PhytoFrontiers™
An Open Access Journal from The American Phytopathological Society

Research

# Farmers' Knowledge and Farm-Level Management Practices of Coconut Pests in Ghana: Assessment Based on Gender Differences

Elizabeth Tettey[1,†] | Owusu Fordjour Aidoo[2,3] | Linda Arhin[1] | Ritter A. Guimapi[4] | Fred Kormla Ablormeti[1] | Frank Dampare[1] | Richard Ampadu-Ameyaw[5] | Jeffet Ekow Cobbah[5] | Yayra Afram[1] | Frank Kwarteng[1] | Ndede Yankey[1] |

[1] Council for Scientific and Industrial Research (CSIR), Coconut Research Programme, P.O. Box 245, Sekondi, W/R, Ghana

[2] University of Environment and Sustainable Development (UESD), School of Natural Resources and Environmental Sciences (SNES), PMB, Somanya, E/R, Ghana

[3] Institute of Teacher Education and Continuing Professional Development (ITECPD), University of Education (UEW), Winneba, Ghana

[4] Norwegian Institute of Bioeconomy Research (NIBIO), P.O. Box 1433, Ås, Norway

[5] Council for Scientific and Industrial Research (CSIR), Science and Technology Policy Research Institute (STEPRI), P.O. Box CT 519, Cantonments, Accra, Ghana

† Corresponding author: E. Tettey; elimbahi@yahoo.com

Accepted for publication 24 March 2022.

**Author contributions:** Conceptualization: OFA, ET, YA, RAA, JEC, NY, FK, and LA. Data analysis: OFA, RAG, FD, ET, NY, and FKA. Original draft of the manuscript: RAA, ET, JEC, and OFA. Methodology: ET, OFA, NY, RAA, and JAC. Writing—original draft preparation: ET, OFA, RAA, and JEC. Writing—review and editing: ET, OFA, LA, RAG, FKA, FD, RAA, JEC, YA, FK, and NY. All authors have read and agreed to the published version of the manuscript. Proofreading: all authors.

**Data availability:** The data for the study are available upon request from the corresponding author.

### Funding

We gratefully acknowledge the financial support of this research by the European Union's Horizon 2020 research and innovation program under the project "Insect-borne prokaryote-associated diseases in tropical and subtropical perennial crops," TROPICSAFE grant agreement no. 727459.

The author(s) declare no conflict of interest.

### Abstract

Coconut production is significantly constrained by a wide variety of pests. Anecdotal evidence also suggests that management of these pests is influenced by gender differences. Therefore, there was a need to assess farmers' knowledge about coconut pests, farm-level pest management strategies, and institutions offering training to farmers to develop an ecologically sound management strategy. To achieve this research need, we surveyed six coconut-growing districts, three each from the Western and Central Regions of Ghana, using face-to-face interviews, discussions, and direct observations. In addition, a multistage sampling technique was used to sample the coconut farmers. The sample population for each town was determined using a proportional to population size approach. The sample population was randomly drawn from each town/village using a sampling frame based on the agricultural sector records. The results showed that a majority of the farmers mentioned *Oryctes monoceros* as the most important coconut pest. Significantly more females than males mentioned weaver birds in their plantations ($P = 0.035$). The number of women who did not mention any of the pests was significantly higher than that of men ($P = 0.007$). There was a significant difference between male and female farmers who used indigenous knowledge (i.e., knowledge accumulated by an indigenous [local] population over generations of living in a certain area) ($P = 0.018$) for pest management. However, pest management strategies did not vary in the Central Region. Our results showed a significant difference between male and female farmers who did not use any of the management strategies, suggesting that future studies and training should consider gender in developing sustainable pest management strategies for the pests.

*Keywords*: coconut, coconut mites, gender, pests, rodents, weaver birds

Coconut (*Cocos nucifera* Linnaeus) is a fibrous one-seeded drupe belonging to the palm family Arecaceae, which is widely distributed in the tropical and subtropical regions of the world (Lim 2012; Niral and Jerard 2018). It provides food and income to the communities involved in its production, processing, and marketing. The inner flesh of the mature nut and the coconut milk derived from it form part of many people's diets. Coconut is rich in manganese, which is vital for bone health and metabolism of carbohydrates, proteins, and cholesterol (Avila et al. 2013). Hundreds of millions of individuals drink coconut water and consume kernel derivatives every day (Foale 2003). In most coconut farming communities, one-third of the production is consumed fresh, and 70% of the total production is consumed domestically (FAO 2001). Over 80 million people directly depend on coconut (FAO 2001). In 2018, global coconut production was 62 million tons, with 74% of the production from Indonesia, the Philippines, and India (FAOSTAT 2018). In Ghana, coconut and coconut-related activities provide employment (formal and informal) for over 700,000 people annually (Abankwah et al. 2010).

Globally, the total cultivated area for coconut is about 12 million hectares, with which a potential production of 70 billion coconuts is estimated annually (Hoe 2018), highlighting the crop's importance and leverage worldwide. In Ghana, for example, total coconut production of 316,300 tons in 2008 was obtained from 55,000 ha, with an annual yield of 57,509 kg/ha (FAOSTAT 2018). Ten years later, the production increased to 394,883 tons from 72,858 ha, with a yield of 54,199 kg/ha. Despite the rise in production, the yield has not reached the global potential capability per year, which has been associated with a myriad of production constraints, of which pests are the most important economically (Kadere 2021; Muyengi et al. 2015). Insect pests such as the centaurus beetle *Augosoma centaurus* Fabricius (Coleoptera: Scarabaeidae), black ants, coconut beetle *Oryctes monoceros* Olivier (Coleoptera: Scarabaeidae), red ants *Oecophylla longinoda* Latreille (Hymenoptera: Formicidae), African palm weevil *Rynchophorus phoenicis* Fabricius (Coleoptera Curculionidae), termites (Blattodea: Termitidae), and the coreid bug *Pseudotheraptus devastans* Distant (Heteroptera: Coreidae) have been reported as coconut pests (Andoh-Mensah et al. 2007). Other pests include weaver birds *Ploceus cucullatus* Müller (Passeriformes: Ploceidae) (Basheer and Aarif 2013; DeGrazio 1978; Philippe and Dery 2004) and coconut mites (eriophyid coconut mite) *Aceria (Eriophyes) guerreronis* Keifer (Acari: Trombidiformes) (Navia et al. 2013). These pests pose a severe threat to the coconut industry, particularly in Ghana. Additionally, rodents, such as the greater cane rat (Grasscutter) *Thryonomys swinderianus* Temminck (Rodentia: Thryonomyidae) and black rat (roof rat) *Rattus rattus* L. (Rodentia: Muridae), are known coconut pests (Geddes 1990). However, information on the current coconut pest status and management strategies as reported by men and women involved in coconut farming is poorly documented.

