Citrus sinensis (Sweet Orange) Extinction Control Against Gummosis Through Artificial Vegetative Breeding Approaches in Sierra Leone

A research project proposal
submitted to

NATIONAL SCIENCE TECHNOLOGY AND INNOVATION COUNCIL (NSTIC)
Ministry of Technical and Higher Education
Government of Sierra Leone

Under the
"**CALL FOR FULL PROPOSALS TO FUND A PROJECT THAT PROMOTES FOOD SECURITY AND MODERN AGRICULTURE**"

1. Name and Address of the Organization

Eastern Technical University of Sierra Leone
Combema Road, Kenema, Sierra Leone.

2. Duration of the Project

2 Years (2024 – 2025)

3. Total Cost of Project

USD 44,999 (Forty-Four Thousand, Nine Hundred and Ninety-Nine US Dollars)

4. Name of the key person, who will be the In-Charge of implementation of the project

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5. Technical Staff

Name and Qualification	Position	Task
Dr. Senesie Swaray PhD. Genetics and Breeding (Crop Science)	Team Leader (Principal Investigator)	The Team Leader and Lead Researcher will bear principal responsibility for the delivery of the project. He will lead in all aspect of project implementation, negotiations (if any) and coordination with sponsors and other relevant stakeholders. He will provide overall leadership and guidance for data quality and results delivery.
Dr. Gelejimah A. Mokuwa PhD. Agronomy (Crops)	Co-Investigator I (System Agronomist I)	As Co-Investigator I, he will support the Team Leader in setting-up crop cutting experiments, and monitoring and evaluation. He will assist in the preparation of technical reports, workshop outlines and reports
Mr. Emmanuel Alpha	Co-Investigator II (System Agronomist II)	As Co-Investigator II, he will support the Team Leader in data collection, analysis and interpretation

MSc and MPhil Crop Science		of results. He will assist in the preparation of technical reports, workshop outlines and reports
Mr. Raymond M. Musa MSc Agric. Edu.	Co-Investigator I (Qualitative Data Analysist)	As Co-Investigator I, he will be responsible for the design and development of tools and training materials, support data transcription, data processing, analysis and drafting of qualitative report component. Support the Team Leader in designing training programme for students, farmers, and other stakeholders.

OCTOBER, 2023

1. EXECUTIVE SUMMARY

The Eastern Technical University of Sierra Leone (ETU-SL) was established primarily to equip people with a range of technical and vocational skills at various stages of life. The speedy extinction *of Citrus sinensis* (sweet orange) in all districts of Sierra Leone, is a serious concern to ETU-SL. Gummosis disease is one of the main causes of sweet orange extinction. Also, the long juvenile period of its growth has discouraged farmers to abandon it production and prioritized cocoa, cashew and oil palm as their major cash crops. Currently, the nation receives little or no revenue from sweet orange production, which has a negative impact on the country to generate foreign exchange, create jobs, and provide food security even with emerging agro-based industries in the Sierra Leone. However, if revamped the production of this crop will contribute towards poverty reduction, improve on the health status of its consumers and above all sustainable sweet orange fruit production in the country will be achieved. It is expected that this proposed project against gummosis in Sweet Orange production will be achieved through innovative technology for large-scale productivity.

Personnel from the host institution including professors/researchers in agriculture and nutritionists, will be assigned to various committees charged with the responsibility to supervise the operation and activities of this project in collaboration with donor partners, Ministry of Agriculture and the University administration, to ensure quality implementation. The total estimated budget is projected at **USD 44,999.99**. It is conceived that ETU-SL shall meaningfully contribute to address the extinction of *Citrus sinensis* in Sierra Leone.

2. BACKGROUND AND RATIONALE

The goal of our current sitting present is to ensure that Sierra Leone is able to feed herself with sustainable food production and busting the economy of which tree crops like citrus are no exception. The aim of any crop cultivation is to increase food production and quality, safe friendly products for consumers, while lowering costs and boosting profits (Sharif *et al*., 2018), through breeding techniques.

