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Status of Groundnut Production in Africa: A Review From 2012 to 2022

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Abstract

Food safety, and security remains a major concern in developing nations. Groundnuts rank the second globally in oil seed production after soya beans and the 11th most important crop for human intake. Limited productivity against the potential of existing crops due to biotic, abiotic, market, and policy factors causes the poor food production trends. This work uses a systematic review approach to determine the productivity of groundnut as a major food crop in Africa for the last 10 years based on the trend of declining yields of groundnut in this duration, and the role of influencing factors. The extracted data is summarized creating a feasible proposal on how the productivity, and quality of the crop could be improved to meet the food security need. Among the top 11 producers of groundnuts in Africa, West Africa accounts for 55% with regions like Nigeria, and Senegal having the highest productivity of 3.3 t, and 1.1 t respectively over the last ten years. In East Africa, Sudan has the highest production of 2.04 t over the 10 years. Despite being the second continent in the size of area under production of groundnut, Africa has the lowest average yields per hectare (1 t/ha), compared to America (3 t/ha), and Asia (1.8 t/ha). Regions that used improved varieties had higher yield than those using local varieties, and less technologies. High disease infestation shows a direct correlation with declining yields of groundnut. Therefore, the low productivity of groundnuts could be associated with social, cultural, and economic factors that create disparities in accessing improved technologies, farming, production and marketing resources. Development of improved varieties and policies in the region that support improved agronomic inputs are feasible practices for attaining cultivars that resist the yield, and quality limiting parameters.

Keywords: aflatoxins, diseases, food safety, food security, productivity, variety

1. Introduction

Africa faces some of the highest cases of malnutrition, and hunger linked to poor access to adequate and high quality foods. Groundnut (*Arachis hypogaea* L.), is a major crop in the Sub-Saharan Africa households with the potential to address the nutritional need if it met its production potential (Ojiewo et al., 2020). The crop is a crucial source of nutrients that enhance human health (Ojiewo et al., 2020). Groundnut provides half of the recommended daily allowance of dietary protein; essential vitamins especially E, energy from its oils, fats, and dietary fiber (Ojiewo et al., 2020; Wessels & Brown, 2012). The crop provides a rich source of minerals like zinc, calcium, magnesium, sodium, potassium, and biologically active compounds like arginine, and flavonoids (Okello et al., 2010). Groundnut is a rich base in therapeutic foods recommended by the World Health Organization of the United Nations as a “ready-to-use therapeutic foods” (RUTF) for management of malnutrition at individual, family, and community levels (FDA, 2017). Groundnut consumption is linked with significant health benefits aligning with the recommendations that transformation to healthy diets by 2050 requires significant dietary changes with more than 100% increment in consumption of healthy foods, such as nuts, fruits, vegetables, and legumes (Ojiewo et al., 2020). Increased intake of total and specific types of nuts was reported to reduce the risk of total cardiovascular disease, and coronary heart disease (Liu et al., 2019). Therefore, the maximum production of groundnut is essential for food safety, and security especially among regions experiencing nutritional challenges.

Groundnut is grown in more than 100 countries globally, majorly arid, and semi-arid tropics (Okello et al., 2010). Approximately 65% of the crop is produced in Asia, and 26% in Africa (Ojiewo et al., 2020). The average groundnut yield in Africa is significantly low (964 kg/ha) compared to US (3500 kg/ha), and other developed countries (Abady et al., 2019; Benard et al., 2020). Poor inputs, unimproved varieties, unreliable rains, diseases and aflatoxins account for the low production of groundnut in Africa leading to the loss of Africa's export potential to various markets (Benard et al., 2020). A study by Mukoye et al. (2019), revealed that resource poor smallholder farmers grow nearly 75 to 80% of the world's groundnut in developing countries obtaining yields of 500 to 800 kg/ha, as opposed to the potential yield of more than 2.5 t/ha. The limited production compromises the economic, and nutritional benefits, which smallholder farmers in Africa depend upon (Benard et al., 2020). Senegal produces approximately 250,000 tons of groundnut which comprises 20% of the gross domestic product while Malawi produces 300,000 tons, and Kenya 16913 tons per year (Georges et al., 2016; Mukoye et al., 2019; Konate et al., 2022). However, the production is only 50% of the region's potential. A research conducted in the Western region of Kenya, revealed that the area produces an average of 600 to 700 kg/ha, which is less than 30 to 50% of the potential yield (Benard et al., 2020; Mukoye et al., 2019). The trend of limited productivity potential in groundnut growing African nations aligns with the high rates of food insecurity and malnutrition hence the need for improved strategies of meeting the groundnut production potential in Africa.

