

2019 - 2023

SLARI ANNUAL REPORT



SIERRA LEONE AGRICULTURAL RESEARCH INSTITUTE

ANNUAL REPORT FOR 2019 – 2023

VISION

The Sierra Leone Agricultural Research Institute (**SLARI**) guiding vision requires the institute and its stakeholders and partners to stretch their future expectations, aspirations, and performance to achieve **“improved and sustainable broad-based agricultural growth”**.

MISSION

The mission statement that expresses the functional purpose of SLARI is **“to enhance sustainable productivity, commercialization, and competitiveness of the agricultural sector through generation and promotion of innovative agricultural technologies and empowerment of stakeholders”**.

WHO WE ARE

The Sierra Leone Agricultural Research Institute (SLARI) is a national research organization working in partnership with the Ministry of Agriculture and Food Security (MAFS), farmers, the private sector, civil society, and other rural development stakeholders, to significantly and sustainably improve the productivity and incomes of resource-poor farmers in Sierra Leone. Beyond its local partners, SLARI also works with various international partners to reduce poverty and unleash the country’s agricultural potential.

The SLARI, along with its partners, is committed to generating and promoting innovative agricultural technologies and empowering stakeholders to enhance the sustainable productivity, commercialization, and competitiveness of the agricultural sector.

The core functions of SLARI include:

- i. To provide information that will assist the government and other stakeholders in the development of agricultural policies for poverty alleviation, food security, and improved livelihoods of the citizens of Sierra Leone.
- ii. To formulate agricultural research policies and programmes taking into account the vision, mission, goals, and objectives of the agricultural sector, in line with government policy, and views of stakeholders, especially those related to sustainable food security, and conservation of renewable resources of Sierra Leone.
- iii. To conduct research on food and cash crops production, livestock production and health, fish production, land and water management, forestry production and conservation, food and nutrition management, technology and socioeconomics of postharvest activities, emerging technologies in agricultural science, bio-safety, and environmental conservation.
- iv. To establish a strong working relationship with extension agents in the public and private sectors in the transfer of technology.
- v. To facilitate and provide the relevant training and manpower development to serve the agricultural needs of the country.
- vi. To produce annual reports highlighting research findings, management, scientific training, and financial aspects of the institute.
- vii. To establish strong links with national, regional, and international agricultural research institutions or agencies involved in science and technology development and transfer.
- viii. To represent the country in regional and international fora.
- ix. To enhance public awareness of the importance of scientific research to agricultural and economic development.
- x. To disseminate knowledge on improved technologies to stakeholders.
- xi. To monitor and evaluate the impact of the adoption of agricultural research on agricultural productivity.
- xii. To process and forward to the government the annual estimates for funding.

- xiii. To mobilize human, financial and capital resources from donors, the private sector and from within the institute to facilitate the work of SLARI.

MESSAGE FROM THE ACTING DIRECTOR GENERAL

Dear Colleagues,



Dr. Abdul Rahman Conteh

I am thankfully grateful for your support accorded to me during the last year. I appreciate and commend your hard work, commitment to excellence, and dedication to meeting SLARI's goals. Last year was fraught with numerous challenges for SLARI; however, we all rose to the occasion and made sure that the institute strives to meet its objectives and commitments. This shows the resiliency of staff and the organizational culture of excellence in SLARI. Management wishes to encourage all staff to contribute their very best in ensuring that SLARI meets its goals and objectives at all times.

Everyone must contribute his or her share through individual and collective resolve to improve our performance and commitment to excellence at all levels.

We continue to reposition SLARI for the task ahead by reviewing our outdated Strategic, Operational, and Investment Plans and Capacity Needs Assessment Report. The hired Consultant has begun work and is expected to finish the 10-year OP and SP (spanning from 2025-2034) by the end of July 2025. The document is expected to capture emerging issues in the agricultural space, making sure that our vision of success aligns with that of the Agricultural Development Agenda of the Government of Sierra Leone through its flagship programme – **Feed Salone Programme**.

The focus has been on:

1. Developing a stronger organizational structure with a redefined focus on research-for-development, partnership, and capacity building.
2. Strengthening the SLARI centres, revamping the Freetown Fisheries Research Centre (**FFRC**) and establishing new ones, replacing retired, deceased and staff that have resigned, as well as recruiting new scientific staff and facilitating technical assistance contracts with IITA and AfricaRice through FSRP by mentoring our young scientists to become greater scientists for new and emerging programmes and projects.
3. Upgrading the knowledge and skills of our valuable technicians and scientists through short-term attachments in international research centres and in workshops and training programmes of our international partners.
4. Aligning our research programmes with that of the Government's Agricultural Development Agenda, and CORAF/WECARD, FARA, ECOWAS, as well as CAADP principles for research for development, and working more collaboratively with other scientists, centres, and partners in the SLARI system.
5. Mobilizing resources by tapping from traditional funding sources, and non-traditional funding sources such as FSRP, AfricaRice, EU, AGRA, NGOs, etc., to ensure that the institute is prepared to take on more challenges.
6. Building a stronger SLARI team and raising staff morale through energized efforts in striving for better conditions of service that are equivalent to or better than the universities, and striving to clear backlog salaries and benefits.
7. Building new relationships, forging and strengthening partnerships to ensure that the right technologies are developed, disseminated, and adopted by our end users.

All these will continue to lead to a stronger organization with a more relevant and focused science-based platform, responsive staff, and more effective institutional mechanisms to ensure efficiency and effectiveness in operations. It will foster proactive and more strategic relationships and networks, along with an increase in non-traditional resources, replacement, and recruitment of more scientific staff to support the success of its research-for-development programs.

The path ahead will continue to be fraught with challenges, but together, we will be able to overcome them. Let us celebrate our successes, but at the same time continue to work harder together towards achieving our goals. I envision more productive years ahead and a stronger SLARI in the future.

Thus, I encourage everyone to be diligent and make sure that SLARI succeeds in its goal of being the leading national research-for-development partner in Sierra Leone in finding solutions to hunger and poverty.

On behalf of Management and Council of SLARI, I wish every staff member good health, wealth, happiness, and another successful year 2024. I look forward to a productive Annual Review and Work planning for 2024.

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OVERVIEW

The agricultural sector in Sierra Leone is not only a means of livelihood for a significant portion of the population but also has tremendous potential to serve as the engine for the country's socio-economic growth and development. The performance of agriculture heavily depends on nearly all other sectors of development. If such a huge socio-economic gain is to be realized, agricultural research unarguably has a vital role to play.

Agricultural research in Sierra Leone has made significant contributions towards the improvement of agricultural productivity and rural development in the past. To strengthen the role of the forestry sector, the government established the Sierra Leone Agricultural Research Institute (SLARI) through an Act of Parliament in 2007 as the country's primary agricultural research and technology-generating body for the benefit of the farming, fishing, and forestry sectors. For its full operations, SLARI needs eight research centres spread throughout the country, of which six are currently fully operational.

Considering the developmental strides at the national, regional, and international levels, SLARI is currently revising the old strategic and operational plans (2012-2021). The revised documents will strategically position SLARI to continue to contribute significantly to the development of the agriculture sector, with relevant emerging issues fully captured. From the regional and global perspectives, the Strategic Plan is in line with the Comprehensive African Agricultural Development Programme (CAADP), the West and Central Council for Agricultural Research and Development (CORAF/WECARD), and the Millennium Development Goals (MDGs).

However, more than ever before, the institute is now required to go beyond research and become a vehicle for development. The SLARI guiding vision that requires the institute and its stakeholders and partners to stretch their future expectations, aspirations, and performance is to see **“Improved and sustainable broad-based agricultural growth”**. The Mission statement that expresses the fundamental purpose and business of SLARI is **“To enhance sustainable productivity, commercialization, and competitiveness of the agricultural sector through**

generation and promotion of innovative agricultural technologies and empowerment of stakeholders”.

Given the institutional strategic direction, SLARI has identified five result areas that are necessary and sufficient to deliver on the institutionally specific objective of generating and promoting innovative agricultural technologies and empowerment of stakeholders. Attainment of this Specific Objective will contribute to the realization of the overall institute’s General Objective of **enhancing sustainable productivity, commercialization, and competitiveness of the agricultural sector through the generation and promotion of innovative agricultural technologies and empowerment of stakeholders**. The five results that are designed to position SLARI strategically as the key driver for **enhancing sustainable productivity, commercialization, and competitiveness of the agricultural sector** include:

- Result 1: Appropriate agricultural product value chains, technologies, and innovations **generated and promoted**.
- Result 2: Appropriate markets and marketing strategies for enhancing agricultural value chains **developed and promoted**.
- Result 3: Appropriate policy options for enhancing agricultural product value chains were **facilitated and advocated**.
- Result 4: Capacity for implementing agricultural product value chains research **strengthened**.
- Result 5: Appropriate mechanisms for managing, sharing and scaling up agricultural knowledge, information and technologies **established and operationalized**.

To position itself strategically as a key driver in the transformation of the agricultural sector from subsistence to a commercial and profitable business enterprise, SLARI has adopted the Agricultural Product Value Chain (**APVC**) approach to research for development within the framework of Integrated Agricultural Research for Development (**IAR4D**). The adoption of this research approach requires SLARI to shift focus from production of commodities to differentiated

agricultural products including increased value addition to commodities within the rural areas and development and promotion of new products that fit the demands of the target market. This would require strengthening of capacity beyond the simple training and, therefore, a need for the development and operationalization of an effective and efficient capacity development programme was identified during the development of the SLARI Strategic Plan. This need for strengthening of capacity for implementing APVCs research was subsequently addressed as one of the institutional-level result areas. It is against this background that the Networking Support Function Four (NSF4) of Forum for Agricultural Research in Africa (FARA), in collaboration with the other FARA Networking Support Functions, initiated the capacity assessment of SLARI and its functional relationship with the wider Sierra Leone national agricultural research system.

A. ROKUPR AGRICULTURAL RESEARCH CENTRE (RARC)

The cereal crops research programme is implemented at the RARC. The programme is aimed at addressing challenges to enhance sustainable productivity, commercialization, and competitiveness of the cereal crops.

Farmers' training programme on "rice and maize-based and composite recipes for household food and nutrition security in Sierra Leone"

The post-assessment of farmers' perceptions regarding various nutritional recipes made from rice and maize revealed that 25, 21, and 23 participants from the three (3) districts did not know how to prepare different nutritional products using composite rice, maize, and wheat flour. In contrast, only a few participants demonstrated fair to good knowledge of preparing various nutritional recipes, such as rich cakes, donuts, and akara. However, these few participants relied only on wheat flour, and they were not aware of the use of composite rice, maize and wheat flour to prepare these nutritious recipes (Figure A1).

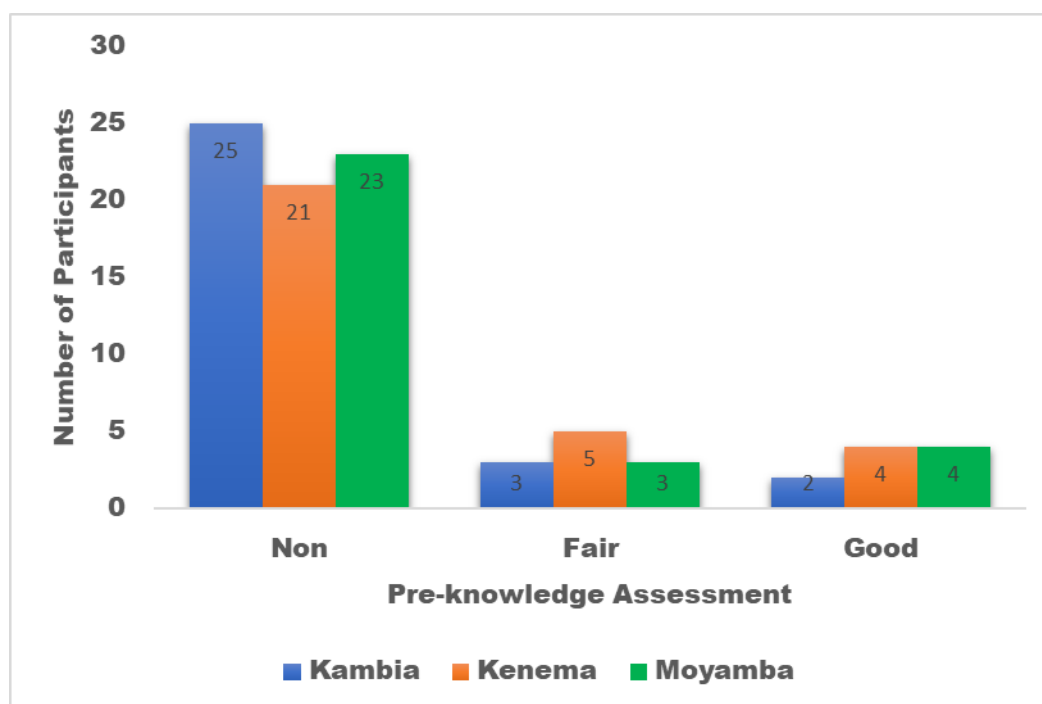


Figure A1. Farmers' prior knowledge of the preparation of different rice/maize nutritional recipes

The post-assessment of farmers' perceptions on taste and aroma of different rice/maize nutritional recipes revealed that more than 90% of the participants showed very high satisfaction with the product's good taste and strong aroma (Figure A2). Hence, the nutritional recipe developed in this training showed huge market potential in terms of quality for such recipes.

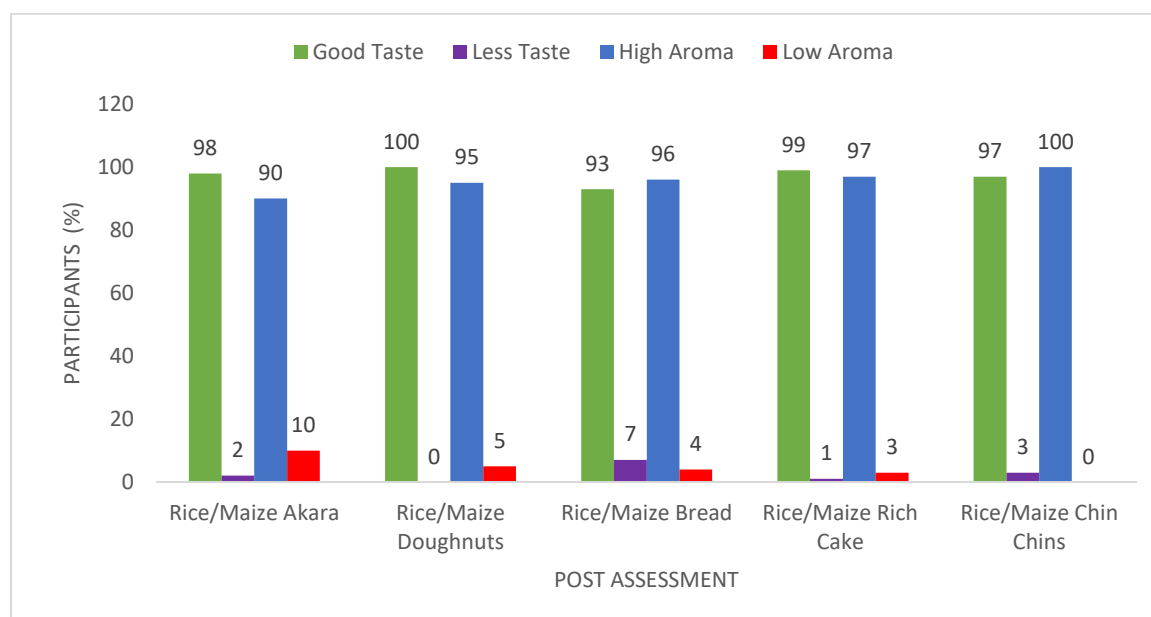


Figure A2. Farmers' perceptions of the nutritional qualities of different rice and maize recipes

The perception of farmers on the level of acceptability of the different nutritional recipes revealed that over 88% of them extremely like the nutritional recipes developed during the training (Figure A3). Findings suggest that the nutritional recipe developed during the training showed a high percentage of acceptability and huge potential for such recipes.