Fruit trees play an important role in any state's economic development of which Sierra Leone is no exclusion. One of the most well-known fruit plant species is the citrus plant, which is high in vitamin C and widely used in Sierra Leone and other Africa nations, the Indian sub-Continent and the Middle East (Manavalan *et al*., 2020). Citrus plants are associated with many health advantages, as well as being used as a raw material in the agricultural industries for the production of several types of other agricultural products, including jams, sweets, ice cream, and confectionery, etc. (Pan *et al*., 2019; Manavalan, 2020; Khattak *et al*, 2021).

Additionally, the importance of citrus cannot be over emphasised. However, many types of oranges are high in fiber and beneficial vitamins. They also contain antioxidants which can have various health benefits, including supporting immune function. Like most citrus fruits, oranges mainly comprise carbs and water, contain very little protein and fat, and are relatively low in calories. Oranges are a good source of fiber, one orange provides 140 grams packs around 10% of its digestive value. Getting enough fiber on a daily basis is essential for overall health and helps keep your digestive system healthy by supporting regularity and fuelling your beneficial instinctive bacteria. Plus, diets rich in fiber are associated with a number of benefits, including decreased risks of heart disease, colon cancer, and obesity.

However, *Citrus sinensis* is one of the most-loved and popular citrus fruits highly consumed in Sierra Leone. In the 80s, Sierra Leone had a lot of *Citrus* farms especially oranges that were providing income for its growers and contributing to the gross domestic products (GDP) of this nation year in year out. Though, research have showed that *Citrus sinensis* is losing their existence on planet earth in Sierra Leone as a result of gummosis. Sweet orange is now at the verge of extinct state across the country, Sierra Leone, as a result of gummosis disease and many more ailments and pests, including lack of recommended crop management systems.

Citrus fruit plants, on the other hand, are vulnerable to a wide range of infections, including black spots, cankers, scabs, greening, and melanose. The canker is highly contagious and is found in citrus trees and is mostly on the leaves or fruit. There are reports of crop losses of approximately 25% to 40% in sweet oranges, 10% in sweet limes and 2% in lemons, respectively (Khattak *et al*, 2021). A large proportion of quality export fruit is refused every year due to signs of citrus fruit diseases (Khattak *et al*, 2021). As a result, timely identification of citrus diseases has the potential to reduce losses and costs while also improving product quality. Grafting and budding are the most successful and recommended against gummosis causing the extinction and to shorting the reproductive phase of *Citrus sinensis*. Therefore, it would be necessary to undertake the raising of *Citrus sinensis* seedlings through grafting and inverted T-budding breeding techniques and train interested farmers in 14 districts the country on its cultivation and management practices before the dissemination of seedlings to the interested trainees and to established demonstration plots on species of citrus on behalf of Eastern Technical University.

3. PROJECT GOAL

The aim of this project is to protect Sweet Orange against gummosis through innovative technology for large-scale production and this will be achieved with the following objectives.

i. To establish a large-scale nursery for orange production.
ii. To train potential farmers on the cultivation and agronomic practices of citrus.
iii. To raised healthy rootstock and high yielding scion that are resistant to soil-borne gummosis disease.
iv. To prepare well designed demonstration plots for teaching and research purposes.

4. PROJECT METHODOLOGY/APPROACH

Sweet and bitter oranges will be used to address the problem of gummosis causing the extinction of sweet orange in Sierra Leone.

4.1 Scope for citrus exploration

However, to solve the problem of gummosis in sweet orange, depends on the successful implementation of five major tasks which includes:

I. Exploration and collection
II. Nursery establishment of the collected seeds of bitter and sweet oranges
III. Equip farmers with the appropriate cultivation knowledge on all citrus
IV. Artificial vegetative propagation (innovative technology) of bitter and sweet oranges
V. Utilization and conservation of the grafted/budded materials

According to Marshall & Brown, (1975), reported that, the task of exploration requires decisions to be made on two key pillars:

1. The regions or districts or chiefdoms in Sierra Leone to be explored based on distribution of the species.
2. The sampling procedure to be adopted within the selected areas in terms of:

a) The total number of sampling sites
b) The number and distribution of citrus to be sampled per site
c) The number of seeds to be collected per sample on both species

Procedure 1. Germplasm collection for rootstock development:

Systematic *Citrus* (sweet and bitter oranges) germplasm collection nation-wide will be carried out. Viable seed per fruit is estimated to be 15 filled seeds. The total seeds needed for each species will be 23,000 (bitter orange) and 23,000 (sweet orange) seeds. One hundred and twenty (120) fruits will be purchased per district on bitter and sweet oranges making a total of 240 fruit per district. The overall total fruit to be collect on each species will be 1,667 (bitter orange) and 1,667 (sweet orange) fruits. Fruits to be selected and collected on both species must base on the following characters; reduction in parental heigh, canopy formation, fruit size, colour, taste, bearing and pests and disease history, plus any other observations on the parental tree. All the collected citrus fruits will be label based on their origin and district and will be taken to ETUSL Bunumbu for processing of seeds. Similarly, after the development of the root stock, the second phase of the collection will be on the scion (budwood) on desirable parent tree of selected sweet orange trees in every district with the exception of Western and Rural districts. A budwood with three functional buds of one foot in length will be harvested and a total of 7,667 budwoods will be harvested for budding at ETUSL Bunumbu.

Procedure 2. Nursery establishment for rootstock: A standard modern nursery will be constructed with dimension of 20 m x 15 m to accommodate 23,000 seeds of bitter orange and 23,000 seeds of sweet orange. After the construction of the nursery, 46,000 polybags will be filled and lined in the nursery at 4 fts wide to any length with 2 fts pathway for easy accessibility to nursery practices. Seeds will be extracted from the collected citrus fruit martials and filled up seeds will be chosen. The selected seeds will be wash with clean water and dried in a shade. Sundry of seeds will be done to reduce the moisture content in seeds for few days. To break seed latency, the hard coat must be gently removed not to damage the embryo and the prepared seeds will now be nurse polybags. Irrigation of the nursery will be carried out especially in the dry season and agro-chemicals such as fertilizers, pests and diseases control chemicals will be used where necessary.

Procedure 3. Training of farmers on citrus best management practices: Three days training on citrus and its management will be undertaken to equip farmers with the knowledge before the grafting/budding exercise and seedling distribution to selected trained farmers. Meanwhile, 10 farmers per district making a total of 140 farmers will be trained in Citrus production practices.

Procedure 4. Grafting in citrus tree (T-budding): Bitter orange will be use as rootstock, while sweet orange scion from selected desirable parent tree**.** Budwood will be collected after the establishment of the rootstock in the growing season. Hardened twigs with buds whose bark have started to harden will be collected as scion. A foot long scion will be harvested and store them in a bag in a fridge for up to three months if necessary. Raised rootstocks of bitter orange (Trifoliate Orange) of best quality robust and disease resistant will be selected. The Trifoliate Orange will now be prepared for grafting/budding. Six inches up from the ground, a one-inch vertical slice will be made use a with a sharp budding knife to cut through the rootstock's bark and another horizontal cut at the bottom of the cut to form an upside-down T will be made. Ater that, bud will be prepared from the harvested scion using the same budding knife. One-inch slice of wood (same length as the T-cut on the rootstock) cut out will be made on the bud from the budwood and insure both wood and bark in the cut with a smooth edge made to enable fast joint together and heal best. The citrus bud will now be inserted up under the flaps made in the rootstock's bark and it must be inserted fully. The goal here is to create a joining between the green cambium layers so nutrients can flow from the roots to the new bud. The top and bottom of the new graft with budding tape will be wrap to hold everything in place and protects the graft/bud as it heals. Care must be taken not to cover the bud itself. After two to four weeks, the budding tape should be removed so it doesn't choke the tree. Once the new bud has started pushing out a few inches of new growth, continue to train the tree to grow upwards. It should be growing much faster than it would from seed.