1.1 Problem Statement

In Africa, groundnut production portrays a gap in yield associated with biotic and abiotic factors (Abady et al., 2019; Nderitu, 2019). The low yields of groundnut are mainly associated with poor quality of seeds, drought, poor agronomic practices, pests, and diverse diseases (Mutegi, 2012; Okello et al., 2012). Mycotoxins infestation during storage and processing of the crop further reduce the quality of groundnut and their products. Use of soil enhancing mechanisms like manures and improved agronomic practices based on farmer training and awareness is associated with better yields (Muzoora et al., 2017). However, the limiting factors of cost, limited awareness and access to production technology, and market, adverse climate, poor control of diseases and pests hinder the attainment of maximum yields (Nderitu, 2019). Different varieties in Africa exhibit varying resistance to diseases, adverse climatic conditions, and mycotoxins hence the need for exploring the best performing varieties for improved yield and quality.

1.2 Study Objective

This review analyzes the production of groundnuts in Africa for the previous 10 years between 2012 and 2022 against the associated biological, cultural, and social economic aspects proposing ways of improving the yield and quality of the crop as a measure of food security

2. Methods

2.1 Search Strategy

The literature review was conducted using credible search engines like Google scholar, sematic scholar, and research gate targeting articles published within the last less than 10 years. However, articles with unique subjects published outside the scope of 10 years were considered for the study. The rationale for considering unique articles with a publication duration of 20 years even when the productivity assessment was the previous 10 years was to increase the scope of additional factors like varieties, diseases and mycotoxins whose trends could extend beyond the ten years under scrutiny. The key words groundnut, production, yield, varieties, diseases, aflatoxins, and Africa were used in the search process. Synonyms of these words like peanuts for groundnut were also considered. Relevant articles were initially identified using title and abstract screening, and secondly by full text.

2.2 Inclusion and Exclusion Criteria

The inclusion criteria for the articles was the use of English language, the publication dates, peer reviewed articles or accredited reports from credible sources like FAO, and articles accessible in full. The search focused on data from West, East, Central, Middle, Northern, and South Africa but most of the analysis focused on the 11 best producers and Kenya as the 12th nation despite being outside the scope of the best producers in the duration between 2012 and 2022. The articles that met the search criteria were used in analyzing the research subject and making recommendations and conclusions based on the trends of the extracted data.

2.3 Critical Appraisal

Critical appraisal of the publications ensured that only relevant high quality studies were included in the review, and low quality studies excluded. This step was based on the Critical Appraisal Skills Programme (CASP) Tools Checklists (CASP 2018). To be included in the review, papers had to adequately, title and abstract screening questions: (1) Does the citation indication publication within the time period specified? (2) Are the title, and abstract in English?

3. Literature Search Findings and Discussions

3.1 Productivity of Groundnuts in Africa

In the previous 20 years, more than 100 improved groundnut varieties have been introduced to the Sub-Saharan Africa for better production (Abady et al., 2019). Nigeria ranks as the highest producer of groundnut producer in Africa with productivity ranging from 3.3-4.2 million tons over the last 10 years between years 2012 and 2022 (FAO, 2022) (Table 1). Sudan, Senegal, Tanzania, and Chad follow Nigeria in productivity with averages of 2.04, 1.2, 0.95, and 0.88 million tons respectively over the last 10 years until 2022 (FAO, 2022; Konate et al., 2022) (Figure 1). Only three nations portray productivity above 1 million tons which is significantly below the potential of the region. Among the reviewed best nations with Kenya as an exception, Malawi, and Kenya had the least productivity over the 10 years of 350,000 tons and 11,000 tons respectively over the last 10 years (FAO, 2022; Konate et al., 2022) (Figure 1). The productivity status among the different African nations changes from time to time due to the effects of the influencing factors. Instability in farming practices, policies governing seeds, and climatic aspects are the key drivers of the crop in Africa.

West Africa has the highest productivity where among the 11 best producers, acting as a leader with a total average productivity of between 6,000 to 10,000 tons over the 10 years (Figure 2). The total production for all the West African nations in the top rank is above 6million tons while for East, Middle and Northern Africa is above 2 million tons. The lowest regions are Southern and Central Africa with a production below 2 million (Figure 2; Table 1). None of the South African countries is in the top ten groundnut producers in Africa for the previous five years. The area under production of the crop is a determining factor for productivity since countries in West Africa which have larger farming ground under groundnuts compared to other African nations have a potential for higher productivity.

The reviewed best producers lack a consistent increase in productivity over the 10 years against the area harvested (Table 1). The productivity majorly declines or remains stagnant accounting for the threatened food security, and export of the crop. Varieties like ICIAR 19 BT, and JL24 have been grown in the high groundnut producing areas like Nigeria due to resistance to diseases and drought (Abady et al., 2019). The regions like Nigeria, Sudan, Ghana, and Chad with high productivity exhibit a higher area harvested than nations with lower production (Figure 1). Despite the consistent increase in the areas under groundnut production in majority of the African regions, the yield lacks significant increase hence the lower productivity (Abady et al., 2019; Konate et al., 2022) (Table 2). High producers like Niger, Sudan, and Nigeria have significantly poor ratio of area under production against the yield where the area is higher than the yields (Figure 1). The trend of a high area under groundnut production but low yield reflects performance below the potential. The poor productivity limits food security, and export of the commodity to international markets. Development of drought and disease resistant varieties and mitigation of aflatoxins is a platform for restoring the productivity of groundnuts in Africa.