Different pest management strategies are often used by men and women based on their gender roles, with men employing early planting to escape infestation, whereas women spend their time in the field searching for pests and destroying them as they are responsible for routine management (Kawarazuka et al. 2020). In coconut production, men are mainly involved in land clearing and the application of pesticides and fertilizers, whereas women perform all other farm activities (Valleser et al. 2020). Anecdotal evidence suggests that men and women are involved in coconut production to meet a wide range of demands, and therefore, preferences for pest management could vary by gender. Examining such variations in gender toward pest management is critical for developing appropriate pest management strategies (Erbaugh et al. 2003). In addition, pest management research and training generally focus on "farmers," ignoring gender perspectives (Kawarazuka et al. 2020).

In the present study, we sought to document the major coconut pests in Ghana and assess gender-based constraints and opportunities regulating farmers' choices in managing these coconut pests. Specifically, we answered questions related to coconut pests as reported by men and women, management strategies used in solving pest problems, and whether institutional training is influenced by gender. This information is essential for key stakeholders involved in the promotion and/or dissemination of new technologies and improved coconut cultivars.

## MATERIALS AND METHODS

### Study design, setting, and participants

We conducted a community-based cross-sectional study in 2020 in the Western and Central Regions of Ghana (Fig. 1), the major coconut-growing areas (Caulum et al. 2012; Okorley and Haizel 2004). The Western Region has mean temperatures between 24 and 30°C, with the lowest temperatures in August and the highest temperatures occurring between March and April. The region has a bimodal rainfall pattern and lies within the moist equatorial and semi-equatorial zones.

The annual rainfall in the region ranges from 1,000 to 2,000 mm. The wettest months are between May and June and September and October. The driest period occurs between December and February. There is a short dry period in August. Fresh fruits and vegetables have a high value in the region, making production in the area suitable. According to the 2020 census, the region has a total population of about 2 million, with 51.6 and 48.9% in the urban and rural areas, respectively (Ghana Statistical Service 2021). The most common crops in the Western Region are coconut, cocoa, cassava, and rubber. However, agriculture is the largest industry and accounts for the highest proportion of employed persons in the districts, except for Sekondi-Takoradi. About 50% of all households in the region are engaged in agriculture. The districts selected for sampling were Shama, Ellembelle, and Ahanta West. The Central Region has 57.9 and 42.1% urban and rural populations, respectively (Ghana Statistical Service 2021), with a total population of about 2.8 million. The population of the region is almost equally divided between the sexes, but females marginally exceed male populations. The mean temperature and average relative humidity are 31°C and 80%, respectively. The wettest months are between May and June, and September and October, whereas the driest months occur between November and March. There is a short dry period in August. The most significant occupational groups (over 70%) in all the districts are agricultural, forestry, and fishery workers. The study was conducted in three major coconut production districts, namely Komenda-Edina-Eguafo-Abirem (KEEA), Abura-Asebu-Kwamankese (AAK), and Agona East (AE).

### Sampling and data collection

We used the sampling and data collection method described by Gesesew et al. (2016) with some modifications. A multistage sampling technique was used to sample the coconut farmers. Six major coconut-growing districts were selected. From each district, towns that are engaged in coconut production were selected. The sample population for each town was determined using a proportional to population size method. The sample population was drawn from each town using a simple random sampling utilizing a sampling frame based on agricultural sector records. To obtain the aforementioned information, we planned face-to-face interviews with the coconut farm owners. Additionally, data were collected through discussions and direct observations due to weak infrastructure, little access to electronic media, and low literacy levels of respondents in the rural areas. Before data collection, 12 data collectors and four supervisors with prior survey expertise were trained on the purpose and were abreast of the importance of data confidentiality, respondent rights, and interview techniques. A standardized and pretested questionnaire was used for the interview. The questionnaire was piloted among farmers in the area of the study, and any necessary changes were made. The questionnaires were examined for validity by a team of research experts from the Council for Scientific and Industrial Research's Coconut-Research program and Science and Technology Policy Research Institute. Afterward, the questionnaires were translated into the native local languages (Fante and Nzema) spoken in the districts to assist respondents who could not understand and speak the English language. In some instances, a farmer was chosen as an interpreter who could speak the local language and explain further. Agricultural extension agents assigned by the Ministry of Food and Agriculture (MoFA) to each location were randomly selected based on their relationships with the surveyed farmers and prior knowledge about the study area for easy administration of the questionnaires. Participants were interviewed in the comfort of their own homes. We sampled 234 coconut farmers from the Central Region (AAK: 70, KEEA: 73, Agona East: 91) and 230 from the Western Region (Shama: 77, Ellembelle: 64, Ahanta West: 90).

The questionnaire had four main sections with questions related to (i) the demographic characteristics of men and women involved in coconut production, (ii) their knowledge about the identification of pest problems, (iii) farm-level management practices adopted by different genders in solving pest problems, and (iv) training received for coconut pest management. The specific questions used for the data collection included farmers' age,