Procedure 5. Distribution of grafted/budded seedlings: A targeted farmers of 10 per district with a grand total of 140 trained farmers in citrus cultivation will be given 150 raised seedlings for the establishment of one-acre sweet orange farm per farmer. A total of 140 acres or 56 hectares will be established across the country. Likewise, 7 acres or 2.7 hectares demonstration plot will be established by ETUSL for students' practical activities and research purposes.

5. OUTPUT AND ANTICIPATED OUTCOME

Orange of all varieties are declining in their tree population every year with a drastic reduction in yield across the country. One of the major reasons for the decline in production is as result of gummosis disease infestation that is prevalent in sweet orange. Therefore, one of the innovative technology known as artificial vegetative propagation, which refers to the practice of taking a small branch or bud from an established tree of the same family to grow a new specimen will be used. There are many reasons to do this instead of starting from seed:

i. Propagating citrus trees through grafting and budding allow you to grow the same variety and one that will grow faster than seed.
ii. To preserve the cultivar, or parent tree's, genetic material so that the second tree is an exact clone.
iii. Grafting/budding helps in solve the problems of major pest and diseases like gummosis which is susceptible to sweet orange but resistant to other citrus species.
iv. Growing a tree from a seed takes too long. Trees grown by propagation reach maturity sooner. This is especially desirable for commercial growers. Propagated trees generally take 2-3 years to mature, while those grown from seed can take 7-15 years.
v. Growing from seed introduces genetic uncertainty. The new tree may never fruit, or the fruit may be undesirable.
vi. Grafting/budding allows the tree to take on desirable qualities from a specific rootstock. These include resiliency or smaller tree size.
vii. Propagation allows you to preserve old varieties. Perhaps a citrus tree is old and frail, but you really like the fruit. Propagate a new tree from its healthy, young growth.
viii. Grafting/budding allows you to grow multiple citrus varieties on one tree to save space. This is often called a "fruit cocktail tree" and is great for people with smaller yards.

By the end of this project 140 farmers will be equipped with the knowledge of citrus production with one acre established citrus plantation in 14 districts in Sierra Leone. ETU-SL will have demonstration plots for trenching and research purposes.

6. KNOWLEDGE UTILIZATION AND DISSSEMINATION

The knowledge to fight gummosis disease in sweet orange will be transferred to farmers through training and the skills acquired will be used by farmers themselves in citrus production thereby improving food security in the country. The ETU-SL students and staff shall use the established sites of citrus for learning and research purposes. There will be a link between ETU-SL as well as farmers and agro-based industries for the availability of raw materials in the processing of their products.

7. PROJECT GOVERNANCE

A Project Steering Committee (PSC) will be set up that will comprise of key stakeholders including the ETU-SL team (Vice Chancellor and Principal (VC&P), Director of Research and Innovation (DRI), Director of Partnership and Resource Mobilization (DPRM), Finance Director, Internal Auditor), District Agriculture Officers (DAOs), and farmers' representatives. The PSC will provide guidance to the implementation of this project. It will advise on issues and problems arising during project implementation; facilitate cooperation among project partners and collaboration between the projects and other relevant programs, projects and initiatives in the countries. The ETU-SL team through the Principal Investigator, will be responsible for overall project management and overall coordination of activities. The DRI will be the secretary of the PSC and he shall present a quarterly report to the PSC. The DAOs will play a vital role in the selection of target communities and beneficiaries due to their long-standing experience in dealing with famers in their districts. The farmers' representatives will serve as points of contact (POC) for their FBOs. They will be responsible for organizing members of their FBOs, and facilitating communication between farmers and the technical team. The PSC will also conduct a regular monitoring and evaluation of the project in line with project outputs, indicators and activities.

8. SUITABILITY OF THE HOST INSTITUTION

The ETU-SL is a technical university that is located in the eastern region of Sierra Leone, which tends to be the bread basket of the country. The institution has campuses located at Bunumbu Campus having

615 acres in Kailahun district, Woama Campus having 317 acres in Kono district, and Kenema Campus with two locations, namely Kenema having 25 acres and Panderu having 100 acres. The region is also endowed with adequate climatic and environmental conditions that favour the growth of crops and general agricultural development.