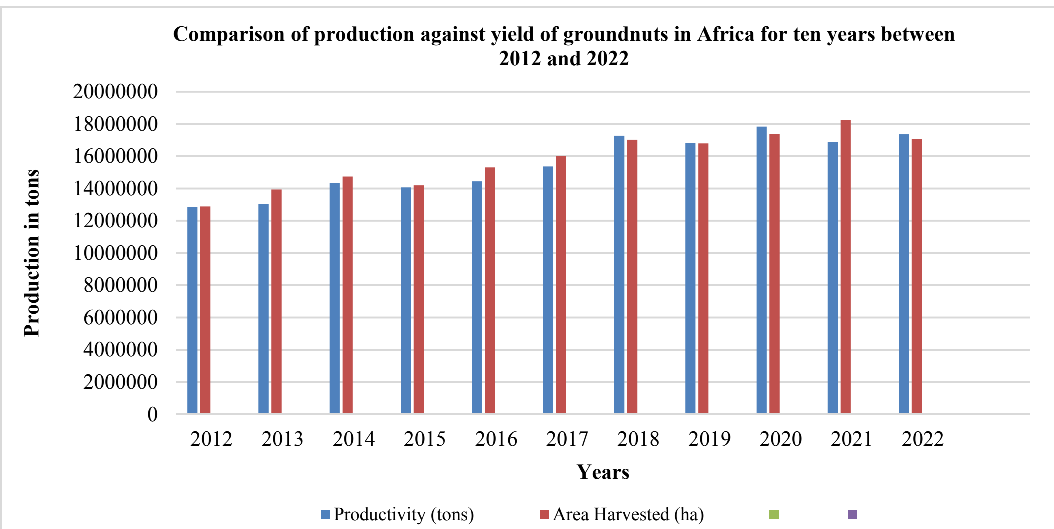

Figure 1. Trend of groundnut productivity in Africa against area harvested for the previous 10 years (2012-2022)

Table 1. Top 11 groundnut producers in Africa from the highest to the lowest between years 2012 and 2022 in tons

	Nigeria	Sudan	Senegal	Tanzania	Chad	Cameroon	Ghana	Burkina	Niger	Congo	Malawi	Kenya
2012	3313500	1032000	692572	810000	1297712	633799	475056	311273.2	291826	405277	368081	24639
2013	2474530	1767000	677456	1425000	965162	635947	408814	349688	342772	413342	380800	94072
2014	3399158	1871000	669329	1635335	791088	578626	426280	335223	403365	421568	397503	56149
2015	3467446	1042000	1050042	1835933	720138	608731	417198.5	365887	427324	422327	274876	28574
2016	4360500	1826000	719000	640000	871249	601104	425824.8	519345	453576.9	434694	275070	10687.2
2017	4521450	1648000	1405223	650000	870094	595960.8	433771.9	334328	461842	443388	386319	19272.5
2018	4600000	2884000	1500588	670000	893940.5	664127.7	521032.1	329783.4	594162	445476	344583	21333
2019	4346335	2828000	1421288	680000	873228	725825.1	563000	396128.7	543950.5	455356	350000	15463
2020	4230560	2773087	1797486	690000	840035	801632.3	565000	630526	593669	465474	350000	15604.2
2021	4227520	2355000	1677804	710000	797952.9	500000	502000	477254	518784	475817	350000	12897
2022	4284000	2500000	1501498	710000	829431	500000	611000	559064.4	670613.5	486389	350000	11000
Avg. productivity (2012-2022)	**3,929545**	**2047826**	**1192026**	**950569.8**	**886366.4**	**622341.2**	**486270.7**	**418954.6**	**481989.5**	**442646.2**	**347930.2**	**28153.72**

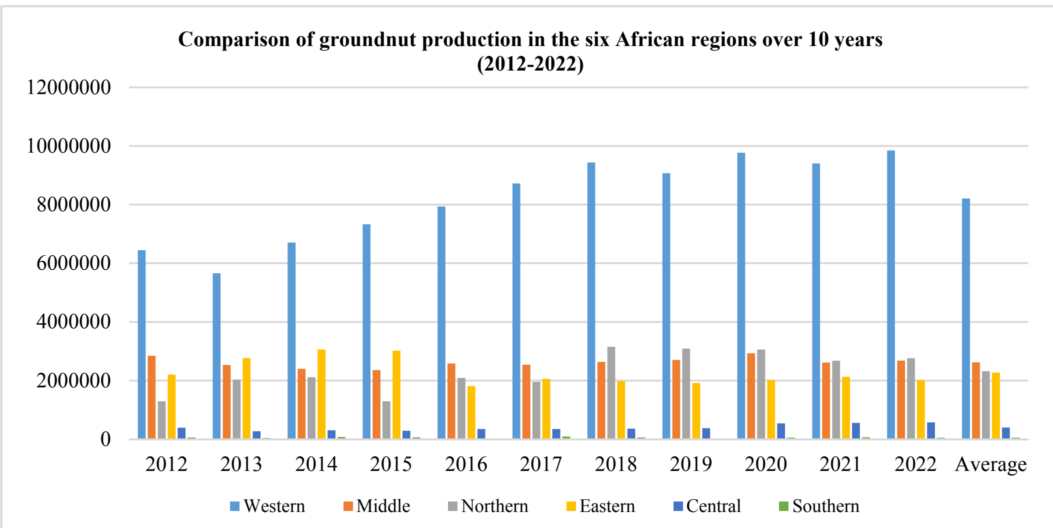

Figure 2. Graph showing groundnuts productivity trend in African regions between years 2012 and 2022 (FAO et al., 2022; Konate et al., 2022)

