Regional context in plant breeding priorities: The case of groundnuts in West and Southern Africa

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Abstract

The regional context significantly influences plant breeding priorities, particularly for crops such as groundnut with diverse uses across regions. This study investigates how local factors in West Africa (Nigeria) and Southern Africa (Malawi) shape breeding decisions by analyzing household consumption patterns, market demand, and value chain roles. Using qualitative data from focus group discussions and key informant interviews, the research reveals that end-use preferences such as oil content, haulm quality, and grain characteristics vary significantly between regions and stakeholders. For example, Nigerian markets emphasize oil content and haulm yield, whereas Malawian markets prioritize grain color, grain size, and aflatoxin tolerance for exports. The findings underscore the necessity of incorporating localized market intelligence into Target Product Profiles to improve breeding efficiency, variety adoption, and overall impact. A demand-led breeding approach that acknowledges nuanced regional contexts is essential for aligning breeding outcomes with user needs and maximizing returns on investment.

Key Points

- Trait prioritization is context-specific. Nigeria and Malawi prioritize different groundnut traits due to variations in end-use demands, for example, high oil content in Nigeria vs. grain color and aflatoxin tolerance in Malawi.
- Market intelligence is crucial to understanding local consumption patterns, cultural practices, and market channels in order to design effective Target Product Profiles.
- In Nigeria, all parts of the groundnut plant, including haulms for animal feed, are commercially valuable, thus influencing broader trait prioritization.
- Aligning breeding programs with localized socioeconomic and agronomic realities will enhance variety relevance, adoption rates, and impact.

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Introduction

Regional context plays a crucial role in shaping breeding priorities for any crop. Traditionally, broad regional factors such as climate have been central to plant breeding, guiding the development and release of varieties optimized for specific regions. These efforts have focused on maximizing yield and addressing key agronomic traits such as resistance to biotic stresses, tolerance to abiotic stresses, and appropriate maturity. As a result, region-specific varieties have been developed with desirable combinations of pest and disease resistance, high yield potential, and suitable maturity timelines largely meeting farmers' agronomic needs.

However, ease of cultivation alone does not guarantee variety adoption. Beyond agronomic performance, end-use considerations shaped by regional context are also critical. The way a crop is used varies significantly across regions, influenced by cultural, historical, and market factors. For example, groundnut production in Nigeria historically served both domestic consumption and export markets. With the decline in the export market, local demand has become the primary driver, thus shifting breeding priorities away from export-focused traits. This raises important questions: What are the dominant local uses? How do these uses influence trait prioritization?

Additionally, the role of the crop at the household level is a key consideration. Is groundnut a staple in the local diet? Are there diverse uses that demand specialized traits? The crop might also hold cultural or religious significance, with specific requirements that should inform variety development for each region.

This study explores these regional differences by examining groundnut use in two major producing regions: West Africa (Nigeria) and Southern Africa (Malawi). We analyze household consumption patterns, processor demands, and alternative uses of various plant parts beyond the grain to inform more targeted breeding strategies.

Groundnut production in Nigeria and Malawi

Groundnut is a vital cash crop in Nigeria, serving as both a nutritious, affordable food source and a key driver of household income through multiple value chains (Vabi et al. 2020; Joshua and Echekwu 2003). It is predominantly cultivated by smallholder farmers under rainfed conditions. Women play a central role in the groundnut value chain – particularly in harvesting, shelling, processing, and marketing – earning the crop the nickname "women's treasure" in Northern Nigeria (Abdulrahaman et al. 2014). Nigeria ranks as the third-largest groundnut producer globally, contributing approximately 10% of global output and 39% of Africa's production (Nigerian Export Promotion Council 2020).

Historically, groundnut held significant economic importance in Nigeria, symbolized by the iconic "groundnut pyramids" of the early twentieth century, with production peaking in the 1960s. However, production declined sharply from 1975 to the mid-1980s due to the oil boom, coupled with increasing biotic and abiotic stresses. These challenges prompted government interventions in the 1980s aimed at reviving the sector (Joshua and Echekwu 2003).

In Malawi, groundnut is one of the most widely cultivated grain legumes and it plays a multifaceted role in smallholder agriculture. It is favored for its contribution to household food security, high nutritional value, income generation, and soil health – thanks to its nitrogen-fixing properties that make it a valuable component of crop rotation systems (Africa RISING 2015). The crop also exhibits resilience against various diseases, further strengthening its role in sustainable farming.

