

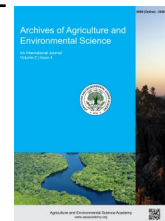


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ORIGINAL RESEARCH ARTICLE



## Baseline assessment of farmer perception on the prevalence of red spider mites in smallholder vegetable production systems in The Gambia

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### ABSTRACT

Red spider mites (genus *Tetranychus*) are among the most destructive arthropod pests affecting vegetable crops globally, particularly in tropical and subtropical production systems. Their rapid reproductive rate, extensive host range, and increasing resistance to acaricides make them a persistent constraint to vegetable productivity. This study aimed to assess farmer perceptions of the prevalence, severity, and crop growth stages associated with red spider mite infestations in smallholder vegetable production systems in The Gambia. A baseline survey was conducted in 2015 among 60 farmers randomly selected from six villages across three major vegetable-producing regions. Data were collected using structured questionnaires and analyzed with descriptive statistics. Results indicated that multiple vegetable crops were affected, with the highest infestation reported in okra (23.56%), bitter tomato (*Solanum aethiopicum*) (23.08%), and eggplant (22.12%), while tomato accounted for 9.13% of reported infestations. Infestations were most frequently observed during the flowering stage (42.31%), followed by maturity (32.69%). A majority of farmers (66.35%) perceived infestations as very severe, while 28.85% reported severe infestations. These findings confirm that red spider mites represent a significant production constraint in The Gambia. The study concludes that reliance on chemical control alone is unsustainable due to resistance development and recurring infestations. Strengthening integrated pest management (IPM) strategies, including biological control with predatory mites and the use of botanical pesticides, offers a novel and environmentally friendly pathway for sustainable management. This baseline evidence provides a foundation for future pest surveillance, farmer training, and the development of context-specific IPM packages to safeguard vegetable productivity and farmer livelihoods in The Gambia.

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### INTRODUCTION

Vegetable production plays a critical role in enhancing food security, improving nutrition, and generating income for smallholder farmers in many developing countries, including The Gambia. In these systems, crops such as

tomato, eggplant, pepper, and okra are widely cultivated under both rain-fed and irrigated conditions (FAO, 2023). However, productivity is increasingly constrained by arthropod pests, with red spider mites (*Tetranychus* spp.), particularly the two-spotted spider mite (*Tetranychus urticae*), recognized as one of the most destructive

worldwide. The species is capable of infesting over 1,100 plant species, including many economically important vegetable crops (Kewedar *et al.*, 2025). Spider mites damage plants by piercing leaf tissues and extracting cell contents, resulting in chlorosis, bronzing, reduced photosynthetic efficiency, and ultimately yield loss (Basha *et al.*, 2021; Ye *et al.*, 2024). Under favorable conditions particularly hot and dry environments mite populations can increase rapidly, leading to severe infestations within a short period (Jakubowska *et al.*, 2022). Management of spider mites is further complicated by their remarkable ability to develop resistance to acaricides. Recent studies indicate that *T. urticae* is among the arthropods with the highest number of documented pesticide resistance cases globally (Ye *et al.*, 2024). This has necessitated a shift toward sustainable pest management approaches, particularly integrated pest management (IPM), which combines biological control, cultural practices, and plant-based pesticides (Isman, 2020; Mutuku *et al.*, 2024).

In Africa, increasing reports highlight the growing importance of spider mites in vegetable production systems, particularly under changing climatic conditions (Mutthuraju *et al.*, 2024b). However, in The Gambia, there is limited documented information on the prevalence, distribution, and severity of these pests in smallholder systems. This study, based on a survey conducted in 2015, provides a baseline assessment of farmer perceptions of red spider mite infestations in smallholder vegetable production systems in The Gambia. By documenting the crops most affected, the growth stages most vulnerable, and the perceived severity of infestations, the research offers novel insights into local pest dynamics. The findings are significant as they establish foundational knowledge for IPM strategies, including biological control and botanical pesticides, which are urgently needed in the context of rising pesticide resistance. The aim of the study is to generate evidence-based information that can guide future pest management interventions, strengthen farmer capacity, and inform national agricultural policies for sustainable vegetable production.

