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# THE NUTRIENT DYNAMICS ON INFESTATION OF FALL ARMYWORM IN SUB-SAHARAN AFRICA: A MINI REVIEW PAPER

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## SUMMARY

**Fall Armyworm (*Spodoptera frugiperda J.E Smith*) (FAW) has emerged as a major pest threatening maize and other staple crops across sub-Saharan Africa (SSA), posing significant risks to food security and livelihoods. Crops worth over USD 13 billion annually are at risk of FAW damage throughout sub-Saharan Africa. This review explores the influence of nutrient dynamics on FAW bionomics and damage potential. It shows how macro and micro-nutrients, organic and inorganic matter, affect plant susceptibility or resistance to the FAW herbivore. Excess nitrogen fertilization is directly linked to enhanced larval development and damage due to increased foliar nitrogen content and reduced defence expression. At the same time, balanced nutrition involving organic matter is associated with strengthened plant structure and provided defence. The influence of soil organic matter and microbial activity in promoting indirect pest suppression and enhancing plant health underscores the importance of integrated nutrient management as a critical component of ecologically-based pest control strategies for FAW. A deeper understanding of these nutrient–pest interactions can guide the development of sustainable, site-specific interventions to mitigate FAW outbreaks and support resilient cropping systems across Sub-Saharan Africa.**

**Keywords:** *Spodoptera frugiperda*, Nutrients, Nitrogen, Organic matter, Maize

## INTRODUCTION

The Fall Armyworm (*Spodoptera frugiperda*) has emerged as a significant invasive pest in sub-Saharan Africa, posing substantial threats to agriculture and food security [1] and was first detected in São Tomé, Nigeria, Bénin, and Togo in early 2016 [2]. By late 2017, it had expanded its infestation range to about 40 sub-Saharan African countries [3]. It rapidly spread across the continent, reaching all SSA by May 2019 [4]. The pest has spread to over 45 African countries, including a few North African countries [5]. Reports showed that the rapid spread of *S. frugiperda* across continents may have been linked to it's high natural wind-assisted flight capability, enabling it to travel several hundred kilometers in a single day [6]

*Spodoptera frugiperda* is highly polyphagous, inflicting damage on a vast array of plant species, surpassing 350 varieties, which notably include economically significant crops like maize (*Zea mays*), rice (*Oryza sativa*), cotton (*Gossypium spp.*), and sorghum (Sorghum bicolour), distributed among approximately 70 plant families [7, 4] The host plants of fall armyworm is predominantly found within the Poaceae, Asteraceae, and Fabaceae families [4], with maize being the primary choice in Africa, closely followed by sorghum and millet [8;

9].

Fall armyworm infestation without effective management, FAW infestations could lead to maize yield losses exceeding any other crop [9] 50% of the total annual production of the affected countries, especially in the low and medium-producing areas [10] ranging from 8.3 to 20.6 million tonnes annually, translating to economic losses between $2.5 and $6.2 million [11,12] Generally, crops worth over 13 billion per annum are at risk of FAW damage throughout sub-Saharan Africa, threatening the livelihoods of millions of poor farmers [13]. The abundance, availability and dynamics of nutrients in crops have significant impact on the crop susceptibility to pests and diseases [14]. Emperical studies have shown that abundance of some nutrients renders the cell wall more susceptibility to proportional insect pests [15]. It has been reported that Nitrogen is the main nutrient for insect growth, survival and reproduction. while sulphur, magnesium and phosphorus also influence insect increase. Information on the influences of insect dynamics promote FAW in some agroecologies, the need to locate and synthesize the information for the concept and control of FAW is crucial, Therefore, this review highlights the necessary information on the economic importance of FAW on major crops, nutrient dynamics, and the role of micro- and macro-nutrients in managing FAW. The rationale behind this phenomenon underscores the imperative of devising and implementing strategies aimed at achieving optimal nutrient equilibrium within the region as a proactive measure against infestation, while simultaneously fostering food security.

