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Yield Gap in Cashew Plantings (*Anacardium occidentale L*) in West Africa: Status, Causes and Prospects (Review)

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Abstract: Cashew cultivation is of paramount importance in West Africa because of its economic, social, and environmental significance. Cashew nuts production in recent years has been growing steadily in this part of Africa, making it the largest producer of raw cashew nuts in whole world. Unfortunately, this success has been achieved by expanding the area under cultivation rather than improving yields. To reverse this trend, it is important to understand the causes of this yield gap despite the high potential, to take stock of the research conducted in this way, and to propose perspectives. For that, documents were collected through Agora, Scopus, and Google Scholar over the period from 2010 to 2020, resulting in the selection of 103 relevant documents on the subject, using specific keyword combinations. Review slips were produced for each document to categorize then synthesize information from the documents. Numerous studies have been conducted in West Africa about the improvement of the plant material, diseases and pest management, soil fertilization, impact of climatic variations, pollination, and application of technical production itineraries. It appears that the yield gap observed in West Africa is due to the poor performance of the plant material that we use, the weak or poor application of good agricultural practices, particularly weeding, pruning, and thinning practices, phytosanitary treatments, and lack of fertilization. The implementation of these practices coupled with the combination of intercropping and beekeeping and the use of growth hormones could more improve cashew nuts production performance in West Africa.

Keywords: Literature Search, Cashew Nut, Agroforestry, Benin, Productivity

1. Introduction

Agriculture is very important to achieve several sustainable development objectives in Africa. The sector is first and foremost a motive of job creation, but also a medium of sustainable and inclusive growth, as well as the foundation of an essential system for ensuring nutritious, safe, and accessible food for all [1]. In West Africa, it represents the largest source of income and livelihood for 70-80% of the population, as well as food supply and export earnings from cash crops [2]. Africa's agricultural exports are largely from cultivation of fruit trees, with a contribution of 44.6 per cent. Africa dominates the global market for some products, such as cashew nuts, accounting for 86.6 per cent out of the global unprocessed cashew exports from 2017 to 2019 [3]. The share of raw cashew nut production for the West African region increased from 1,371,866 tons in 2009 to 1,575,910 tons in 2019 [4]. That makes this region of Africa the leading cashew-producing area in the whole world. Despite this performance, African agricultural productivity still lags other regions of the world [5, 1]. The cashew nut sector is not immune to this situation of lower productivity in Africa. Indeed, the evolution of cashew nut production in West Africa is linked to the increase in plantation area rather than yield improvement [6-8]. The average cashew yield is still lower in West African countries compared to other producing countries

outside Africa, such as India, Vietnam, and Brazil. Indeed, the average in the whole world is 1,300 kg/ha while that in Africa is 700 kg/ha [8]. With the local varieties, the productive capacity of West African cashew is 1000 to 1500 kg/ha [9, 10]. Faced with the reduction in cultivable land for expansion and the reduction in the sale price of raw cashew nuts in recent years, it is important to take actions to improve the productive capacity of the plantings. To achieve this, it is important to know the probable causes of this production gap in West Africa, with a specific focus on Benin, and then to propose perspectives for the progressive resolution of these identified bottlenecks. The reason to focus is the recent effort of Benin government to increase investments in the cashew sector and increase its contribution to the national GDP. Through this literature review, scientific advances in Benin, West Africa, and the rest of the world will be capitalized on to identify priority research areas to be considered with a view to reducing the observed yield gap.

2. Methodology

2.1. Target Species

The cashew tree (*Anacardium occidentale* L.) is a tree which occurs in tropical regions, resistant to high heat but very sensitive to low temperatures. It is therefore generally found at low altitudes. The trunk is highly branched, with dense evergreen foliage and a globular habit. The cashew tree is a spontaneous species, used for reforestation, and increasingly cultivated for its fruit: the cashew nut. Its maintenance and management requirements vary according to use. They are very low for reforestation. It requires little water, no fertilizer or special care and can grow in poor soils such as ferralitic or ferruginous soils with laterite armor. Its requirements increase in fruit production [11, 12]. The cashew tree spontaneously starts to produce fruit at about 5 old years, but fruits can occur earlier at 2 old years under suitable growing conditions. A tree produces an average of 15 kg of fruit each year under suitable conditions (up to 150 kg) and the tree has an average life span of 20 to 30 years [11]. The economic life of cashew trees is 20 to 25 years, after which yields start to decline. The actual fruit of the cashew tree is the cashew nut, which is attached to the base of a swollen stem, known as the cashew apple (Figure 1).

Figure 1. *A cashew plant.*

2.1.1. Origin

The cashew tree or Anacardium occidentale is an arboreal species from the North-East of Brazil. In the 16th century, Portuguese introduced it to India and Portuguese colonies in Africa, such as Mozambique. From India, cashew trees spread throughout the Southeast Asia and then from Mozambique to the tropical regions of Africa. Early cashew trees were planted to protect soils from erosion in coastal areas, as they are fast growing, tolerate salinity and thrive on sandy soils. Nowadays, cashew cultivation has mainly done for cashew nuts production in 46 countries (Figure 2) in Africa, Asia, Latin America, and the Caribbean [13, 14].

