new technology	23	33	56	46	23	-		536	89.3	3

Table 3a: Percentage positions and their corresponding Garett's table values

Ranks	Percentage position		Garrett table value
1	100 (1–0.5)/6	8.3	77
2	100 (2–0.5)/6	25	64
3	100 (3–0.5)/6	41.7	55
4	100 (4–0.5)/6	58.3	46
5	100 (5–0.5)/6	75	37
6	100 (6–0.5)/6	91.7	23

3.4. Stakeholders' linkage and technology exchange

Sharing duties among stakeholders would consolidate the triple linkages of farmers-extension-research, and that was in turn vital to sustainable technology promotion. Therefore, in this study, about 43.6% participant farmers hand over the new teff technology to interested fellow farmers. The agricultural experts at different levels were also handling tasks to facilitate technology dissemination via continuous follow-up and consultation. Being an innovative stakeholders, different NGOs were involved in technology dissemination to other areas. The cooperation among concerned actors in the promotion boosted compared to preceding years, and the strengths, weaknesses, opportunities, and threats in the process were described below (Table 4). Moreover, the solid seed exchange system took the front line in the diffusion of improved varieties (Mihiretu and Assefa, 2019), hence 43.6% pre-scaling participant farmers delivered the variety for interested fellow farmers in different arrangements. The amount of seed disseminated to interested farmers in/outside the study areas by participant farmers was 648 kg (Figure 1).

Table 4: SWOT analysis of stakeholders' linkage in new teff technology promotion and diffusion

	Farmers	Experts	Researchers
Strengths	• Had high technology demand • Good contact with stakeholders throughout the promotion process • Sowing in cluster and use as seed source	• Good contact in the promotion process • Including NGOs in the process • Inviting media for broadcasting	• Good contact in the promotion process • Avail inputs and training on time • Collect and analyse the data on time
Weaknesses	• Gap in technology package application • Problem of maintaining the seed quality	• Scarce follow-up by the nearby actors • Stumpy technical backup to farmers	• Stumpy technical backup to farmers
Opportunities	• Presence of NGOs working on technology upscaling • Technology usage suits the government's focus on rising production • Farmers have good information and experience with Teff • Existence of seed exchange culture in the community via local arrangements, i.e. cash, kind, free for non-eligible		
Threats	• Being dry land, low and erratic rainfall with high temperature • High-risk experience of drought occurrence • Stumpy willingness for inputs due to the expensive price • Increasing dependency on relief food aids		

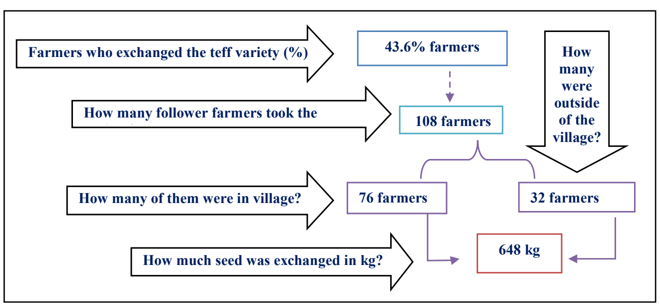

Figure 1: Seed exchange and diffusion network of the new teff technology

4. CONCLUSION

The innovative technology demonstrated significant advantages over the existing production practices, both in grain and straw yields. This was achieved despite challenges such as skill gaps, complexity of the new technology, and initial skepticism among participating farmers. Providing comprehensive training and information about the new teff technology was thus facilitate its expansion to similar areas. Additionally, organizing closing workshops to connect stakeholders was advisable to develop strategies for disseminating the technology to a broader community in sustainable manner.

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6. REFERENCES

Anonymous, 2016. Database of Agricultural Production, FAO Statistical Databases (FAOSTAT) 2016. Available from: http://faostat.fao.org/default.aspx. Accessed on: April, 2024.

Anonymous, 2022. The Federal Democratic Republic of Ethiopia Central Statistical Agency Agricultural Sample Survey Crop and Livestock Product Utilization (Private Peasant Holdings, Meher Season); ESS: Addis Ababa, Ethiopia, 2021. Available from: www.ess.gov.et. https://www.scirp.org/reference/referencespapers?referenceid=3309990. Accessed on: February, 2024.

Assefa, K., Cannarozzi, G., Girma, D., 2015. Genetic diversity in teff *[Eragrostis tef (zucc.) trotter]*. Frontiers of Plant Science 6(1), 177. DOI: https://doi.org/10.3389/fpls.2015.00177.