## MATERIALS AND METHODS

### Study area

The study was conducted during the 2015 dry season in three major agricultural regions of The Gambia, namely the West Coast Region (WCR), Lower River Region (LRR), and Central River Region North (CRRN). These regions are among the country's vegetable-producing zones, largely due to the presence of irrigated community

gardens and reliable access to both surface and groundwater resources. A map showing the geographical location of the study areas within The Gambia is presented in Figure 1. The Gambia is situated within the Sudano-Sahelian agro-ecological zone and is characterized by a tropical climate with a distinct rainy season extending from June to October and a prolonged dry season from November to May. Annual rainfall varies geographically, ranging from approximately 500 mm in the eastern parts of the country to about 900 mm in the western coastal regions (AFDB, 2023; World Bank, 2024). These climatic conditions strongly influence vegetable production cycles and pest dynamics, including the occurrence of red spider mites.

### Sampling procedure

A purposive sampling approach was initially employed to select six villages with active smallholder vegetable production systems across the three study regions. In the West Coast Region, Lamin and Sibanor were selected; in the Lower River Region, Jara Kanikunda and Jara Madina were included; while Kaur Wafh Town and Jahour Mandinka were selected from the Central River Region North. Following village selection, respondents were chosen using a simple random sampling technique to ensure representativeness within each location. Ten (10) farmers were randomly selected from each village, resulting in a total sample size of sixty (60) respondents for the baseline survey. A summary of the study regions, selected villages, and number of respondents is presented in Table 1. This sampling approach is consistent with recent agricultural survey methodologies that combine purposive site selection with random respondent sampling to balance representativeness and feasibility (Bako *et al.*, 2022; Singh *et al.*, 2022).

### Data collection

Primary data were collected through the administration of structured questionnaires to individual farmers. The survey instrument was designed to capture key information related to vegetable production and red spider mite infestations. Specifically, data were collected on the types of vegetable crops cultivated, the occurrence of red spider mite infestations, the crop growth stages most affected, and the perceived severity of infestations. Farmers were asked to identify the crops affected by red spider mites based on their field experience and to indicate the stages of crop development during which infestations were most prevalent. The survey relied on farmer knowledge and perception, which is particularly



**Figure 1.** Map of The Gambia showing study areas (Source: GADM, 2025, version 4.1).

important in contexts where formal pest surveillance data are limited. Reliance on farmer knowledge and perception is a recognized approach in contexts where formal pest surveillance data are limited, and has been widely applied in participatory pest management studies (Mutuku *et al.*, 2024).

### Data analysis

Data obtained from the survey were coded and entered into Stata version 13 for statistical analysis. Descriptive statistics including frequencies, percentages, and cross-tabulations were used to summarize farmer responses on crop susceptibility, infestation stages, and perceived severity levels. The prevalence of red spider mite infestation across vegetable crops was calculated using percentage distribution, following standard epidemiological methods for pest prevalence studies (Espitia-Buitrago *et al.*, 2025).

$$\text{Prevalance (\%)} = \frac{\text{Number of responses for a crop}}{\text{Total Responses}} \times 100$$

Similarly, the distribution of infestations across crop growth stages and severity categories was determined using percentage frequencies. Results were presented in tables and figures to facilitate interpretation, consistent with best practices in agricultural survey reporting (Bako *et al.*, 2022).

## RESULTS AND DISCUSSION

### Distribution of red spider mite infestation across vegetable crops

The results of the survey revealed that red spider mites infest a wide range of vegetable crops cultivated in small-holder production systems in The Gambia. Among the crops reported by farmers, okra recorded the highest infestation frequency (23.56%), followed closely by bitter

**Table 1.** Distribution of sampled respondents across regions and villages.

Region	Village	Number of respondents
West Coast Region (WCR)	Lamin Village	10
	Sibanor	10
Lower River Region (LRR)	Jara Kanikunda	10
	Jara Madina	10
	Kaur Wafh Town	10
Central River Region-North (CRRN)	Jahour Mandinka	10