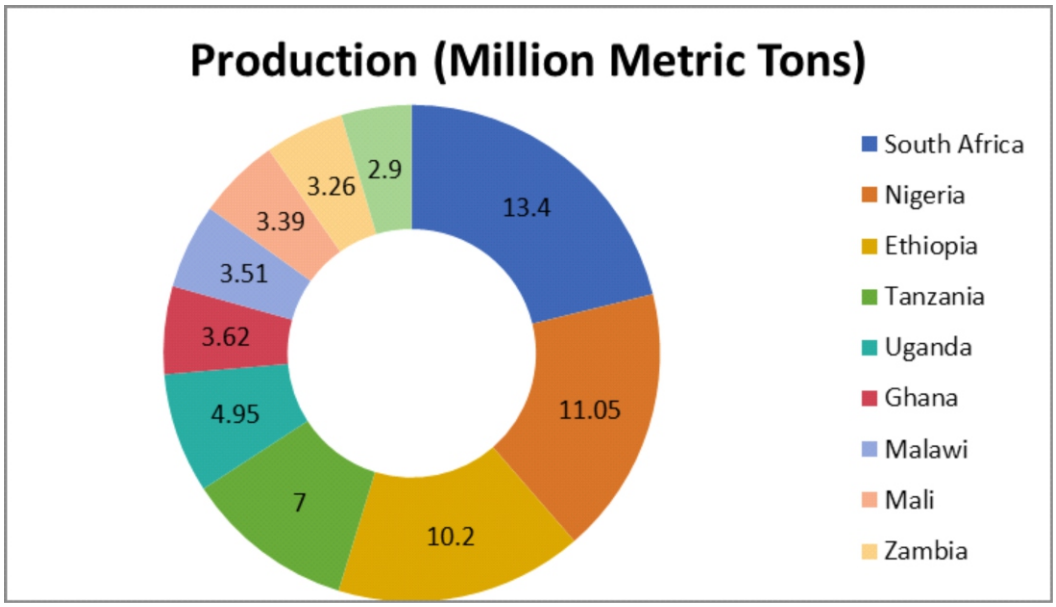



**Figure 1: Top 10 Maize-Producing Countries in sub-Saharan Africa (2023)**
**Source: –Top 10 Maize Producers in Africa 2023/2024 Marketing Year - Milling Middle East & Africa Magazine - No 1 Grains Industry Magazine & Website for Africa & the Middle East.**

**Table 1: Roles of Macro and Micro-nutrients in Crop Resistance to Fall Armyworm (FAW) in Sub-Saharan Africa**

| Nutrient Type | Nutrient Element | Role in Maize Resistance to FAW | Citation |
|---|---|---|---|
| Macronutrient | Nitrogen (N) | Enhances vegetative growth; however, excessive N can make crops more susceptible to FAW due to increased leaf tender tissues that pest can feed on. | [46] [52] [26] |
| Macronutrient | Phosphorus (P) | Supports root development and energy transfer, improving plant vigour and tolerance to FAW attack. | [53] [26] [54] |
| Macronutrient | Potassium (K) | Increases cell wall strength, improves drought tolerance and enhances the production of phenolic compounds, which deter FAW. | [55] [56] |
| Macronutrient | Calcium (Ca) | Stabilizes cell walls and membranes, aids in wound healing and systemic acquired resistance (SAR) to chewing insects like FAW. in enhancing maize resistance to FAW. | [57] [58] |
| Macronutrient | Magnesium (Mg) | Healthy photosynthesis is central to chlorophyll production, which improves overall plant immunity. Magnesium levels in host plants can cause FAW infestation rates. | [59] [60] |
| Micronutrient | Zinc (Zn) | Enhances enzyme systems and hormone production, boosting plant defence responses against FA. | [61] |
| Micronutrient | Iron (Fe) | It is involved in chlorophyll synthesis and supports defensive peroxidase activity against FAW larvae. | [59] [57]. |
| Micronutrient | Manganese (Mn) | Functions in lignin biosynthesis and detoxification of reactive oxygen species (ROS), strengthening plant resistance to FAW. | [57] |
| Micronutrient | Copper (Cu) | Activates enzymes involved in lignification and phenolic production, limiting insect digestion. | [62] |
| Micronutrient | Silicon (Si) | It forms a physical barrier in leaves, deters larval chewing and boosts induced resistance mechanisms. | [63] |

