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Pre-extension Demonstration of Banana *(Musa spp.)* Technology with Supplementary Irrigation under Farmers Management at Gofa and Basketo Zones of Southern Ethiopia

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Abstract: Although Gofa and Basketo Zones have diverse agro-ecologies that are suitable for different fruits including banana, their coverage is very limited. Based on this, Arba Minch Agricultural Research Center has conducted banana technology from 2022 to 2024. The aim of this activity was variety demonstration and sucker multiplication. Based on banana production potential,1 Kebele selected from each district. A total of 14 farmers were selected for the demonstration based on their willingness to participate in the activity. Training sessions for target and non-target farmers, Development Agents and other stakeholders were provided at both districts. A total of 850 William -01 suckers have been delivered to 14 farmers. The suckers were planted in planting holes of 60 cm deep with 2.5 m and 3 m distances between plants and rows respectively. Data were collected through measurements and Focus Group Discussion. As a result, the average fruit yield from Salayish-01 and Angile-03 Kebele's were 28.07 and 28.95 tha-1 respectively. Farmers were fetching good income from banana technology. Farmers' perception of the demonstration showed that the technology is viable and in demand by many farmers. Therefore, the extension system of the area should access and scale up William-1 banana to the wider community and similar agro-ecology under irrigation production system.

Keywords: Banana, Basketo, Fruit Yield, Farmers Management, Melo-Koza, Method Demonstration, Supplementary Irrigation, Sucker, William-01.

Research Paper

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INTRODUCTION

Banana (Dessert banana and plantain *(Musa sp.)* is a major fruit crop grown in many developed and developing countries (Molla, 2017) and globally, it is the fourth most important crop of the food market next to rice, wheat and maize (Zenebe *et al.*, 2015).It can be cultivated in a temperature range of 10° C to 40° C with an average temperature from 20-30° C and 100 mm of average monthly rainfall distribution. Temperature below 10° C is unsuitable and leads to choke or impeded inflorescence and bunch development. Chilling injury occurs at temperatures below 12º C. Banana can also grow in frost free cold areas. (Molla, 2017). Banana can be grown in all types of soils. Heavy, clayey soils are suboptimal, especially if they are low in organic matter and aeration. Soil must not be compact. Banana is highly nutritious and easily digestible than many other fruits. Digestion time of banana fruit is less (105 min) than apple (210 min) (Sharrock and Lustry, 2000). Bananas are considered as a rich source of vitamin A, vitamin B complex, vitamin C, manganese, potassium and digestible food fibers are present in the fruits in sizeable levels (Elayabalan *et al.*, 2017). The fruit is easy to digest, free from fat and cholesterol. Banana powder is used as the first baby food. It helps in reducing risk of heart diseases when used regularly and is recommended for patients suffering from high blood pressure, arthritis, ulcer, gastroenteritis and kidney disorders.

In Africa, banana production is falling in East and West Africa, where it is a fundamental subsistence and food security crop. In this regard, Ethiopia is the major banana producer, following Tanzania, Rwanda, Kenya, Burundi, Sudan, Malawi, and Uganda (FAOSTAT 2021).

In Ethiopia, the modern banana production was started at the beginning of this century with the establishment of the state farms and different plantations such as large-scale sugarcane plantations. The crop grows in various parts of the country in the form of home garden crop at a household level to large scale plantations (Zinabu *et al.*, 2019). The production system of the crop is mainly composed of small plantations in home gardens owned by small farmers-especially in the South-Western and Western states; medium-sized plantations of not more than 10 hectare supplying local consumers; and relatively large plantations above 20 hectare developed to supply export markets. The export business of banana in Ethiopia dates back to 1961 where the country started at about 5,000 tones. This figure, however, increased to 60,000 tones by the year 1972 when the country exported to different countries of Europe, Asia and Africa. In 1975, the total production of banana in the country has reached about 100,000 tones. At present it is believed to cover about 86% (478,251.04 tones) of the total fruit production.