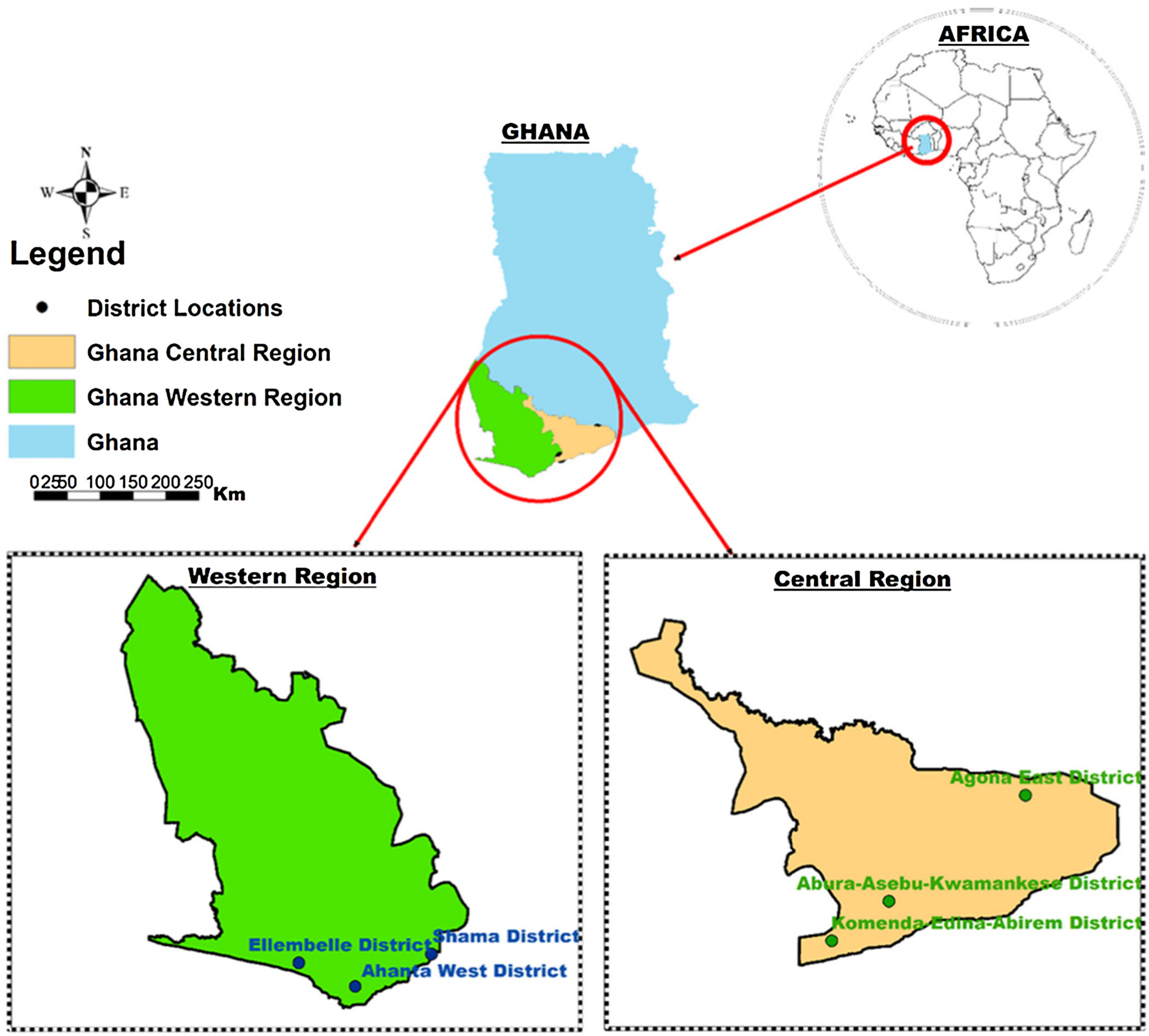


FIGURE 1

Map representing the six study districts in two main coconut regions of Ghana. Green color represents districts sampled in the Western Region; orange represents districts sampled in the Central Region of Ghana.

gender, level of education, size of farm in hectares, years of coconut farming experience, years of formal schooling, any training in coconut farming, and which organization/program provides such training. To collect data on pest problems, each farmer was provided with a chart that included all the coconut pests based on scientific literature (Andoh-Mensah et al. 2007; Basheer and Aarif 2013; DeGrazio 1978; Geddes 1990; Navia et al. 2013; Philippe Dery 2004). Farmers were asked if they had a pest problem and the type of pest based on the pictorial chart; if the pest was not included on the chart, the farmers were asked to describe the pest based on the appearance and damage symptoms, as well as what management strategies they use to control the pests.

### Data analysis

Field data received from the field enumerators were regularly checked for quality to ensure that the data collected met the relevant requirements. When the field survey was completed, the data were entered into Microsoft Office Excel format. The data were coded before analysis. The data sets were exported to the Statistical Package for the Social Sciences (SPSS) version 27 (2020) for analysis. The calculation of percentages and means was done using descriptive analysis. To compare the data by gender, we grouped the data based on farmers' age, experience, pests, farm size, education, and pest management strategies. We compared the above parameters by gender using the $z$ test. The test was computed as follows:

$$Z = \frac{(\bar{x} - \mu)}{(\sigma/\sqrt{n})}$$

where $\bar{x}$ = mean of sample, $\mu$ = mean of population, $\sigma$ = standard deviation of population, and n = number of observations.

All the analyses were tested at a 95% confidence level.

## RESULTS

### Demographic characteristics of the study population

The demographic analysis showed that there was no significant difference between male and female coconut farmers across the different age groups in the Central and Western Regions ($P > 0.05$) (Fig. 2A and B). In both regions, none of the farmers interviewed were under 15 years old. Our results showed that more males than females have had basic education, whereas more females than males lack formal education in the two regions (Fig. 2). Overall, the percentage of males who had basic education was significantly higher than that of female farmers in the Central Region ($z = 2.23$, $P = 0.026$). Significantly more female than male farmers had no formal education ($z = -3.79$, $P = 0.0001$) (Fig. 2C). In the Western Region, the results showed that the percentage of males who had basic education was significantly