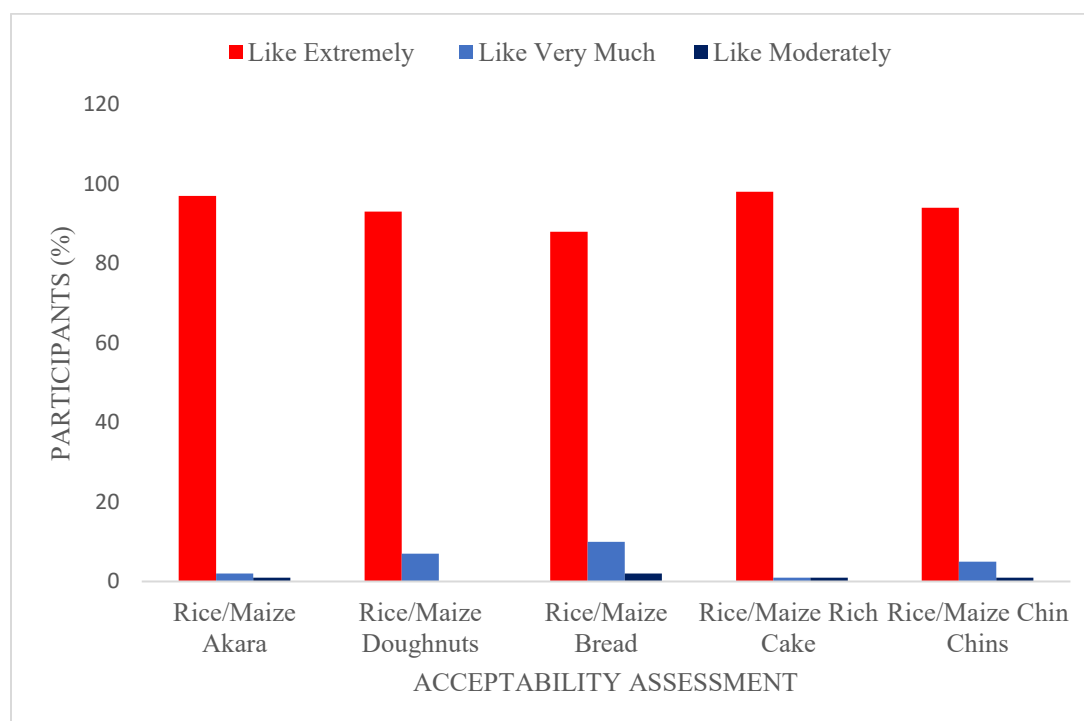


Figure A3. Perception of farmers on the level of acceptability of the different nutritional recipes

The Smart Valley Project 2019

The objective was to train Farmers' Based Organizations (FBOs) on the use of the SMART IV methodology and approach for an increase in rice productivity. Results revealed that > 4,000 farmers, including women and youth in 80 FBOs, were trained on swamp development using the SMART–IV approach (Table A1). About 63% (3010) of the farmers trained were youth, and 34% (1,650) were women. The recommendations from this study included (i) that FBOs should be put into zones and that postharvest facilities like community stores, dry floor, threshers, winnowers should be built and managed by them; (ii) that the FBOs be linked with the proper market for their rice seed; organizations like the World Food Program (WFP) and other seed business companies; (iii) use of an Integrated Soil Fertility Management as a sustainable soil fertility management strategy; and (iv) that the farmers be supplied with simple machines like power tillers, mini transplanters and mini combine harvester for ease of work and to reduce some of the postharvest qualitative and quantitative losses identified by survey done by SLARI.

Table A1. Demography of farmers in the project implementing area

Study Area		Adults 40 and above		Youth below 40		Total	Area developed (ha)
Chiefdom	Communities	Male	Female	Male	Female		
Lokomasama	6	200	100	500	300	1100	20
Kamasondo	4	120	70	280	130	600	15
Kasseh	35	600	200	700	300	1700	70
Dibia	25	350	250	500	300	1400	45
Total	70	1270	620	1980	1030	4,800	150

Survey on the status of disseminated and adopted technologies for mangrove swamp rice in Sierra Leone

The objective of this study was to evaluate disseminated mangrove swamp rice technologies and their adoption status in Sierra Leone. Findings revealed nine mangrove varieties CP4, ROK4, ROK5, ROK8, ROK9, ROK10, ROK21, ROK22 and ROK23 identified (Table A2). Most of the farmers in Kambia District were knowledgeable about all the RARC mangrove varieties, but farmers in Port Loko and Moyamba Districts were more knowledgeable about ROK4, ROK5, and ROK10. In total, ROK5 and ROK10 were the most well-known varieties by farmers in all the districts surveyed. About 528 farmers had knowledge about ROK5, while 321 farmers had knowledge about ROK10. The percentages on the knowledge and use of the varieties indicated that some varieties are specific to some areas, while others are grown in several localities. It was noted that improved released varieties are given local names linked to the source of access, the performance of the variety, or physical traits.

The Mangrove rice varieties grown by farmers at least once are presented in Table A3. ROK5, ROK10, and ROK4 were the most cultivated varieties grown at least once by some farmers in all the districts. 380 farmers grow ROK5, while 215 farmers grow ROK10 and 98 farmers grow ROK 4. For CP 4, more farmers in Mambolo (44%) and Samu (33%) Chiefdoms, Kambia District have grown the variety at least once than those in the other districts. ROK8, ROK9, ROK21, ROK22, and

ROK23 are not widely grown by farmers in all districts interviewed because farmers are not too aware of them. Farmers in Moyamba District have never grown ROK9, ROK21, and ROK22, while farmers in Port Loko District, due to inaccessibility and / or unawareness, have not grown ROK21 and ROK3.

Results in Table A4 reveal the number of farmers who cultivated the varieties at least once and who are still cultivating them. ROK 5 (163) and ROK 10 (86) were the most cultivated varieties, while ROK 4 (30) and CP 4 (23) were grown by farmers in all the districts surveyed. ROK 8 was not cultivated in Samu, Lokomasama, and Bumpeh Chiefdoms, whereas ROK 21 and ROK 22 were not cultivated in Port Loko and Moyamba Districts. However, ROK 23 was cultivated by one farmer each in Samu and Ribbi Chiefdoms in Port Loko and Moyamba Districts, respectively. These variances in adoption rates of varieties are partly attributable to a lack of awareness, availability, and accessibility. Findings suggest that ROK 5 and ROK 10 were the most available and adopted varieties.

Table A2. Knowledge of RARC mangrove varieties

		Grown Variety at least once					
District	Chiefdom	CP4		ROK 4		ROK 5	
		Count	%	Count	%	Count	%
Kambia	Mambolo	81	81.0	66	66.0	97	97.0
	Samu	61	61.0	66	66.0	98	98.0
Port Loko	Kaffu Bullom	26	26.0	61	61.0	92	92.0
	Lokomasama	32	32.0	46	46.0	90	90.0
Moyamba	Bumpeh	22	22.0	21	21.0	89	89.0
	Ribbi	20	20.0	31	31.0	62	62.0
	Total	242		291		528	
		ROK 8		ROK 9		ROK 10	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	36	36.0	34	34.0	98	98.0
	Samu	34	34.0	34	34.0	88	88.0
Port Loko	Kaffu Bullom	15	15.0	14	14.0	34	34.0
	Lokomasama	17	17.0	17	17.0	61	61.0
Moyamba	Bumpeh	6	6.0	9	9.0	24	24.0
	Ribbi	8	8.0	7	7.0	16	16.0
	Total	116		115		321	
		ROK 21		ROK 22		ROK 23	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	51	51.0	60	60.0	48	48.0
	Samu	26	26.0	22	22.0	24	24.0
Port Loko	Kaffu Bullom	1	1.0	5	5.0	4	4.0
	Lokomasama	15	15.0	11	11.0	11	11.0
Moyamba	Bumpeh	5	5.0	4	4.0	4	4.0
	Ribbi	6	6.0	4	4.0	5	5.0

Total	104	106	96
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Table A3. Mangrove varieties have been grown by farmers at least once

		Grown a variety at least once					
		CP4		ROK 4		ROK 5	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	44	44.0	22	22.0	88	88.0
	Samu	33	33.0	20	20.0	84	84.0
Port Loko	Kaffu Bullom	6	6.0	28	28.0	57	57.0
	Lokomasama	7	7.0	12	12.0	57	57.0
Moyamba	Bumpeh	7	7.0	4	4.0	61	61.0
	Ribbi	2	2.0	12	12.0	33	33.0
	Total	99		98		380	
		ROK 8		ROK 9		ROK 10	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	6	6.0	5	5.0	94	94.0
	Samu	8	8.0	8	8.0	68	68.0
Port Loko	Kaffu Bullom	4	4.0	2	2.0	10	10.0
	Lokomasama	1	1.0	1	1.0	33	33.0
Moyamba	Bumpeh	0	0.0	0	0.0	4	4.0
	Ribbi	2	2.0	0	0.0	6	4.0
	Total	21		16		215	
		ROK 21		ROK 22		ROK 23	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	11	11.0	29	29.0	12	12.0
	Samu	7	7.0	5	5.0	6	6.0
Port Loko	Kaffu Bullom	1	1.0	1	1.0	0	0.0
	Lokomasama	2	2.0	0	0.0	1	1.0
Moyamba	Bumpeh	0	0.0	1	1.0	0	0.0

Ribbi	1	1.0	0	0.0	1	1.0
Total	22		36		17	

Table A4. Adopters of RARC mangrove varieties

		Adopters are still growing the variety.					
		CP4		ROK 4		ROK 5	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	11	17.5	5	7.9	40	63.5
	Samu	4	21.1	2	10.5	11	57.9
Port Loko	Kaffu Bullom	1	3.3	14	46.7	23	76.7
	Lokomasama	0	0.0	1	4.0	19	76.0
Moyamba	Bumpeh	5	10.6	2	4.3	45	95.7
	Ribbi	2	7.4	6	22.2	25	92.6
	Total	23		30		163	
		ROK 8		ROK 9		ROK 10	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	1	1.6	0	0.0	53	84.1
	Samu	0	0.0	0	0.0	9	47.4
Port Loko	Kaffu Bullom	1	3.3	0	0.0	3	10.0
	Lokomasama	0	0.0	0	0.0	15	60.0
Moyamba	Bumpeh	0	0.0	0	0.0	2	4.3
	Ribbi	2	7.4	0	0.0	4	14.8
	Total	4		16		86	
		ROK 21		ROK 22		ROK 23	
District	Chiefdom	Count	%	Count	%	Count	%
Kambia	Mambolo	1	1.6	4	6.3	0	0.0
	Samu	0	0.0	0	0.0	1	5.3
Port Loko	Kaffu Bullom	0	0.0	0	0.0	0	0.0

	Lokomasama	0	0.0	0	0.0	0	0.0
Moyamba	Bumpeh	0	0.0	0	0.0	0	0.0
	Ribbi	0	0.0	0	0.0	1	3.7
	Total	1		4		2	

Findings on probit regression are presented in Table A5. All the variables in the model except farm income have the expected signs, and eight are significant in explaining the use of the RARC improved rice technologies. The positively related and significant variables include: farmers' level of education, training, access to credit, farm size, extension contact and farming experience as expected. This means that improvement in these major factors would lead to a higher level of technology adoption.

Table A5. Parameter estimates for the probit model

Parameter	Estimate	Std. Error	Z	Sig.
Age	-0.126***	0.187	-0.673	0.005
Educational level	0.014***	0.047	0.291	0.01
Farmer's income	-0.166	0.006	-0.183	0.255
Training	0.055*	0.023	0.247	0.065
Access to credit	0.202**	0.02	0.92	0.038
Membership of the association	0.01	0.159	0.06	0.352
Farm size	0.044***	0.022	0.323	0.008
Sex	-0.167***	0.183	-0.624	0.009
Extension contact	0.289***	0.325	0.297	0.007
Farming experience	0.072**	0.096	0.086	0.041
Intercept	0.369	1.08	0.341	0.733

***, ** and * indicate significance at 1 per cent, 5 per cent and 10 per cent probability levels, respectively

Improving Agricultural Resilience to Salinity through Development and Promotion of Pro-poor Technologies (RESADE) Project

This study aimed at increasing the production and productivity of marginal saline areas, thereby mitigating the problems using climate-smart and salinity-resilient agricultural models and approaches. Findings revealed that the two crops that survived had high responses to fertiliser in F2 and F3 treatments. This implies that the use of fertiliser at a rate of NPK 80:40:40 kg ha⁻¹ had similar biomass and grain yields comparable to the F3 treatment at NPK 80:40:40 kg ha⁻¹ + Foliar fertiliser application (2.5 tha⁻¹), but significantly higher than the remaining treatments (Figures A4-A9).

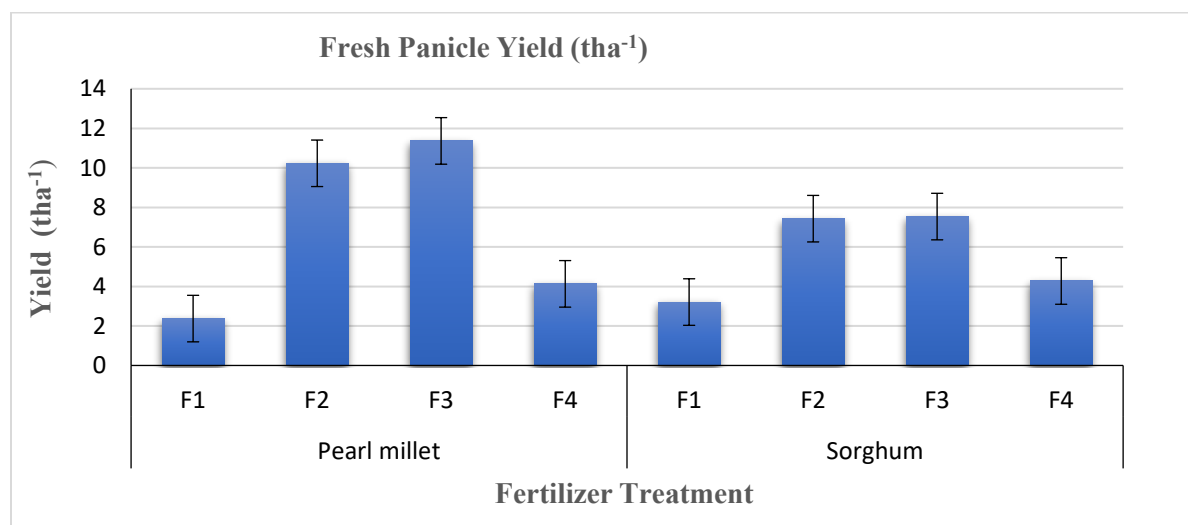


Figure A4. Crop response to fertiliser on fresh panicle yield.

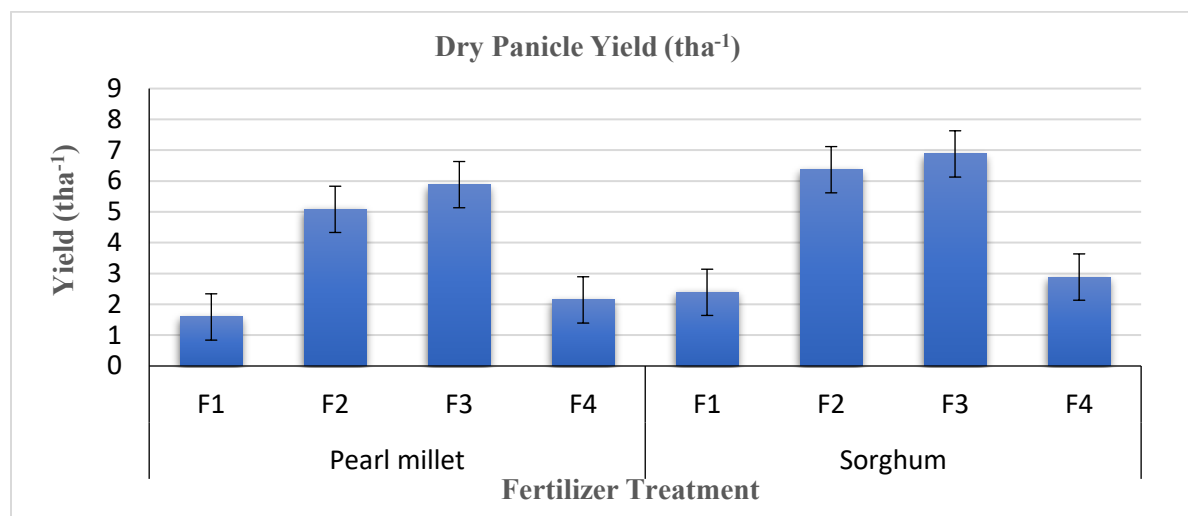


Figure A5. Crop response to fertiliser on dry panicle yield.

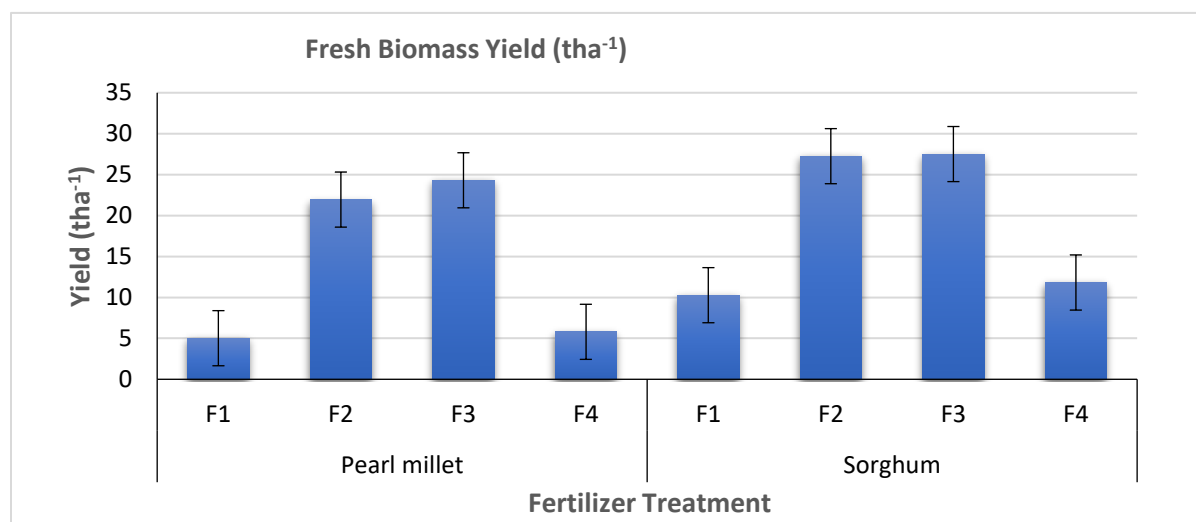


Figure A6. Crop response to fertiliser on fresh biomass yield.