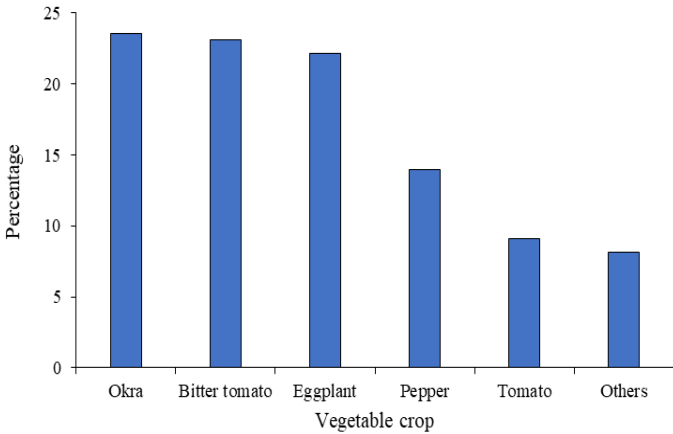
tomato (*Solanum aethiopicum*) (23.08%) and eggplant (22.12%). Pepper accounted for 13.94% of reported infestations, while tomato represented 9.13% (Figure 2). The wide host range observed in this study is consistent with the known polyphagous nature of *T. urticae*, which is capable of infesting over a thousand plant species globally (Jakubowska *et al.*, 2022). Similar patterns of infestation across multiple vegetable crops have been reported in tropical production systems, where favorable environmental conditions support continuous pest development (Basha *et al.*, 2021; Mutthuraju *et al.*, 2024b). Recent studies confirm similar host preferences: El-Karim *et al.* (2024) found that okra exhibited relatively higher resistance to spider mites compared to cucumber, while eggplant genotypes varied significantly in susceptibility, with some wild types showing strong resistance (Kırışık *et al.*, 2021). The relatively higher infestation levels observed in okra, bitter tomato, and eggplant may be associated with morphological and physiological characteristics of these crops, such as leaf surface structure and nutrient composition, which can influence mite colonization and reproduction. Previous studies have shown that host plant characteristics significantly affect spider mite population dynamics and feeding behavior (Isman, 2020).

### Crop growth stages associated with infestation

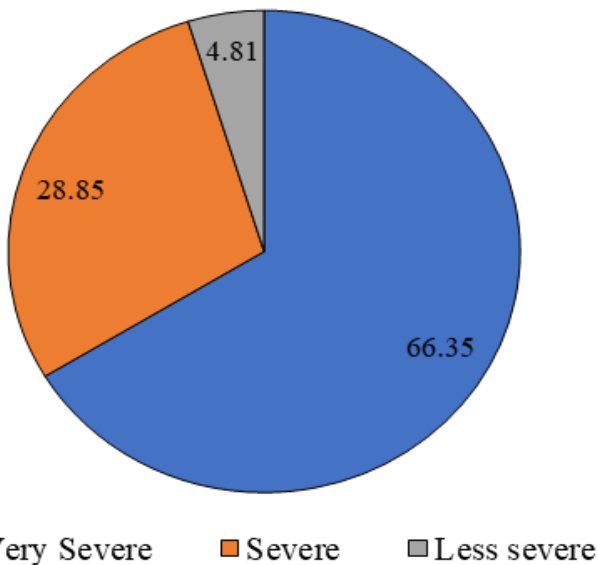
Red spider mite infestations were reported to occur across different crop growth stages; however, the flowering stage was identified as the most vulnerable, accounting for 42.31% of responses, followed by the maturity stage at 32.69% (Table 2). Infestations during early growth stages such as germination were relatively low (1.44%), although some farmers reported occurrences across multiple growth stages. The predominance of infestations during the flowering and maturity stages may be explained by increased canopy development and leaf biomass, which create favorable microclimatic conditions such as higher temperatures and reduced humidity within the plant canopy. These conditions are known to enhance spider mite reproduction and survival (Mutthuraju *et al.*, 2024a). Furthermore, reproductive stages of crops are

**Table 2.** Farmers' responses on crop growth stages affected by red spider mite infestation.

Growth Stages	Frequency	Percentage
Germination	3	1.44
Flowering	88	42.31
Maturity	68	32.69
Germination & Flowering	7	3.37
Germination & Maturity	4	1.92
Flowering & Maturity	28	13.46
All stages	10	4.81



**Figure 2.** Farmers' perception of vegetable crops most affected by red spider mites in surveyed gardens.



**Figure 3.** Farmers' perception of red spider mite infestation severity.

often associated with increased nutrient allocation, which may enhance host suitability for mite feeding. Similar findings have been reported in vegetable systems where peak spider mite populations coincide with flowering and fruiting stages (Basha *et al.*, 2021; Ye *et al.*, 2024).