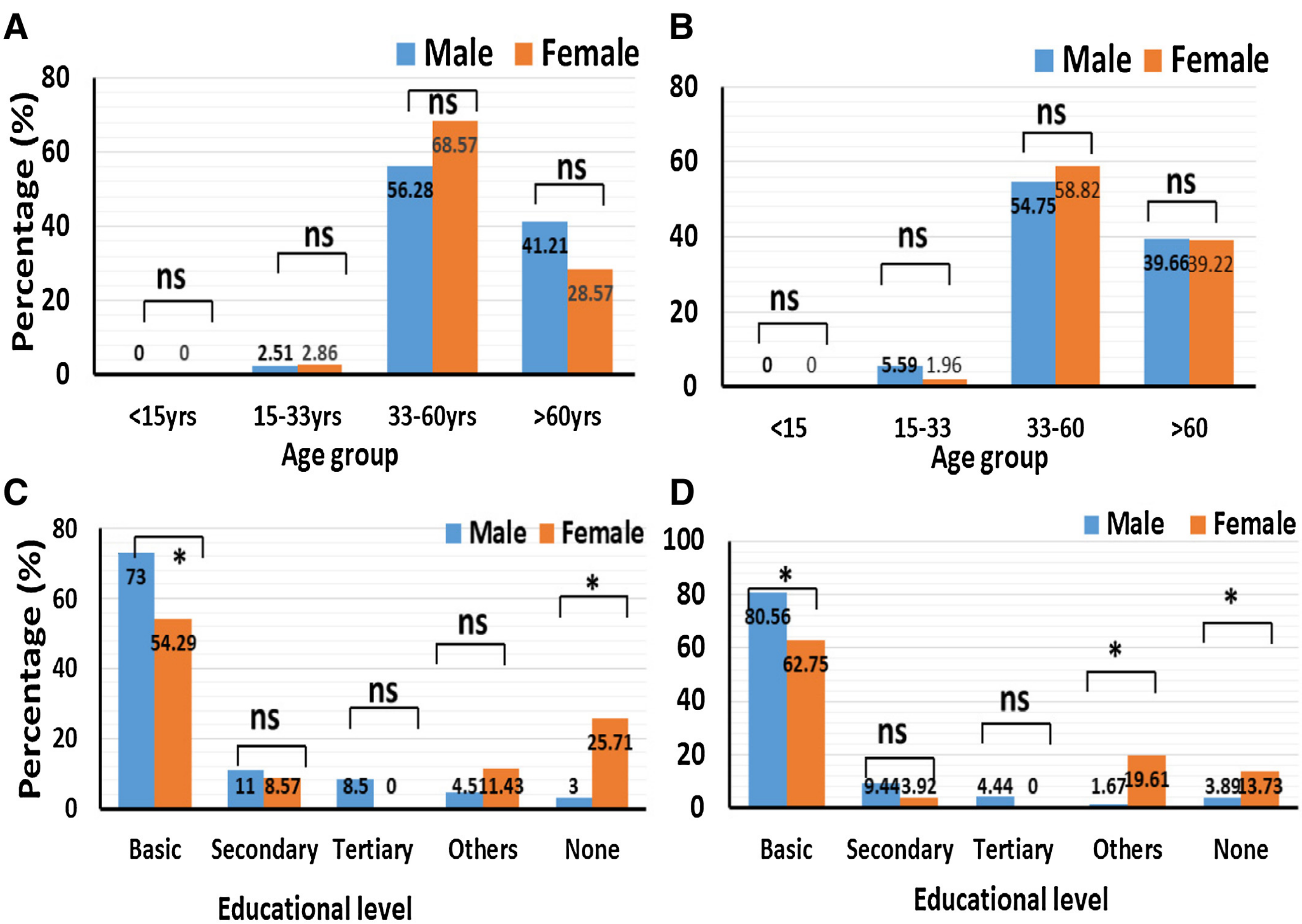


FIGURE 2
Percentage of coconut farmers' age by gender in the Central Region (**A**) and Western Region (**B**), and percentage of farmers' educational level by gender in the Central Region (**C**) and Western Region (**D**). Bars with "ns" are not significant, whereas "*" indicates a significant difference for male and female respondents, $P < 0.05$, two-proportion $z$ test.

higher than that of females ($z = 2.65$, $P = 0.008$), whereas significantly more females had received other forms of education ($z = -4.91$, $P = 0.0001$). In addition, significantly more females than males had no formal education in the Western Region ($z = -2.60$, $P = 0.009$) (Fig. 2D).

In the Central and Western Regions, overall, there was no significant difference between the years of farming experience and gender (Fig. 3A and B). Similarly, our overall analysis showed that farm size did not vary by gender in the Central Region (Fig. 3C). In the Western Region, except for less than 1 ha ($z = 2.23$, $P = 0.005$), the farm sizes did not significantly vary by gender (Fig. 3D).

### Pests mentioned by coconut farmers

The pests mentioned by the coconut farmer in the Central and Western Regions are shown in Figure 3. In the Central Region, a similar proportion of male and female farmers mentioned all the pests ($P > 0.05$), except for weaver birds ($z = -2.40$, $P = 0.016$) (Fig. 4A). In the Western Region, significantly more females than males did not mention any pest incidence ($z = -2.83$, $P = 0.005$) (Fig. 4B).

Overall, significantly more females than males mentioned weaver birds on their farms ($z = -2.10$, $P = 0.035$). The results showed that more female than male coconut farmers did not mention any pest problem ($z = -2.71$, $P = 0.007$) (Fig. 5).

### Farm-level insect pest management strategies

In the Central Region, the pest management strategies did not significantly vary by gender in KEEA and AAK ($P > 0.05$) (Table 1). However, in Agona East, more males than females use chemical control for pest management. Moreover, a significant difference was observed between female and male farmers who do not use any of the management approaches ($z = -2.34$, $P = 0.019$). In the Western Region, a similar proportion of male and female farmers use different pest management strategies in all the districts except for Ahanta West (Table 1). In the Ahanta West district, we found that more males than females use an integrated pest management strategy.

## DISCUSSION

Coconut is an important crop that contributes to food security and social life in some of the world's poorest regions (Gurr et al. 2016; Oyoo et al 2015), but small-scale surveys of coconut are scarce, particularly in terms of gender role in pest management. Our survey had a broad scope and was conducted in two major coconut-producing regions. It covered three main sections: (i) demographic features of the farmers, (ii) pest problems, and (iii) farm-level management strategies. A majority of the sampled farmers were over 33 years old, with only a few farmers within the age bracket of 15 to 33 years. These findings are consistent with those of Okorley and Haizel (2004), who reported that most Ghanaian coconut farmers were in the older age group, with more male than female farmers involved in coconut production in Ghana.

The results of this study suggest that most of the female coconut farmers had no formal education. However, they had received more "other forms" of training such as vocational and technical. This result agrees with that of Okorley and Haizel (2004), who found that women in coconut production were less educated than men. It has been demonstrated that gender and level of education can affect knowledge acquisition and farm-level