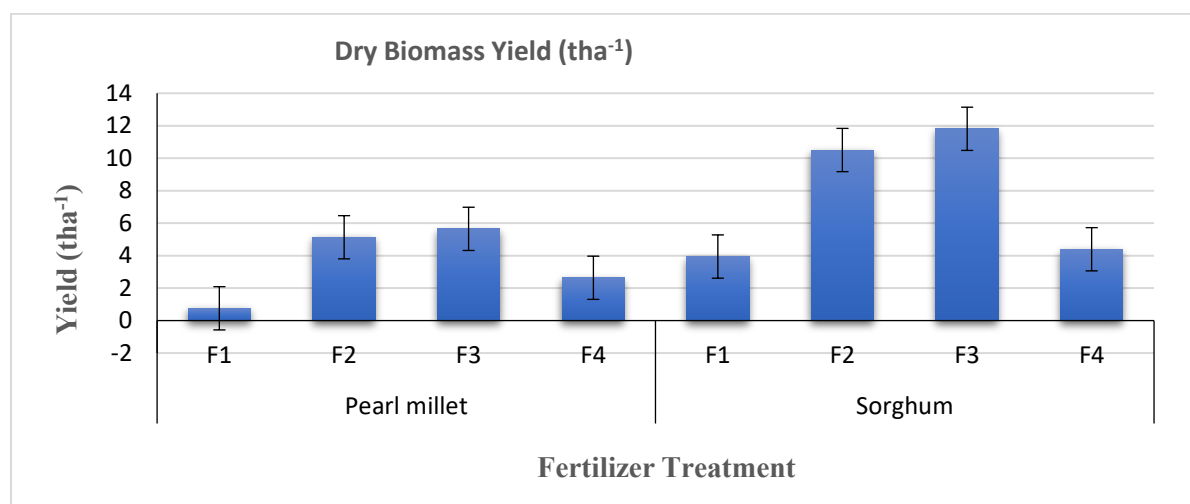


Figure A7. Crop response to fertiliser on dry biomass yield.

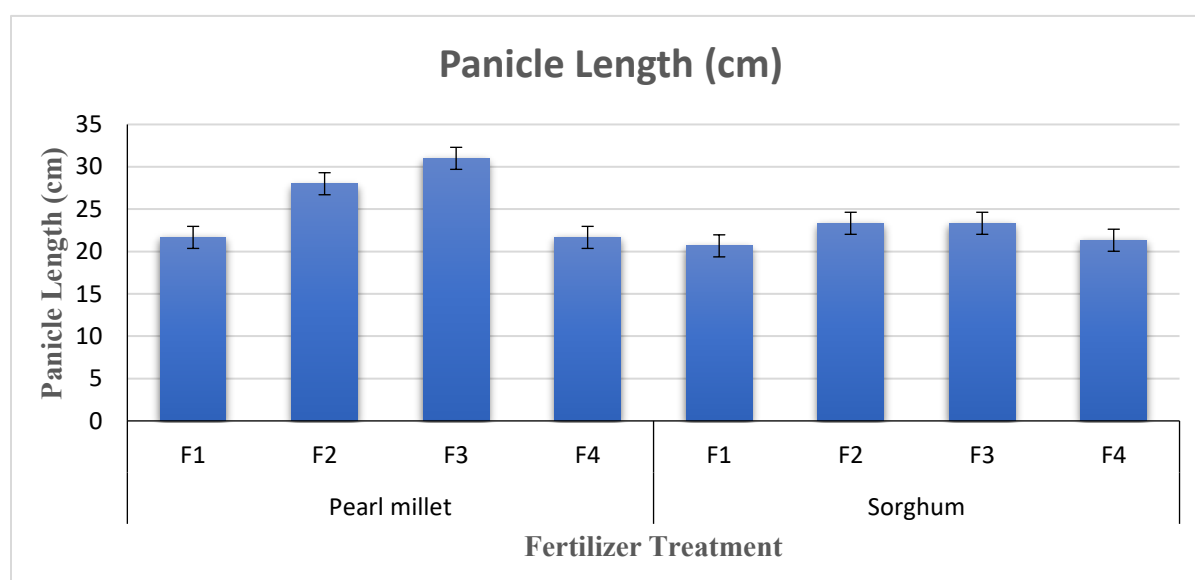


Figure A8. Crop response to fertiliser on panicle length after harvest.

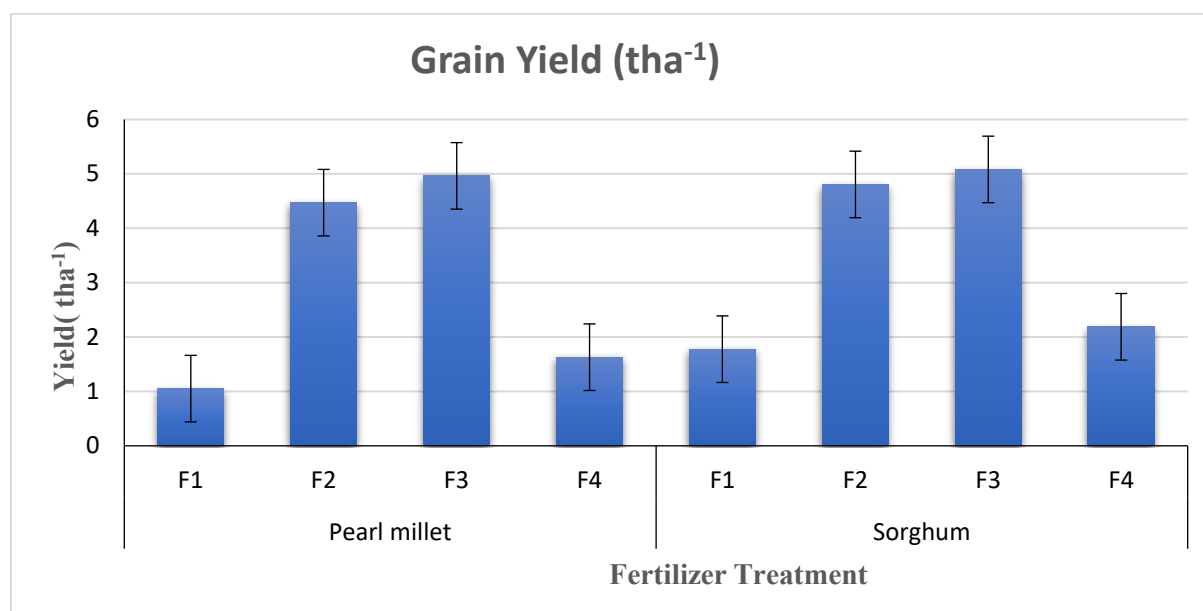


Figure A9. Crop response to fertiliser on grain yield.

The achievements in this project included:

- i. Establishment of a best practice hub with irrigation facilities to support screening crops for adaptability to saline conditions;
- ii. Procurement of small-scale processing machines;
- iii. Rehabilitation of crop processing building;
- iv. Trained over 1,000 farmers and some Extension staff on pro-poor technologies for saline conditions;
- v. Trained scientific staff in and out of the country on crop modelling techniques and other related courses;
- vi. Introduced salt tolerant crops and best agronomic practices; and
- vii. Developed value chains for introduced cropping systems.

Breeder seed production and maintenance, and foundation seed production by SLARI under the SLARiS

The objective was to strengthen the rice seed value chain, contribute to food security, and support the sustainable development of Sierra Leone's agricultural sector. Breeder rice seed

production and maintenance, and foundation seed production in Sierra Leone under the Sierra Leone Agribusiness and Rice Value Chain Support Project (SLARiS) revealed that 119 bags of 50 kg breeder seeds were processed and stored at RARC. The processed breeder seeds comprised 67 bags of Nerica L19 sub one, 27 bags ROK 24, 20 bags Nerica L19, and 5 bags ROK 34. For the foundation seed production during 2023, about 792 bags of 50 kg were processed and stored for distribution.

Soil fertility assessment across WFP farm sites in seven districts in Sierra Leone

The World Food Program (WFP), in collaboration with SLARI, conducted soil sampling across WFP-sponsored farm sites in seven (7) Districts and 145 localities in the North and South-East of Sierra Leone. Three composite soil samples were collected from each target swamp site and analysed for physical and chemical properties. The results of the soil analysis were used to develop a fertiliser recommendation for each swamp. Findings showed that the swamps vary widely in their fertility levels. Even within the same swamp, the fertility level significantly varied. While some swamps had adequate nutrient levels, some had lower nutrient levels than required for rice production. Thus, fertiliser recommendations were based on the soil test levels. Two approaches for fertiliser applications have been recommended, depending on whether straight fertilisers (Urea, TSP, MOP) are available or applying urea in combination with compound fertilisers (NPK 0:20:20).

A key limitation to soil management in almost all of the swamps is soil acidity. Most of the soils (98%) are acidic with a pH lower than the optimum pH requirement for rice. These soils, like most soils in Sierra Leone, require liming to reduce the effect of acidity and improve plant nutrient uptake and yield. Thus, it was recommended that farmers be adequately trained on (i) swamp management, (ii) fertilizer use and management and (iii) integrated soil fertility management for sustainable rice production in IVS.

Training on the production and marketing of rice and maize for the women farmers' association in Sierra Leone

The training was held at MAFS Training Centre, Chinese Farm Lamabayama, Kenema. It was held from 31st May to 2nd June 2023, targeted at 30 women participants. The objectives were: (i) to improve on farmers' rice and maize production and marketing techniques; and (ii) to promote a sustainable increase in yield and income for the women farmers' association. Some of the lessons that were most appreciated by the participants were the concept of entrepreneurship, record keeping, and the differences between grains and seeds.

Field monitoring technique for technicians on rice and maize production in Sierra Leone

The target groups included Technicians of The Rokupr Agricultural Research Centre, Ministry of Agriculture and Forestry, and Non- Non-Governmental Organisations Youth from Kambia, Moyamba, and Kenema Districts. The programme was held at the Chinese Farm, Kenema, on the 19th and 20th January 2022. It involved 18 male and 12 female participants. The training involved the following: nursery preparation and management for rice; improving seed quality; cropping calendar; rice culture management; lowland development and water control; fertiliser manipulation; major pests, diseases, and weeds of rice and maize in Sierra Leone; and harvesting and post-harvest handling of rice and maize.

B. NJALA AGRICULTURAL RESEARCH CENTRE (NARC)

The root, tuber, and grain legume crops research programme is implemented at the NARC. The programme is aimed at addressing challenges to enhance sustainable productivity, commercialization, and competitiveness of the root, tuber, and grain legume crops.

Training on Semi-Autotrophic Hydroponics (SAH) Technology

Low multiplication ratio of 1:5 or 1:10 using the conventional cassava stem cutting technique in the field hampers the wide distribution of stem cutting planting materials to farmers, thereby

contributing to the prolongation of the breeding process of the crop. However, the development of Semi-autotrophic hydroponics (SAH) has contributed to the rapid multiplication of cassava, yams, and potatoes to support the seed system. The training on this technique was facilitated by Kajibwami Angelique, from IITA DRC. A total of 9 NARC staff were trained.

The training content covered various topics, including:

- i. Lab arrangement - Presentation on advanced methods for SAH;
- ii. Preparation of items;
- iii. Micro-stem planting of SAH;
- iv. Production and treatment of SAH plants;
- v. Monitoring and maintenance in lab, field, and screen house settings;
- vi. Multiplication of SAH plantlets;
- vii. Introduction of TC plantlets into SAH;
- viii. Training on transplanting SAH materials in the field (including plantlets, pencil, stem, micro-stem, and cuttings);
- ix. Seed system course;
- x. Business aspects related to SAH seeds;
- xi. Recapitulation of lessons and practices.

The trainees had hands-on experience in nutrient preparation, filling SAH boxes with substrate, micro-stem cutting treatment and planting micro-stems into SAH boxes. About 250 boxes of SAH plantlets of SLICASS 4, 6 and 7 were in the growth room ready for recutting. Of which, 40 boxes of SLICASS 4 and 7 plantlets were ready for transplanting in the field.



Photographic display of the Hon. Deputy Min. (I) MAFS and the SAH trainees

Molecular and phenotypic profiling of white Guinea yam (*Dioscorea rotundata*) breeding lines

Phenotypic and genotypic profiling help identify genotypes with suitable and complementary traits to progress genetic improvement in crops. A total of 32 traits were assessed in 36 genotypes of white Guinea yam established in a 6×6 triple lattice design. The objective was to evaluate an array of plant traits that define the genetic merits of breeding lines for yam improvement. Different analytical tools were used to identify and prioritise relevant traits defining the genetic merits of breeding lines in the yam improvement programme. Of the 32 traits measured, the linear combination of 31 traits (Table B1) and 14 traits (Table B2) that minimise within-group variance and maximise between-group variance for discriminating the genetic values of yam breeding lines were identified.

When best linear unbiased prediction with genomic relationship matrix (GBLUP) was applied, the accuracies of genomic breeding values were higher ($r=0.87$ to 0.97) for the seven traits (dry matter content, intensity of flesh oxidization of shredded tuber, pasting temperature, pasting time, tuber flesh colour, yam mosaic virus and fresh tuber yield) with high broad-sense heritability values ($H^2_m > 0.6$) (Table B3). While for the remaining seven traits with low ($H^2_m < 0.3$) to medium ($H^2_m = 0.3$ to 0.54) broad-sense heritability values, the accuracies of genomic estimated breeding values (GEBV) were low ($r < 0.4$) to medium ($r = 0.4$ - 0.8). Breeding lines with higher breeding values for fresh storage tuber yields included TDr08-21-2, TDr8902475, TDr9501932,

TDr9518544, TDrNndu, TDrFakesta, TDr9700793 and TDr9519158. Genotypes with high dry matter content were TDr04-219, TDr8902157, TDr8902475, TDr8902665, TDr9518544, TDr9518988, TDrAlumaco, TDrNndu, TDrUfenyi and TDrYangbedu. Those with the lowest AUDPC value for yam mosaic virus included TDr89/02475, TDr95/18988, TDrLeusi, TDrMeccakusa, TDrNndu and TDrPampars. Genotypes with high peak viscosity breeding values are TDr00/00362, TDr04-219, TDr89/02157, TDr89/02475, TDr08-21-2, TDr89/02665, TDr95/18544, TDr95/18988, TDrFakesta, TDrMeccakusa, TDrPampars, TDrPouna, TDrUfenyi, and TDrYangbedu. Complementation of estimated breeding values with genomic estimated breeding values revealed higher prediction accuracy and genetic values of the profiled white yam traits of progenitors. The genotype–trait (GT) biplot display revealed superior clones with desirable genetic values for the key traits. These results are relevant for parental selection aimed at improving key agronomic traits in white Guinea yam.

