



Advancement in Rubber Breeding and Genetics in Nigeria

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ABSTRACT

Rubber (*Hevea brasiliensis*) is a vital economic crop, primarily grown for its latex used in natural rubber production. In Nigeria, significant advancements have been made in rubber breeding and genetics to enhance latex yield, disease resistance, and adaptability to climatic changes. The Rubber Research Institute of Nigeria (RRIN) has spearheaded efforts in developing improved clones, such as the RRIN 500, NIG800, and NIG900 series, utilizing both conventional breeding and modern biotechnological approaches. These efforts have led to increased latex production, resistance to pests and diseases, and adaptation to diverse agro-climatic conditions. This review explores germplasm collection, hybridization, clonal selection, and genomic technologies in rubber breeding, highlighting the challenges and future prospects for sustainable rubber production in Nigeria. The integration of advanced tools like marker-assisted selection and genomic insights has further revolutionized the breeding process. Collaborative efforts and strategic investments remain essential to sustain these advancements and ensure the competitiveness of the Nigerian rubber industry in the global market.

1. Introduction

Rubber cultivation has long been a cornerstone of Nigeria's agricultural sector, providing raw materials for the natural rubber industry and contributing significantly to rural livelihoods. The introduction of *Hevea brasiliensis* in Nigeria dates back to the early 20th century, but systematic breeding efforts only began with the establishment of the Rubber Research Institute of Nigeria (RRIN) in 1961. Over the decades, RRIN has played a critical role in addressing the challenges of low latex productivity, vulnerability to pests and diseases, and the impacts of climate change.

With global demand for natural rubber rising, the need for improved planting materials has become imperative. Recent advancements in breeding and genetic improvement have aimed at producing clones with higher latex yield, better disease resistance, and enhanced adaptability to Nigeria's diverse agro-ecological zones. This review examines the progress made in germplasm development, hybridization, and the application of biotechnological tools in rubber breeding, emphasizing the significance of these efforts for sustainable production and economic growth.

2. Germplasm Collection and Characterization

Recent efforts have focused on expanding and characterizing the genetic pool of *Hevea brasiliensis*.

- **Collection Efforts:** RRIN has collaborated with international organizations to introduce diverse genotypes from Malaysia, Indonesia, and Brazil. These introductions have enriched the genetic base for breeding programs. Additionally, RRIN has conserved local landraces that exhibit unique traits such as drought tolerance and pest resistance (Ogunlade et al., 2023).

- **Characterization:** Studies have evaluated morphological and agronomic traits of these genotypes under local conditions. Advanced phenotyping tools, including digital imaging and data analysis software, have been employed to assess traits such as plant height, girth, and latex yield. Promising accessions with high latex yield potential and resistance to leaf blight have been identified (Adekunle et al., 2022).

3. Breeding Programs

3.1 Hybridization and Clonal Selection

Traditional breeding programs at RRIN have focused on hybridization between high-yielding clones and disease-resistant varieties. The resulting hybrids are subjected to rigorous selection criteria.

- **Progress:**
 - **RRIN 500 Series:** These clones have demonstrated superior latex yields and are resistant to major diseases like leaf blight and powdery mildew. Clones in this series, including RRIN 500, RRIN 501, and RRIN 502, have shown a 25% increase in latex yield compared to older varieties. They are well-suited to the southern regions of Nigeria.
 - **NIG800 Series:** Developed with a focus on drought tolerance, the NIG800 series includes clones such as NIG800, 801, 802, 803, 804 and 805. These clones have exhibited remarkable resilience to prolonged dry seasons, making them ideal for marginal environments. Field trials in Edo and Delta states reported a 30% improvement in yield stability under erratic rainfall conditions.