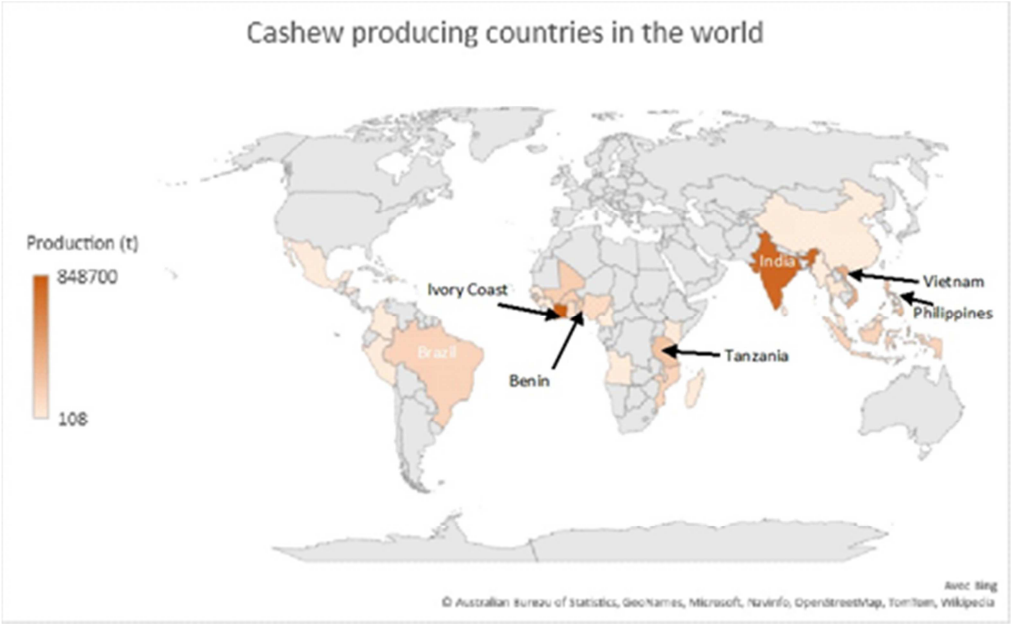

Figure 2. *Cashew producing countries in the world; Source: FAOSTAT (Accessed December 2021).*

Among the major cashew cultivation areas, West Africa is the newest and most dynamic in the whole world. In West Africa, cashew trees have been cultivating since the 1950s mainly as a resource for diversification and reforestation. Cashew has been becoming an important cash crop since the 1990s. The increase in trade between Asia and Africa and the increasing demand for cashew nuts have stimulated this new sector and provided a new opportunity for small-scale farmers who have invested heavily in the crop.

Since 2014, cashew has become the second most important cash crop in West Africa in terms of export value behind cocoa and ahead of cotton, rubber, palm oil or banana [15, 16]. Cashew nut cultivation is spread throughout the region (Figure 3), with 3 main production zones: the central zone (Côte d'Ivoire, Ghana, Burkina Faso, Guinea, Mali, and Togo), the eastern zone (Nigeria and Benin), and the western zone (Guinea Bissau, Senegal, and Gambia).

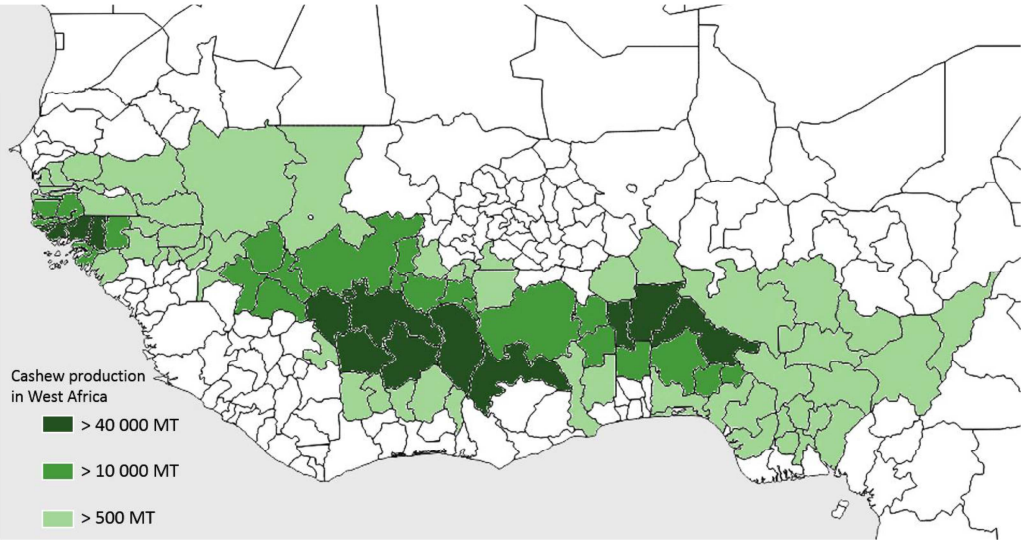

Figure 3. *Main cashew producing regions in West Africa; Source: n'kalô Service – www.nkalo.com.*

2.1.2. Botany of the Species

The cashew tree (*Anacardium occidentale* L.) belongs to the Anacardiaceae family, which comprises some 60 genera and 400 species, including mango (*Mangifera indica* L.) and pistachio (*Pistacia vera* L.). Cashew trees are evergreen and grow rapidly to 20 m, but generally reach 8-12 m height. *Anacardium occidentale* L. is an andromonoid species, with male and hermaphroditic flowers on the same plant and in the same panicle [13]. The diameter at breast height of the cashew tree can vary between 1.2 and 1.5 m depending on the growing conditions [17, 13].