Table B1. Eigen vectors, Eigen values, per cent variation and accumulated variation accounted by the first ten principal components

Traits	PC1	PC2	PC3	PC4	PC5	PC6	PC7	PC8	PC9	PC10
ASHC	0.13	0.26	0.22	0.72	-0.09	0.15	0.10	-0.12	-0.17	0.17
BV	0.71	-0.08	0.40	-0.33	0.05	-0.05	0.22	-0.12	-0.03	0.21
CTBRS	-0.15	0.40	0.19	-0.74	-0.07	0.05	0.10	0.03	0.15	-0.27
DMC	0.63	0.25	-0.11	-0.15	0.28	0.01	0.11	0.50	-0.24	0.14
FPV	-0.22	0.59	-0.56	0.11	0.33	0.05	0.00	0.18	0.09	-0.08
FYLD	0.62	-0.29	-0.48	-0.04	0.15	0.03	-0.10	0.11	0.28	0.19
ITTS	-0.09	0.21	0.72	-0.07	0.36	-0.02	-0.29	-0.09	0.21	0.14
HS	-0.59	0.44	-0.48	0.25	0.20	0.04	0.00	0.10	0.08	0.04
PLOSS	-0.27	0.16	0.74	0.11	-0.01	-0.04	0.14	0.18	-0.30	-0.31
PTB	0.05	-0.30	0.15	0.15	-0.26	0.63	-0.35	0.32	0.26	0.03
PTIME	-0.50	0.26	-0.55	0.29	0.06	0.05	-0.22	-0.18	0.07	-0.16
PTEMP	-0.76	-0.25	-0.07	0.03	-0.20	0.06	-0.10	0.07	0.01	0.28

PV	0.77	0.19	0.00	-0.31	0.21	0.03	0.14	0.04	0.04	-0.06
SBN	-0.35	0.36	0.04	-0.62	0.19	0.13	0.12	0.06	0.41	0.06
RTBS	-0.31	0.48	0.47	0.11	0.37	-0.27	-0.32	0.05	0.04	0.07
SCMR	0.16	-0.15	-0.08	-0.05	0.49	0.50	0.02	-0.11	0.03	-0.45
SPNSB	-0.50	0.32	-0.02	-0.07	0.29	0.47	0.37	-0.15	0.02	0.06
SPNAB	-0.28	0.07	0.26	-0.03	0.30	0.59	0.39	0.07	-0.26	0.19
STNP	0.57	0.66	0.04	0.14	-0.23	0.10	0.20	-0.19	0.03	0.07
TBRFLC	-0.47	-0.23	0.11	-0.25	-0.04	0.32	0.08	0.11	-0.27	0.31
SYLD	0.70	0.04	-0.43	-0.30	0.15	0.05	-0.12	0.22	-0.04	0.27
TBR5	0.20	-0.06	0.33	0.41	-0.19	0.48	-0.22	0.46	0.19	-0.10
TTBRYLD	0.38	-0.35	0.11	0.55	0.37	0.11	0.12	-0.09	0.05	-0.19
YMVAUDPC	-0.53	0.32	0.12	-0.27	-0.44	0.26	-0.16	-0.01	-0.10	0.04
STDP	-0.19	-0.73	0.00	-0.21	0.30	-0.03	0.05	-0.09	-0.09	0.07
PLNV	0.54	-0.24	0.19	0.35	0.41	0.16	0.06	-0.17	0.14	0.09
TTB	0.54	0.63	-0.08	0.08	-0.21	0.24	-0.19	0.00	-0.04	0.08
PRTBS	-0.20	0.37	0.47	0.07	0.54	-0.25	-0.38	0.05	0.06	0.14
RKN	0.32	0.19	0.32	0.25	-0.24	-0.43	0.26	0.34	0.12	0.02
INTOXDS30	-0.50	0.10	-0.24	0.39	0.25	-0.14	0.20	0.01	0.00	0.33
TBRNP	0.50	0.68	-0.14	0.13	-0.22	0.16	0.09	-0.25	-0.12	-0.02
PROTEINC	-0.12	-0.07	0.29	0.12	-0.29	0.06	0.42	-0.23	0.62	0.18
Eigenvalue	6.76	4.10	3.60	3.08	2.42	2.19	1.76	1.38	1.25	1.12
Percentage of										
variance	20.49	12.43	10.92	9.33	7.34	6.64	5.32	4.18	3.80	3.38
Cumulative										
percentage of										
variance	20.49	32.92	43.84	53.17	60.51	67.14	72.47	76.65	80.45	83.84

Principal component; values in bold represent traits that contributed most to variability in the various PCs

Table B2. Variance inflation factor (VIF) values of 31 traits and 14 traits were determined based on multicollinearity and path coefficient analysis, respectively, in 36 genotypes of white yams.

Trait	First (multicollinearity)	VIF	Trait	Second VIF (Path coefficient)
Ash content (ASHC)	9.5		ASHC	1.95
Breakdown value (BV)	130.5		DMC	2.56
Cracks on the tuber surface (CTBRS)	20.2		PTIME	1.94
Dry matter content (DMC)	7.7		PTEMP	3.11
Final paste viscosity (FPV)	405.8		SBN	2.23
Flour yield (FYLD)	42.8		SCMR	1.99
Intensity of thorns or spines on tuber surface (ITTS)	11.4		SPNAB	1.64
Holding strength (HS)	273.6		TBRFLC	1.78
Peel loss (PLOSS)	48.2		TBRS	1.55
Position of tuber branching (PTB)	12.8		YMVAUDPC	2.21
Peak time (PTIME)	9.9		STDP	1.78
Peak temperature (PTEMP)	9.4		INTOXDS30	1.52
Peak viscosity (PV)	240.7		PROTEINC	2.11
<i>Scutellonema bradys</i> nematode (SBN)	9.7			
Roots on the surface of the tubers (RTBS)	15.7			
Leaf chlorophyll content (SCMR)	5.0			
Spines on stem base (SPNSB)	25.2			
Spines on stem above base (SPNAB)	6.3			
Stem number per plant (STNP)	64.5			
Tuber flesh colour (TBRFLC)	5.3			
Starch yield (SYLD)	81.3			
Tuber shape (TBRS)	8.3			

Total tuber yield (TTBRYLD)	9.6
Yam mosaic virus (YMVAUDPC)	8.7
Stem diameter per plant (STDP)	8.8
Plant vigour (PLNV)	26.4
Tendency of tuber to branch (TTB)	28.7
Place of roots on tuber surface (PRTBS)	22.5
Intensity of flesh oxidation of shredded tuber (INTOXDS30)	6.0
Tuber number per plant (TBRNP)	28.8
Protein content (PROTEINC)	9.6

VIF=variance inflation factor; values in bold represent traits with low VIF < 10 based on Amos *et al.* (2019); the second VIF based on path coefficient analysis revealed low VIF < 5 values for 14 traits.

Table B3. Trait heritability, standard error, prediction accuracy and reliability estimates of breeding values (BV) under best linear unbiased prediction (BLUP) and genomic estimated breeding value (GEBV) under the genomic best linear unbiased prediction (GBLUP)

Trait	Model 0: BV under BLUP				Model 1: GEBV under GBLUP			
	H ² _m	SE	r ²	r	h ²	SE	r ²	R
ASHC	2.40e ⁻⁰⁶	0.00	0.000	0.001	0.002	0.13	0.26	0.50
DMC	0.83	1.30	0.81	0.90	0.48	1.10	0.89	0.94
INTOXDS30	0.80	0.48	0.77	0.88	0.07	0.45	0.76	0.87
PROTEINC	1.51e ⁻⁰⁶	0.00	-14.81	NA	0.00	0.16	0.18	0.43
PTEMP	0.76	0.54	0.74	0.86	0.11	0.47	0.85	0.92
PTIME	0.88	0.11	0.86	0.92	0.01	0.10	0.93	0.96
SBN	0.32	0.19	0.31	0.56	0.001	0.10	0.20	0.45
SCMR	0.54	1.63	0.53	0.73	0.25	1.32	0.56	0.74
STDP	0.47	0.39	0.46	0.68	0.02	0.33	0.62	0.78

SPNAB	-	-	-	-	-	-	-	-
TBRFLC	0.84	0.24	0.82	0.90	0.03	0.22	0.87	0.93
TBRS	0.47	0.39	0.45	0.67	0.01	0.29	0.46	0.67
YMVAUDPC	0.90	97.70	0.87	0.93	0.999	86.13	0.94	0.97
TTBRYLD	0.75	2.13	0.74	0.86	0.70	1.83	0.87	0.93

r=prediction accuracy (<0.4=low, 0.4-0.8=medium, and >0.8=high accuracies); r^2 =reliability; SE=standard error; ASHC=ash content; DMC=tuber dry matter content; INTOXDS30=intensity of flesh oxidization of shredded tuber; PROTEINC=protein content; PTEMP=pasting temperature; PTIME=pasting time; SBN=*Scutellonema bradys* nematode; SCMR=leaf chlorophyll content; STDP=stem diameter per plant; SPNAB=spines on stem above base; TBRFLC=tuber flesh colour; TBRS=tuber shape; YMVAUDPC=yam mosaic virus; TBRYLD=total fresh tuber yield

Paternity assignment in white Guinea yam (*Dioscorea rotundata*) half-sib progenies from polycross mating design using SNP markers

White Guinea yam is mostly a dioecious outcrossing crop with male and female flowers produced on distinct plants. Fertile parents produce high fruit set in an open pollination polycross block, which is a cost-effective and convenient way of generating variability in yam breeding. However, the pollen parent of progeny from polycross mating is usually unknown. This study aimed to determine paternity in white Guinea yam half-sib progenies from a polycross mating design. A total of 394 half-sib progenies from random open pollination involving nine female and three male parents were genotyped with 6602 SNP markers from the DArTSeq platform to recover the full pedigree. A higher proportion of expected heterozygosity, allelic richness, and evenness was observed in the half-sib progenies.

A complete pedigree was established for all progenies from two families (TDr1685 and TDr1688) with 100% accuracy, while in the remaining families, paternity was assigned successfully only for 56 to 98% of the progenies (Tables B4 and B5). Our results indicated unequal paternal contribution under natural open pollination in yams, suggesting unequal pollen migrations or gene flow among the crossing parents. A total of 3.8% of progenies lacking paternal identity due

to foreign pollen contamination outside the polycross block was observed. This study established the efficient determination of parental reconstruction and allelic contributions in the white Guinea yam half-sib progenies generated frutilisingollination polycross using SNP markers. Findings are useful for parental reconstruction, accurate dissection of the genetic effects, and selection in the white Guinea yam-breeding program utilizing polycross mating design.

Table B4. Summary statistics: minor allele frequency, major allele frequency, proportion of heterozygosity, and QC = quality check of genetic (6602 SNPs, 394 individuals) of segregating progenies of white yams.

Family	Sample	Sample after QC	Hybrid	Proportion of Heterozygous					Minor Allele Frequency	Major Allele Frequency
				Mean	Min	Max	σ^2	σ		
TDr1685	50	50	50	0.28	0.19	0.49	0.002	0.04	0.205	0.794
TDr1686	50	50	37	0.28	0.12	0.53	0.004	0.07	0.211	0.788
TDr1687	50	46	46	0.29	0.23	0.40	0.001	0.03	0.209	0.791
TDr1688	50	50	50	0.33	0.29	0.41	0.000	0.02	0.233	0.766
TDr1689	50	28	28	0.33	0.16	0.52	0.002	0.05	0.238	0.762
TDr1690	45	44	44	0.27	0.26	0.44	0.001	0.03	0.186	0.813
TDr1691	49	48	48	0.28	0.22	0.36	0.001	0.03	0.204	0.795
TDr1692	50	50	49	0.29	0.25	0.46	0.001	0.04	0.209	0.791

σ^2 = variance, and σ = standard deviation

Table B5. The number and proportions of progenies with recovered paternal identity.

Female	Family	Male			Progeny with a fully recovered pedigree	Per cent of progenies with a fully recovered pedigree
		TDr9501932	TDr9902789	TDr9902607		
TDr9700793	TDr1685	26 (52%)	1 (2.0%)	23 (46%)	50	100
TDr8902157	TDr1686	12 (24%)	0 (0%)	25 (50%)	37	74
TDr8902475	TDr1687	46 (92%)	0 (0%)	0 (0%)	46	92

TDr9700632	TDr1688	23 (46%)	1 (2%)	26 (52%)	50	100
TDr9700205	TDr1689	18 (36%)	6 (12%)	4 (8%)	28	56
TDr9519158	TDr1690	39 (86.7%)	0 (0%)	5 (11.1%)	44	97.8
TDr9518988	TDr1691	45 (91.8%)	0 (0%)	3 (6.1%)	48	97.9
Ojuiyawo	TDr1692	22 (44.0%)	27 (54%)	0 (0%)	49	98
Total		231	35	86	352	
progenies						
%		65.63	9.94	24.43	100	96.2
contribution						

Identification of quantitative trait nucleotides and candidate genes for tuber yield and mosaic virus tolerance in an elite population of white Guinea yam (*Dioscorea rotundata*) using a genome-wide association scan

This study assessed quantitative trait nucleotides (QTNs) and the underlying candidate genes related to tuber yield per plant (TYP) and yam mosaic virus (YMV) tolerance in a panel of 406 white Guinea yam (*Dioscorea rotundata*) breeding lines using a genome-wide association study (GWAS). Findings revealed that broad-sense heritability estimates were high, 0.708 for tuber yield per plant and 0.903 for yam mosaic virus. The phenotypic value for the tuber yield ranged from 0.93 to 1.47 kg plant⁻¹ with an average of 1.19 kg (Table B6). The area under the disease progress curve for YMV ranged from 100.56 to 2900.45 with an average of 936.16. Population structure analysis using 5,581 SNPs differentiated the 406 genotypes into four distinct sub-groups.

Table B6. Descriptive statistics of tuber yield per plant (TYP) and yam mosaic virus (YMV)

Traits	Minimum	Maximum	Mean	Standard Deviation	Broad heritability (H ²)	sense
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TYP	0.93	1.47	1.19	0.11	0.708
YMV	100.56	2900.45	936.16	481.19	0.903

TYP: tuber yield per plant; YMV: yam mosaic virus (AUDPC value)

Marker-trait association (MTA) analysis using the generalised linear model identified ten QTN regions significant for TYP and five for YMV (Tables B7 and B8). We identified variants responsible for predicting higher yield and lower virus severity scores in the breeding panel through the marker-effect prediction. Gene annotation for the significant SNP loci identified several essential putative genes associated with the growth and development of tuber yield, and those that code for tolerance to mosaic virus.

Table B7. SNP markers associated with the tuber yield per plant and yam mosaic virus severity score.

Trait	Marker name	Chr	Position (Bp)	PVE (%)	Variants	MAEF	LOD	MAF
TYP	chr06_965642	6	965,642	62.13	TC	-0.02	4.12	0.376
	chr08_13478676	8	13,478,676	62.08	AT	0.04	3.95	0.095
	chr08_21789522	8	21,789,522	62.19	AT	0.05	4.35	0.096
	chr14_8143018	14	8,143,018	62.13	TA	0.03	4.06	0.155
	chr14_11128124	14	11,128,124	62.74	GC	0.05	4.70	0.154
	chr14_14292173	14	14,292,173	62.62	GA	-0.07	4.44	0.069
	chr14_14300070	14	14,300,070	62.74	AC	-0.08	4.71	0.069
	chr14_15507116	14	15,507,116	62.53	AT	0.05	4.24	0.071
	chr15_4138634	15	4,138,634	62.36	AT	-0.03	4.00	0.181
	chr19_9446619	19	9,446,619	62.03	AG	0.03	4.00	0.091
YMV	chr03_6338751	3	6,338,751	12.42	GT	169.09	4.28	0.455
	chr04_23336802	4	23,336,802	12.95	AG	-225.25	4.10	0.254
	chr10_613339	10	613,339	12.38	AT	138.99	4.36	0.388
	chr10_1116193	10	1,116,193	12.85	GA	-240.87	4.00	0.26

chr16_1325272	16	1,325,272	13.52	CT	295.41	4.12	0.069
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TYP: tuber yield (kg plant⁻¹), YMV: Yam mosaic virus severity score (AUDPC value); LOD: Logarithm of odds; Chr: chromosomes; bp: base-pair; MAF: Minor allele frequency; PVE: Phenotypic variance explained and MAEF: Marker effect

Table B8. Frequencies and marker prediction effects of various haplotypes associated with tuber yield (kg plant⁻¹) and reaction to yam mosaic virus infestation (AUDPC value)

Trait	Marker name	Haplotype	Sequence	Frequency	Adj. Prob	Significance
TYP	chr06_965642	Hap1	CCTC	0.27	0.035	*
		Hap2	CCTT	0.33	1.16 e ⁻⁰⁷	****
		Hap3	TCTT	0.40	0.001	***
	chr8_21789522	Hap1	AAAT	0.47	0.132	ns
		Hap2	AATT	0.47	0.319	ns
		Hap3	ATTT	0.07	0.110	ns
	chr8_13478676	Hap1	AAAT	0.47	0.272	ns
		Hap2	AATT	0.47	0.272	ns
		Hap3	ATTT	0.06	0.110	ns
	chr14_8143018	Hap1	AATA	0.11	1.000	ns
		Hap2	AATT	0.44	1.000	ns
		Hap3	TATT	0.45	1.000	ns
	chr14_11128124	Hap1	CCCG	0.45	1.90 e ⁻⁰⁷	****
		Hap2	CCGG	0.44	4.71 e ⁻¹⁴	****
		Hap3	CGGG	0.11	0.043	*
	chr14_14292173	Hap1	GAGG	1.00	0.007	**
	chr14_14300070	Hap1	AAAC	1.00	0.008	**
	chr14_15507116	Hap1	AAAT	0.48	0.001	***
		Hap2	AATT	0.47	0.003	**
		Hap3	ATTT	0.05	0.534	ns

	chr15_4138634	Hap1	AAAT	0.46	0.004	**
		Hap2	AATT	0.40	0.004	**
		Hap3	ATTT	0.14	0.169	ns
	chr19_9446619	HAP1	AAAG	0.47	0.002	**
		HAP2	AAGG	0.48	1.99 e ⁻⁰⁶	****
		HAP3	AGGG	0.05	0.971	ns
YMV	chr03_6338751	Hap1	GGGT	0.4	1.000	ns
		Hap2	GGTT	0.24	1.000	ns
		Hap3	GTTT	0.36	1.000	ns
	chr04_23336802	Hap1	AAAG	0.47	0.013	*
		Hap2	AAGG	0.3	0.000	***
		Hap3	AGGG	0.23	0.002	**
	chr10_613339	HAP1	AAAT	0.4	0.190	ns
		HAP2	AATT	0.24	0.023	*
		HAP3	ATTT	0.33	0.190	ns
	chr10_1116193	Hap1	AAGA	0.23	0.239	ns
		Hap2	AAGG	0.31	0.003	**
		Hap3	GAGG	0.47	5.25e ⁻⁰⁷	****
	chr16_1325272	Hap1	CCCT	0.49	0.576	ns
		Hap2	CCTT	0.45	2.08 e ⁻⁰⁶	****
		Hap3	CTTT	0.06	0.029	*

Ns=non-significant, *, **, ***, and **** indicate significant association between haplotypes and markers

Results provided valuable insight for marker validation and deployment for tuber yield and mosaic virus tolerance in white yam breeding. The information on SNP variants and genes from the present study would fast-track the application of genomics-informed selection decisions in breeding white Guinea yams for rapid introgression of the targeted traits.