Groundnuts are primarily grown by smallholder farmers, particularly women, under rainfed conditions (Waliyar et al. 2021). Farmers typically sell their produce to local traders, aggregators, and large-scale buyers, including processors such as NASFAM, which handle shelling, cleaning, and packaging for both local and export markets (FAO 2018). The crop is mainly cultivated in the central and southern Agricultural Development Divisions of Kasungu, Lilongwe, Machinga, Mchinji, Ntchisi, and Blantyre, regions that account for 75% of Malawi's total groundnut production area (Malawi Investment and Trade Centre, n.d.).

Yields for smallholder farmers generally range from 1,500 to 2,500 kg/ha (Salonga et al. 2023). Groundnuts serve both commercial and subsistence purposes: approximately 15% of the total harvest is exported, 60% is consumed at the household level, and the remaining 25% is sold in domestic markets (Nyondo et al. 2018; Malawi Investment and Trade Centre, n.d.).

Methodology

This study employed a qualitative research approach, using primary data collected through focus group discussions (FGDs) and key informant interviews (KIIs), respectively, with farmers and other stakeholders, conducted in Malawi and Nigeria. FGDs were held with farmers to understand household-level use and preferences, while KIIs targeted key stakeholders, including traders, exporters, government officials, processors, and seed companies.

Data collection took place in Lilongwe and Mchinji districts in Malawi and in Kaduna, Kano, and Abuja in Nigeria (Table 1). These locations were selected based on their high concentration of relevant stakeholders and groundnut activity. We conducted the research in collaboration with the Department of Agricultural Research Services (DARS) in Malawi and the National Agricultural Seeds Council (NASC) in Nigeria, both of which are responsible for developing, regulating, and disseminating seed system technologies, as well as offering advisory and regulatory support to farmers. We gathered additional insights through visits to local markets, supermarkets, and groundnut processing facilities, allowing for a more comprehensive understanding of the crop's end-use dynamics.

The interviews and discussions focused on identifying the key factors that influence groundnut variety choices and preferences among stakeholders. Topics included seed characteristics such as color, size, oil content, maturity period, and taste. Participants also discussed how variety selection is influenced by the crop's intended end uses – ranging from household consumption to commercial processing and market demand.

Results and discussion

Groundnut production in both Nigeria and Malawi is predominantly carried out by smallholder farmers under rainfed conditions, with limited use of fertilizer or other external inputs (Table 2). Women play a crucial role across the value chain, particularly in harvesting, shelling, and processing, highlighting the crop's importance in supporting household livelihoods and gender empowerment.

In both countries, shelling methods vary depending on the scale of production: hand shelling is commonly used for small quantities, especially at the household level, while mechanical shellers are preferred for larger volumes, particularly by traders and processors. Although intercropping with crops such as maize and sorghum is practiced in some areas, the majority of farmers cultivate groundnut as a monocrop, reflecting its economic importance and the need to optimize land use for cash returns.

Table 1. Data collection in Nigeria and Malawi through focus group discussions (FGDs) with farmers and key informant interviews (KIIs) with other stakeholders.

Respondents	Nigeria	Malawi
Groundnut farmers	4 (2 male FGDs and 2 female FGDs, 6–8 farmers each)	4 (2 male FGDs and 2 female FGDs, 6–8 farmers each)
Groundnut processors	1 small, 1 medium, and 1 large	1 small, 1 medium, and 1 large
Groundnut traders	2	1 small, 1 medium, and 2 large
Groundnut exporters		2 large
Groundnut seed producers (e.g., seed companies and outgrowers)	2 medium	1 medium and 1 large
Groundnut breeders		Department of Agricultural Research Services (DARS)
Associations		NASFAM, Pyxus
Government	2 officials	1 Ministry of Trade official

Table 2. Groundnut production in Nigeria and Malawi.