The tree's habit is globose, a slightly flattened hemisphere with a broad canopy reaching down to the ground in lack of neighborhood or invasive species competition. In the face of invasive species competition or poor soil, the density of the foliage decreases and instead of having a bushy habit, it adopts a loose habit that will produce few flowers and few fruits. The leaves are simple, alternate, oblong to lanceolate or oval, rounded at the top, wedge-shaped at the base, parchment-like, hairless, leathery and have a thick cuticle with prominent veins on the upper surface. The bark is grey and generally quite smooth (Figure 4). The cashew tree bears both unisexual male flowers and hermaphrodite flowers. The flowers are white or pale yellow with pink or red-green stripes, numerous, grouped in terminal panicles or cymes and fragrant. The cashew tree often has a central taproot and horizontal lateral roots [13].

Figure 4. *Cashew tree fructification.*

2.1.3. Ecology of the Species

Although the cashew tree is known for its great hardiness, it can grow in very poor soils and under very severe climatic conditions. Abundant and regular production of quality nuts can only be achieved under certain ecological conditions. These are climatic and edaphic factors [18]. Four (04) climatic factors have a major impact on cashew production.

(i) Rainfall and rainfall distribution

Cashew trees require an annual rainfall of 800 to 1,800 mm spread over five to seven months, as well as a marked dry season of seven to five months, to produce fruit.

(ii) Temperature

The cashew tree is sensitive to cold and altitude, its

production decreasing significantly from 600 meters. In East Africa, in cashew production areas, average monthly temperatures vary according to latitude, from 18 to 24°C in the dry season and from 26 to 28°C in the rainy season.

(iii) Sunshine

The tree requires good irradiation to produce an abundant harvest. All fruiting takes place at the tip of the branches on the current year's shoots and for good production the crown must be well exposed to the sun from all sides.

(iv) Relative humidity

During the dry season, it must be low. In fact, the phytosanitary state of trees subjected to a humid climate all year round is generally poor (anthracnose, various insects).

About edaphic factors, the variety of soils on which cashew trees occur in tropical zones leads to the conclusion that it is a tree that adapts to diverse pedological conditions. It does not require a high level of fertility, but it has a predilection for light, sandy, deep and, above all, well-drained soils, as its pivot is very sensitive to flooding.

2.2. Cashew Production in West Africa

Cashew cultivation is an increasingly popular activity in West African countries. The culture is favorable, and the cashew production calendar does not hinder the promotion of annual crops. Côte d'Ivoire is the largest producer of raw cashew nuts in West Africa and the world. It accounts for about 23.8% of the world's raw cashew nut production [16]. Figure 5 presents the raw cashew nut production data for the West African zone.

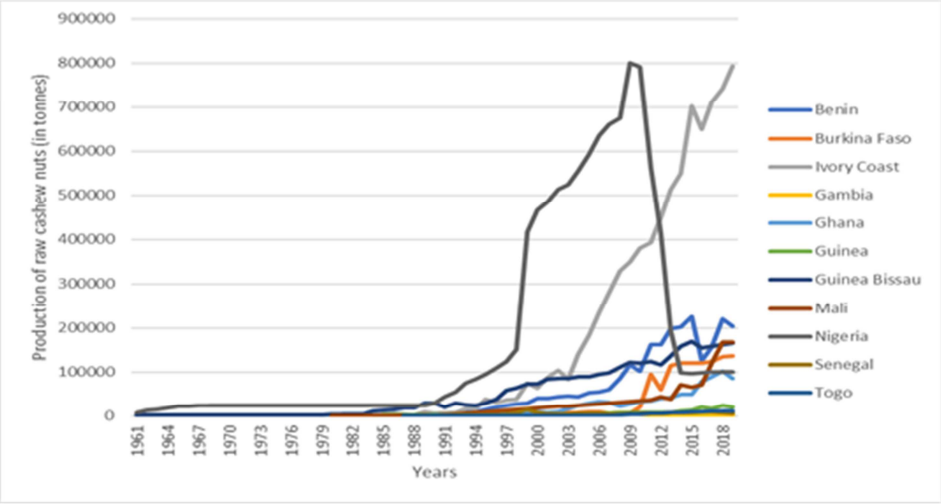

Figure 5. *Raw cashew nut production in West Africa; Source: FAOSTAT (Accessed October 2021).*

The average raw cashew nut yield is around 360 kg/ha for the year 2018. Efforts are still needed in the various countries to fill this production gap (Figures 6 & 7). Knowing the potential yield in West Africa, which is in the order of 1000 to 1500 kg/ha, and the Vietnamese reference, which is lower, the short- and medium-term objective is first to reach the reference. To do this, the main levers remain the implementation of good agricultural practices (cleaning, pruning, thinning, grafting, fertilizer application and phytosanitary treatments), the improvement of plant material and the implementation of innovative operations.