Genetic parameter estimation and selection in an advanced breeding population of white Guinea yam

This study determined genetic parameters for fresh tuber yield, tuber dry matter content and quantitative field tolerance to yam mosaic virus in 49 clones grown in multi-environment trials (METs). We conducted genomic prediction involving 6337 single-nucleotide polymorphisms (SNPs) and phenotypic field evaluation of data collected on the three traits. Results revealed that additive genetic and non-genetic factors contributed significantly to phenotypic variation of studied yam traits in METs but to varying degrees (Table 9). The non-genetic effects were relatively high for most of the measured traits. Narrow-sense heritability values were low (<0.30) for all studied traits. Further analysis of the performance of the clones at test sites with additive main effects and multiplicative interaction (AMMI) analysis exhibited significant genotype by environment interactions (GEI) for the three traits (Table 10). The AMMI identified TDr10/00412, TDr11/00055, and TDr09/00135 clones with the lowest mean trait stability index and outstanding performance for fresh tuber yield (t ha^{-1}), tuber dry matter and mosaic virus resistance across sites (Table 11). The elite clones identified could serve as a useful source of alleles for the genetic improvement of the crop and could be considered for release to farmers.

Table B9. Estimated genetic and non-genetic parameters of agronomic and quality traits from multi-environment white Guinea yam elite clones trials.

Trait	Mean SED	Range	σ^2_a	σ^2_{rg}	σ^2_{ng}	% σ^2_a	σ^2_g/σ^2_{ng}
YMV	2.86±0.19	2.16-3.64	0.03	0.09	0.09	25	1.33
TBRYLD	10.33±1.96	6.14-15.61	1.73	3.53	8.52	33	0.62
DMC (%)	31.96±1.47	27.61-35.96	0.05	4.22	7.61	1	0.56
Trait	h^2	H^2	GCV	PCV	GA	GAM	
YMV	0.15	0.58	12.1	16.0	0.5	17.5	
TBRYLD	0.13	0.38	22.2	35.9	2.9	28.1	
DMC (%)	0.004	0.36	6.5	10.8	2.6	8.1	

SED: average standard error of difference; σ^2_a : additive genetic variance; σ^2_{rg} : residual genetic variance; σ^2_{ng} : non-genetic variance; $\%\sigma^2_a$: % of total genetic variance that is additive; σ^2_g/σ^2_{ng} : ratio of total genetic variance to non-genetic variance, h^2 : narrow sense heritability; H^2 : broad sense heritability; GCV: genotypic coefficient of variation; PCV: phenotypic coefficient of variation; GA: genetic advance; GAM: genetic advance based on mean; YMV: days to first sprout emergence; TBRYLD: fresh tuber yield; DMC: dry matter content.

Table B10. Additive mean and multiplicative interaction (AMMI) analysis of variance for fresh tuber yield, dry matter content and yam mosaic virus severity.

Source	Degrees of freedom	Fresh tuber yield		Dry matter content		Yam mosaic virus	
		Sum of squares	Mean squares	Sum of squares	Mean squares	Sum of squares	Mean squares
IPC1	50	5976.86	119.54***	4149.06	82.98***	67.01	1.34***
IPC2	48	4184.85	87.18***	3486.86	72.64***	46.81	0.97***
Genotype(G)	48	1760.83	36.68***	1568.46	32.68***	36.62	0.763***
Environment(E)	3	2770.54	923.51***	1032.13	344.04***	20.16	6.72***
REP(ENV)	52	1019.46	19.60***	723.97	13.92***	10.80	0.21***
G×E	141	1473.39	10.45**	1376.65	9.76*	18.57	0.13***
Residuals	141	980.54	6.95	956.54	6.78	9.58	0.07

*, **, ***=non-significant, significant at $p < 0.05$, $p < 0.01$ and $p < 0.001$, respectively.

IPC1=interactive principal component 1; IPC2=interactive principal component 2;

REP(ENV)=replication by environment; G×E =genotype by environment interaction

Table B11. Additive mean and multiplicative interaction (AMMI) stability statistics dissecting the performance stability for fresh tuber yield ($t\ ha^{-1}$), tuber dry matter content (%), and mosaic virus susceptibility scale on 49 elite clones of white Guinea yam grown at four sites in Nigeria in 2017/2018.

Clones	Fresh tuber yield (tha ⁻¹)			Tuber Dry matter (%)			Yam mosaic virus susceptibility scale			Mean Stability
	Mean	ASV	YSI	Mean	ASV	SI	Mean	ASV	SI	index
TDr09/00135	13.231	0.358	14	32.961	0.469	27	2.870	0.657	74	<u>38.3(5)</u>
TDr10/00310	11.563	0.153	17	27.608	0.545	70	2.904	0.172	42	43.0(16)
TDr11/00055	14.261	0.579	18	30.166	1.016	82	2.231	0.204	21	40.3(8)
TDr10/00412	10.669	0.156	25	32.451	0.406	31	2.561	0.062	10	<u>22.0(1)</u>
TDr00/00001	12.280	0.537	25	28.398	0.754	73	2.368	0.341	39	45.7(20)
TDr10/01012	10.705	0.256	26	32.400	1.505	68	2.970	0.469	73	55.7(34)
TDr09/00052	12.069	0.489	27	32.749	0.917	53	2.608	0.108	18	<u>32.7(3)</u>
TDr09/00220	10.834	0.407	29	33.793	0.942	44	3.086	0.141	48	40.3(8)
TDr11/01272	12.206	0.656	32	27.656	0.328	54	2.796	0.208	40	42.0(13)
TDr89/00983	13.070	0.955	35	34.863	0.619	28	2.430	0.259	33	<u>32.0(2)</u>
TDr11/00128	10.233	0.452	37	32.916	0.962	52	3.111	0.224	58	49.0(24)
TDr10/00600	10.693	0.603	37.5	34.546	1.326	52	2.793	0.185	35	41.5(10)
TDr10/00605	15.621	1.222	38	30.314	0.219	45	2.626	0.290	42	41.7(11)
TDr11/00291	8.344	0.089	39	32.970	0.439	24	3.229	0.060	48	<u>37.0(4)</u>
TDr10/00052	13.271	1.246	42	31.244	0.874	65	2.686	0.241	40	49.0(24)
TDr10/00021	13.765	1.278	43	30.414	0.876	72	2.843	0.518	69	61.3(41)
TDr09/00267	9.150	0.437	44	31.149	0.456	48	3.641	0.570	96	62.7(42)
TDr09/00122	12.990	1.200	44	31.506	0.875	63	2.424	0.094	11	39.3(6)
TDr09/00121	12.133	1.142	46	33.331	0.960	47	2.703	0.260	43	45.3(19)
TDr11/00734	10.693	0.847	46.5	32.924	1.526	61	3.199	0.451	86	64.5(46)
TDr10/00563	8.326	0.256	47	35.585	1.119	44	2.573	0.484	52	47.7(22)
TDr09/00013	9.865	0.641	48	32.859	0.721	42	3.103	0.228	58	49.3(26)
TDr09/00404	9.711	0.635	49	31.877	0.497	43	2.648	0.319	45	45.7(20)
TDr10/00248	8.043	0.217	49	30.124	0.516	61	2.765	0.288	46	52.0(28)
TDr10/00228	7.981	0.162	49	31.052	1.943	85	2.968	0.113	39	57.7(37)

TDr09/00263	13.045	1.497	51	34.688	1.915	54	2.159	0.407	39	48.0(23)
TDr11/01408	10.103	0.801	52	33.841	0.391	16	3.158	0.236	66	44.7(17)
TDr11/01142	6.950	0.204	52	32.474	0.397	29	3.121	0.445	78	53.0(29)
TDr10/00149	9.509	0.658	53	30.321	0.504	56	2.898	0.269	55	54.7(31)
TDr11/00629	11.868	1.402	55	30.701	0.801	66	3.135	0.121	51	57.3(36)
TDr11/00015	11.474	1.263	55	28.875	0.861	73	2.821	0.190	38	55.3(32)
TDr10/00060	7.064	0.401	56	35.075	0.968	41	2.821	0.102	28	41.7(11)
TDr11/00180	12.939	1.692	57	30.768	1.077	78	2.356	0.493	48	61.0(40)
TDr09/02079	8.309	0.622	58	34.766	1.013	44	2.623	0.183	26	42.7(14)
TDr10/00913	8.911	0.874	62	32.883	0.211	19	2.786	0.380	54	45.0(18)
Danacha	8.709	0.938	65	32.220	0.409	35	3.015	0.589	81	60.3(39)
TDr11/00008	8.970	1.028	65	31.488	0.323	37	2.656	0.125	26	42.7(14)
TDr09/00408	11.081	2.078	66	31.665	0.062	30	3.308	0.120	58	51.3(27)
TDr89/02665	8.118	0.767	66	35.966	1.215	45	2.351	0.100	9	40.0(7)
TDr09/00295	10.575	1.476	66	32.051	0.530	45	2.959	0.337	62	57.7(37)
Oju-iyawo	8.780	0.980	67	31.395	0.741	59	2.844	0.412	63	63.0(43)
TDr09/00134	6.831	0.693	71	31.977	0.551	49	3.133	0.354	74	64.7(47)
TDr10/00245	10.210	1.518	71	33.703	1.132	53	3.061	0.091	37	53.7(30)
TDr09/00341	10.169	1.663	73	27.871	0.187	49	2.979	0.399	69	63.7(44)
TDr10/00144	9.805	1.511	74	32.161	0.580	48	2.871	0.194	44	55.3(32)
TDr10/00282	8.163	1.185	76	32.773	0.386	25	3.195	0.233	67	56.0(35)
TDr11/00228	8.920	1.417	76	28.704	0.863	75	3.163	0.093	47	66.0(48)
TDr09/00152	8.018	1.037	77	32.290	0.536	43	3.155	0.306	72	64.0(45)
TDr11/01701	6.133	0.964	79	31.526	0.506	47	3.224	0.507	91	72.3(49)

ASV: AMMI stability value; YSI: yield stability index; SI: AMMI stability index; bold values indicate the top five clones combining superior respective trait value with performance stability across

different sites. Mean stability index refers to the average stability index value for simultaneous selection for fresh tuber yield, tuber dry matter, and yam mosaic virus severity, while the number in parentheses is the ranking based on the mean stability index. Bold and underlined values indicate the top 5 ranking genotypes based on the mean stability index.

Evaluation of introduced white yam genotypes in Sierra Leone

The objectives were to identify clones with desired traits under Sierra Leone conditions and multiply materials for multi-location testing, adaptability, and stability analyses. A total of 20 white yam genotypes were used. Sett sizes of 100 g each were pretreated with wood ash for 2 h before planting in holes made on the crest of ridges at a spatial arrangement of 1 m × 0.5 m. Findings revealed that the breeding values of the measured traits significantly varied among genotypes (Table B12). The disease pressure was mild for most of the genotypes, except for eight genotypes with YMV scores ranging from 2.6 to 2.8, and TDr9700205, with a 2.6 YAD score, had low infections of the disease. Findings also revealed 14 genotypes with a mean yield >10 t ha⁻¹.

Table B12. Breeding values of 20 genotypes of white yams for tuber yield, tuber number, and foliar diseases

Genotype	Tuber yield (t ha ⁻¹)	Tuber number per plant	Anthracnose disease severity	Yam mosaic virus severity
TDr0900122	16.44	1.1	1.8	2.0
TDr0900135	11.18	1.0	1.9	2.3
TDr0900263	13.67	1.2	2.0	2.1
TDr1000021	10.78	1.2	2.0	2.3
TDr1000605	16.06	1.2	2.0	2.2
TDr1100055	12.49	1.3	1.7	1.9
TDr1100180	14.08	1.2	2.0	2.3
TDr8902157	5.72	2.0	2.0	2.6
TDr8902475	7.82	1.5	2.1	2.7
TDr8902607	9.56	1.4	2.0	2.6
TDR9501932	11.57	1.3	2.0	2.6
TDr9518544	12.77	1.7	2.0	2.0
TDr9519158	11.61	1.0	2.0	2.1
TDr9700205	2.77	1.0	2.6	2.8
TDr9700793	13.16	1.1	2.0	2.4
Fakesta	11.26	1.3	2.1	2.6
Leusi	17.63	1.5	2.0	2.0
Nndu	5.16	1.1	2.1	2.8
Ojuiyawo	4.9	1.3	2.0	2.7
Pampass	12.32	1.2	2.2	2.0
SED	2.66	0.20	0.05	0.07
F pr	<0.001	0.006	0.335	0.022

SED=standard error of difference

Assessment of growth and yield parameters of early generation families of white yam (*Dioscorea rotundata*)

This study evaluated the growth and yield potentials of some introduced early generation botanical seed families of white yam (*Dioscorea rotundata*). A total of 1000 experimental materials comprising 100 botanical seeds, each of 10 white yam families, were used. The 10 seed-families included TDr190068, TDr190065, TDr190055, TDr190053, TDr190051, TDr190048, TDr190046, TDr190023, TDr190016 and TDr190113. The experimental materials were introductions from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. Findings revealed significant variations among families for days to first emergence (DAYFE), days to 50% emergence (DAYSE), and tuber yield potential of first filial generation. The study demonstrated that the delayed germination of botanical seeds contributes to a reduction in the effective growth and development of yams.

The segregating progeny exhibited the widest range of variability for DAYFE, DAYSE, and fresh tuber weight that could be exploited for the genetic improvement of the crop. Family TDr190016 took the shortest duration of 14 days to emerge, while families TDr190053 and TDr190113 took the longest duration of at least 20 days to emerge. Family TDr190016 took the shortest DAYSE of 20 days, while families TDr190053 and TDr190113 took the longest periods of 32 and 49 DAYSE, respectively. Family TDr190046 significantly produced the heaviest tubers per plant (0.0304 kg), while family TDr190048 (0.0070 kg) had the lightest tubers. Family TDr190053 exhibited the widest range of variability (0.002–0.1605 kg) and the heaviest mean value of 0.0407 kg for fresh tuber weight per plant, while family TDr190048, with tubers ranging from 0.0006–0.0175 kg and a mean tuber of 0.0070 kg, had the lightest tubers. Improvement of seed germination, growth, and tuber yield potential traits could enhance the identification of superior progenies at the early-stage yam breeding trials. Genetic analysis of seedling traits could be exploited to combat the poor seed germination in yams.

Effect of pot size and transplanting date on the yield of introduced SAH-derived micro-tubers of white yam

Virus-free semi-autotrophic hydroponics (SAH)-derived micro-tubers of white yam (*Dioscorea rotundata* Poir var TDr9719177) introduced from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, were used to evaluate the effect of pot size and transplanting date on tuber production of introduced SAH micro-tuber-derived white yam during 2020 – 2021. Findings revealed that pot size and transplanting date significantly ($P < 0.001$) influenced mini-tuber production in SAH-derived micro-tuber white yam. Pot size 38.5 × 28.5 cm significantly ($P < 0.001$) produced heavier fresh tuber weight per plant and fresh tuber weight per tuber than pot size 29.5 × 23.0 cm. Pot size 38.5 × 28.5 cm produced heavier fresh tuber weight per plant (107.1 g) and fresh tuber weight per tuber (81.8 g) compared to 33.8 g and 21.1 g obtained in pot size 29.5 × 23.0 cm, respectively. Per cent difference in fresh tuber weight per plant was higher in pot size 29.5 × 23.0 cm (75.7%) than in pot size 38.5 × 28.5 cm (75.1%). Transplanting in September exhibited significantly higher mean fresh tuber weight per plant of 123.4 g and fresh tuber weight per tuber of 88.8 g than transplanting in October, with mean values of 17.4 g and 14.1 g, respectively. Transplanting in October (53.0%) exhibited a higher difference between pot sizes than transplanting in September (51.9%). Conversely, the per cent difference in fresh tuber weight per tuber was higher in pot size 38.5 × 28.5 cm (73.5%) than in pot size 29.5 × 23.0 cm (68.7%). Transplanting in September (59.9%) had a higher difference between pot sizes than transplanting in October (53.4%).