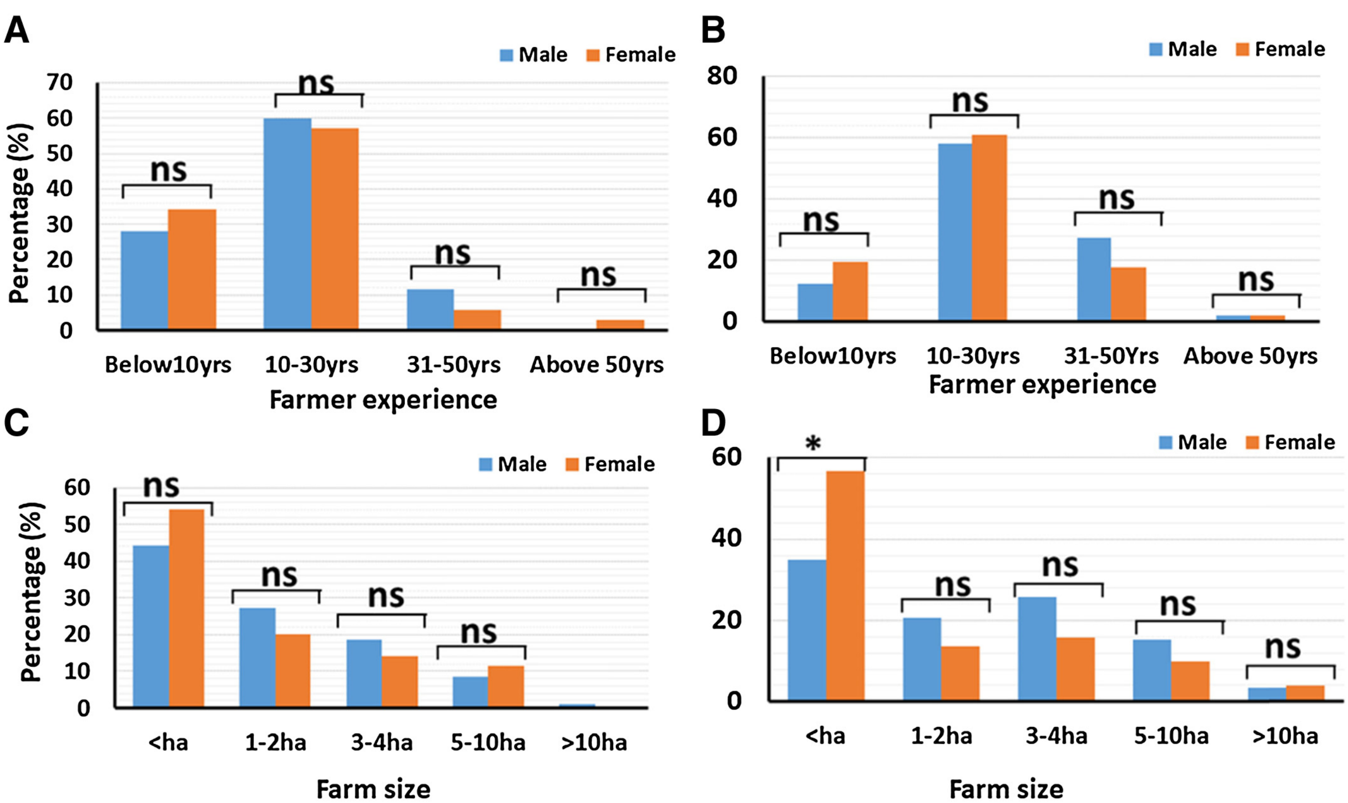


**FIGURE 3**

Percentage of coconut farming experience by gender in the Central Region (**A**) and Western Region (**B**), and percentage of farmers' farm size by gender in the Central Region (**C**) and Western Region (**D**). Bars with "ns" are not significant, whereas "*" indicates significant differences for male and female respondents, $P < 0.05$, two-proportion $z$ test.

decision-making, and this should be fully understood if agricultural research and extension programs are to design suitable technologies for small-scale farming systems (Erbaugh et al. 2003).

A previous study on maize in Ghana showed that resource availability was more important than gender in technology adoption decisions (Doss and Morris 2000). Concerning coconut farming experience, male and female farmers had a similar experience in the Western and Central Regions, suggesting that farmers could identify and adopt coconut farm-level pest management strategies. This is particularly important for the coconut industry. For instance, stakeholders' level of awareness and knowledge of pesticides is critical in adopting new strategies aimed at preventing environmental and health risks associated with the overuse of chemical pesticides. Moreover, Okorley and Haizel (2004) previously reported that most farmers interviewed had more than 10 years of coconut farming experience, which is consistent with

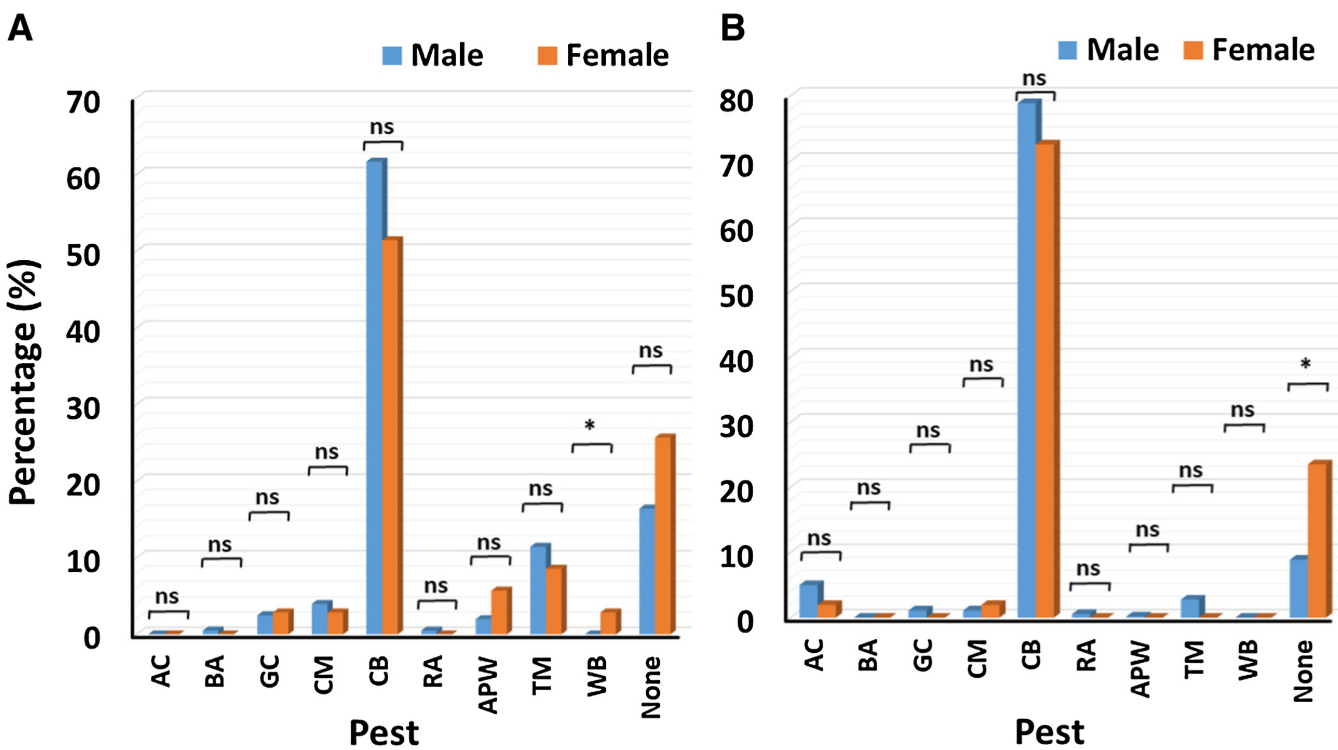


**FIGURE 4**

Percentage of pests mentioned by gender in the Central Region (**A**) and Western Region (**B**). Bars with "ns" are not significant, whereas "*" indicates a significant difference for male and female respondents, $P < 0.05$, two-proportion $z$ test. *Augosoma centaurus* (AC), black ants (BA), *Thryonomys swinderianus* (GC), *Eriophyes guerreronis* (CM), *Oryctes monoceros* (CB), *Oecophylla longinoda* (RA), *Rynchophorus phoenicis* (APW), termites (TM), *Ploceus cucullatus* (WB), none.