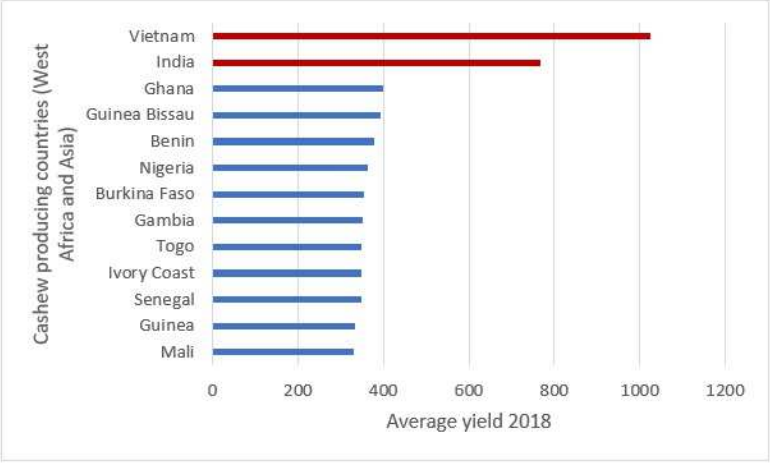

Figure 6. *Average raw cashew nut yield per country; Source: Nitidæ (June 2019) & FAOSTAT (Accessed October 2021).*

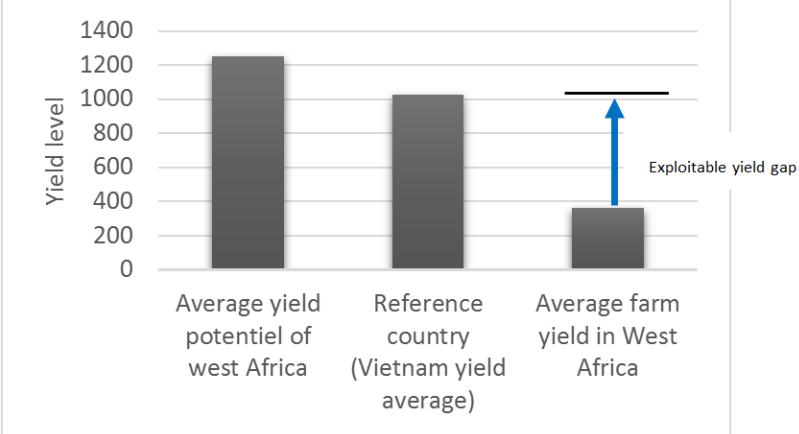

Figure 7. *Different production level; Source: Nitidæ (June 2019), FAOSTAT (Accessed October 2021) & Tandjiekpon et al, 2005.*

2.3. Data Collection and Analysis

Several steps of which the literature search allowed us to carry out this literature review. After defining the subject to be studied, the search for related scientific documents was carried out through Scopus, a transdisciplinary database of abstracts and citations of scientific publications. The search was complemented by AGORA, an Internet portal that provides access to the main scientific journals in the field of agriculture and related biological, environmental, and social sciences and Google Scholar, a Google service for searching scientific articles and publications. Searches for work on productivity and production gap issues were conducted over the period 2010-2020 using different combinations including the following keywords: *Anacardium occidentale*, cashew, anacarde, productivity, yield, gap, and year (after 2009). A total of 173 documents were retrieved through this global search. For cashew research in West Africa, it covered the period from 2010 to 2020 with combination of the following words: cashew, cajou, anacarde, Benin, west Africa. This specific country-focused search yielded a total of 132 documents. After the data collection, a careful selection of the useful documents was done (Table 1). The focus was on the careful reading of 103 documents with the production of reading sheets categorized for the bibliographic synthesis.

Table 1. *Summary of the literature search.*

Subject	Database	Results	Relevant documents
Productivity and production gap	Scopus / AGORA	173	50
Cashew in West Africa	Google Scholar	132	53
TOTAL		305	103

3. Results

3.1. Status of Cashew Research in West Africa

Cashew (*Anacardium occidentale*) is a crop promoted in various West African countries for its economic, social, and environmental importance. To provide solutions to the problem of low yield, scientists have been conducting research for several years. A summary of the publications that contribute to the improvement of cashew plantation productivity is given in the figure 8.