Plate 2. Photographic display of fresh tubers harvested from SAH micro-tubers transplanted in:
(a) September 2020 in pot size 38.5 × 28.5 cm; (b) October 2020 in pot size 38.5 × 28.5 cm; (c)
September 2020 in pot size 29.5 × 23.0 cm; and (d) October 2020 in pot size 29.5 × 23.0 cm

Genetic parameter estimates and correlations in introduced *Dioscorea rotundata* (white yam) genotypes

The study aimed to determine the genetic parameter estimates and genetic relationships among selected agronomic traits in introduced white yam (*D. rotundata*) genotypes using phenotypic marker information. A total of 20 introduced genotypes of *Dioscorea rotundata* (white yam) from the International Institute of Tropical Agriculture (IITA), Nigeria, were used for this study. A total of 14 morphological traits were collected. Findings revealed that the five top-performing genotypes, including TDrLeusi (17.0 t.ha⁻¹), TDr1000605 (15.2 t.ha⁻¹), TDr0900122 (14.0 t.ha⁻¹), TDr1100180 (13.7 t.ha⁻¹) and TDr0900263 (13.5 t.ha⁻¹), were identified with high tuber yields. The high genetic variability and good trait values of the introduced white yam genotypes would serve as useful resources for the genetic conservation, management, short-term recommendation for release and genetic improvement of the crop. The yam genotypes possess useful genetic parameter estimates for the eight quantitative traits that could be exploited through direct selection or a population improvement scheme. It is, however, recommended that the genotypes be tested across various ecologies for their adaptability and stability before recommendation for release and deployment in the production environments.

Assessment of growth and reproductive traits of some introduced varieties of African yam bean (*Sphenosylis stenocarpa* Hochst. ex. A. Rich Harms)

The objective of this research was to evaluate the growth and reproductive traits of ten introduced genotypes of African yam bean. Ten introduced genotypes of African yam bean (*Sphenostylis stenocarpa*) from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria, were utilised for this study. Findings revealed that six genotypes had the highest mean final per cent germination, ranging from 90.0-96.7%, whereas the remaining genotypes with

mean final per cent germination of 70.0-86.7% had the lowest. Genotypes TSs11 (25.05 cm) produced the tallest plants, similar to TSs2 (22.77 cm), TSs424 (22.33 cm) and TSs432 (22.53 cm), whereas genotypes TSs10A, TSs151B, TSs433 and TSs60 significantly had the shortest plants with mean height ranging between 16.73 and 19.08 cm. Genotypes TSs11, TSs2 and TSs450 had the largest stem diameter (6.2-7.2 cm). Genotypes TSs151B, TSs2, TSs282, TSs450 and TSs60 significantly had longer peduncles (9.3-10.5 cm, whereas TSs10A had the shortest peduncle of 8.0 cm. Genotypes TSs11, TSs424, TSs432, and TSs450 produced the smallest number of floral buds per peduncle of 5.0, 6.5, 5.4, and 5.1, respectively, whereas the remaining genotypes had at least 9 floral buds. These vegetative and reproductive characteristics can serve as indices for selection in breeding programmes. The reported genotypes are suggested for further yield-related research that could lead to genetic improvement of African yam bean.

Effects of set size on sprouting, growth, yield and related traits of semi-autotrophic-derived white yam (*Dioscorea rotundata*) genotype

This study aimed to evaluate the seedling growth and yield traits in *Dioscorea rotundata* using different sett sizes on tuber production. The experimental material comprised yam setts obtained from genotype TDr97019177. The different set weights, including 20 g, 50 g, 100 g, and 200 g, were used. Findings revealed that variations among different sett weight planting materials were significant for days to first emergence, days to fifty per cent emergence, final per cent germination, sprouting index, plant height, stem girth and seedling vigour index. Variations in sett weight, planting material sprouting, growth, yield and related traits could be exploited for efficient deployment of yam cultivation in farmers' fields, as well as in agronomic and breeding trials. The present study revealed that delayed sprouting contributes to a reduction in the effective growth and development duration of white yams. The big sett weight categories of 200 g started sprouting in 16 days and were the earliest to reach 50% sprouting in 24 days after planting, compared to the small sett weight categories. The big sett weight categories of white yam produced the tallest vines, largest stem girth per plant, highest sprouting index, highest seedling vigour index, highest tuber yield of 25.4 t ha⁻¹ and heaviest weight of tubers per plant of

2.5 kg, whereas the treatment small sett weight 20 g had the lowest yield (7.1 t ha⁻¹) and lightest weight of tubers per plant of 0.7 kg.

Sprouting, growth, yield and related traits as influenced by planting materials (bulbils, seed yams, head, middle and tail portions) of water yam (*Dioscorea alata*)

This study aimed to assess the sprouting, growth and related traits of various planting material types (bulbils, seed yams, head, middle and tail portions) of water yam (*Dioscorea alata*). The experimental material was obtained from recently released yams in Sierra Leone known as Sierra Leone Improved Yam 1 (SLIYAM1). The experimental material comprised six categories of yam planting materials (bulbil 1 (20 g), bulbil 2 (5 g), seed yam (200 g), head portion 200 g, middle portion (200 g) and tail portion (200 g)) obtained from genotype TDa0000194 (SLIYAM1). Results revealed that mean days to first emergence (DAYFE), days to fifty per cent emergence (DAYSE), coefficient of velocity of germination (CVG), and germination index (GI) exhibited significant ($p < 0.05$) variations among planting materials studied, whereas final per cent germination (FPG) assessed at 2 months after planting had non-significant variation. The treatment head portion sprouted earliest (10 days), reaching 50% sprouting at 13 days after planting (DAP). The treatment middle tuber portion took the longest period (30 DAP) to sprout, and the longest period to reach 50% sprouting at 37 DAP, similar to the tail portion, which exhibited 27 and 31 DAYFE and DAYSE, respectively. Treatments head portion (0.19), seed yam (0.34), and bulbils (0.22 and 0.19) significantly exhibited the smallest CVG, whereas treatments middle (2.13) and tail (1.91) portions had the highest CVG. Similarly, treatment head portion (4.39), seed yams (2.41) and bulbils (3.68 and 3.99) significantly had the highest CVG values, whereas treatment middle and tail portions exhibited the lowest CVG of 0.61 and 1.45, respectively. Vines derived from the proximal or head portion of TDa00/00194 significantly exhibited the highest seedling vigour index (SVI) values of 89.5 and 194.7 at one and two months after planting (MAP), respectively, whereas the middle portion (2.8%), distal portion (5.4%), and bulbil 2 (16.4%) planting materials had the lowest SVI values at 1 MAP. At 2 MAP, seedlings derived from bulbils 2 (i.e. each bulbil weighing 5 g) had the lowest SVI of 64.2, similar to those measured from seed

yams (101.3) and tail (120.7) planting materials. The plants obtained from the proximal or head portion significantly exhibited the tallest plants at one (89.5 cm) and two (194.7 cm) MAPs, whereas the distal portion (8.0 cm), the middle portion (5.5 cm) and bulbil 2 (17.9 cm) planting materials had the shortest plants at 1 MAP. At 2 MAP, seedlings derived from bulbil 2 (i.e. each bulbil weighing 5 g) had the shortest plants. Stem number per plant was highest for the two-bulbil categories utilised in the study, whereas the middle portion produced the lowest number of stems per plant. Vines derived from the head portion had the largest stem per plant (8.18 mm), whereas those from the lower weight bulbils (i.e. each bulbil weighing 5 g) produced the thinnest vines per plant (4.07 mm). Proximal portion significantly exhibited the highest tubers per plant (2.9) and heaviest tuber weight per plant (2.4 kg), whereas bulbil 2 (5 g) and bulbil (20 g) were among treatments with the lowest tuber number per plant (1.5-1.7) and lightest tuber weight per plant (0.7 kg). Tuber yield of bulbil 1 (20 g) (30.6 t ha⁻¹) significantly outyielded head portion and the remaining tuber setts, followed by bulbil 2 (5 g) (28.2 t ha⁻¹), whereas the middle (200 g) portion had the lowest yield of 17.9 t ha⁻¹. The results generally indicated that yield metric traits measured in water yams increase with decreasing spatial arrangement, coupled with the type of planting materials utilised for crop establishment.

Assessment of growth and yield parameters of tuber families of white yam (*Dioscorea rotundata*)

A total of 10 white yam families including TDr190068, TDr190065, TDr190055, TDr190053, TDr190051, TDr190048, TDr190046, TDr190023, TDr190016 and TDr190113 were used. The experimental materials were introductions from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria (Table B13).

Table B13. Phenotypic attributes of *Dioscorea rotundata* crossing parents used in the study

Crossing parents	Family code	Female clone attributes	Male clone attributes
TDr3010 × TDr1500043	TDr190016	Profuse flowering with a wide window	Low soil nutrient adaptability, DM=32.-

			34.7%, no oxidation, yield=37.4 t ha ⁻¹
TDr2826A × TDr1500135	TDr190023	Oxidation(-), DM=32.0%, stable yellow flesh color	Low soil nutrient adaptability, Oxi (-)
TDr2826A × TDr1500096	TDr190046	Oxidation (-), DM=32.0%, stable yellow flesh color	No oxidation, Low soil adaptability, high DM, yield=31.2 t ha ⁻¹
TDr3010 × TDr1500100	TDr190048	Profuse flowering with a wide window	Low soil nutrient adaptability, high DM, oxidation (-), yield=36.0 t ha ⁻¹
TDr3010 × TDr1500031	TDr190051	Profuse flowering with a wide window	Low soil nutrient adaptability, yield=35 t ha ⁻¹
TDr1401220 × TDr9501932	TDr190053	DM=32.0%, oxidation (-), stable creamy white flesh colour	DM=36.0-36.7%, no oxidation, VR, high flowering, cooking quality, multiple tubering, YLD=29.2 t ha ⁻¹
TDr1400012 × TDr1500135	TDr190055	Oxidation (-), DM=32.0%, stable yellow flesh colour	Low soil nutrient adaptability, oxidation (-)
TDr1100873 × TDr0900324	TDr190065	Oxidation (-), good DM, stable creamy flesh colour	Oxi (-), DM=30.0-32.0%, stable creamy flesh colour

TDr9518544 × TDr1500043	TDr190068	Earliness, cooking quality, multiple tubering, oxidation (-)	Low soil nutrient adaptability, DM=32.0-34.7%, no oxidation, yield=37.4 t ha ⁻¹
TDr9700917 × TDr1500096	TDr190113	Virus-tolerant, early bulk, high flower	No oxidation, low soil nutrient adaptability, high DM, yield=31.2 t ha ⁻¹

Families TDr190053, TDr190051 and TDr190048 significantly ($p < 0.05$) produced the tallest vines of 217.8, 215.3 and 210.9 cm, respectively, whereas families TDr190065, TDr190055 and TDr190068 exhibited the shortest plants of 85.5, 87.3 and 92.6 cm, respectively. Family TDr190051 exhibited the largest mean stem girth (7.34 mm) with weights ranging from 3.37-10.02 mm, whereas families TDr190055 (2.21 mm) and TDr190065 (3.35 mm) had the thinnest stems. Family TDr190053 had significantly the highest number of stems (2.5), whereas all clones of families TDr190048, TDr190055, and TDr190068 produced the lowest value of 1 stem per plant. The significant variations among families for the growth traits are indicative of the inherent genetic differences in the yam clones developed using different crossing parents. The higher coefficient of variation of the growth parameters implies a higher level of dispersion around the mean. Family TDr190065 significantly ($p < 0.05$) produced the highest mean number of tubers per plant (2.5), with the number of tubers ranging from 2-3, whereas families TDr190048, TDr190055, and TDr190068 exhibited the lowest number of tubers per plant of 1.0. Family TDr190053 produced the heaviest mean tubers per plant (450 g) with weights ranging from 400-500 g, whereas family TDr190068 exhibited the lightest tubers per plant (92.0 g) with weights ranging from 25-350 g. Family TDr190046 exhibited the widest range of variability (5.0–850.0 g) for fresh tuber weight per plant. The wide variability in fresh tuber weight and related tuber number per plant among families could be partly attributed to the differences in the effective individual plant

growth periods after sprouting. The higher coefficient of variation of fresh tuber weight per plant and tuber number per plant indicates a higher level of dispersion around the mean.

Seedling vigour index and tuber yield traits as influenced by genotype and pre-sprouted sett and direct planting materials

The objective of this study was to assess the effect of pre-sprouting and direct planting of yam setts on genotypic seedling vigour index and fresh tuber yield in white yam genotypes. Findings revealed that mean SVI and fresh tuber yield significantly ($p < 0.05$) varied with genotype, treatment, and the interaction between genotype and treatment. The pre-nursed sets of genotypes TDr9700793 (15363) had the highest SVI, followed by TDr8902475 (12429) and TDr1000021 (10869), whilst TDr1100055 had the lowest of 5430. For the direct planted setts, genotype TDr1000021 (10625) had the highest, whereas TDr8902475 (3775) had the lowest. Comparison of the genotypic mean values of the two sets of treatments (pre-sprouted setts and direct planted setts) revealed a differential SVI increase of 29.5% in pre-sprouted setts relative to those established using direct planted setts. Generally, the mean fresh tuber yield of pre-nursed planting materials (14.71 t ha^{-1}) significantly out-yielded those established with non-sprouted materials (12.05 t ha^{-1}). The magnitude of the yield variation depends on genotype. For genotypes established using pre-sprouted materials, TDr1100055 (24.00 t ha^{-1}) had the highest fresh tuber yield, followed by Ojuiyawo (15.80 t ha^{-1}), whilst TDr0900122 had the lowest of 10.75 t ha^{-1} . For the direct planted setts, genotypes TDr9700793 (15.29 t ha^{-1}) had the highest, followed by TDr1100055 (14.38 t ha^{-1}), whereas TDr8902475 had the lowest of 9.88 t ha^{-1} . Genotypic mean values revealed a differential fresh tuber yield increase of 18.1% in pre-sprouted planting materials relative to those established using direct-planted setts. Moreover, the differential mean value was widest in TDr1100055, ranging from 14.38 t ha^{-1} to 24.00 t ha^{-1} in direct planted and pre-sprouted planting materials, respectively. The yield gap range was narrowest for TDr0900122, which exhibited 10.75 t ha^{-1} and 10.83 t ha^{-1} , respectively. This study demonstrated the presence of significant variations in the seedling vigour index and fresh tuber yield traits of introduced white yam genotypes established using pre-sprouted sett and direct planting

materials that could be exploited for the development of an agronomic package for smallholder farmers.

Estimation of genetic parameters for selected quantitative traits in introduced African Yam bean (*Sphenosylis stenocarpa* Hochst. ex. A. Rich Harms) genotypes

This study determined the genetic variability and genetic parameter estimates among 10 introduced African yam bean genotypes. Results revealed that genotype TSs11 (72.2) had the highest breeding values for seed emergence speed, while TSs450 had the lowest value of 41.0. Genotypes TSs432 (1464), TSs424 (1405), TSs11 (1384), TSs151B (1371), and TSs2 (1348) had the highest seedling vigour index (SVI), while TSs60 had the lowest of 954. TSs10A (998.6 kgha⁻¹) had the highest seed yield, whereas TSs11 (388.3 kgha⁻¹) had the lowest. The breeding values of reproductive traits significantly ($p < 0.001$) varied among genotypes. Genotype TSs11 significantly took the longest period to initiate flower bud (110.3 days), flower (121.8 days) and pod initiation (124.8 days), whereas TSs151B took the shortest periods of 103.3, 109.5 and 113.2 days, respectively. The phenotypic coefficient of variation (PCV) values were slightly higher than the genotypic coefficient of variation (GCV) values for all traits (Tables B14 and B15). The slightly higher PCV values compared to the GCV generally imply that some traits were less sensitive to environmental effects. Seed emergence speed (37.5%), SVI (22.8%) and seed yield (36.8%) had high PCV, whereas final germination per cent (12.0%) had intermediate PCV, and the remaining traits had low PCV. Seed yield (20.7%) had high GCV, whereas seed emergence speed (10.8%) and SVI (12.1%) had intermediate and the remaining traits exhibited low GCV of 2.0-3.5. Traits with high PCV and GCV signify a high possibility of selecting clones possessing superior values for the trait in the next clonal generation. Days to flower bud initiation (62.4%) had high broad-sense heritability, whereas seed yield (31.5%), days to flowering (56.8%) and days to pod initiation (59.1%) had medium heritability, and the remaining had low heritability. A trait with high heritability indicates that it is less influenced by environment and that selection would be effective for its improvement.

Table B14. Genetic parameter estimates of growth and yield traits

Parameter	Seed emergence speed	Seedling vigour index	Final germination per cent	Seed yield (kg ha ⁻¹)
Mean	54.1	1255.0	89.9	695.2
Minimum	8.3	554.4	55.0	249.8
Maximum	100.0	1984.0	100.0	1810.0
Standard error	47.6	15616.0	13.5	13333.0
Phenotypic coefficient of variation	37.5	22.8	12.0	36.8
Genotypic coefficient of variation	10.8	12.1	3.5	20.7
Broad sense heritability	8.4	28.1	8.3	31.5
Genetic advance	6.5	13.2	2.1	23.9
Genetic advance of the mean	12.0	1.1	2.3	3.4

Table B15. Genetic parameter estimates of reproductive traits

Parameter	Days to flower bud initiation	Days to flowering	Days to pod initiation
Mean	106.5	114.3	117.7
Minimum	98.0	102.0	106.0
Maximum	112.0	130.0	135.0
Standard error	2.3	6.1	4.7
Phenotypic coefficient of variation	2.5	3.9	3.3
Genotypic coefficient of variation	2.0	3.0	2.6
Broad sense heritability	62.4	56.8	59.1
Genetic advance	3.2	4.6	4.0
Genetic advance of the mean	3.0	4.0	3.4

Seed yield (23.9) and SVI (13.2) exhibited high and medium genetic advance (GA), respectively, while the remaining traits had low GA. Seed emergence speed (12.0) had medium genetic advance as per cent of the mean (GAM), whereas the remaining traits had low GAM (1.1-4.0). This study demonstrated the presence of variations in the breeding values and genetic parameter estimates of selected growth, yield and reproductive traits of introduced African yam bean genotypes that could be exploited for breeding.