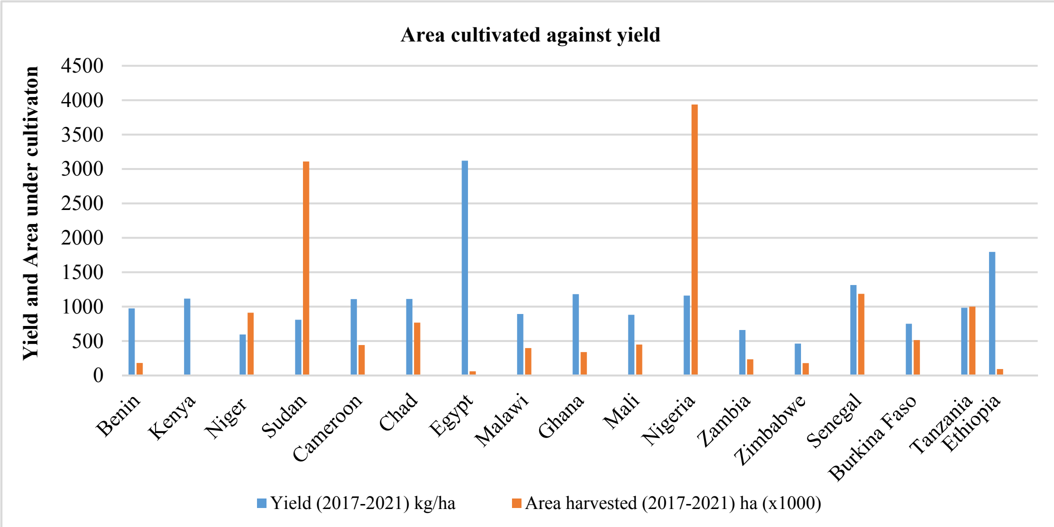

Figure 3. Area cultivated against yield

3.2 Varieties of Groundnut Grown in Africa and the Productivity Potential

The development of new varieties using breeding techniques, and genome modification focus on resistance to leafspots, rust, drought, groundnut rosette, aflatoxins, and improved nutritional quality (Abady et al., 2019; Garba et al., 2015). West Africa portrays the best groundnut productivity and highest use of improved varieties compared to the other African regions (Table 2). Sudan in East Africa is documented as one of the top five groundnut producers giving 14% of the world's groundnut demand (FAO et al., 2022). The crop accounts for 35% of cash crop in the region. An experimental study determined the yield outcomes of local or popular (Barberton), and improved varieties (Gubeish) alongside intensification parameters like plant density and soil enrichment (Abdalla et al., 2018). Findings indicated that the improved variety (Gubeish) had a 20% higher productivity than the local even before the seed priming, and improved plant density (Abdalla et al., 2018). Therefore, improved varieties could be attributed to better yield due to higher resistance to diseases, pests, and adverse climatic changes. The gaps in improvement of varieties however are the lack of adequate research revealing the type of genomic characteristics that would thrive in specified African regions. The blind use of improved varieties could be eliminated through conducting a chain of research that helps tailor seed varieties that align with the drivers of productivity in the specific nations.

In Kenya, there are four main groundnut growing regions with varying productivity; Nyanza (56% production), Western (22%), Eastern (11%) and Rift Valley (8%) (International Crop Research Institute for the Semi-Arid Tropics, 2020). The most common grown varieties in the region are the runner type and the bunch type, which mature in 90-100 days and 60-75 days respectively. However, the local varieties have poor quality and quantity compared to the improved varieties (ICRISAT, 2020; Njoki et al., 2023). Farmers using improved varieties attain more than double the price of groundnut due to the high quality, and quantity as compared to those engaging in farming the locally used varieties (ICRISAT, 2020). A survey by ICRISAT revealed that growth of a local variety called "*Chemblambus local*" by farmers in Elgeyo Marakwet indicated late maturity, small seed size, susceptibility to diseases and low yields of 700 kg per ha compared to potential yields of 2,000-3,000 kg per ha. (ICRISAT, 2020). Comparison of improved varieties fetched from Malawi namely CG7, ICGV 90704 and ICGV 83708 fetched higher yields, and income compared to the local variety (ICRISAT, 2020). The large seeded improved varieties gave profits of $1.20 per kg as compared to US$0.50 per kg for the smaller seeded local varieties (ICRISAT, 2020). The findings align with Njoki et al., 2023 where improved varieties grown in Nyanza, Kenya had higher yield outcomes. The yield was determined using 100-pod weight, 100-seed weight, biomass, harvest index, and total pod weight. The improved varieties have higher resistance to diseases, and adverse climatic conditions hence the higher yield. Enhancing policies and programs that promote access to improved varieties could increase the groundnut quality, and yield hence food security in Kenya, Africa, and beyond.