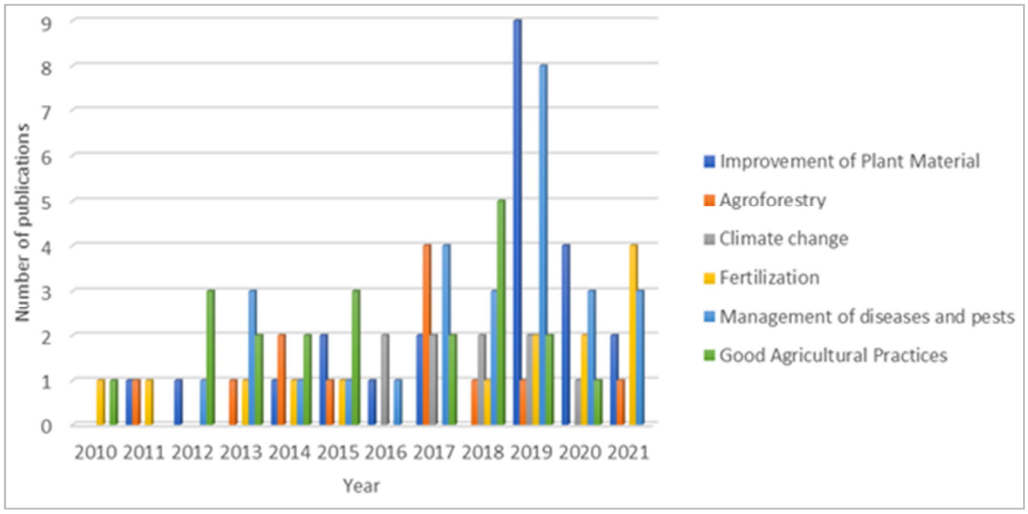

Figure 8. *Publications on cashew yield improvement practices in West Africa.*

The most covered thematic areas are, in order of priority, the following Disease and pest management, plant material improvement and good agricultural practices. Publications have been increasing in these thematic areas since the 2017 years and the peak is observed in 2019. This peak in publication in 2019 was favoured by the holding of the International Cashew Scientific Exchange Symposium (CIESA) in 2017 with the publication of the symposium proceedings in 2019.

In terms of publications by country, Benin leads followed by Nigeria, Ghana, and Côte d'Ivoire. The thematic areas most affected by Benin are the same as those observed in West Africa (Figures 9 & 10).

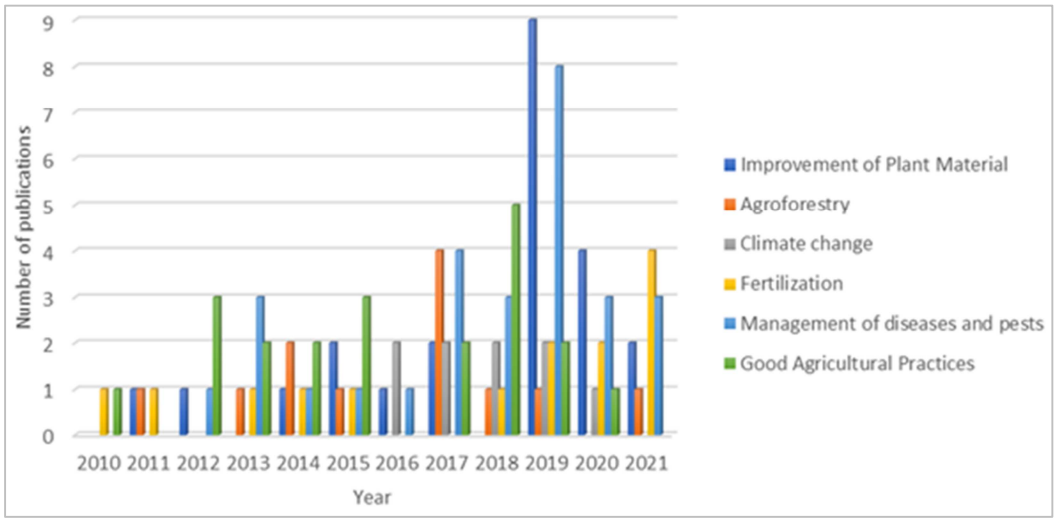

Figure 9. *Publications in Benin on cashew yield improvement practices.*

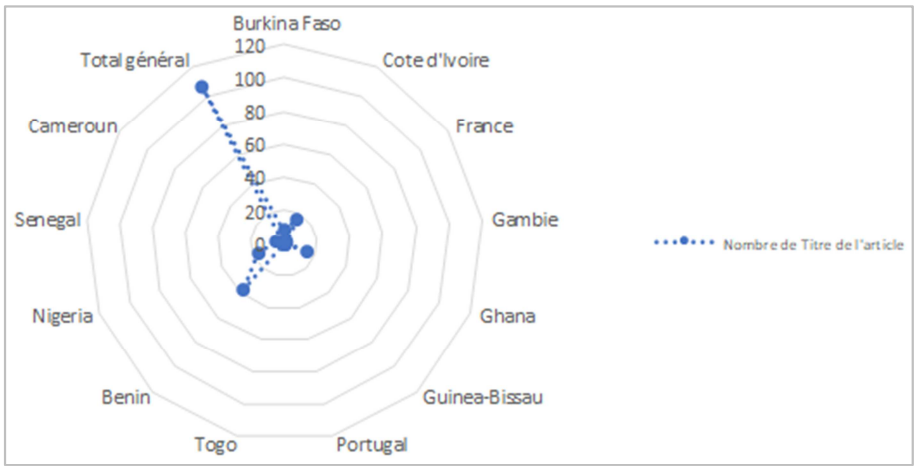

Figure 10. *Publications on cashew yield improvement practices by country in West Africa.*

3.2. Main Research Results in West Africa on Cashew Productivity

3.2.1. Application of Technical Itineraries

As the use of reforestation was the primary reason for the introduction of the cashew tree in West Africa, the implementation of fruit production requirements that producers were not accustomed to is struggling to become a habit. According to Balogoun, I. et al. [19], recommended spacings are not respected by them and manuring and pest control are very little practiced (less than 10%) in cashew production areas in Benin. The same observation is made in other countries, as evidenced by the work of Edward, E. [20] in Ghana and Adeola, R. G. [21] in Nigeria.

Balogoun, I. et al. [22] and N'Djolosse, K. et al. [23] suggested the use of mineral and organo-mineral fertilizers to sustainably offset nutrient exports and increase cashew yields. Results of work in the demonstration plots for producers on good plantation maintenance and management practices highlighted improved cashew yields [24]. The implementation of good agricultural practices has led to an improvement in yield of around 22% in Côte d'Ivoire [25]. The main constraints for cashew producers are related to weed management and tree maintenance as the dry season approaches, pest and disease management, forest fires, and

cashew theft [26-28, 6].