Farming characteristics	Nigeria	Malawi
 **Land size**	Average farm size ranges from 0.5 to 2.5 acres, with less than 1.0 acre (0.4 ha) dedicated to groundnuts.	Average farm size ranges from 0.5 to 5.0 acres, with 1.5 to 2.0 acres dedicated to groundnuts.
 **Yield**	Farmers report harvesting 900 to 1,300 kg/ha. Wet-season varieties yield more.	Farmers report an average of 3,000 kg/ha for CG7 and CG9 and 1,500 kg/ha for CG11.
 **Fertilizer use**	Fertilizer use is not widespread; some farmers use manure or compost. Fertilizer is applied after land clearing and before planting in some cases.	Most farmers do not use fertilizer, except those under contractual agreements with organizations such as Pyxus, from which they receive training and input packages.
 **Cropping system**	Farmers practice intercropping with crops such as sorghum and maize for various benefits, although monocropping is common. Crop rotation is used to manage soil health.	Most farmers monocrop but are interested in crop rotation to manage soil health.
 **Shelling**	Hand shelling is labor-intensive, often performed by women and children, and involves soaking groundnuts to ease the process. Machine shelling is used for larger production quantities and is more efficient, but hand-shelled groundnuts are preferred for planting and exporting because of their cleanliness and lower breakage.	Hand shelling is done for small production quantities or seed use, while machine shelling is used for commercial purposes because of its efficiency. Groundnuts are soaked to facilitate hand shelling.

Uses of groundnut in Nigeria

Groundnut is a vital cash crop in Nigeria, providing a variety of affordable, nutritional food sources while also enabling multiple income streams for households (Vabi et al. 2020; Joshua and Echekwu 2003). Groundnut in Nigeria plays a unique role in both farming households and targeted consumer groups. Farmers have several target groups that take up groundnuts for different end uses. This includes direct consumers who use groundnuts either while boiled or roasted, processors who use groundnuts for oil and kuli kuli production, and lastly haulm traders and livestock farmers. As a cash crop, the entire groundnut crop in Nigeria is useful, with different end uses that call for specific trait considerations and prioritization in the breeding program. Work done in Kano and Kaduna has demonstrated several end uses of groundnuts in Nigeria, such as those in Table 3.

Uses of groundnut in Malawi

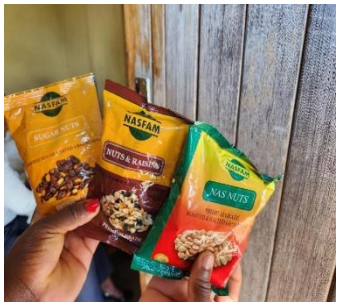
Groundnuts serve multiple market segments, being consumed raw, boiled, roasted, and processed into peanut butter or flour (Table 4). Additionally, groundnut by-products, such as shells and haulms, are used for animal feed and manure. As a cash crop, groundnuts provide quick financial returns since they mature within 90 to 120 days, allowing at least two growing seasons per year in areas such as Nkhatabay and Karonga districts. Women significantly benefit from groundnut farming, as they dominate processing and selling, making it an important source of income and empowerment.

Groundnut exports are large given the demand from the Southern African market (Zambia and Mozambique), which prefers red varieties (CG7 and CG9), while the South African market prefers tan varieties (CG11 and Chalimbana). The stable demand for groundnut ensures continuous income throughout the year, especially during economic crises. Overall, groundnuts contribute to food security, economic stability, and women's empowerment, making them a valuable crop in many agricultural systems.

Table 3. Uses of groundnut in Nigeria.

Groundnut use	Pictorial demonstration
Oil production Groundnut oil production in Nigeria is done at the cottage industry level and industrial level. Groundnut has the highest oil content of all food crops and is second only to soybean in terms of protein content (20–30%) among the food legumes (Khan et al. 2004).	 *Groundnut oil extraction in FCT (March 2024)*
Processing – *kuli kuli* The by-product obtained after oil is extracted from groundnut paste is called groundnut cake. Groundnut cake is prepared by adding water intermittently to soften the thick groundnut paste for easy molding into desired shapes. These are fried in a small frying pan containing hot oil extracted from the groundnut paste.	 *Kuli kuli making in FCT (March 2024)*
Whole-grain consumption when boiled or roasted Low oil content is the key attribute considered for groundnuts intended for boiling or roasting.	 *Kampala variety found in a market in FCT (March 2024)*
Haulms for animal feed Haulm yield and quality are important across all groundnut market segments.	 *Groundnut haulms sold at a market in FCT (March 2024)*

Table 4. Uses of groundnut in Malawi.