ETU-SL has well-structured faculties and programmes that are career-driven, with qualified staff for teaching, research and community services. As a technical university, it caters for the development of the middle man power and contributes to improving the quality of life for citizens, increasing agricultural productivity, promoting the environmental wellbeing of families and conserving the natural resources. Project of such nature is well suited to the mission and development objective of the institution and could serve as a gateway to the eastern region and the country as a whole.

Lastly, the university has undertaken a series of project since its inception in collaboration and partnership with several national and international, governmental and non-governmental organizations including MAFS, MTHE, Ministry of Youth, Gola Forest, WHH, BADIA etc. The university also has standard infrastructure that could facilitate the implementation of this project.

With these potentials and experiences, the university is well positioned and capacitated to undertake such project.

9. C APACIBILTIY BUILDING

ETU-SL students shall be included in some of the activities during the implementation of the project for them to setup enterprises on their own when they shall have complected their studies. Similarly, farmers will be equipped with the skills and knowledge in citrus production.

10. MONITORING AND EVALUATION

A year after field establishment, monitoring and evaluation team (MTHE, ETUSL and donor partners) will visit sweet orange production site and assess activities on the production of citrus. The monitoring and evaluation reports will be submitted to the relevant authority's concern.

11. GENDER, EITHICS AND SUITABILITY

11.1 GENDER

Gender aspects and youth issues are considered important by the project. To sustain project activities, the project will develop a gender mainstreaming strategy to reduce gender inequalities through participation in identifying relevant interventions for achieving gender equity, encouraging gender-specific activities and increased participation by women. The increased participation of women and youths in the project will help increase the benefits among households, thus leading to more investments in technologies being promoted. For this reason, both male and female will be incorporated into the project based on skills requirement. During the start of the project, baseline survey on key agricultural attributes will be conducted. Through this, the project will provide job facilities for male and female youth that will comprise of students.

11.2 ETHICAL ISSUES

The proposed project involves the deployment of innovative technologies which are well known and widely tested in similar agro-ecologies in West Africa and other subregional countries. They have been widely accepted as safe and offer a range of options for better productivity of crops combined with good resource management. They are based upon existing changing climate, in the context of farming systems that are evolving. In addition, participatory mechanisms of technology transfer which treat farmers as equal partners in project implementation will facilitate technology adoption. However, the efficiency of these technologies depends both on scale of production and on the organization of work. The project would pay attention to these issues to ensure that the local communities participating in the project are aware of these factors of productivity.

11.3 SUSTAINABILITY

Five key elements will contribute to the sustainability of this project after its lifespan. These are 1) the development of strong partnerships, 2) the use of participatory approaches, 3) strengthened community-based organizations, 4) the mainstreaming of gender, and 5) the use of research knowledge and proven technologies. The project will forge a partnership with relevant stakeholders to work together to deliver

the outputs targeted by the project. The stakeholders will participate in the identification of the problem and work together to provide solutions through technology deployment. Farmer participation in the process will provide feedback to researchers to fine tune technologies for deployment. Working with existing groups and encouraging the formation of new ones, building their capacity through technical, organizational and leadership training will lead to the formation of common interest groups, which will evolve into farmer-owned and managed organizations that are capable providing services to members. Training will be undertaken in ways which will reinforce each other based on the principles that people learn from practical experience and better from their peers. A gender mainstreaming strategy will be developed to reduce gender inequalities through participation in identifying relevant interventions for achieving gender equity, encouraging gender-specific activities and increased participation by women. The increased participation of women and youths in the project will help increasing benefit among households leading to more investments in technologies being promoted. The strong use of research knowledge and technologies through backstopping by researchers will increase productivity of the production systems and reduce poverty. This will allow for further investments in agriculture and lead to sustainable livelihoods after the project phases out.

13. LITERATURE CITED

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