According to Degla, P. [29], the cashew production system in current contexts is very extensive and could be improved by intensive use of labour and capital. Indeed, the average technical efficiency score of cashew producers was 0.63 (minimum 0.10, maximum 0.88) with a modal class [0.70-0.80]. It is through thinning, pruning, and weeding that the productivity of plantations could be improved. Conversely, according to the results of Wongnaa, C. A. and Ofori, D. [30] in Ghana, Farmers should be encouraged to increase the use of land, fertilizers, and pesticides to increase productivity. Indeed, Land, fertilizer and pesticides were underutilized, while labour and capital were overutilized. Depending on the country context, priority should be given to the type of advice to be provided to producers. In this regard, the level of education, experience in cashew production, age, gender, farm size and access to credit play a determining role in the adoption of good agricultural practices [19, 21, 25, 29, 31-34].

The establishment of annual crops in agroforestry is a common practice to be promoted to concomitantly maintain the cashew plantation. Combined crops also allow for the diversification of income sources and ensure the availability of food for consumption, given the lack of arable land. Thus, several cashew agroforestry systems have been identified in West Africa, including 14 in Benin [35]. The cashew-yam system is very popular with farmers in West Africa and the combination of legumes also promotes the growth of cashew trees [19, 35-38]. Most cashew trees are grown in association with other trees when they are in the juvenile stage (less than 10 years). Beyond this age, the trees are drastically pruned to facilitate solar radiation infiltration for annual crops.

3.2.2. Improvement of Plant Material

Most existing plantations in West Africa are derived from direct seeding of raw cashew nuts from old plantations [19, 39]. This was a result of insufficient or non-existent improved planting material [40, 41]. According to the work of Balogoun, I. et al. [19] in Benin, 78.45% of producers installed their plantations by direct seeding. Indeed, nut seeding does not guarantee the maintenance of the genetic characters of the mother trees and the plants produced are heterogeneous [42]. It is rather the voice of vegetative or asexual multiplication that guarantees the maintenance of the genetic characters of the mother trees and the plants produced are homogeneous [43]. Thus, varietal improvement work has begun at research institutes and universities in the sub-region. The grafting method is the most widely used in West Africa, along with the selection procedure for elite cashew trees. For example, from 2013 to 2015, 357 elite cashew trees were selected out of 1,868 trees identified. The average nut productivities of the selected elite cashew trees were 27.36 kg, 35.47 kg, and 42.14 kg for the 5-9, 10-15, and over 15-year age groups, respectively [7]. Similarly, Tarparga, W. V. et al [44] also identified elite cashew trees with yields ranging from 34.27 to 104.42 Kg/ha. These high performing trees are currently being used to supply quality scions to produce cashew seedlings. Other work has been done to improve the success rate of grafting, reduce the length of the production cycle and the quality of the substrate used. For example, according to Batamoussi, M. H. et al. [45], Bognina, A. et al. [42] and Yélouassi, D. et al. [46], side plating grafting gives better results than end slit grafting. Kodjo, S. et al. [47] studied the factors that ensure a better success rate to comfort nurserymen who engage in the production of grafted cashew seedlings. This study resulted in the need to adopt an effective and efficient nursery management process, mainly rootstock cultivation, proper sunlight management, proper seedling alignment and grafting process. The use of biological extract of Ashoka (*Polyalthia longifolia*) scythe as a growth hormone applied to cashew grafts significantly improved the time to graft recovery, increased the number of leaves, leaf area and height of the seedlings [48]. In addition, several authors have highlighted considerable genetic variability that could be exploited to develop superior cashew hybrids [49-51]. The current trend is manual pollination to obtain polyclonal nuts. Adu-Gyamfi, P. K. K. et al [52] studied the specific combination ability of three clones from Brazil, Benin, and Ghana on the three best clones recommended to Ghanaian growers. At four (04) years the yield was about 477.8 Kg/ha and at (06) years after installation, 939.4 kg. The Beninese progeny outperformed the Brazilian progeny in crop efficiency. according to this author, cashew tree size and nut quality are under genetic control and the clones identified represent a suitable genetic resource pool to increase productivity.

3.2.3. Effect of Climate Variation

Cashew as a perennial crop has an undeniable potential for carbon sequestration in mitigating climate variations [53, 54]. At the same time, rainfall, temperature, and evapotranspiration are factors that impact on the yield of these plantations. August to September rainfall (except in the Southern region), mean temperature and evapotranspiration September (except in the Southern region), mean temperature and evapotranspiration are the main factors determining cashew productivity [55, 56]. Bello, D. O. et al. [53], predicts a decrease in rainfall of up to 12% and an increase in temperature of 20-30% by 2050. Unfortunately, the increase in temperature further reduces the capacity of cashew trees to store atmospheric carbon.

Regarding producers' perceptions of the effects of climate change, they agree on an increase in temperature, a decrease in rainfall and the appearance of violent winds (harmattan) from time to time. This leads to the drying of flowers and in turn to lower yields [57, 58]. However, it is important to put this into perspective because the impact of climate variation on cashew is very negligible (2%) compared to annual crops such as maize (52%) according to the work of Adjei, V. et al. [59] in Ghana. Cashew is rather positioned as a crop that enhances mitigation strategies such as reduced tillage, ecosystem preservation, reduction of slash and burn cultivation method.