**TABLE 1**

Practices used by farmers who controlled insect pests on coconut in the Central Region and Western Region in Ghana[a]

| | Central Region | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage of farmers | | | | | | | | | | | |
| | Komenda-Edina-Eguafo-Abirem | | | | Abura-Asebu-Kwamankese | | | | Agona East | | | |
| Control method | Male (%) | Female (%) | *z* value | *P* value | Male (%) | Female (%) | *z* value | *P* value | Male (%) | Female (%) | *z* value | *P* value |
| Conventional | 20.37 | 21.05 | –0.06 | 0.950 | 37.88 | 20 | 0.80 | 0.424 | 45.68 | 9.09 | 2.31 | 0.021 |
| Indigenous | 12.96 | 26.32 | –1.35 | 0.177 | 9.09 | 0 | 0.70 | 0.481 | 13.58 | 27.27 | –1.19 | 0.236 |
| Integrated | 38.89 | 21.05 | 1.41 | 0.159 | 24.24 | 20 | 0.21 | 0.830 | 12.35 | 0 | 1.23 | 0.217 |
| None | 27.78 | 31.58 | –0.31 | 0.753 | 25.76 | 60 | –1.64 | 0.101 | 28.4 | 63.64 | –2.34 | 0.019 |

| | Western Region | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage of farmers | | | | | | | | | | | |
| | Shama | | | | Ellembelle | | | | Ahanta West | | | |
| Control method | Male (%) | Female (%) | *z* value | *P* value | Male (%) | Female (%) | *z* value | *P* value | Male (%) | Female (%) | *z* value | *P* value |
| Conventional | 17.74 | 26.67 | –0.62 | 0.533 | 44.9 | 46.67 | –0.12 | 0.904 | 39.13 | 61.9 | –1.84 | 0.066 |
| Indigenous | 8.06 | 13.33 | –0.45 | 0.655 | 8.16 | 20 | –1.29 | 0.199 | 10.14 | 19.05 | –1.09 | 0.275 |
| Integrated | 58.06 | 40 | 1.26 | 0.207 | 28.57 | 20 | 0.66 | 0.511 | 31.88 | 9.52 | 2.03 | 0.042 |
| None | 4.84 | 6.67 | –0.19 | 0.846 | 18.37 | 13.33 | 0.45 | 0.651 | 1.45 | 0 | 0.55 | 0.579 |

[a] Conventional = conventional (chemical control) pest management; indigenous = indigenous knowledge pest management; integrated = integrated pest management (chemical, cultural, physical control).

our current study and could influence the adoption of agricultural technologies. However, it is worth mentioning that farming experience is mainly useful for specific crops in the early stages of implementing a given technology when farmers are still checking their potential benefits (Ainembabazi and Mugisha 2014). We found that significantly, more females than males owned coconut farmlands of less than 1 ha. Additionally, most of the farmers had farmlands of less than 1 ha. Previous work showed that land is a highly marketable commodity that provides input for food and most revenue-generating activities and plays a crucial role in socioeconomic activities, particularly in developing nations (Meinzen-Dick et al. 2019). Moreover women were usually involved in food processing, food storage, transportation of produce, hoeing and weeding, harvesting, and post-harvest care of produce, which is in agreement with the report of Drafor et al. (2005). According to Okorley and Haizel (2004), women are involved in the marketing and processing of coconut products rather than being directly involved in their cultivation.

Insect pests continue to be a pivotal setback to the coconut industry in Sub-Saharan Africa, attacking crops, leading to substantial economic losses (Philippe and Dery 2004; Pole et al. 2014). In all the study areas, most of the coconut farmers interviewed mentioned *O. monoceros* as a major constraint to coconut production, which was also previously reported as a key coconut pest in Ghana (Philippe and Dery 2004). Others include *E. guerreronis*, *A. centaurus*, *T. swinderianus O. longinoda*, *R. phoenicis*, *P. cucullatus* termites, and black ants (Andoh-Mensah et al. 2007; Nkansah-Poku et al. 2015). *O. monoceros* was a key pest reported by the farmers in the two regions. Its activity inflicts physical damage to palms by boring through the petiole bases and feeding on the succulent spear, leading to a fan shape of fronds and subsequent death of the emerged spear. Five to six beetles could attack the same crown, and feeding holes might serve as entry points for lethal secondary attacks by *R. phoenicis* or other pathogens (Bedford 1980; Omotoso and Adedire 2008). For instance, in Ivory Coast, damage up to 40% has been recorded (Allou et al. 2006). Currently, management strategies of *O. monoceros* include the use of fishing nets, chemical pesticides, chemical pesticides mixed with sawdust, and sharp metal hooks for the removal of adult beetles (Philippe and Dery 2004). Insect pest damage affects production and has been associated with the loss of millions of palms annually (Allou et al. 2006).

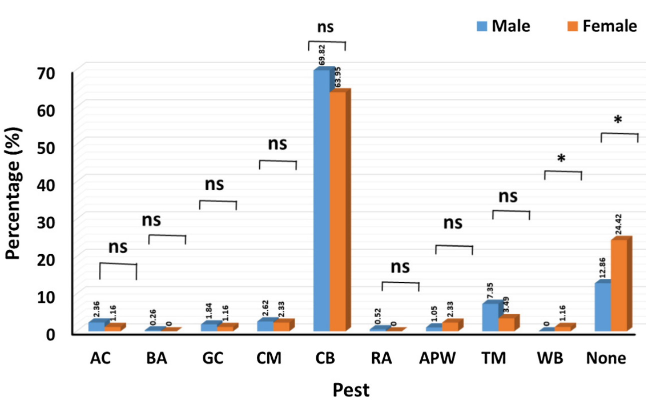


**FIGURE 5**

The overall percentage of pests is shown by gender in the Central and Western Regions. Bars with "ns" are not significant, whereas "*" indicates a significant difference for male and female respondents, $P < 0.05$, two-proportion $z$ test. *Augosoma centaurus* (AC), black ants (BA), *Thryonomys swinderianus* (GC), *Eriophyes guerreronis* (CM), *Oryctes monoceros* (CB), *Oecophylla longinoda* (RA), *Rynchophorus phoenicis* (APW), termites (TM), *Ploceus cucullatus* (WB), none.

The coconut mite (*E. guerreronis*), which was also mentioned by coconut farmers in both regions, is a serious coconut pest worldwide (Fernando et al. 2003; Howard et al. 1990) and has been associated with colossal economic losses (Aratchige et al. 2016). For instance, yield losses were estimated at 10% in Benin (Nair et al. 2016), 16% in Ivory Coast (Julia and Mariau 1979), about 30% in Mexico (Navia et al. 2013), up to 31.5% in St. Lucia (Moore et al. 1989), and 2 to 3% in Sri Lanka (Wickramananda et al. 2007). In addition to insect pests and coconut mites, the farmers reported birds and rodents as other coconut pests in Ghana. Rodents that are also known to attack coconut include grasscutter (Caulum et al. 2012) and bush rat (MoFA 2015).