Azeb, B., Tadele, M., Latha, D. A., 2017. Determinants of smallholder farmers in teff market supply in Ambo district, West Shoa Zone of Oromia, Ethiopia.

International Journal of Advanced Research in Management and Social Sciences 6(2), 133–140. Available from: https://garph.co.uk/IJARMSS/Feb2017/10.pdf.

Bachewe, F., Dereje, M., Bart, R., Alemayehu, M., Taffesse, S., Tamru, S., 2019. The transforming value chain of Ethiopia's "orphan" tef crop. Planta 250, 769–81. DOI: https://doi.org/10.1007/s00425-019-03224-0.

Bayable, M., Tsunekawa, A., Haregeweyn, N., 2020. Biomechanical properties and agro-morphological traits for improved lodging resistance in Ethiopian te/ (*Eragrostis tef* (Zucc.) Trottor) accessions. Agronomy 10(7), 1012. DOI: https://doi.org/10.3390/agronomy10071012.

Bekele, A., Chanyalew, S., Damte, T., Assefa, K., Tadele, Z., 2017. Lead farmers approach in disseminating improved tef production technologies. Ethiopian Journal of Agricultural Sciences 27(1), 25–36. Available from: https://www.ajol.info/index.php/ejas/article/view/150333.

Belachew, K.Y., Maina, N.H., Dersseh, W.M., Zeleke, B., Stoddard, F.L., 2022. Yield gaps of major cereal and grain legume crops in Ethiopia: a review. Agronomy 12(10), 2528. DOI: https://doi.org/10.3390/agronomy12102528.

Hashimoto. T., Perlot, T., Rehman, A., Trichereau, J., Ishiguro, H., Paolino, M., Sigl, V., Hanada, T., Hanada, R., Lipinski, S., 2012. ACE2 links amino acid malnutrition to microbial ecology and intestinal inflammation. Nature 487, 477–481. DOI: https://doi.org/10.1038/nature11228.

He ,T., Li, C., 2020. Harness the power of genomic selection and the potential of germplasm in crop breeding for global food security in the era with rapid climate change. Crop Journal 8(5), 688–700. DOI: https://doi.org/10.1016/j.cj.2020.04.005.

Mihiretu, A., Abebaw, L., 2020. Scale-wide evaluation and promotion of improved te/ technologies under dry land scenario: economic pro3tability, farmers' preference and constraints in Northeast Amhara, Ethiopia. Cogent Food & Agriculture 6(1). Article ID 1746228. DOI: 10.1080/23311932.2020.1746228.

Mihiretu, A., Asresu, M., 2022. Inclusive technology performance evaluation in the production of teff (*Eragrostis tef* (Zucc.) Trotter). Advances in Agriculture 6(1), 9031999. DOI: https://doi.org/10.1155/2022/9031999.

Mihiretu, A., Assefa, N., 2019. Comparative evaluation and demonstration of field pea production practices in intermediate altitudes of Northeastern Amhara, Ethiopia. Turkish Journal of Agriculture-Food Science and Technology 7(11), 1901–1907. DOI: https://doi.org/10.24925/turjaf.v7i11.1901-1907.2857.

Mihretie, F., Tsunekawa, A., Bitew, Y., Cheklia, G., 2020. Teff [*Eragrostis tef* (Zucc.)] rainfed yield response to planting method, seeding density, and row spacing. Agronomy Journal 113(1), 111–122. Available from: https://www.cabidigitallibrary.org/doi/full/10.5555/20210147085.

Ortiz-Bobea, A., Ault, T.R., Carrillo, C.M., Chambers, R.G., Lobell, D.B., 2021. Anthropogenic climate change has slowed global agricultural productivity growth. Nature Climate Change 11(3), 06–12. DOI: https://doi.org/10.1038/s41558-021-01000-1.

Ruiz-Giralt, A., Nixon-Darcus, L., Andrea, A.C., Meresa. Y., Biagetti, S., Lancelotti, C., 2023. On the verge of domestication: early use of C4 plants in the Horn of Africa. In: Proceedings of the National Academy of Sciences (PNAS). DOI: https://doi.org/10.1073/pnas.2300166120.

Woodhill, J., Kishore, A., Njuki, J., Jones, K., Hasnain, S., 2022. Food systems and rural wellbeing: challenges and opportunities. Food Security 14, 1099–1121. DOI: https://doi.org/10.1007/s12571-021-01217-0.