Nowadays in Ethiopia, banana is produced throughout the country wherever there is adequate rainfall or irrigation practice. In Ethiopia 2022/23 production season about 95,954.13 ha of land were covered by banana and 8,983,548.19 Qt yield obtained. From these 61,705.80 ha were covered in South Ethiopia region the leading banana producer and about 5, 98,031.05Qt total yield were gained which covers 40% of the country's total production (CSA,2023). However, A summary report by (Nicholas, 2013) based on a baseline survey results of the Agricultural Transformation Agency of Ethiopia (ATA) indicate that the average yield and revenue obtained from banana sales by banana growing households in Ethiopia is only 8,759 kg/ha and 21.3 Birr/year respectively. As stated by (Tekle *et al*., 2014), inputs of production, agronomic and management practices, lack of improved varieties is as well one of the critical factors that affect the production and productivity of banana in Ethiopia. Lack of skills on banana ripening and handling as well as transporting, low supply of improved banana varieties (Tinzaara *et al*., 2021). As a result, the productivity of banana in most places in Ethiopia is 5-8.95 tons/ha which is far below the world average of 15.8 tons/ha (FAOSTAT, 2012).

In the country, the Southern Ethiopia region is the major banana-producing region and cultivated more than15,358 hectares of arable land with more than 118,358 tons of production in 2020 (CSA 2021). The area coverage and productivity of major fruits including banana is indicated hereunder (Table 1).

Table 1: Area coverage and productivity of major fruit crop history in Melokoza and Basketo district in 2024

		Laska Zuria				Melo-Koza			
No.	Fruit type	Variety	Introduction year	Coverage /ha	Productivity/ha in Qt	Variety	Introduction year	Coverage /ha	Productivity/ha
1	Tomato	Unknown	2012	20	200	Unkonwn	2012	20	200
2	Onion	Red bombe	2008	50	180	Red Bombe	2008	50	180
3	Mango	Local	-	450	190	Local	-	450	190
4	Banana	Dwarf Cavendish	15	7000	220	Dwarf Canvedish	2015	7,000	220
5	Avocado	Local	-	6500	230	Local	-	6,500	230

Source: Melokoza and Basketo districts, Agricultural office record, 2024

Banana account 12.3% of fruit production at Melo-Koza and 9.78 % at Basketo and ranked 2nd most important fruit of the area in area coverage and production.To solve this problems, Arba Minch Agricultural Research Center conducted the adaptation trial for 8 improved banana varieties which include Dwarf Canvedish, Medium Canvedish, Giant Canvedish, William 01, Grand Nain,Psang Sri, Psnang Raj and Red banana and the William 01 adapted and variety performed best in lowland areas of Gofa and Basketo Zones. The main aim of undertaking Pre Extension Demonstration of banana is enhancing the diffusion and adoption of the technology to increase production and productivity.

Objectives

- To increase the level of awareness of farmers on banana production and management.
- To analyze costs and benefits of the banana technology under farmers' conditions.
- To assess farmers perception towards the banana technology.

MATERIALS AND METHOD

Description of the Study Areas

The activity was implemented in Basketo Zuria and Melo-Koza district among potential banana producing districts of Southern Ethiopia in 2022-2024 cropping season. The study areas were selected based on the potential and area coverage of the crop. The selection

was done in collaboration with district experts of the respective offices of Agriculture.

Geographically, Melo-Koza district located in latitude of 6°30′N and longitude 36°40′E.The district has 3 agro-ecologies, Dega (21.73%), Woyna Dega (52.43%) and Kola (25.84%). The soil of the district is mainly clay-loam (50%), sand-loam (35%) and clay (15%). The district has 2 rain-seasons, 'Meher' season (from July to Oct) and 'Belg' season (from last week of Jan to April). The average annual rainfall is 950 mm. The average annual temperature is 21.3 °C. The major crops grown are maize, wheat, sorghum, common bean, and teff. The potential fruits of the area also include avocado, banana and mango.

Geographically, Basketo Zuria District is also located in latitude of 6°14'60.00" N and longitude of 36°34'59.99" E. Altitude ranging from 780-2200 metres above sea level; average annual rain fall is 1200 mm with average annual temperature of 21ºC which is considered as suitable rainfall for common bean production. The soils of the district classified as 18% clay, 52% loam and 30% sandy in all agro-ecologies (Kiflu, 2015). The type of soil on which the demonstration conducted is vertisol. The major crops grown in the area include teff, maize and common bean and sorghum. The potential fruits of the area also include avocado, banana and mango. The general features of Melokoza district and Basketo Zone map is described below in (Figure: 1).