3.2.4. Diseases and Pest Management

The production of raw cashew nuts has long remained

traditional in West Africa without the application of disease and pest management measures. Unfortunately, these pests of cashew cause considerable losses to the producers involved.

The main diseases affecting cashew are fungal or bacterial in origin. Regarding these diseases, the main pathogens observed are Colletotrichum *gloeosporioides, Lasiodiplodia theobromae, Oidium anacardii, Pestalotia heterocornis, Cephaleuros virescens* and *Xanthomonas axonopodis* [60-62]. For example, the average yield loss due to inflorescence blight and gummosis with *Lasiodiplodia theobromae* as the causal agent was estimated to be 40-50% and could result in a reduction in nut yield of up to 70% [63]. A study conducted in Ghana by Muntala, A. et al [62] showed the presence of 10.45% and 22.9% on average of infected plantation for gum disease and anthracnose respectively. Several authors have conducted studies for the control of these diseases with a priority on *Colletotrichum gloeosporioides* responsible for anthracnose and gum disease given its presence in different countries [61, 63-67]. Following the work of Tonon, D. et al. [64], the efficacy of the fungicides Mancozeb 80 WP and Chlorothalonil-Carbendazim 65 SC against *Colletotrichum gloeosporioides* causal agent of anthracnose was proven. Thus, the fungicides Mancozeb 80 WP at the rate of 2 kg/ha and Chlorothalonil-Carbendazim 65 SC at the rate of 2 l/ha effectively protect cashew plants against anthracnose. With respect to biological control, neem oil and chili extracts completely inhibited the growth of *C. Gloeosporioides* in Cameroon [67].

About pests, the main ones in West Africa are beetles: *Apate terebrans*, also known as the wood borer, *Analeptes trifasciata* and *Plocaederus ferrugineus* [68-71]. One preventive measure against plantation infestation by these pathogens remains plantation maintenance and management. Systematic collection and burning of dead wood reduce the pressure of this beetle in plantations [70, 72-74]. This result emanates from advances in knowledge of the ecology and biology of these pests. It is important to also note the incidence to a lesser but not insignificant extent of the leaf miner *Eteoryctis gemoniella* Stainton (Lepidoptera: Gracillariidae) and a diversity of bugs in the genus Helopeltis [75, 76]. One effective means of controlling these insects is the use of weaver ants in cashew plantations [77, 78]. In terms of chemical control, agricultural extension advises the use of Pacha 25 EC at the rate of one litre per hectare or neem oil as a repellent [79].

To better understand cashew diseases as well as pathogens in Benin, an inventory was conducted by Afouda, L. C. A. et al. [60]. These authors did not fail to evaluate the incidence and severity of these diseases in the different production areas in Benin. Red rust (*Cephaleuros virescens* Kunze ex E. M. Fries), anthracnose (*Colletotrichum gloeosporioides* Penz) and bacterial blight (*Xanthomonas axonopodis* pv. anacardii) are the main diseases ranked by severity.

The different countries of West Africa are confronted to cashew diseases and pests, but at different levels of severity. For some, control is systematic while for others it is not a priority.

4. Discussion

4.1. Causes of the Yield Gap in Cashew Production

Despite the strategies implemented to improve cashew production for optimum yield, this sector faces difficulties that explain the yield gaps observed over the years. Cashew nut farmers face attacks from diseases, pests, and diseases as well as insufficient or lacking expertise of the supervisory staff [80-82]. Difficulties related to the lack of development and management of cashew plantations due to neglect of maintenance practices are also responsible for these observed differences [82, 83]. Variability in climatic conditions such as temperature, sunshine, rainfall, relative humidity, and nutrition across seasons are also reasons for the yield differences recorded [84]. The influence of rainfall on flowering and water stress on cashew plants [85]. The work of Olubode, O. O. et al. [82] notes the gaps in research on production practices, biotic and abiotic factors that affect cashew yield. In addition to shortcomings in maintenance practices, management and climatic hazards that cause cashew yield variations, the previously used propagation method based on direct seed from harvesting shows large variations in the usual growth, quality, and yield of cashew nuts.

4.2. Perspectives on Cashew Yield Improvement

A variety of practices are being tested or adopted in cashew producing countries around the world to improve cashew yields. These include practices to improve cashew pollination, the use of fertilizers, the adoption of silvicultural practices that favour raw nut production and the use of growth hormones.

4.2.1. Pollination

Cashew is a bisexual reproductive plant, both hermaphroditic and fertilized by male flowers. Wind and insects naturally play an important role in the pollination process. According to Free, J. B. [86], pollination improves the quality and quantity of agricultural production. Bees contribute to more than 80% of the world's agricultural services [87, 88]. The disappearance of flower visitors (insects) leads to a deficit in cashew pollination which may be an important factor in the low cashew yield [89]. The introduction of beehives or intercrops that are attractive to foraging insects can improve cashew yield through pollination. Indeed, African Cashew Initiative (ACI) [90] conducted research on the effects of integrating beekeeping into cashew plantations in Benin and Ghana from 2011 to 2013. The study found that pollination activities by bee colonies increased raw cashew yields by 116.7% in Ghana and 212.5% in Benin. Furthermore, Layek, U. et al. [91] tested the hypothesis in India that sharing of pollinators among cashew trees and co-flowering of bee-friendly magnetic plants facilitates higher cashew productivity. At the end of the research, the association of magnetic plants increased raw cashew nut yields through improved pollinator services. Also, in this perspective of promoting the pollination of cashew seedlings to obtain a good yield, new techniques have been implemented such as artificial pollination and artificial hybridization

techniques [92].