C. KENEMA FORESTRY AND TREE CROPS RESEARCH CENTRE (KFTCRC)

The forestry and tree crops research programme is implemented at the KFTCRC. The Programme is aimed at addressing challenges to enhance sustainable productivity, commercialization, and competitiveness of the forestry and tree crops.

Development and promotion of cocoa product value chains

The International Fund for Agricultural Development (IFAD) supported the KFTCRC from 2013 to 2015 in the rehabilitation of the Pendembu and Kpuwabu cocoa clonal gardens. Moreover, a 1 ha cocoa clonal garden was established for the production of planting materials to support stakeholders such as the Sustainable Tree Crop Project (STCP) in Liberia. The Smallholder

Commercialisation and Agribusiness Development Project (SCADeP) from 2017 to 2023. The key deliverables included: Rehabilitation of water supply system at Kpuwabu; Solar electrification of the Kpuwabu senior staff quarters; Installation of a greenhouse at Kpuwabu; Construction of multipurpose farm building at Pendembu; Construction of drying floor at Pendembu; Rehabilitation of conference hall and laboratory at Pendembu; Procurement of assorted laboratory tools and implements at Pendembu; Training of a one staff in the use of laboratory tools and implements at the IITA; Support to 150 cocoa farmers in Kenema and Kailahun districts for the establishment of 150 ha of cocoa (1 ha per farmer); Support to 30 oil palm farmers in Bombali and Kambia districts for the establishment of 30 ha of improved oil palm planting materials that were imported from the Oil Palm Research Institute (OPRI) of Ghana; and Administrative support to the KFTCRC for the procurement of office consumables.

Support from the Boosting Agriculture and Food Security (BAFS) Project started in 2018, and the following results:

About 10,000 seedlings of C67 and C77 were nursed as root stocks at Pendembu and Kpuwabu so that they can be budded/grafted for gap filling of missing cocoa trees at Pendembu. These buddings/grafts were used for gap filling so that pure genetic lines of the existing materials in the clonal gardens can be maintained.

A borehole was dug at the staff quarters to provide water for staff, and an irrigation system (EMAS Pump) was installed at the Pendembu nursery site. Of the 30 clones introduced from Reading University in 2015 by the Agriculture for Development (A4D) Project, five survived and four were budded and transplanted at Kpuwabu (111 budded plants of CCN51, 180 budded plants of MO20, 4 budded plants of PA 88 and 10 budded plants of MAN15/60). Additionally, thirty-nine (39) clones were imported from the Reading University quarantine centre under the BAFS project. These have been budded, and 27 of them survived and were planted.

Under the Agricultural Value Chain Development Project (AVDP), an International Consultant (cocoa breeder) was hired to rebrand the cocoa clonal seed gardens at Pendembu and Kpuwabu. A total of 15 ha comprising 10 ha in Pendembu and 5 ha in Kpuwabu was rebranded. To facilitate this, an MoU between SLARI and the Kew Garden of the Reading University Quarantine (RUQ)

Centre was signed for the transfer of Standard Material Transfer (SMT). This MoU has, over the years, helped the SLARI/KFTCRC to import elite clones of cocoa from the UK.

Development and promotion of the coffee product value chain

A coffee rooting chamber with a capacity of 5,000 cuttings was established at the Pendembu nursery by the BAFS Project under the 11th European Development Fund.

Cuttings of the ‘highland’ coffee (*Coffea stenophylla*) obtained from the Kambui and Kasewe hills were planted in the rooting chamber. The survival rate was extremely poor. Similarly, cuttings of *C. liberica* were established in the rooting chamber. These were transplanted in polythene bags and later to a permanent site. The *C. stenophylla* and *C. liberica* coffee could provide a niche market due to their availability in the country and high global demand.

The BAFS Project supported the importation of 10 varieties (MGSCATIGUA’ 3, CATUCAI AMARELO (2SL), IAC 125 RN, CATUCAI AMARELO (IAC 62), PAQAISO 2, PAQAISO (H 419-1), TOPAZIO MG 1190, MUNDO NOVO (IAC 379-19), CATUAI VEQMELHO (IAC 144), and OEIRAS MG 6851) of Arabica coffee from Embrapa in Brazil.

Development and promotion of the Cashew product value chain

KFTCRC was supplied with 10 varieties (TAN 393, SG 185, SG 278, SG 261, SG 265, SG 273, SG 276, and SG 266) of improved cashew (3.05 ha) at the Kpuwabu clonal garden by the Competitive Cashew Initiative (ComCashew) Programme through the Solidaridad West Africa (SWA SL) project for establishment of cashew clonal garden. Additionally, another 8 varieties of improved cashew seedlings (2 ha) were supplied to KFTCRC by ComCashew and transplanted in the field at the Pendembu clonal seed garden. The KFTCRC has acquired 2 hectares of land at Bombali Shebureh for the establishment of a cashew clonal garden under the BAFS Project.

Development and promotion of the Oil palm crop product value chain

Oil palm germplasm established for the oil palm breeding programme and replacement of damaged plantlets in 2019 at Pendembu was infested by rodents. These materials were identified for inclusion in the oil palm breeding programme at the KFTCRC. It was hoped that we would

replace damaged/affected plantlets in 2019. However, we were unable to do the replacement as a result of a lack of funds. The oil palm breeding plots and NAIFOR varieties at Pendembu are regularly maintained in Pendembu and Kpuwabu.

Development and promotion of the Fruit crop product value chain

Grafted fruit trees obtained from Guinea have been fully established at the Pendembu clonal seed garden using the randomised complete block (RCB) design. The following have been established at Pendembu: Five varieties of mango viz-a-viz Keith (73 seedlings i.e. 0.72 ha), Kent (70 seedlings i.e. 0.7 ha), Palmer (75 seedlings i.e. 0.76 ha), Eldon (65 seedlings i.e. 0.64 ha) and Irwin (67 seedlings representing 0.68 ha) at a planting distance of 10 m × 10m; four varieties of citrus viz-aviz Pemplemousse (102 seedlings i.e. 0.67 ha), Nandarine (101 seedlings i.e. 0.65 ha), Sokotoro (41 seedlings i.e. 0.28 ha) and Timbo (35 seedlings occupying 0.24 ha) at a planting distance of 8 m × 8 m; one variety of lime i.e. *Lime tapriti* (11 seedlings occupying 0.012 ha) at a planting distance of 4 m × 4m; three varieties of avocado viz-a-viz Polock (20 seedlings i.e. 0.13 ha), Lula (20 seedlings i.e. 0.13 ha) and Avocado seedlings (77 seedlings i.e. 0.49 ha) at a planting distance of 8 m × 8 m and three varieties of banana viz-a-viz Grande naime (102 seedlings i.e. 0.16 ha), FHIA -23 (85 seedlings i.e. 0.14 ha) and SH –L45 (90 seedlings i.e. 0.14 ha) planted at 4 m × 4 m. Hence, a total of 6.7 ha (83.75%) of grafted fruit trees have been established. It is hoped that when local germplasms must have been collected, the improved fruit trees will be grafted onto the remaining 1.3 ha (16.25%) before the end of the project.

Agroforestry

Approximately 2 ha of agroforestry plots have been established at the Bambawo research station. Two experimental plots were established with *Tectona grandis* being intercropped with *Theobroma cacao* L., and so is *Terminalia ivorensis*. Seedlings of certain economic trees and cocoa/cashew will be nursed this year so that several mini-experimental plots with different variables will be compared to achieve maximum and reliable results that may be recommended to smallholder farmers. The first experimental plot contains *T. ivorensis* with cocoa, which has a spacing of 3 m x 3 m in between rows was established on the 13th September, 2019. The second

plot contains *Tectona grandis* intercropped with cocoa and was planted on the 16th of October 2019 with the same spacing of 3 m × 3 m in between rows.

D. KABALA HORTICULTURAL CROPS RESEARCH CENTRE (KHCR)

The horticultural crops research programme is implemented at the KHCR. The Programme is aimed at addressing challenges to enhance sustainable productivity, commercialization, and competitiveness of the horticultural crops.

Testing and selection of at least 5 varieties/crop of 10 major vegetable crops during 4 years

A focus group discussion (FGD) was conducted in five cluster locations (Kabala, Kathombo II, Senekedugu, Koromasalia, and Suliamania) to determine the criteria farmers consider when selecting varieties of vegetables for cultivation using matrix ranking. Findings revealed that high market value, high yield, short maturity period, and resistance to pests and diseases are the major criteria used by vegetable farmers for variety selection.

Improved varieties of 14 vegetables were introduced by NIHORT, the Kokopelli Foundation, and the World Vegetable Centre. The status of these varieties is presented in Table D1.

Table D1. Status of introduced improved varieties of vegetable crops

No.	Vegetable crop	2019 NIHORT	2020 KF	2024 NIHORT	2024 WVC	Total number of IVM introduced	Number of varieties as of October 2024
1	Okra	38	3	8	0	49	10
2	Tomato	30	5	10	18	63	30
3	Krain Krain	30	0	10	0	40	10
4	Green	8	0	10	0	18	11
5	Garden egg	0	0	8	0	8	8
6	Eggplant	3	10	2	0	15	4
7	Chilli Pepper	10	7	0	13	30	19

8	Cucumber	0	5	0	6	11	8
9	Beans	0	3	0	0	3	2
10	Lettuce	0	3	0	0	3	2
11	Pumpkin	0	4	0	7	11	9
12	Watermelon	0	5	0	0	5	2
Total		119	45	48	49	261	124

Note: KF: Kokopele Foundation, NIHORT: Nigeria Horticultural Research Institute, WVC: World Vegetable Centre

Multi-locational screening, characterisation, selection of improved vegetal materials (IVM), and local accessions of 10 different vegetable crops were done using agro-morphological markers. Findings revealed the existence of useful genetic variation that could be exploited for the genetic improvement and utilisation of the various vegetable crops (Figure D1).



Figure D1. Photographic display of a: lettuce and b: pumpkin, c: beans, d: watermelon, e: okra, f: cucumber, g: pepper, h: eggplant, i: African eggplants, and j: tomato screened and characterised

Production of seeds for the development of the vegetables

A total of 20 farmers were trained in vegetable seed production. Participants included farmers participating in the out-station vegetable seed production and MAFS Crops and Extension staff. To further enhance the seed production capabilities of the Research Centre and farmers during the off-season, SLARI has committed to the establishment of a two-hectare seed multiplication

site along the river in Musaia. Each site was equipped with solar-powered irrigation facilities, one 10,000-litre storage tank, and water pipes and hoses for irrigation of the fields.

Characterization, testing and multiplication of under-utilized and new crops

A total of 20 vegetable crops comprising 9 underutilised and 11 new crops were introduced by CIP, NIHORT, Kokopele Foundation, AgroFraternity, World Vegetable Centre and local collections. Field trials were established to evaluate these crops at the Mamudiakoro crop site. The current status of the new and underutilised is presented in Table D2.

Table D2. Packaging and distribution of vegetable seeds to Kusalako Women Vegetable Farmers' Cooperative members at Mamudiakoro

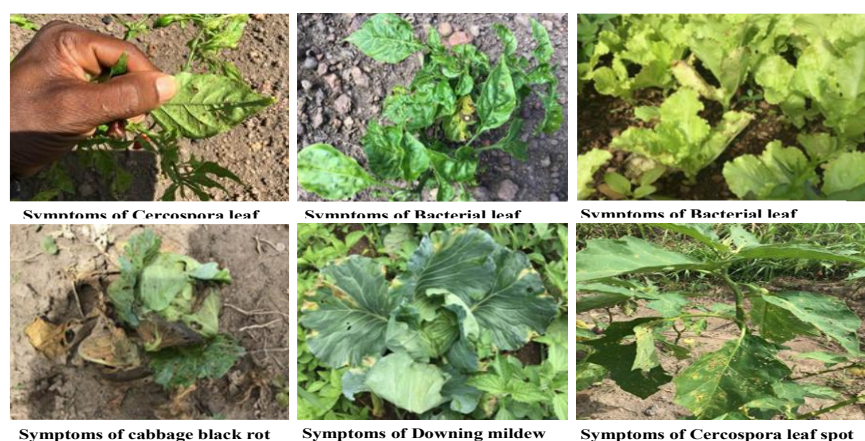
Crop	2019		2020			2024		2024
	Local collection	CIP	NIHO RT	Koko pele	Agro Fraternity	World Vegetables Centre	Total	Number of varieties available
Underutilized								
Onion				3			3	0
Egusi melon			5				5	2
Sorrel			6				6	1
Sweet pepper				5		12	17	13
Amarantus				3		6	3	7
Ginger	6						6	2
Basil				3			3	1
Oseille (sorrel)				1			1	0
African eggplant	7						7	2
Total	13	0	11	15	0		39	10
New								
Chinese cabbage				2			2	0

Courgette								0
(Zucchini)			3			3		0
Coriander			2			2		0
Parsil			2			2		0
Sauge (sage)			1			1		0
Kiwano			2			2		0
Irish potato	35		0	9		44		0
Thyme			1			1		0
Medicinal plants			2			2		0
Physalis			1			1		0
Mung beans					6	6		6
Total	0	35	16	8	6	67		6

Survey to identify major pests and diseases of vegetable crops

30 vegetable farms were visited during the study. 12 farms in the Western Area, 12 in the Koinadugu district and 6 in the Falaba district to identify pests and diseases by IPM scientists from the Njala Agricultural Research Centre (NARC).



Figure D1. Key pests identified in vegetables**Figure D2.** Key diseases identified in vegetable crops**Establishment of garden biopesticide plants**

A clonal garden of pesticide plants was established and maintained at the Mamudiakoro crop site to develop biopesticides to manage major insect pests and diseases (Fig. D).

**Figure D3.** Biopesticide plants established at the Mamudiakoro crop site

A survey on farmers' perception of climate change and its impact on vegetable production

The study was conducted in the Koinadugu district and Western Rural Area to assess the effects of extreme weather events on vegetable production, identify climate change adaptation strategies used by vegetable farmers, and identify the needs of vegetable farmers to enable them to adapt to climate change. The sample size was 382 households.

The key findings of the study were:

- ✓ The majority of the vegetable growers in both districts are female (62.6%) with no formal education (67.3%) and no training on climate change adaptation techniques (69.6%), and access land for vegetable cultivation through inheritance (68.3%).
- ✓ The average age (40 years), household size (7.7), and experience in growing vegetables (14.8 years) revealed that most of the farmers are adults with large family sizes and extensive experience in vegetable production.
- ✓ Cultivation of vegetable crops is significantly (p -value of $X^2 < 0.05$) affected by location, season, and gender. The number of farmers cultivating cabbage, lettuce, onion, eggplant, African eggplants, cucumber, green peas, and tomato in the Koinadugu district is significantly higher than in the Western Rural district. The number of farmers growing carrots and peppers in the rainy season is significantly higher than in the dry season. The number of women growing lettuce, onion, eggplant, African eggplant, okra, Krain Krain, green, green peas and sour is significantly higher than men.
- ✓ 79.6% of vegetable farmers interviewed in the study area perceived a change in the local temperature over the last years, out of which 48.4% perceived an increase in the local temperature at night, 57.9% perceived an increase in local temperature during the day, and 39.5% perceived a decrease in the harmattan period.
- ✓ 78.5% of vegetable farmers perceived a change in the local rainfall, of which 46.1% perceived an early start of the rainy season, 35.6% early end of the rainy season, and 42.7% a reduction in the length of the rainy season.
- ✓ 82.5% of the vegetable growers interviewed in the study area perceived a negative impact of temperature and rainfall changes on vegetable production. The majority of the vegetable

farmers have experienced yield loss (78.5%), high incidence of pest and disease (78.3%), and high weed infestation (74.3%).

- ✓ Majority (59.4%) of vegetable farmers are aware that agricultural activities could contribute to climate change. They revealed that deforestation (58.1%) can contribute the most to climate change, followed by the burning of vegetative cover (54.2%), erosion (39.8%), mechanical cultivation (37.7%), and excessive use of inorganic fertiliser. Their main source of information is from NGOs and MAF Extension.
- ✓ Majority (90.3%) of the farmers opined that extreme weather events have affected their vegetable production. The extreme weather events that have affected most of the farmers are heavy rainfall (78.2%), drought (77.3%) and flooding (69.8%).
- ✓ 85.6% of the farmers revealed that extreme weather events have reduced their crop yield, of which the level of reduction in crop yield of which 30.4% of the farmers had low (<25%), 45.4% of them had a moderate (25–50%), and 9.8% percent was a high (>50%).
- ✓ 54.9% of the farmers revealed that extreme weather events have increased the expenditure on vegetable production, of which 23.7% of the farmers were low (<25%), 44.5% of them were moderate (25–50%) and 12.3% percent were high (>50%).
- ✓ Majority (61.6%) of the farmers interviewed in the study area revealed that they use climate change adaptation practices in vegetable production, but the proportion of farmers differs by districts (Koinadugu = 71.4% and Western Area = 51.7%).
- ✓ The climate change adaptation practice used by the majority of the farmers in the Koinadugu district is are cropping calendar (61.8%), crop diversification (64.3%), planting of short-duration crops or varieties (60.6%), and application of organic manure (53.1%).
- ✓ The climate change adaptation practice used by the majority of the farmers in the Western Area is crop diversification, mulching, and application of organic manure (51.7%).
- ✓ 82.6% expressed the need for training on climate change adaptation practices for vegetable production. The Kendall's test of concordance showed a significant ($p < 0.0001$) positive and moderate agreement (Kendall's $W = 0.47$) among the farmers in the ranking of training needs for climate change adaptation. The selection of crop varieties and techniques (mean = 1.4)

was ranked 1st, followed by preventive techniques and response to climate change (mean = 2.2), importance and use of meteorological information (mean = 2.8), and water management and irrigation systems (3.5).