The farmers reported *O. longinoda* as a nuisance pest. An earlier study showed that *O. longinoda* is generally recognized as a natural enemy, but under heavy infestations, they could be recognized as a pest due to their nuisance during harvesting, weeding, and picking of coconuts after harvesting (Van Mele 2009).

Our results showed that more females than males use indigenous knowledge for pest management, whereas more males than females use conventional pest management strategies for coconut pest management. The differences in pest management by gender could be attributed to expertise and participation in pest management strategies. The findings could be associated with the fact that males are mostly involved in the spraying of chemical pesticides. This, however, confirms that male and female farmers play different roles in agricultural production and have different levels of expertise and participation in managing pests (Kawarazuka et al. 2020; Valleser et al. 2020).

A crucial way to address pest problems is by preventing pest outbreaks (Darfour and Rosentrater 2016; MoFA 2015) and understanding the role of gender in managing pests to develop ecologically sound management technologies (Kawarazuka et al. 2020). Hence, we have, for the first time, assessed men's and women's knowledge and farm-level management of coconut pests to enhance our understanding in designing sustainable management strategies for the pests and managing them at a large scale. Additionally, behavioral variability including the relationship between gender and pest management is a crucial problem for understanding and predicting the effectiveness of the distribution of pest control information throughout a community (Paredes et al. 2010).

The respondents indicated that the Ghanaian MoFA (Agriculture Extension service) was the central agency providing training for the farmers on coconut pest management. The agriculture extension service support included technology transfer, farmer training, farmer field schools, and input delivery distribution (Akotia 1999). The ministry is in charge of agricultural production and growth in Ghana, in which its main mission is to promote sustainable agriculture and productive agribusiness through the development of science and technology, successful expansion, and other support services to ensure better livelihoods for farmers, processors, and traders (MoFA 2014).

Food insecurity continues to be a major challenge in Ghana, with about 5% of the Ghanaian population (i.e., 1.2 million people) being food insecure (Darfour and Rosentrater 2016). An earlier observation noted that extension services focus on cash crops, typically owned by men; thus, the extension does not capture women (Akotia 1999). Men owned the cash crop farms, and women worked on them and cultivated food crops that were not covered by the extension service. In combating rural poverty and food insecurity, agricultural extension programs considering gender should be recognized as key because they can transfer new technologies, encourage rural adult learning, help farmers solve problems, and actively engage farmers in the knowledge and information system of agriculture (Christoplos and Kidd 2000). Although men and women have a similar agricultural position, they continue to have unequal access to resources (Anaglo et al. 2014), as shown in the present study.

## CONCLUSIONS

More men than women cultivate coconut in Ghana. However, male farmers own larger farms than females do. Women are less educated than men, which could affect their adoption of agricultural technologies. The farmers have prior knowledge of coconut production to receive and adopt new pest management technologies. The key coconut pest is *O. monoceros.* The farmers use integrated, conventional, and indigenous knowledge for pest management, but some farmers do not use any of the management strategies. More females than males do not use any pest management strategy in the Central Region. Pest management strategy did not vary in the Central Region but varied in the Western Region.

## LITERATURE CITED


Abankwah, V., Aidoo, R., and Tweneboah-Koduah, B. 2010. Margins and economic viability of fresh coconut marketing in the Kumasi metropolis of Ghana. J. Dev. Agric. Econ. 2:432-440.

Ainembabazi, J. H., and Mugisha, J. 2014. The role of farming experience on the adoption of agricultural technologies: Evidence from smallholder farmers in Uganda. J. Dev. Stud. 50:666-679.

Akotia, E. R. 1999. The influence of gender relations on extension delivery in Dangme West District of Ghana (Doctoral dissertation, University of Ghana).

Allou, K., Morin, J. P., Kouassi, P., N'klo, F. H., and Rochat, D. 2006. *Oryctes monoceros* trapping with synthetic pheromone and palm material in Ivory Coast. J. Chem. Ecol. 8:1743-1754.

Anaglo, J. N., Boateng, S. D., and Boateng, C. A. 2014. Gender and access to agricultural resources by smallholder farmers in the upper west region of Ghana. J. Interprof. Educ. Pract. 5:13-19.

Andoh-Mensah, E., Philippe, R., and Owusu-Nipah, J. 2007. Preliminary investigation of poor nut yield performance of Sri Lanka Green Dwarf in the coconut belt of South-Western Ghana. CORD 23:26-31.

Aratchige, N. S., Kumara, A. D. N. T., and Suwandharathne, N. I. 2016. The coconut mite: Current global scenario. Pages 321-342 in: Economic and Ecological Significance of Arthropods in Diversified Ecosystems. Springer, Singapore.

Avila, D. S., Puntel, R. L., and Aschner, M. 2013. Manganese in health and disease. Pages 199-227 in: Interrelations Between Essential Metal Ions and Human Diseases. Springer, Dordrecht.

Basheer, M., and Aarif, K. M. 2013. Birds associated with the coconut palm *Cocos nucifera* in an agroecosystem in the Western Ghats region of Kerala, Southern India. Podoces 1:19-21.

Bedford, G. O. 1980. Biology, ecology, and control of palm rhinoceros beetles. Ann. Rev. Entomol. 25:309-339.

Caulum, B. R., Wagner, M. R., Allen, J. A., and Hoftetter, R. W. 2012. Coconut palm on the coastline of Western and Central Regions of Ghana. Professional Paper Submitted in Partial Fulfilment of a Master of Forestry Degree, Northern Arizona University.

Christoplos, I., and Kidd, A. 2000. Guide for monitoring, evaluation and joint analyses of pluralistic extension support. Neuchatel Group, Lindau.

Darfour, B., and Rosentrater, K. A. 2016. Agriculture and food security in Ghana. In 2016 ASABE Annual International Meeting. American Society of Agricultural and Biological Engineers (1).

De-Grazio, J. W. 1978. World bird damage problems. Pages 9-24 in Proceedings of the Eighth Vertebrate Pest Conference, Sacramento, CA.

Doss, C. R., and Morris, M. L. 2000. How does gender affect the adoption of agricultural innovations? The case of improved maize technology in Ghana. Handb. Agric. Econ. 25:27-39.

Drafor, I., Kunze, D., and Al-Hassan, R. 2005. Gender roles in farming systems: An overview using cases from Ghana. Ann. Arid Zone 44:421-439.

Erbaugh, J. M., Donnermeyer, J., Amujal, M., and Kyamanywa, S. 2003. The role of women in pest management decision making in Eastern Uganda. J. Agric. Educ. Ext. 10:71-81.

FAO. 2001. Information sheet. Coconut. https://agris.fao.org/agris-search/search.do?recordID=XR2012216252 (Accessed December 20, 2020).