Table 2. Summary of groundnut varieties in reviewed African regions, yield and area under production

Region	Yield (2012-2022) (kg/ha)	Area harvested (2012-2022) (ha)	Varieties	Reference
West Africa				
Nigeria	1160.44	3937405	SAMNUT 1-20, SAMNUT 21-23, SAMNUT 24, and SAMNUT 25 and 26	Ahmed et al., 2020; Shuaibu et al., 2022; Desmae et al., 2022
Niger	595.62	911604.2	RRB, 55-437 and ICGV 9346, ICIAR 19 BT, JL24	Bakoye et al., 2019; FAOSTAT, 2016
Mali	883.06	448875.2	G1-G15	Sanogo et al., 2019
Ghana	1181.86	340600	Sarinut 1 and Sarinut 2 (Improved)	Kotu et al., 2022
Senegal	1314.44	1187744	GH119-20, 73-33, 28-206, Fleur 11, and 55-437	Georges et al., 2016; Desmae et al., 2022
Chad	1113.48	767664.6	ICIAR 19 BT, JL 24	Gamoung et al., 2017
East Africa				
Sudan	810.82	3108636	Gubeish (Improved), Barberton (local)	Abdalla et al., 2018; Yousif et al., 2015
Kenya	1116.44	15338.8	Red Valencia, runner type, Spanish (Main categories) Homabay local, Nyaluo, makulu red (local) 12991, CG7, CG12, CG9, ICGV-SM 90704 (Improved)	ICRISAT, 2020; Njoki et al., 2023; FAO, 2018
Tanzania	984	1,000,000	Naliendele 2009, Mangaka 2009, Masasi 2009, Nachi 2015; ICGV-SM 90704) (Improved) Old varieties :Dodoma bold, Red mwitunde, Nyota, Johari, Sawia, and Pendo	Akpo et al., 2021 Mwalongo et al., 2020
Central Africa				
Cameroon	414,046	455,692	Garoua/Fastigiata	Chotangui et al., 2022
South Africa				
Malawi	893.46	398926	Chalimbana (local) CG7, Chitala, Chalimbana 2005, ICGV-SM 90704 (Nsinjiro), JL 24 (Kakoma), and IGC 12991 (Baka) (improved)	Tsukaka et al., 2016; Katunga et al., 2021

4. Factors Associated with Groundnut Production in Africa

4.1 Diseases

Biotic factors play a major role in limiting the productivity of groundnut. Among these biotic factors, diverse diseases compromise the yield, and quality of the crop. In Africa, groundnut diseases account for 50% decline in productivity of the crop (Mukoye et al., 2019). Limited knowledge of the diseases, their causes and mitigation strategies account for their persistence through the seasons. Exploring the range of diseases identified in the target African region, their causal pathogens, and prevalence creates a sustainable basis for management.

Majority of the diseases with a high severity and incidence in groundnuts in Africa are foliar fungal and viral diseases, which affect productivity (Abady et al., 2019). The viral Groundnut Rosette Disease (GRD), early leaf spot, late leaf spot, and rust are all foliar, and comprise the quality of quantity of groundnut production. The findings of disease types, severity and incidence in the African region align with diverse studies that report foliar diseases as the most destructive in groundnuts (Sudini et al., 2015). Findings reveals that GRD viral disease is the most significant in causing groundnut losses, alongside fungal diseases like leaf spots, and rusts (Ashish et al., 2014; Sudini et al., 2015). The seed sources, climatic conditions, and agronomic practices based on farmer awareness play a central role in management, and prevention of groundnut diseases (Benard et al., 2020; Sudini et al., 2015). Development of integrated disease management strategies in Africa could help in meeting the production potential, its associated economic, and nutritional benefits.

4.1.1 Viral Diseases

Breeding programs led to the development of more than 100 groundnut varieties in Africa over the last years focusing on drought and disease resistance (Abady et al., 2019). The GRD disease which causes 100% losses, and lacks adequate management, and prevention is a key target in development of improved varieties (Tabe-Ojong et al., 2022). A study by Ahmed et al., 2020 revealed that improved varieties had three fold more yield than local varieties associated with the higher resistance to GRD. The findings align with Abady et al. (2019) where majority of the breeding and improvement of groundnut varieties in Africa seeks to enhance resistance to drought, and GRD. Based on symptoms, rosette is categorized into the chlorotic rosette, which is ubiquitous in SSA, while the green rosette occurs in West Africa, Uganda, and Angola; the third less frequently occurring type, the mosaic rosette, is recorded only in East and Central Africa (Hema et al., 2014). The source of seed could be a significant contributor to the incidence of the virus and severity of the disease in groundnut. Inadequate knowledge on the presentation of symptoms, occurrence of disease, prevention and management strategies among the groundnut farmers increase the risk of the viral disease. Besides obtaining certified seeds from the appropriate sources, and controlling insects, and pests, which spread the disease, farmer awareness on the disease enhances local management.