- ✓ 83.6% of the farmers interviewed expressed the need to acquire improved crop varieties of vegetable crops for climate change. The Kendall's test of concordance showed a significant ($p < 0.0001$) positive and moderate agreement (Kendall's $W = 0.48$) among the farmers in the ranking of types of improving varieties of vegetable crops they need for climate change adaptation. Short-duration crop varieties (mean = 1.3) were ranked 1st, followed by drought-resistant crop varieties (mean = 2.0), pest-resistant, and disease-resistant varieties (2.7).
- ✓ 74.0% of the farmers interviewed expressed the need for meteorological information on local climatic variables. The Kendall's test of concordance showed a significant ($p < 0.0001$) positive and moderate agreement (Kendall's $W = 0.50$) among the farmers in the ranking of their needs for meteorological information on local climatic variables. Rainfall (mean = 1.4) was ranked 1st, followed by temperature (mean = 1.9) and relative humidity (2.8).

E. TEKO LIVESTOCK RESEARCH CENTER (TLRC)

The livestock research programme is implemented at the TLRC. The programme is aimed at addressing challenges to enhance sustainable productivity, commercialization, and competitiveness of the livestock farming system. TLRC has two stations: Teko in Makeni, Bombali district, and Musaia in Falaba district. TLRC has been implementing two main projects: Smallholder Commercialisation and Agribusiness Development Project (SCADeP) and Boosting Agriculture and Food Security (BAFS) Projects.

The achievements of the SCADeP included (i) construction of a modern poultry experimental building with a fence. The building has a clinic, inbuilt office space with restroom, brooding apartment and breeding apartment with six replications; (ii) provision of laptop computers, desktop computers and printers, a vehicle and two motor bikes; and (iii) provision of day-old chicks, local chicken, Guinea fowl, animal feed and veterinary drugs and vaccines (Figure D1).

The achievements of the BAFS projects included (i) six thematic areas under implementation; Poultry unit (chicken, ducks, turkey and Guinea fowl), small ruminant unit, large ruminant unit, Forage unit, Animal Health unit and Non-Conventional unit (Cane rat & Rabbit); (ii) construction of 2 experimental poultry and 1 feed mill buildings; (iii) construction of small ruminant pen and hatchery building; (iv) rehabilitation of piggery building; (v) procurement of some experimental building materials; (vi) procurement of some equipment like power tiller and field tools; (vii) training of farmers (75 on work oxen, 15 on poultry management); (viii) breed improvement of animals (goat, sheep, pigs and chicken); (ix) distributions of 380 chicken and 24 weaner pigs to COVID-19 Farmers in 2020; (x) supported 3 baseline surveys (PPR, forage and animal traction) and publication of articles; (xii) supported with animal feed, germplasm collection on local grasses and improved forages (xiii) supported blood sample collection in districts for PPR analysis; (xiv) provision of 1 vehicle and 4 motor bikes; (xv) provision of 5 Laptop computers, 1 field camera and assorted stationeries; and (xiv) procurement of some local and improved animals for breed improvement. Some of these achievements are presented in Figures D2-D4.



Figure D1. Photographic display of a: local chicken; b: grower kebu breed of local chicken; c: helmeted Guinea fowl; d: fenced experimental poultry building; e and f: poultry feed

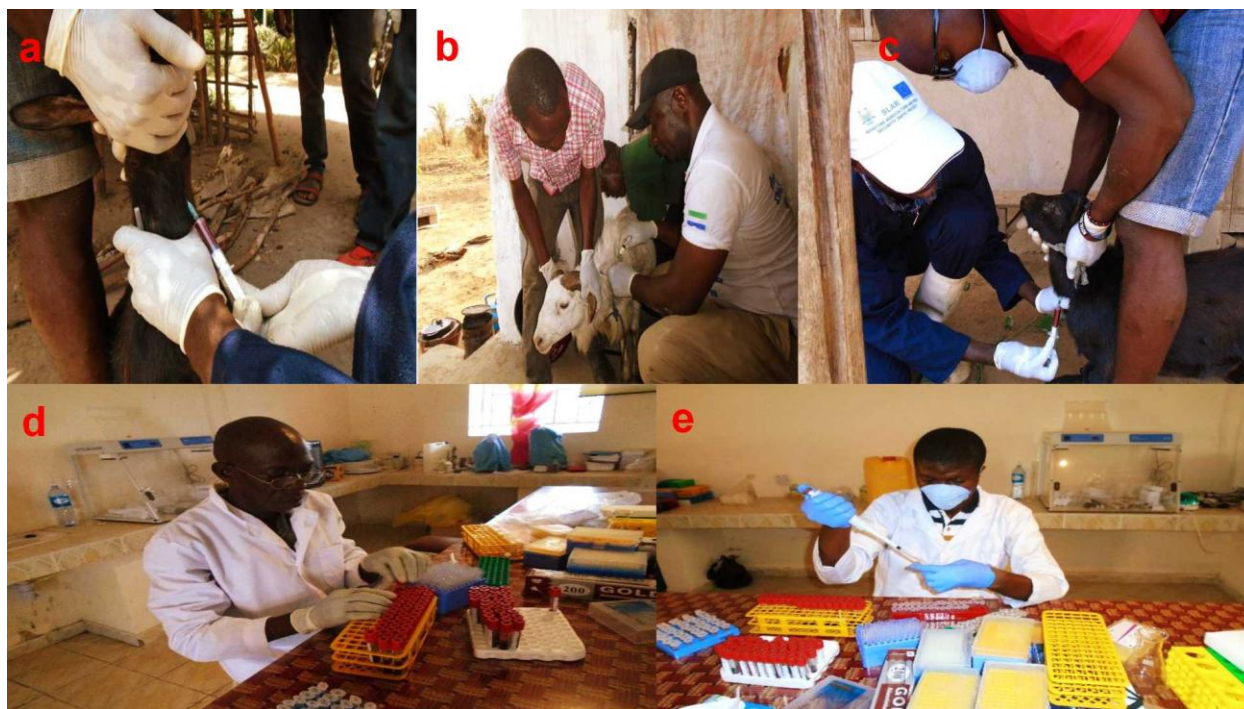


Figure D2. Photographic display of a, b and c: nationwide sample collection for PPR Analysis; d and e: transferring sera to Eppendorf tubes for PPR analysis



Figure D3. Photographic display of a-d: processed and cleaned forage seeds; e: nursing of seeds; f: seedlings of forages grown at Teko.



Figure D4. Photographic display of a and b: training and field demonstration of animal traction; c: fabricated animal traction implements from Guinea; d-g: COVID-19 farmer beneficiaries receiving improved chicken and pigs after training workshop

Workshop/ training

1. National training course on soil, water and nutrient management by Christoph Müller and Mohammad Zaman held on the 21st – 22nd April, 2021.
2. Workshop on Plant Variety Design for Emerging Markets in Africa Online Webinar Series, Hosted by the University of KwaZulu-Natal's African Centre for Crop Improvement, held on the 29th June 2021.
3. Training on "Selection for biochemical traits with improved quality and yield in mutant rice and cassava lines". Hosted by Njala University. 17th – 21st October, 2022.
4. Training on "Sample collection, genotyping procedures, documentation and data analysis" held at Central and West African Virus Epidemiology (WAVE) headquarters (Pôle Scientifique et d'Innovation de l'Université Félix Houphouët-Boigny), Abidjan, Côte d'Ivoire from February 28, 2023 to March 03, 2023.

5. Training on “Climate-smart agricultural practice for maize and cassava production in Sierra Leone” held at the University Guest House Conference Hall, Njala Campus, Sierra Leone on 24th to 26th of April 2023. Organised by Njala University, in collaboration with the Sierra Leone Agricultural Research Institute (SLARI), through the National Liaison Office, Nuclear Safety and Radiation Protection Authority, Ministry of Environment
6. A seed business summit titled ‘Building a roadmap for seed sector transformation’ was held at the Bintumani Hotel, Freetown, Sierra Leone from the 18th-20th September, 2023. Organised by Sierra Leone Seed Certification Agency (SLeSCA), Sierra Leone Agricultural Research Institute (SLARI) and Ministry of Agriculture and Food Security (MAFS) in collaboration with both national (Farmers’ Group Federation, Private Seed Companies, Njala University, Ernest Bai Koroma University of Science and Technology) and international (BASICS II, TAAT, IITA, IDB, USAID, AfDB, World Bank, SASAKAWA, AfricaRice and BMGF) partners.
7. Training on SAH modified techniques (micro-stem preparation, SAH plants production, treatment, Lab, field, screenhouse monitoring and maintenance; SAH plantlets multiplication and TC plantlets introduction into SAH; and seed system course, business with SAH seed and lessons and practices recapitulation) held at NARC Tissue Culture facility from 11th October to 14th October, 2023.

Participation in Webinars

1. Plant Breeding: Perspectives from Industry and Academia. Organised by The Plant Sciences Symposia Series Students Advisory Council Virtual Symposium and Corteva Agriscience held on Friday, April 24th, 2020.
2. How plant breeding can be deployed to mitigate the impacts of COVID-19 on food and nutrition security across the African continent, organised by The Institute for Agricultural Research (IAR) Samaru, and the Faculty of Agriculture, Ahmadu Bello University Zaria, Nigeria, held on June 10, 2020.
3. Molecular plant breeding and data analysis methods and applications held on August 22, 2020.

4. What early generation seed business models in the era of COVID-19: harvesting best practices in sub-Saharan Africa, held on September 15, 2020.
5. Invited speaker at the online summit on plant science and agriculture (PSA-2021), Belgium, Chapter 1, on 25/03/2021, organised by Science, Technology, Engineering, and Mathematics International Organisation (STEMIO), Singapore. The presentation was on “Pollination success, paternity test and seedling traits assessments in white yam (*Dioscorea rotundata*) progenies generated using nested and polycross mating designs.”
6. Invited speaker at the 2nd Webinar on “Plant Science & Genomics” held on April 29-30, 2021, organised by Coalesce Research Group, USA. The presentation was on “Trait profiling of white Guinea yam (*Dioscorea rotundata*) breeding lines using breeding values and genomic estimated breeding values.”
7. Guest at the 3rd International Webinar Conference on “Plant Science & Research (Plant-2021)” held during May 10-11, 2021, organised by USG United Scientific Group, USA.
8. Invited speaker at the online webinar on “Demand-led plant variety design for emerging markets in Africa” held on June 29, 2021, organised by the University of KwaZulu-Natal, Pietermaritzburg, South Africa.
9. Participant in a webinar training on “The Guest Editor Experience: An Inside Look”, organised by SAGE journals in their SPECIAL COLLECTIONS WEBINAR on 30th November 2022.
10. guest at the Zoom discussion on Successes, Challenges, and Opportunities of Plant Transformation Research in Africa, on September 13th, 2023, at 9:00-11:00 AM ET/14:00-16:00 UK. Organised by PlantGENE community and other organisations dedicated to developing crop varieties to benefit farmers across the globe and create a more equitable and sustainable agricultural system.

PROPOSALS SUBMITTED FOR FUNDING OPPORTUNITY

The oil palm project by the Islamic Development Bank (IsDB). Under this project, it was hoped that the IsDB would sponsor research on farmers' fields, establish a tissue culture laboratory at Pendembu and train 2 staff to PhD in Breeding and entomology at the University of Malaysia (the two PhD staff were trained, although the other staff have not been able to complete their programme). It was also hoped that the IsDB would train 2 laboratory technicians to run the tissue culture laboratory. The project budget is one million dollars (US\$1,000,000). However, SLARI has not been able to access the funds, probably due to reasons beyond the understanding of the KFTCRC management. There is a need to make a follow-up on this at the NAO.

The Food and Agriculture Organisation (FAO) of the United Nations approached KFTCRC for the development of a proposal leading to the development of an 'oil palm model farm' across the country. This proposal has been developed to the tune of \$368,025 and awaits funding or further negotiations.

The KFTCRC has also collaboratively worked with Solidaridad West Africa to develop a concept note on the 'REDDA' grant call. The acronym stands for Reversing Environmental Degradation in Africa and Asia. The proposal, if approved, will be dubbed 'Community-led Ecosystem Restoration and Climate-resilience (CERC) Project'. The proposal developed is to the tune of £1,500,000.

A proposal was also written and submitted to the Agricultural Value Chain Development Project (AVDP – approved and implementation is in progress) to the tune of \$250,000 for the development of the clonal gardens at Pendembu and Kpuwabu. This has been submitted to the donor for a 'no objection'. The proposal has been approved, and the first tranche of 40% of the funds is yet to be disbursed for the commencement of operation.

One of the other scientists (Edward Amara) who was attached to ICRAF has completed his PhD at Helsinki University in Finland. Also, Mohamed M. Luseni is pursuing his PhD through a sandwich programme, i.e. collected data in Sierra Leone and is currently at the Swedish University of Agricultural Sciences. Sidique Kutubu has recently submitted his PhD thesis, but has not been awarded the doctorate yet on the grounds that he needs to address comments from external examiners in Pakistan. Paul Musa Lahai is on his PhD at Njala University under the

sponsorship of the AVDP. He has completed in-country data collection and analysis and is awaiting the molecular analysis results from the United States Department of Agriculture (USDA).

SLARI PUBLICATIONS 2019-2023

1. Journal Articles

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2. Conference Proceedings

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3. Book Abstracts

(1) Norman, P.E., Agre, P.A., Danquah, A., Tongoona, P.B., Danquah, E.Y., De Koeyer, D., Ikeogu, U.N., Asiedu, R., & Asfaw, A. (2021). Pollination success, paternity test and seedling traits assessments in white yam (*Dioscorea rotundata*) progenies generated using nested and polycross mating designs. In: Book of Abstract Online Summit on Plant Science and Agriculture, organised by Science Technology, Engineering and Mathematics (STEM) International Organisation. 21 pp.

(2) Norman, P.E., Asfaw, A., Danquah, A., Agre, P.A., Tongoona, P.B., Danquah, E.Y., Agbona, A., Asiedu, R., & Matsumoto, R. (2021). Trait profiling of white Guinea yam (*Dioscorea rotundata*) breeding lines using breeding values and genomic estimated breeding values. Book of Abstract Online Summit on Plant Science and Genomics, organised by Coalesce Research Group, 33 Market Point Dr, Greenville, SC 29607, USA. p 34. 2nd Webinar on Plant Science & Genomics, April 29 - 30, 2021.

(3) Agre, P.A., Norman, P.E., Asfaw, A. and Asiedu, R. (2021). Identification of quantitative trait nucleotides and candidate genes for tuber yield and mosaic virus tolerance in an elite population of white Guinea yam (*Dioscorea rotundata*) using genome-wide association scan. Genomics and Molecular Biology Summit (GMB-2021) September 28th, 2021. Hosted by STEM International Organisation. www.stemio.org. p 8.

(4) Norman, P.E., Kamara, L., Gborie, K., Kargbo, A.S., Saquee, F.S., Norman, Y.S.G.E., & Beah, A. (2023). Influence of variety and rates of nitrogen fertilisation on grain yield and agronomic parameter estimates of maize (*Zea mays* L.). In: *Proceedings of the 10th International Conference on Agriculture 2023*(AGRICO 2023) 21st – 22nd September 2023, Jakarta, Indonesia. p 30. Co-hosted by The South-South Aquaculture and Fisheries Cooperation, Bulacan Agricultural State University, Philippines and Universitas Andalas, Indonesia. The Conference is organized by The International Institute of Knowledge Management (TIKM) in collaboration with; Maharana Pratap University of Agriculture and Technology, India, Poznań University of Life Sciences, Poland, Southern Leyte State University, Philippines, Georgian Technical University, Georgia, Sher-e-Bangla Agricultural University (SAU), Bangladesh, College of Agriculture, Don Mariano Marcos Memorial State University La Union, Philippines, Palestine Technical University Kadoorie, Palestine and Field Crops Research Institute, and Agricultural Research Center, Egypt.

4. Technical Reports

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APPENDICES

		
Plate 1. Photos showing assorted vegetables	Harvesting of rice	Maize flour-rich cake



Plate 2. Photos showing botanical seedlings of families TDr190048 (A), TDr190046 (B), TDr190023 (C), TDr190016 (D) and TDr190113 (E) sampled at 6 weeks after sowing