## How nutrient deficiency or excess influences crop vulnerability to FAW in Sub-Saharan Africa

A study conducted in Northern Ghana investigated the effects of varying nitrogen fertilizer rates combined with pesticide application on maize growth and the incidence of FAW infestation. It revealed that higher nitrogen rates, particularly at 100 kg/ha, were associated with increased FAW egg masses, larvae and greater severity of leaf injury [64]. Conversely, a 40 kg/ha nitrogen rate resulted in the lowest FAW infestation levels. This suggests that

while higher nitrogen rates can enhance maize yield, they may also increase the risk of FAW infestation, necessitating integrated pest management strategies [64]. In addition, a study in Eastern Zimbabwe observed higher FAW incidences in nitrogen-fertilized plots, underscoring the need for balanced nitrogen management [50]. Elevated levels of phosphorus and magnesium have been linked to increased FAW damage [20], and higher concentrations of these nutrients may compromise the plant's defence mechanisms, making them more susceptible to FAW attack. These nutrients contribute to more substantial plant structures and improved stress responses. [65] suggest their role in reinforcing plant defences.

Effect of Soil Fertility Management on FAW Infestation

**Organic Fertilizers and FAW Infestation**

Organic soil fertility management practices, such as using crop residue and animal manure, not only improve soil fertility but also reduce insect pests infestation and improve crop productivity through different mechanisms [66]. In Eastern Zimbabwe, [50] found lower FAW damage levels in maize plots with manure application, and [67] observed a decrease in the performance of FAW treated with manure-fertilized Maize. In addition, organic soil fertility management practices, such as livestock manure, reduce insect pests infestation [68] through different mechanisms that enhance plant resistance to insect pest infestation.

Also, a study in southwest Ethiopia evaluated the effects of incorporating maize residue and cattle manure on FAW infestation in maize fields. The findings revealed that plots with 100% maize residue retention exhibited significantly lower FAW infestation rates -15.4 % in Mana and 24.1% in Omo Nada—compared to plots without residue retention, which experienced infestation rates of 26.4% and 42.5%, respectively. Additionally, maize plots treated with cattle manure stored under a grass roof showed the lowest FAW infestation rates, with 10.8% in Mana and 22% in Omo Nada. These results suggest that organic amendments, such as crop residue retention and properly managed cattle manure, can enhance soil fertility and reduce the incidence of FAW infestation [69]. The comparative analysis suggests that organic soil fertility management practices, including crop residues and well-managed cattle manure, reduce FAW infestation in maize crops. These practices improve soil health and plant vigour and create favourable conditions for natural enemies of FAW, thereby enhancing biological control.

**Inorganic Fertilizers and FAW Infestation**

Applying inorganic fertilizers, primarily those rich in nitrogen, has been associated with increased FAW infestations. High nitrogen levels can lead to lush, vegetative growth, which may attract herbivorous pests; application of nitrogen fertilizer typically increases herbivore feeding preference, food consumption, survival, growth, reproduction, and population density except in a few instances where nitrogen fertilizer reduces the herbivore performance such as FAW. For instance, a study in Eastern Zimbabwe and Northern Ghana showed a higher incidence of FAW in maize plots where nitrogen fertilizers were applied [43]. This suggests that while nitrogen is essential for plant growth, excessive use without balanced nutrient management can inadvertently exacerbate

FAW problems [64]. In contrast, the indiscriminate use of inorganic fertilizers, especially those high in nitrogen, may increase the risk of FAW infestations due to enhanced vegetative growth that attracts pests [70]

**Justification of Soil Nutrient Management for Fall Armyworm (FAW) Control**

Soil nutrient management is crucial in enhancing crop health and resilience against pests, including the Fall Armyworm (*Spodoptera frugiperda*). In Sub-Saharan Africa, where FAW poses a significant threat to Maize and other staple crops, improving soil fertility through targeted nutrient management offers a sustainable and eco-friendly pest control method.