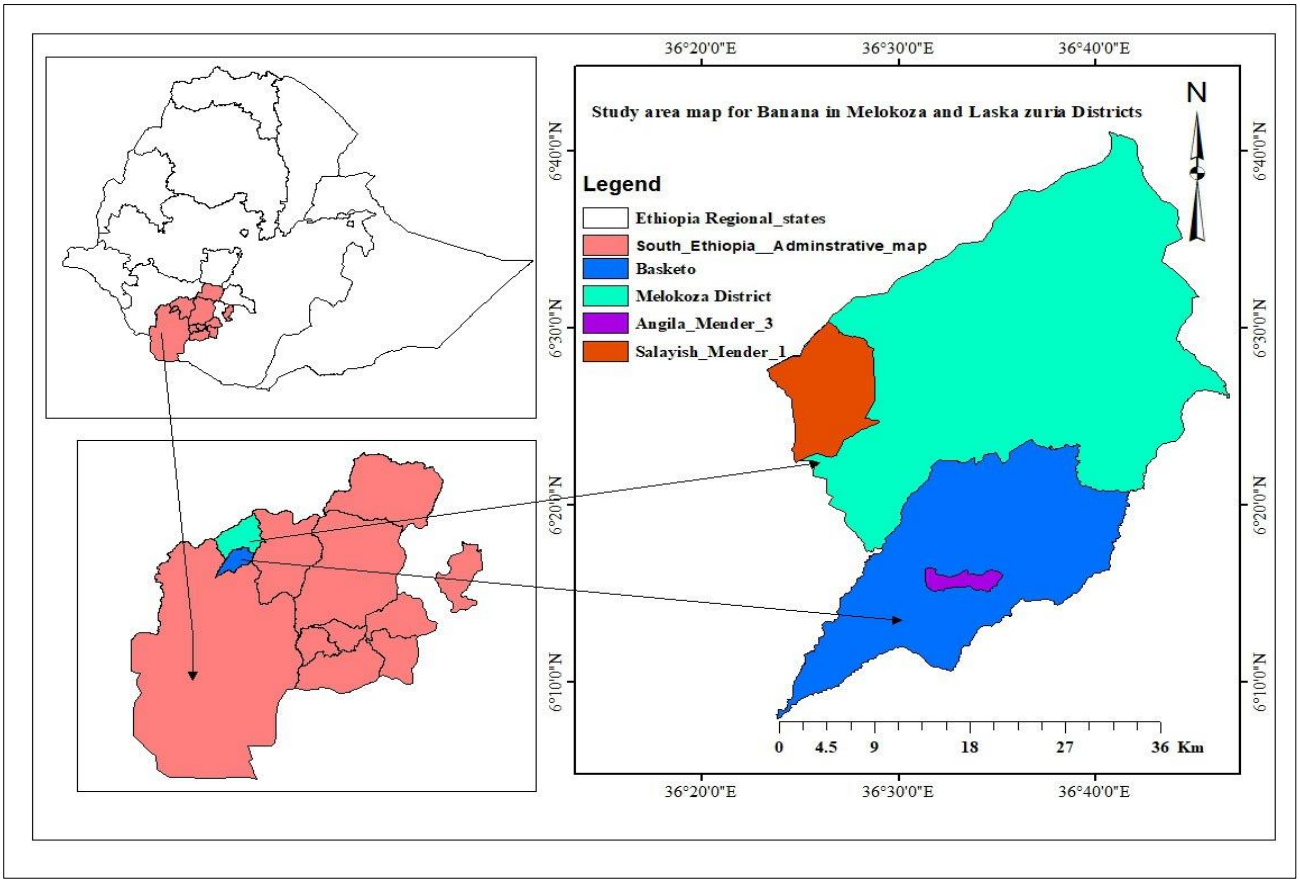

Fig. 1: Map of the study area

Descriptions of the Variety

Williams is exotic variety of Musa species cultivar (group). It is one of the Cavendish group originated from Australia.

Location, Site and Farmers' Selection

The Laska Zuria district in the Basketo zone and the Melo-Koza district in the Gofa Zone were purposively selected based on potential of banana production and irrigation access. From each district, 1 Kebele was selected. 30 representative farmers (15 from each Kebele) were purposively selected based on availability of land, access to irrigation and willingness to manage field. Based on this, more than 10,384 suckers of Wiliam banana varieties were delivered and planted on 7.114 hectares of farmers' land at each district (Table 2).