Groundnut use	Pictorial demonstration
Floor production Groundnut flour production in Malawi is done at the cottage industry level and industrial level. Groundnut flour, which is locally known as *nsinjiro*, is a common household food item and is used as an additive to most dishes.	 *Groundnut oil extraction in Malawi (April 2024)*
Processing – peanut butter Groundnut is processed at both the cottage and industrial level into peanut butter.	 *Peanut butter from a processor (April 2024)*
Whole-grain consumption when processed Groundnuts are processed and packed as various products such as sugar nuts, nuts, and raisins.	 *Packed peanut products at NASFAM (April 2024)*
Groundnut for export Groundnut is largely sourced for export, with high demand from Southern and South African markets.	 *Packed unshelled groundnuts for export (April 2024)*

Implications for trait prioritization in Nigeria and Malawi

In Nigeria, every part of the groundnut crop is valued, making it a highly versatile commodity. As a result, trait preferences vary by end use and are reflected in the Target Product Profiles (TPPs) for different market segments. Groundnuts processed for oil and *kuli kuli* require varieties with high oil content, making this trait a top priority in breeding for these uses. In such cases, other characteristics such as seed color and size are less relevant.

In contrast, for groundnuts consumed boiled or roasted, high oil content is undesirable. These uses prioritize taste and texture, and anecdotal evidence from interviews suggests that high-oil varieties can take longer to cook or have a less preferred flavor profile, points that warrant further investigation.

Beyond grain use, groundnut haulms (the vegetative parts) are a critical by-product for Nigeria's livestock sector. Haulms are actively traded in markets and used as animal feed, particularly during dry seasons. Consequently, haulm quantity and quality are important considerations across all groundnut varieties, regardless of the primary grain use.

Given groundnut's role as a major cash crop in Nigeria, high yield remains a fundamental breeding priority for profit maximization. Additionally, time to market closely tied to crop maturity duration directly impacts farmers' cash flow.

Early-maturing varieties are particularly favored for enabling multiple harvests per year and faster income generation. For instance, in the Kaduna and Kano regions, one of the most popular varieties is known locally as "Three Months," prized for its short growing cycle and rapid return on investment.

Trait preferences in Malawi depend on the targeted market segments. Farmers prefer groundnut seed varieties that are high yielding and rosette tolerant. These qualities ensure that farmers have enough groundnuts to sell and keep for home consumption. During the FGDs, some farmers also expressed their preference for early-maturing varieties. However, it is worth noting that the farmers mentioned that they are not aware of the trade-offs in terms of yield loss that comes with early-maturing varieties. Farmers intending to sell their grain to processors prefer varieties with low oil content. They also prefer the tan varieties because of market demand. Large-scale processors, large-scale traders, and seed companies are concerned about aflatoxin since most of them target export markets. They prefer varieties that are perceived to be aflatoxin tolerant. In addition to the traits highlighted above for the Malawi groundnut market, groundnut color is an important consideration as an end-user requirement. The size of the grain is also critical as well as uniformity, especially for export markets.

The different end uses identified in the two countries influence trait prioritization in the TPPs for the two markets (Table 5).

Table 5. Groundnut traits prioritized in Nigeria and Malawi.

Trait prioritization	Nigeria	Malawi	Trait prioritization	Nigeria	Malawi
Oil content	✓	✗	Maturity	✓	✓
Haulm quality and quantity	✓	✗	Size	✗	✓
Color differentiation	✗	✓	Aflatoxins	✓ Yes, but no market-driven economic incentive	✓

Conclusions

Effective breeding prioritization must holistically consider regional context to ensure that the traits driving variety adoption are fully understood and appropriately targeted. Treating regional context in overly broad or generalized terms risks misaligning breeding objectives with the actual needs of farmers, processors, and consumers in specific regions. This could result in allocating resources toward traits that have little relevance in the target market or, worse, neglecting traits that are critical for adoption, both of which represent significant inefficiencies and lost opportunities for breeding programs.

To avoid these pitfalls, the integration of detailed market intelligence specific to each regional context is essential. This includes understanding not only agronomic conditions but also cultural practices, end-use preferences, value chain dynamics, and socioeconomic factors that influence trait desirability. In countries such as Nigeria and Malawi, where groundnuts serve diverse purposes across multiple market segments, breeding must align with local realities – from oil content for processors to haulm quality for livestock use and early maturity for cash flow optimization.

Ultimately, a demand-led breeding approach rooted in localized insights enables the development of varieties that are not only agronomically sound but also market-relevant and socially acceptable. This ensures more efficient use of breeding resources and significantly enhances the likelihood of widespread adoption and impact.

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