4.1.2. Fungal Diseases

Both early, and late leaf spots are fungal diseases of groundnut dominant throughout the Western, Eastern, Central, and Southern Africa regions causing 50% losses globally (Dewnar et al., 2021). However, the prevalence of the fungal groundnut diseases varies with climate where the early leafspot more commonly appears, and destroys the crop in the high-rainfall areas (Dewnar et al., 2021). The pathogens causing leaf spots could persist from season to season on volunteer, and groundkeeper plants, and in infected crop debris since there lacks known hosts of the pathogen outside the *Arachis genus* (Tanzubil, 2016). Seasons influence the onset, and progression of leaf spot, and back crossing of varieties was a major way of addressing the diseases (Isa Bwala et al., 2020). The fungal diseases are majorly eliminated through spraying with fungicides which vary from one nation to another. Early planting of groundnut, and sensitivity to seasonal factors plays a significant role in reducing the incidence of leafspot in African regions

4.1.3 Bacterial Diseases

A significant gap exists in the study of bacterial diseases of groundnuts in Africa. Globally, bacterial wilt is the most common, and well identified disease (Obasa & Haynes, 2022). The disease causes seed rot, pre, and post-emergency damping off, low seed vigor, and compromised root development in groundnut plants hence low quality (Obasa & Haynes, 2022). Fungal, and viral diseases dominate the groundnut farming practices in Africa. However, additional research would reveal the association between the groundnut varieties and bacterial pathogens since their resistance to bacterial diseases is a positive aspect that could be applied in other crops. Groundnut farming in Africa majorly happens in high temperature and low rainfall areas (Njoki et al., 2023). The climatic conditions in the groundnut growing regions could reduce the spread of bacteria.

4.2 Aflatoxin Occurrence in Groundnut in Africa

Mycotoxins portray toxic secondary metabolites of fungi contaminating foods, and causing adverse effects human, and animal consumers alongside significant economic losses (Kimanya, 2015). Aflatoxins are a group of mycotoxins produced by at least 20 fungal strains of *Aspergillus* section Flavi, Nidulantes, and Ochraceorose (Omara et al., 2021). Twenty different types of aflatoxins of toxicological importance have been reported namely; aflatoxin B_1 (AFB_1), aflatoxin G_1 (AFG_1), aflatoxin M_1 (AFM_1), aflatoxin B_2 (AFB_2), and aflatoxin G_2 (AFG_2) (Okoth et al., 2018). The different types of aflatoxins contaminate a variety of food, and feed substances ranging from cereals, spices, and animal feed which facilitate the presence of the toxic metabolites in animal products like meat and eggs (Monda et al., 2020). Diverse studies reveal high incidences of aflatoxins in the Sub-Saharan region due to the tropical, and sub-tropical climate, which favors growth of the aflatoxin producing fungi (Omara et al., 2021). Aflatoxins are majorly produced by *Aspergillus flavus,* and *Aspergillus parasiticus* (Okoth et al., 2018; Monda et al., 2020). However, additional aflatoxin producing fungi like *A. niger*, *A. terreus*, and *A. versicolor* have been reported in Eastern Africa (Omara et al., 2021). The aflatoxin associated deaths in the year 2004 caused by acute aflatoxicosis in Kenya and subsequent years led to diverse studies of the toxic metabolite in food, and feed in Africa including groundnuts

Research findings in the last 10 years indicated aflatoxin contamination in groundnut as a problem in different Sub Saharan African countries. The levels of contamination in these nations exceed the maximum regulatory limits for groundnut and groundnut products meant for human consumption set by the Codex Alimentarius at 5 µg/kg (AFB1) and 20 µg/kg (total) which the nations should adhere to (Mupunga et al., 2017). The impacts of aflatoxins in groundnut comprise shifts to reduced restriction in export markets and poorly regulated domestic markets.