Table: 2 Area covered and number of participant farmers in the demonstration

No	Zone	District	Kebele	No of participants	Sucker provided in number	Remark
1	Gofa	Melo-Koza	Salayish M-01	18	450	25 sucker for each
2	Basketo	Laska Zuria	Angila M-03	16	400	
3	**Total**			**34**	**850**	

Implementation Procedures

To integrate active and passive farmers and also include follow farmers, Farmer Research Group (FRG) approach was employed in which none FREG farmers and concerned stakeholders were encouraged to participate in the technology demonstration and promotion process. Accordingly, one FREG in every selected scheme was established with 12 members. During FREG establishment all categories of gender were considered (i.e., adult men, adult women, young men, and young females). Selection of farmers to be held in FREG was considered on farmers' willingness to be held as members, good history of compatibility with groups, and commitment to share innovations with other farmers.

Before starting the implementation of the activity, training was provided for 43 farmers, 4 Kebele level Development Agents' and 4 District level experts, 6 administrative bodies on techniques of banana production (use of specialized equipment during weeding, irrigation water application, irrigation scheduling), sucker hoeing, manure application, post-harvest handling (storage and ripening issue), post-harvest management, preparation for market issues, canopy and pest and disease management including fungicide recommendation(Table:3). Desuckering (cutting off unwanted shoots from the stems of the mother banana plant) was also one of the trained titles covered.

Table 3: Number of training participants

Participants	Laska Zuria			Melo-Koza			Total		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
Development Agents	2	0	2	1	1	2	3	1	4
Administrative bodies	3	0	3	3	0	3	6	0	6
District level Experts	2	0	2	2	0	2	4	0	4
Farmers	20	2	22	20	1	21	40	3	43
Total	**27**	**2**	**29**	**26**	**2**	**28**	**53**	**4**	**58**

Research Design and Agronomic Practices

0.018ha from each participant farmer plot size was provided from each farmers from the 2 Districts. Each farmer's field was considered as replication of the trial. The demonstration site cleared and ploughed by man power to a depth of 25-30 cm and allowed to dry for 2 weeks before planting. 25 banana suckers of William-01 was delivered for each farmers from Arba Minch Agricultural Research Center. After land preparation, hole preparation and planting depth with 50 cm diameter and 50 cm depth are dug using the recommended spacing. Then, the sucker is placed and sub-soil is returned 25 suckers of Willium-01 was planted on single plot basis by using raw planting method to make a unit plot area in spacing of 3 m between rows and 2.5 m between plant (Singh *et al.,* 2014). Manure application frequency is 10Kg per plant during planting**,** 2nd and 4th month after planting. Since the area is arid, supplementary irrigation of every 3 days in summer and every 8 days in winter was applied.

Spacing of 3.0m b/n row and 2.5m b/n plant in sole cropping system, sucker rate 1600 sucker/tree per hectare: 1 sucker/ hole with planting hole: 0.9 m wide x 0.6 m depth (knee height) and fertilizer rate: -@ 10 kg/plant manure/cow dung intervals from 60th day after planting upto 320 days .Weed management is hand method using a hoe to cover the exposed rhizomes and avoid weed.

Supplementary Irrigation Water Management

Banana needs 120-150 mm monthly rainfall. In time of mean annual rainfall below 1500 mm, it needs supplementary irrigation. Every 3 days in summer and every 7 days in winter was applied in this demonstration.

Method of Data collection

The agronomic data was collected by the researchers directly from the field. Frequency of harvest, number of bunches per plant, the total number of bunches per plot, the weight of bunch per Kilogram and the selling price of a 1-Kilogram banana were the data types collected by using measurements, counting and interview using data sheet. Fruit yield data: Sample taken from the 10 banana tree found at (62.5m2) from each sample field.-10 for fruit yield considered to compensate yield loss like cattle damage and others. The weight of bunch in Kg and the selling price of a 1-Kg banana collected by measurement & interview. The data on number of farmers and other stake holders participated on training and field day was also taken from each district. In addition, perception and lessons learned data was collected using Focus Group Discussion.

Method of Data Analysis

The collected data was analyzed by using simple descriptive statistics such as mean, frequency and percentage and farmers perception was analyzed by using Likert scale. The costs and benefits of the banana technology was analyzed using benefit-cost ratio. The net income for each treatment was computed by subtracting all the production costs from the gross incomes. All calculations were undertaken, based on a unit area of 1 ha, according to Cetin *et al*., (2008).

$$\text{Benefit Cost Ratio} = \frac{\text{Net return from banana Production}}{\text{Total cost to banana production}}$$

Monitoring and Evaluation and Field Day

The method demonstration assumes the acceptance of a practice and focuses on teaching how to apply the technology/practice. In method demonstration, the purpose is to show how to complete a task. A field day for wider demand creation and experience sharing, joint monitoring and evaluation for effective implementation, mass media for advocacy of the events were organized and implemented. Extension materials like banners, posters, brochures, leaflets were used for the demonstration. Farmers and researchers work together on the implementation of trials, and evaluation. By combining informal research by farmers with formal participatory testing procedures, indigenous knowledge, and science-based knowledge were mixed to meet farmers' needs.