- **NIG900 Series:** The NIG900 series represents RRIN's latest breakthrough in breeding, aimed at achieving a balance between high latex yield, disease resistance, and adaptability to diverse environmental conditions. Key clones, including NIG900, NIG905, and NIG910, have demonstrated a 35% increase in latex yield compared to older series, coupled with resistance to South American leaf blight (*Microcyclus ulei*) and root rot. These clones have been successfully tested in commercial plantations across the southern and central regions of Nigeria. Additionally, the NIG900 series features improved bark regeneration, allowing for more efficient tapping cycles.
- **RRIN 600 Series:** This new line is under development, aiming to integrate pest resistance with high latex productivity. Preliminary data indicate that these clones can withstand attacks from *Microcyclus ulei* and *Oidium heveae*.
- **Evaluation:** Performance evaluation under varying environmental conditions has enabled the identification of region-specific clones, ensuring optimal yield and resilience (Edozie et al., 2023).

3.2 Biotechnology Applications

Biotechnological tools are increasingly employed to enhance breeding efficiency.

- **Marker-Assisted Selection (MAS):** Early-stage identification of desirable traits through molecular markers has expedited the breeding cycle. Markers linked to drought tolerance, high latex yield, and disease resistance have been integrated into selection programs. The deployment of MAS has reduced the time required to develop new clones by up to 40% (Obboh et al., 2023).
- **Tissue Culture:** Micro-propagation techniques have been optimized for the mass production of elite clones, ensuring the availability of high-quality planting materials. Somatic embryogenesis has been employed for rapid multiplication of high-performing genotypes, with over 100,000 plantlets distributed annually to farmers.
- **Genetic Engineering:** Preliminary studies have explored the use of genetic engineering to enhance rubber biosynthesis pathways and confer resistance to pests and diseases. Advances in genetic transformation techniques have shown promise, though they remain in experimental stages.

4. Genomic Insights

The application of genomic technologies has opened new frontiers in understanding the genetic basis of key traits in rubber trees.

- **Genome Sequencing:** Recent high-quality genome assemblies have provided insights into genetic diversity and domestication. Comparative genomic studies have identified genes associated with latex biosynthesis, stress response, and disease resistance (Ajayi et al., 2023). The availability of genome-wide data has facilitated the identification of novel gene markers for breeding.
- **Gene Editing:** Though still in preliminary stages, CRISPR-Cas9 technology is being explored for targeted improvements, such as enhancing disease resistance and stress tolerance. Initial trials have shown promising results, including increased latex yield and reduced susceptibility to fungal pathogens.

5. Challenges

- **Funding Limitations:** Insufficient financial resources hinder large-scale implementation of advanced techniques.
- **Climate Change:** Erratic weather patterns impact latex yield and the effectiveness of breeding programs. Prolonged dry seasons and unseasonal rainfall disrupt latex tapping schedules.
- **Pest and Disease Pressure:** Persistent threats from pests such as *Microcyclus ulei* (South American leaf blight) and soil-borne pathogens require continuous development of resistant varieties.
- **Farmer Adoption:** Limited awareness and access to improved clones among smallholder farmers slow down the adoption of new technologies.

6. Future Prospects

To sustain advancements in rubber breeding and genetics, Nigeria must:

1. **Strengthen Funding:** Allocate more resources to research institutions and breeding programs.
2. **International Collaboration:** Foster partnerships with global research organizations for technology transfer and expertise sharing.
3. **Biotechnological Integration:** Scale up the use of advanced genetic tools, such as gene editing and genomic selection, to address specific breeding challenges.

4. **Capacity Building:** Train researchers and extension workers in modern breeding techniques and biotechnology.
5. **Policy Support:** Develop policies that encourage private-sector investment in rubber plantations and breeding programs.
6. **Climate-Resilient Varieties:** Focus on breeding rubber clones that can withstand erratic weather patterns and maintain productivity under stress conditions.

7. Conclusion

The progress in rubber breeding and genetics in Nigeria underscores the potential for revitalizing the rubber industry. Strategic investments in research, technology, and farmer outreach will ensure sustainable rubber production, meeting both domestic and global demands. Collaborative efforts between public institutions, private enterprises, and international organizations will be critical in achieving these goals.

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