**Perceived severity of infestation**

The severity of red spider mite infestations was perceived to be high among the majority of farmers. Approximately 66.35% of respondents classified infestations as very severe, while 28.85% reported severe infestations. Only 4.81% indicated low levels of infestation (Figure 3). The

high proportion of farmers reporting severe infestations underscores the significant impact of spider mites on vegetable production systems. Severe infestations are known to cause extensive damage through chlorosis, leaf bronzing, and defoliation, ultimately reducing photosynthetic capacity and crop yield (Ye *et al.*, 2024; Mutthuraju *et al.*, 2024a). The persistence and severity of infestations observed in this study may also be linked to the development of resistance to commonly used pesticides. *Tetranychus urticae* is widely recognized as one of the most pesticide-resistant arthropods, with resistance reported across multiple chemical classes (Adesanya *et al.*, 2021). Current studies confirm the persistence of severe infestations due to acaricide resistance. For example, Xu *et al.* (2026) highlight that *T. urticae* has evolved resistance to nearly all major acaricide classes, driven by genetic mutations and metabolic detoxification pathways. Other studies have further demonstrated that symbiotic microorganisms such as *Wolbachia* can enhance pesticide resistance in spider mite populations, complicating control efforts (Ye *et al.*, 2024). In addition, the reliance on chemical control methods without proper resistance management strategies in smallholder systems may contribute to reduced efficacy of pesticides and recurring infestations. This highlights the importance of transitioning toward sustainable pest management approaches. Some studies have demonstrated the effectiveness of integrated pest management (IPM) strategies in controlling spider mite populations. Biological control using predatory mites such as *Phytoseiulus persimilis* has shown promising results in reducing mite populations under field conditions (Mutuku *et al.*, 2024). Similarly, botanical pesticides, including plant extracts such as garlic and neem, have been reported to provide effective and environmentally friendly alternatives to synthetic acaricides (Nkiwane & Tibugari, 2025; Isman, 2020).

**Implications for smallholder vegetable production systems**

The findings of this study highlight the widespread occurrence and severity of red spider mite infestations in smallholder vegetable production systems in The Gambia. The

combination of a wide host range, favorable climatic conditions, and potential pesticide resistance creates a conducive environment for persistent infestations. Given the reliance of smallholder farmers on vegetable production for income and food security, the impact of spider mites represents a significant constraint to productivity. Similar concerns have been raised in other African and tropical production systems, where pest pressures are exacerbated by climate variability and limited access to effective pest management tools (Mutthuraju *et al.*, 2024b; Mutuku *et al.*, 2024). These findings emphasize the need for targeted interventions, including farmer training on pest identification, monitoring, and the adoption of IPM strategies. Strengthening extension services and promoting sustainable pest control methods will be critical for mitigating the impact of spider mites in the region.

### Conclusion and recommendations

This study provides important baseline information on the prevalence, distribution, and perceived severity of red spider mite infestations in smallholder vegetable production systems in The Gambia. The findings reveal that infestations are widespread across multiple vegetable crops, with the highest occurrence reported in okra, bitter tomato, and eggplant. Infestations were observed predominantly during the flowering and maturity stages of crop development, which are critical periods for yield formation. The majority of farmers perceived the infestations as severe to very severe, underscoring the significant threat posed by red spider mites to vegetable productivity and farmer livelihoods. The results highlight the urgent need for effective and sustainable pest management strategies tailored to smallholder production systems. In particular, strengthening integrated pest management (IPM) approaches is essential. This should include the promotion of biological control options, such as the use of predatory mites, as well as the adoption of botanical pesticides derived from locally available plant resources. These approaches offer environmentally friendly and potentially cost-effective alternatives to synthetic acaricides, especially in the context of increasing pesticide resistance. In addition, there is a need to enhance farmer capacity through training and extension services focused on pest identification, monitoring, and timely intervention. Improved awareness of pest dynamics and management options will enable farmers to make informed decisions and reduce crop losses. Future research should prioritize field-based validation of sustainable control strategies under local conditions, as well as the development of context-

specific IPM packages for vegetable crops. Furthermore, establishing regular pest surveillance systems will be critical for monitoring population trends, detecting emerging resistance, and informing evidence-based pest management policies in The Gambia.

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### DECLARATIONS

**Author contribution statement:** Conceptualization: I.M. and B.O.C.; Methodology: B.O.C.; Software and validation: I.M. and B.O.C.; Formal analysis and investigation: B.O.C.; Resources: I.M.; Data curation: B.O. C.; Writing—original draft preparation: I. M. and B.O.C.; Writing—review and editing: I.M.; Visualization: I.M.; Supervision: I.M. and B.O.C.; Project administration: I.M. and B. O. C.; Funding acquisition: I.M. All authors have read and agreed to the published version of the manuscript.

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**Ethics approval:** This study was conducted in view of the institutional ethical guidelines and does not harm the animal and human participants.

**Consent for publication:** All co-authors gave their consent to publish this paper in AAES.

**Data availability:** The data that support the findings of this study are available on request from the corresponding author.

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