Table 3. Occurrence of different types of aflatoxins in African nations

Region	Product	Type of aflatoxin	Range (μg kg^{-1})	Reference
Malawi	(1) Groundnut-based therapeutic foods	Total	1.6 and 2.9	Matumba et al., 2014
	(2) Locally processed groundnut butter	Total	34.2-115.6	Matumba et al., 2014
	(3) Groundnut seeds from 11 regions	B1	2197-3240	Monyo et al., 2012
	(4) Locally processed skinned	Total	0.5-2.5	Matumba et al., 2014
	(5) Locally processed deskinned	Total	0.6-36.9	Matumba et al., 2014
Ghana	Raw groundnut and groundnut paste	Total	0.38±0.04-230.21±22.14	Kortei et al., 2021
	Raw groundnut and groundnut paste	AFB1	0.38±0.02-270.51±23.14	Kortei et al., 2021
Senegal	Groundnut seeds	AFB1	Above 4	Diedhiou et al., 2012
	Groundnut oils	AFB1, AFB2, AFG1, AFG2	Above 40	Diedhiou et al., 2012
Nigeria	Groundnut seeds	AFB1	20-455	Bankole & Adebajo, 2014
South Africa	Groundnut seeds	Total Aflatoxins	2.1-73.5	Kamika et al., 2014
D.R. Congo	Groundnut seeds	Total Aflatoxins	2.19-1258	Kamika et al., 2014
Sudan	Groundnut seeds	Total	0.01 and 0.02	Ali Ahmed et al., 2016
	Groundnut products and seeds	B1	17.57-404.00	Ali Ahmed et al., 2016
Tanzania	Groundnut seeds	Total Aflatoxins	10.3 to 40.3	Kuhumba et al., 2018
Kenya	Raw	Total aflatoxins	0-2345	Nyirahakizimana et al., 2013
	Roasted coated		0-382	
	Roasted de-coated		0-201	
	Raw groundnuts	Aflatoxin B1	0-115.15	Menza et al., 2015
		Aflatoxin B2	0-46.23	
		Aflatoxin G1	0-34.90	
		Aflatoxin G2	0.01-15	

4.2.5 Regulation of Aflatoxin Levels in Foods in Africa

Regulation of aflatoxin levels secures the consumers from harm of toxicity. The African regulatory limits differ from country to country, and among food products. Codex Alimentarius sets aflatoxins limits in Sub-Saharan Africa at 5 µg/kg (AFB1), and 15 µg/kg (total) (FAO, 2015; Mupunga et al., 2017). The East African Community has a limit of 10 µg/kg for total aflatoxins, and 5 µg/kg for aflatoxin B1 (FAO, 2015). Some regions like Malawi, and Nigeria have lower total aflatoxin limit of 4 µg/kg similar to the E.U. levels. Kenyan maximum regulatory limit for total aflatoxin in maize and applicable in groundnuts is 10 µg/kg for total aflatoxins, and 5 µg/kg for AFB1 (Herman et al., 2020; Kibugu et al., 2019). Public authorities like the Ministry of Health, the Agriculture Food Authority of the Ministry of Agriculture, and county government's public health agencies work collaboratively in regulating the levels of aflatoxins in foods (Herman et al., 2020; Kibugu et al., 2019). Additionally, international agencies contribute to management of aflatoxins in foods in African nations. The regulations in different regions vary based on the national standards (Table 4). The aflatoxin regulations limit production since farmers get restricted by the market regulations.

Table 4. Regulatory limits for aflatoxins in groundnut in Africa

Region	Food type	Aflatoxin limits by National Regulating bodies	Aflatoxin limits by US-FDA	Aflatoxin limits by European Union (E.U.)	Codex Alimentarius	Type of mycotoxin	Reference
Africa	Foods (Groundnut, maize)		20ppb	2ppb 4ppb	5 µg/kg 15 µg/kg	AFB1 Total	Mupunga et al., 2017
Kenya	Groundnut	10 ppb				Total AFB1	FDA, 2017; Kibugu et al., 2019
	Groundnut	5 ppb	20 ppb	3 ppb		Total AFB1	FDA, 2017; Kibugu et al., 2019
Malawi	Groundnut	4 ppb	20 ppb	3 ppb		Total Aflatoxin	FDA, 2017
Ghana	Groundnut seeds Groundnut butter	10 µg/kg 5 µg/kg 4 µg/kg	20 ppb	3 ppb		Total Aflatoxins AFB1	Omari et al., 2020
Nigeria	Groundnut	4 ppb 2 ppb	20 ppb	3 ppb		Total Aflatoxins AFB1	FAO, 2020
South Africa	Groundnuts	10 µg/kg 5 µg/kg	20 ppb	3 ppb		Total Aflatoxins AFB1	FAO, 2020
Senegal	Groundnuts	10 µg/kg	20 ppb	3 ppb		Total Aflatoxins	Abady et al., 2019
Tanzania	Groundnut	10 µg/kg 5 µg/kg	20 ppb	3 ppb		Total Aflatoxins AFB1	Kuhumba et al., 2018

4.3 Social-Cultural Factors, Economic and Political Factors

Social networks and cultural inclinations influence the adoption of technologies in groundnut farming impacting the productivity of the crop. A survey based study in East African region determined the role of social cultural aspects in groundnut productivity using face to face interviews in Kenya and Uganda (Thuo et al., 2014). Findings of the study indicated that weak ties with external support like agricultural officers, and researchers influenced acquisition of knowledge hence adoption of technologies (Thuo et al., 2014). Gender, farm size, household size, and geographical location created disparities in information attainment hence limited adoption or use of improved technologies that would enhance productivity (Thuo et al., 2014). Individuals with large farm sizes, nearer the location of external support offices and with a link to researchers and extension offices were likely to have more knowledge of high yielding varieties and technologies hence record higher yields of groundnut (Thuo et al., 2014). The findings were supported by a study in Ethiopia comprising 400 groundnut producers. The mixed study revealed that age, gender, education levels, access to credit facilities and amount of land owned determined the levels of productivity among the farmers (Katundu et al., 2014). Individuals with higher levels of education and knowledge were likely to access credit facilities, links to improved technologies and varieties hence produce better yields and quality of groundnuts (Katundu et al., 2014). In Burkina Faso, a qualitative study indicated that women farming groundnuts had lower access to land, and production resources hence lower productivity compared to men doing the same practice (Sinare et al., 2021). Therefore, the gender roles in the African regions where the male gender mainly own land and control production while women are involved in the manual work contributes to the low productivity. Additionally, disparities in land size and access to support teams influences the production cycle.