Enhanced Plant Vigour and Resistance

Healthy, well-nourished plants can withstand and recover from pest attacks. Macronutrients like nitrogen (N), phosphorus (P), and potassium (K), as well as secondary nutrients (e.g., calcium, magnesium), contribute to stronger plant tissues, better root systems, and increased chlorophyll content—all of which enhance resistance to FAW feeding. Fall armyworms typically perform better on and prefer plants grown in nitrogen-rich soils [71]. Phosphorus has been reported to play a functional role in defence hormone signalling and is also involved in plant-microbe associations that confer resistance to herbivores and pathogens [28]. Additionally, [36] said potassium may inhibit fall armyworm growth and development, though the mechanisms are unclear. They showed that limiting nitrogen is linked to suppressing nitrogen-rich proteins, such as those used for plant defences. Also, it has been reported that nutrient-deficient plants are more vulnerable to herbivore attacks due to reduced metabolic capacity to produce defensive compounds [ 28] [69].

Influence of Soil Nutrients on Insect Herbivory

Soil nutrients affect the nutritional quality of crops, which in turn influences pest-feeding behaviour and reproduction. High nitrogen availability often increases the concentration of amino acids and soluble proteins in plant tissues, thereby enhancing the nutritional quality for insects [28]. In the case of *S. frugiperda*, high nitrogen levels have been shown to promote larval development, survival, and fecundity due to improved food quality [72] Reports have shown that Insect performance metrics are commonly limited by the nutritional components of their diet, and nutrient variation can alter herbivore performance and population dynamics. A balanced nutrient profile can reduce FAW's preference for specific crops and limit its ability to complete multiple generations on the same host. Elevated nitrogen levels alone can sometimes favour FAW development. However, integrated nutrient management—particularly combining organic and inorganic sources—has been shown to deter infestation by creating less favourable plant tissue compositions [73]

Soil Organic Matter and Microbial Activity

Using organic inputs (e.g., compost, green manure, crop residues) improves soil structure and microbial activity, enhancing nutrient availability and stimulating natural pest suppression mechanisms in the rhizosphere. Research by [69] reported that organically managed soils and microbial communities may play an unappreciated role in reducing plant attractiveness to pests by increasing plant resistance.It was

reported [74] that soils with high organic matter and active soil biology generally exhibit good soil fertility. Crops grown in such soils generally exhibit a lower abundance of several insect herbivores, reductions that may be attributed to lower nitrogen content in organically farmed crops. Plots with higher organic matter show reduced FAW incidence, likely due to improved soil health and the activity of beneficial soil organisms that indirectly support crop resistance [69].

## CONCLUSION

The complex interplay between nutrient dynamics and *Spodoptera frugiperda* infestation in Sub-Saharan Africa highlights the urgent need for a holistic understanding of soil nutrient-plant insect interactions in the region. Evidence from multiple studies suggests that soil fertility, plant nutritional status, and micronutrient balance significantly influence the susceptibility of Maize and other host crops to Fall Armyworm (FAW) attacks. Excessive nitrogen fertilization, in particular, has been linked to increased FAW damage due to improved palatability and nutritional quality of foliage. In contrast, balanced nutrient management has shown potential in enhancing plant resistance. Moreover, nutrient-rich soils favour plant vigour and resilience, indirectly supporting natural enemies through improved habitat structure and food availability. However, the variability in soil types, farming practices, and agroecological zones across Sub-Saharan Africa requires that nutrient management strategies be tailored to local contexts. An integrated approach that combines nutrient-based resistance enhancement with ecological pest control and sustainable land management practices is essential to manage FAW infestation effectively. Future research should identify region-specific nutrient thresholds that reduce pest pressure while sustaining crop productivity. In this way, nutrient management can become a powerful tool in the long-term suppression of FAW and contribute to food security and environmental sustainability in Sub-Saharan Africa.

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