RESULTS AND DISCUSSION

Fruit Yield Performance of Banana in the Study Areas

Whereas the minimum number of finger per bunch (101). On the other hand, the average length of randomly sampled fingers showed that the longest finger (16.54 cm) that gave fruit yield of 640 to 750 quintals per ha per year were promoted. The highest number of finger per bunch (142) was recorded. They were able to get about 160 to 180 fingers of banana per bunch, 22 to 34 Kg of banana fruit yield per tree and 28.7 and 28.97 tha-1 fruit yield per hectare was recorded from Melo-Koza and Laska Zuria district respectively (Table:4). The result is greater than the adaptation trial yield (25.76 tone/ha-1) at Chano Mile site of Arba Minch Zuria District and also national banana productivity (25.4 tonha-1) in 2023 (CSA,2023). Tesfa Binalfew and Mekias Damtew (2015) also indicated that the highest fruit yield (20.1 tones ha-1) was obtained by Willium-1.

Table 4: Fruit Yield of Willium-1 in toneha-1/year (n=34)

No	District	Mean fruit yield (toneha-1)	Standard Deviation
1	Melo-Koza	28.07	0.23
2	Laska Zuria	28.95	0.29
	Grand Mean	28.51	

Sucker Yield Performance of Banana in the Study Areas

Farmers increased sucker yield from 850 to 4,462 in the 2 locations (Table 5).

Table 5: Number of sucker from the demonstrated banana (n=34)

District	Initially delivered in 2023	Sucker/farmer/year on average	Currently in 2025	Difference	
				Increase in umber	%
Melo-Koza	400	150	2,400	2,000	16
Basketo	450	152	2,912	2,462	17.2

Fig. 2: Sample sucker yield performance photo from Melo-Koza district

Costs and Benefits of the Banana Technology at the Study Area

Land was provided by the farmers as their own and the other related costs include purchase of sucker, hired labor and others calculated as follows. The cost benefit analysis includes the production cost of banana and the earnings from selling of banana fruits and suckers. The average net profit from 1 hectare of land was 244,900 ETB in Laska Zuria and 236,100 ETB in Melo-Koza District. Mean income from the sale of sucker in 2 locations from 2022 to 2024 is no much difference in locations. The net benefit of banana in Laska Zuria is higher than in Melo-Koza indicating that, the difference might be farmers management practices. The technology was profitable at both locations (Table 6).

Table 6: Cost Benefit Analysis of banana technology per farmer at Laska Zuria (n=10)

No	Variables	Unit	Districts	
			Laska Zuria	Melo-Koza
1	Total banana fruit yield obtained ha-1/year	tone	28.95	28.07
2	Farm gate (Selling) price of 1 Kg banana fruit (ETB/Kg)	ETB	10	10
2	Average banana suckers sold/ha-1/ year	Numbers	400	400
3	Unit cost of sucker	ETB/Number	10	10
4	Income from sale of fruit ha-1/year	ETB	289,500	280,700
5	Income from sale of sucker ha-1/year	ETB	400* 10=4,000	400* 10=4,000
	Gross Returns (GR)	ETB	293,500	284,700
1	Purchase of suckers	ETB/ha-1	15*1,600= 24,000	15*1,600= 24,000
2	Land preparation	Person per day	25*200=5,000	25*200=5,000
3	Planting	Person per day	10*200=2,000	10*200=2,000
4	Irrigating (48 times/year)	Birr/ha-1	48*200=9,600	48*200=9,600
5	Weeding (Round)	weeding/year	4*10*200=8,000	4*10*200=8,000
	Total Variable Cost (ETB/ha) TC		48,600	48,600
	Net Return (GR-TC)		244,900	236,100
	Benefit Cost Ratio		5.04	4.85