4.2.2. Fertilization

The non-use of fertilizers is one of the elements negatively influencing cashew (*Anacardium occidental* L.) production. Efforts to obtain a better yield in this sector should focus much more on this aspect. To this end, it is necessary to carry out fertilization policies for cultivable land. The use of fertilizers allows maximizing production and, in turn, the profit of producers. Thus, it is important to compensate for the nutrients that cashew trees draw from the soil. In this perspective, specific fertilizers composed of macronutrients such as Phosphorus, Potassium, Nitrogen, and micronutrients such as Calcium, Sulphur, Zinc, Copper, Iron and Manganese are to be developed for use by cashew producers [93, 94]. This is the case for example with Santhagreens organic farmyard manure (FYM) which contains most of the macro and micronutrients required for complete plant growth from seedling stage to flowering and fruiting highlighted by Mohapatra, A. et al. [93]. The effectiveness of this product is even better with a combination of urea, i.e., 25% FYM and 75% urea according to Patil, S. V. et al. [94]. However, organic fertilization practices regenerate and maintain soil nutrients [82]. Organic constituents such as urea influence on vigour, plant growth and very high dryness in production time. The same effects are felt at flowering time [95].

4.2.3. Growth Hormones

Growth hormones are used both in the nursery and in the plantation [48, 84, 96]. According to Olawalé, M. A. et al. [84], gibberellic acid (GA3) applied to cashew foliage in the pre-flowering period resulted in a fivefold increase in flowering and fruiting and an increase in fruit holding capacity by about 69% and nut size by 25%. The prescribed dose was 50-100 mg L-1 of GA3 at the pre-flowering stage.

According to another study in India, the highest leaf area and nut yield was recorded on trees treated with GA3 at 50 ppm and Ethrel at 50 ppm [96].

4.2.4. Farmer's Education and Agricultural Extension

The yield gap in cashew plantations is also due to the non-adoption of recommended agricultural practices. To this end, it is important to place a special emphasis on extension in raw cashew producing countries [97, 98]. The implementation of agricultural advice significantly improves the yield of cashew plantations. Notwithstanding, the strengthening of extension, it is important to highlight that the determinants of the adoption of recommended practices are among others the level of education of producers, membership in a cooperative and the price of the product [99]. Also, engaging in production under a label such as fair trade or organic agriculture allows producers to adopt good practices [100, 101]. Indeed, the production of this type of product obeys production standards and principles that integrate good production practices with an internal and external audit mechanism. Obtaining and maintaining the certificate is subject to external audits by an accredited certification body.

4.2.5. Silvicultural Practices

One of the important practices in plantation management is pruning. Pruning dead wood and cross branches alone can increase yields by 30-40% [102]. Proper training pruning of young cashew trees gives them an umbrella-shaped canopy characteristic of fruit trees. Cashew plants with compact canopies are preferable to those with loose canopies [103]. Canopy development can be influenced and differentiated by its compactness. This depends either on the cultivar or on management practices. In older cashew plantations, removal of dry or dead wood, intertwined branches, water shoots, low branches improve plantation yield through adequate exposure of the tree interior to sunlight [104]. The high-density cashew planting technique provided higher yields and better economic returns per unit area in the early years [105-107]. This practice requires regular annual canopy pruning and is followed by systematic thinning as the trees grow. Furthermore, the establishment of intercropping allows for diversification of income sources and maintenance of the cashew plantation at the same time. According to Lenka, P. C. et al. [106], annual cropping not only conserves the soil but also increases nut yields by 1.5 times compared to plots with pure cashew cultivation.

5. Conclusion

Cashew is a perennial crop of economic utility to the producers who grow it as well as the states to which they belong. Despite West Africa's prominent position among the world's cashew nut producing regions, it is important to work on reducing the yield gap. This will further improve Africa's position, reduce deforestation by minimizing the need for area expansion but also improve the incomes of cashew producers. To this end, priority actions deserve to be implemented, starting with the improvement of plant material through grafting and over grafting, the proper and timely implementation of production practices including weeding, pruning, thinning, fertilization, and phytosanitary treatments. In addition, the adoption of the high-density production technique during the first years of production coupled with systematic thinning or the establishment of intercropping to diversify the sources of income. The use of growth hormones improves the yield of cashew plantations, as does the association of beekeeping with cashew orchards or the cultivation of plants attractive to foraging insects.

The main lines of research arising from this study are as follows: (a). Innovative practices to improve the plant material used; (b). Causes of non-adoption of popularized good practices; (c). Pruning practices for cashew trees that promote good yields from plantations; (d). Conditions for combining annual crops with cashew orchards over longer periods; (e). Formulation of cashew-specific fertilizers with essential macro- and micro-nutrients; (f). Experimentation with organic fertilizers and growth hormones; (g). Disease and pest management with low or no environmental impact.

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