FAOSTAT. 2018. Production database from the Food and Agriculture Organization of the United Nations. http://www.fao.org/faostat/

Fernando, L. C. P., Aratchige, N. S., and Peiris, T. S. G. 2003. Distribution patterns of coconut mite, *Aceria guerreronis*, and its predator *Neoseiulus* aff. *paspalivorus* in coconut palms. Exp. Appl. Acarol. 31:71-78.

Foale, M. 2003. The Coconut Odyssey: The Bounteous Possibilities of the Tree of Life. Australian Centre for International Agricultural Research, Canberra.

Geddes, A. M. W. 1990. The relative importance of crop pests in sub-Saharan Africa. NRI Bulletin No. 36.

Gesesew, H. A., Woldemichael, K., Massa, D., and Mwanri, L. 2016. Farmers knowledge, attitudes, practices and health problems associated with pesticide use in rural irrigation villages, Southwest Ethiopia. PLoS One 11:e0162527.

Ghana Statistical Service. 2021. 2020 Population and Housing Census Report. Ghana Statistical Service.

Gurr, G. M., Johnson, A. C., Ash, G. J., Wilson, B. A., Ero, M. M., Pilotti, C. A., and You, M. S. 2016. Coconut lethal yellowing diseases: A phytoplasma threat to palms of global economic and social significance. Front. Plant Sci. 7:1521.

Hoe, T. K. 2018. The current scenario and development of the coconut industry. Planter 94:413-426.

Howard, F. W., Abreu-Rodríguez, E., and Denmark, H. A. 1990. Geographical and seasonal distribution of the coconut mite, *Aceria guerreonis* (Acari: Eriophyidae), in Puerto Rico and Florida, USA. J. Agric. Univ. P. R. 74:237-251.

Julia, J. F., and Mariau, D. 1979. New research on the coconut mite, *Eriophyes guerreronis* K., in the Ivory Coast. Oléagineux 34:181-189.

Kadere, T. T. 2021. A survey on coconut production and constraints faced by farmers Kilifi and Kwale counties in Kenya. Int. J. Soc. Sci. Inf. Technol. 6:33-54.

Kawarazuka, N., Damtew, E., Mayanja, S., Okonya, J. S., Rietveld, A., Slavchevska, V., and Teeken, B. 2020. A gender perspective on pest and disease management from the cases of roots, tubers and bananas in Asia and sub-Saharan Africa. Front. Agron. 2:7.

Lim, T. K. 2012. *Cocos nucifera*. Pages 301-334 in: Edible Medicinal and Non-Medicinal Plants. Springer, Dordrecht.

Meinzen-Dick, R., Quisumbing, A., Doss, C., and Theis, S. 2019. Women's land rights as a pathway to poverty reduction: Framework and review of available evidence. Agric. Syst. 172:72-82.

MoFA. 2014. Ministry of Food and Agriculture: Northern Region Agricultural Development Unit. http://mofa.gov.gh/site/about-us/regional-agricultural-development-units (Accessed December 25, 2020).

MoFA. 2015. Ministry of Food and Agriculture: Pilot Program Based Budget (PBB) for 2013-2015.

Moore, D., Alexander, L., and Hall, R. A. 1989. The coconut mite, *Eriophyes guerreronis* Keifer in St. Lucia: Yield losses and attempts to control it with acaricide, polybutene and *Hirsutella* fungus. Int. J. Pest Manag. 35:83-89.

Muyengi, Z. E., Msuya, E., and Lazaro, E. 2015. Assessment of factors affecting coconut production in Tanzania. J. Agric. Econ. Dev. 4:083-094.

Nair, R. V., Jerard, B. A., and Thomas, R. J. 2016. Coconut breeding in India. Pages 257-279 in: Advances in Plant Breeding Strategies: Agronomic, Abiotic and Biotic Stress Traits. Springer, Cham.

Navia, D., Guedes, M., Gondim, J. C., Aratchige, S. N., and Moraes, J. G. 2013. A review of the status of the coconut mite, *Aceria guerreronis* (Acari: Eriophyidae), a major tropical mite pest. Exp. Appl. Acarol. 59:67-94.

Niral, V., and Jerard, B. A. 2018. Botany, origin and genetic resources of coconut. Pages 57-111 in: The Coconut Palm (*Cocos nucifera* L.): Research and Development Perspectives. Springer, Singapore.

Nkansah-Poku, J., Quaicoe, R. N., and Sam, G. 2015. Incidence of coconut mite, *Eriophyes guerreronis* Keifer (Acari: Eriophyidae) infestation on coconut in the Western and Central regions of Ghana. JGSA 16:36.

Okorley, E. L., and Haizel, E. 2004. Farmers' attitudes and problems associated with the adoption of Cape Saint Paul resistant coconut hybrid in the Western Region of Ghana. Agron. Afr. 16:83-89.

Omotoso, O. T., and Adedire, C. O. 2008. Potential industrial uses and quality of oil of palm weevil, *Rhynchophorus phoenicis* F. (Coleoptera: Curculionidae). Biol. Sci. - PJSIR 51:93-97.

Oyoo, M. E., Najya, M., Githiri, S. M., Ojwang, P. O., Muniu, F. K., Masha, E., and Owuoche, J. O. 2015. In-situ morphological characterization of coconut in the coastal lowlands of Kenya. Afr. J. Plant Sci. 9: 65-74.

Paredes, M. 2010. Peasants, Potatoes and Pesticides. Heterogeneity in the Context of Agricultural Modernisation in the Highland Andes of Ecuador. Wageningen University, published doctoral dissertation.

Philippe, R., and Dery, S. K. 2004. New way of controlling *Oryctes monoceros* (Coleoptera, Dynastidae), A coconut pest in Ghana. CORD 20:34-34.

Pole, F. N., Nguma, B., and Mohammed, N. 2014. Status of coconut farming and the associated challenges in Kenya. CORD 30:11-11.

Valleser, V. C., Aradilla, A. R., and Paulican, S. M. 2020. Establishment of gender-inclusive coconut-based multi-storey farm model in Bukidnon, Philippines. Agric. Soc. Econ. J. 20:57-66.
Van Mele, P., Camara, K., and Vayssieres, J. F. 2009. Thieves, bats and fruit flies: Local ecological knowledge on the weaver ant *Oecophylla longinoda* in relation to three 'invisible' intruders in orchards in Guinea. Int. J. Pest Manag. 55:57-61.
Wickramananda, I. R., Peiris, T. S. G., Fernando, M. T., Fernando, L. C. P., and Edgington, S. 2007. Impact of the coconut mite (*Aceria guerreronis* Keifer) on the coconut industry in Sri Lanka. CORD 23:1-16.