Farmers Perception

Farmers were asked to respond from 1-5 on each attribute of the crop where 1= very poor 2= poor 3= average 4= good and 5= very good towards the William-1 banana based on 6 criteria's. Plant height, fruit yield, fruit sweetness, bunch size, résistance to disease, number of sucker. After scoring, each value of the score were added and divided to the number of the parametrs listed by the farmers. The mean score at the 2 locations at farmer's field indicates that farmers selected the Willium-1 banana technology near to good (Table: 7). Its fruit is very sweet with a good aroma, suited for long distance transportation, large bunch size with well-developed fruits. Low susceptibility to *Fusarium*, suitable for wind prone areas at garden, crop duration from planting to harvest, medium crop duration (10-12 months), 8-12 hands each hand with 11-18 fingers. Medium plant height, excellent bunch size and finger thickness, large number of suckers per plant. The negative perception of the farmers on the variety include it needs stick to support the stem during maturity.

Table 7: Farmers perception at the 2 district

Districts	Parameter's							
	PH	FY	FS	BS	RD	NS	Total Score	Mean Score
	5	4.84	4.86	4.4	4	4	36.1	4.51
Melo-Koza	4.43	4.14	4.71	3.86	3.14	5	33.93	4.25

Note: PH=Plant height, FY=Fruit Yield, FS=Fruit Sweetness, BS=Bunch size, RD=Resistance to disease, NS=Number of sucker.

Almost all participant farmers in the demonstration do not know planting space and irrigation water frequency in banana production (Table 8).

Table 8: Farmers awareness on the recommended practices of banana technology (n=34)

No	Recommendations	No of farmers who do not know before			percentage
		M	F	T	
1	Spacing	14	--	14	100
2	Irrigation water application frequency	14	-	14	100
3	Planting hole depth	5	-	5	30

No	Recommendations	No of farmers who do not know before			percentage
		M	F	T	
4	Compost application	7	-	7	50
5	Disease management	8	-	8	62.5

Challenges Faced

- Shortage of water for irrigation during dry seasons
- Lack of organized market and market linkage at Laska Zuria district by the case of road problem to other area, because of this farmers sell your bananas on the streets or at a roadside stall
- Frequent turnover of Kebele level Development agents for continuous follow up and communication

Opportunities

- High demand for banana/ fruits in the locality specially at Melo-Koza.
- Government emerging support for horticultural sector.
- Presence of suitable agro ecology, which is suitable to produce fruits.
- Availability of land for banana production.
- Used as a source of income for youths, unemployed, and farmers etc.

Lessons Learned

- It was confirmed that the neighboring farmers did also plant new banana fields taking suckers from the initial beneficiaries
- Expansion of banana plantation within the selected locations and outsiders is also another great achievement
- The performances of improved banana variety on farmers' fields with farmers' own management were excellent
- Feedback assessment from Monitoring and Evaluation frequent field visit and field days showed that demand was created on the improved banana technology
- Access to the banana sucker was partially solved
- The farmers will be used as learning place and seedling/sucker source for other potential banana-growing areas

CONCLUSION AND RECOMMENDATIONS

Pre-extension demonstration of banana technology was conducted at Melo-Koza and Laska Zuria District of Gofa Zone and Basketo Zones respectively which was selected purposively based on banana production potential and access to irrigation from 2022 to 2024. Accordingly, 16 farmers from Melo-Koza and 18 farmers from Laska Zuria District selected for the demonstration. Capacity building theoretical and practical training, periodic monitoring and evaluation, mini field days undertaken. Farmers were able to get 28.07 from Laska Zuria and 28.95 tone ha-1 of banana fruit from Melo-Koza district respectively. The performances of William-1 on farmers' fields with farmers' own management was excellent. Frequent field visit and field days showed that demand was created on the improved banana technology played roles for the successes of the banana demonstration. Participant as well as other farmers committed to multiply suckers to other fields even out of the district. About 850 banana suckers of Willium banana variety was delivered and planted on 7.114 hectares of farmers' fields. The technology was profitable and highly demanded by farmers at both locations. Hence for the farmers of Basketo and Melo-Koza Zones wherever there is irrigation opportunity; engaging in banana production is an advantage, both for consumption and income generation. This achievement should be scaled up to other banana and fruits potential areas of the Melo-Koza and Laska Zuria Districts by the District extension system to enhance production and productivity of banana in the area.

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Authors Contribution

LL: Conceptualization, material preparation, writing the original draft and editing analyzed data and wrote the whole manuscript, ANB, ME, AB: and CHDN investigatate the field, data curation, reviewed the whole manuscript. All authors approved the complied and submitted version manuscript.

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