Adequate market for agricultural products enables smallholder farmers to transit from subsistence to market-oriented farming (Sinare et al., 2021). Connecting farmers with the market and enhancing their ability to supply the produce increases their income and ability to explore high quality production processes (Sinare et al., 2021). Market balances consumption and sales of farmers' agricultural products is dependent of quality, and safety hence the role of regulating policies (Thuo et al., 2014). Marketing of groundnuts at the international market platform is constrained by major factors like aflatoxins which compromise safety and quality (Sori, 2021). The regulations limit the farmer's capacity as supported by a study in Ghana where policy support in linking to international market could reduce poverty by 3.6% yet without the policy, the poverty levels could barely be reduced by 2% within nine years (Kotu et al., 2022). The findings of these studies confirm that policies regulating the market supply of groundnuts alongside social aspects which determine access to farming and production resources are a major contributor to the low productivity levels of the crop in Africa.

5. Analysis of Productivity and Influencing Factors Among African Regions

West Africa portrays the highest groundnut productivity (8,210,670 tons) of groundnuts in Africa, followed by Middle (2,621,544 tons), Northern (2,319,958 tons), and East Africa (2,271,934 tons) in a duration of 10 years from 2012 to 2022 (Figure 2). South and Central Africa are the lowest producers but also have the least areas harvested which could account to the low yields. The trend of diseases in the different African countries does not reveal a variation since viral and fungal diseases are the most prevalent with their severity determined by the climatic status of these different seasons. However, West Africa shows a high rate of using improved varieties which could be associated with the highest productivity since the improved varieties had higher resistance to diseases to adverse climatic conditions compared to the locally used varieties (Konate et al., 2022). Besides the varieties, and areas under cultivation, the variance in climatic status with some regions having higher rainfall than others and the soil status could be attributed to the difference in productivity in the diverse African regions. The review on mycotoxins confirms that post storage losses and compromised quality of the crop is experienced across all the regions but with a higher prevalence in East Africa (ICRISAT, 2020). The high humidity and temperatures in the region are the main cause of mycotoxin infestation hence the need to invest in quality drying and storage mechanisms. Social and economic factors portrayed as gender roles, access to research outcomes and technologies, marketing platforms, and regulatory cycles created disparities in groundnut productivity in different African regions (Thuo et al., 2014). Therefore, biotic and abiotic factors together with the social cultural aspects are the major contributors of below the potential groundnut productivity in Africa.

6. Conclusion and Recommendations

The production of groundnut in Africa is a crucial practice in meeting the food safety, security, and economic goals since the region experiences multiple cases of malnutrition and food shortage. Nigeria, Sudan, Senegal, Chad and Tanzania are the largest groundnut producers in Africa with between 0.88 and 4.2 million tons annually for the last 10 years since 2012. However, the regions have large areas under cultivation of the crop compared to the smaller producers hence a higher potential for increasing the yield and productivity. The review findings indicate that areas with higher access to improved varieties, marketing platforms, extension officers, and knowledge of production technologies have better yield of the crop. Therefore, the choice of improved varieties, that resist diseases and mycotoxins guided by policy and awareness among groundnut farmers are useful and sustainable aspects of improving the quality, and quantity of groundnut production in Africa. Economic, social, cultural, and biological factors play a collaborative role in the declined production of groundnut thus the need for broad scope inputs majorly guided by farmer awareness and structures that define production and marketing of the crop. Adopting new improved varieties with screened effectiveness towards disease, pest and adverse climatic resistance is the most feasible approach of increasing productivity of groundnut in Africa. Agronomic practices that reduce disease infestation like rotation, timely planting, and use of organic soil enhancers are crucial in the sustainability of producing the crop. Additionally, it would be necessary policies are developed, and implemented on the regulation of seed quality, storage, marketing and farming practices that favor the productivity of groundnut. The review confirms that productivity is influenced by multi-disciplinary factors hence the need for collaborative measures among the relevant stakeholders.

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Authors Contributions

Conceptualization, (Loise Mumbi and Sheila Okoth), methodology, (Loise Mumbi, Sheila Okoth and Peter Wachira), data analysis, (Loise Mumbi), resources, (Sheila Okoth), writing-original draft presentation, (Loise Mumbi), writing-review and editing, (Loise Mumbi, Victor Kagot, Abigael Ouko, Peter Wachira and Sheila Okoth), supervision, (Sheila Okoth, Peter Wachira, and Abigael Ouko), project administration (Sheila Okoth), All authors have read and agreed to the published version of the manuscript.

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