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# Abundance and Dispersion Indices of *Helicoverpa armigera* (Lepidoptera: Noctuidae) on Tomato Plant in Nigeria

## Nijerya'da Domates Bitkisinde *Helicoverpa armigera* (Lepidoptera: Noctuidae)’nın Popülasyon ve Dağılım İndeksleri

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**ABSTRACT**

*Helicoverpa armigera* is among the major insect pests that pose a threat to tomato production in Nigeria with an insufficient understanding of its population parameters, and available environmentally friendly control materials which are essential for the development of reliable and sustainable management strategies that can minimize the frequent use of synthetic pesticides; which are hazardous to the environment, non-target organism, and humans. The present study was conducted with the objectives of establishing population abundance and dispersion of *H. armigera.* Surveys were conducted in the savannah agroecological zone of Nigeria through fortnightly field visits to tomato farms from July to September 2019 (rainy season), and month of December 2019 to March 2020 (dry season), making a total of seven (7) and Nine (9) visits respectively. Ten plants were randomly selected and tagged from each farm, for observation of the presence of *H. armigera* larvae on the upper and lower parts early in the morning (6:00-7:30 am) on all sampling. Numbers found on each plant were counted and recorded with dates. Data obtained were subjected to analysis of variance and the least significant difference (LSD) at 0.05% level of probability was used to separate significant means. Data were further used in calculating the various dispersion indices. The result indicates that *H. armigera* was higher at 8 weeks after planting and aggregated on the upper part of the plant with a higher population in the dry season. Abundance and dispersion indices of *H. armigera* on tomato plants reported in this study will provide for appropriate decision-making in designing eco-friendly management of the pest.

**Keywords:** Tomato, *Helicoverpa armigera*, fruit worm, population, dispersion, Savannah

**ÖZ**

*Helicoverpa armigera*, popülasyon parametrelerinin yeterince anlaşılmaması ve sentetik pestisitlerin sık kullanımını en aza indirebilecek güvenilir ve sürdürülebilir yönetim stratejilerinin geliştirilmesi için gerekli olan mevcut çevre dostu kontrol materyallerinin yetersiz anlaşılmasıyla Nijerya'da domates üretimine müdahale eden başlıca zararlılar arasındadır. Tarım ilacı; çevre, hedef olmayan organizma ve insanlar için tehlikelidir. Bu çalışma, *H. armigera*' nın çalışma alanındaki popülasyon dağılımını belirlemek amacıyla yapılmıştır. Anketler, Temmuz-Eylül 2019 (yağmur mevsimi) ve Aralık 2019-Mart 2020 (kurak mevsim) arasında iki haftada bir domates çiftliklerine saha ziyareti yoluyla Nijerya'nın savan agro-ekolojik bölgesinde gerçekleştirildi. Tüm örnekleme günlerinde sabahın erken saatlerinde (06:00-7:30) üst ve alt kısımlarda *H. armigera* larvalarının varlığının gözlemlenmesi için her çiftlikten rastgele on (10) bitki seçildi ve etiketlendi. Her bitkide bulunan *H. armigera* sayıları sayıldı ve tarihlerle birlikte kaydedildi. Elde edilen veriler varyans analizine tabi tutulmuş ve anlamlı ortalamaları ayırmak için %0,05 olasılık düzeyinde en küçük anlamlı fark (LSD) kullanılmıştır. Veriler ayrıca çeşitli dağılım indekslerinin hesaplanmasında kullanıldı. Sonuç, *H. armigera* 'nın dikimden 8 hafta sonra daha yüksek olduğunu ve kurak mevsimde daha fazla nüfusa sahip bitkinin üst kısmında toplandığını göstermektedir. *H. armigera*'nın bu çalışmada bildirilen domates bitkisi üzerindeki dağılım ve dağılım indeksleri, zararlının çevre dostu yönetimini tasarlamada uygun karar verme için sağlam bir temel sağlayacaktır.

**Anahtar Kelimeler:** Domates, *Helicoverpa armigera*, meyve kurdu, popülasyon, dağılım, Savannah

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## Introduction

Tomatoes are among the most important commodities and widely crop plants grown in Africa and the world (Ciceoi et al., 2021). They are considered culinary vegetables which are used in different types of recipes such as salads, sandwiches or soups (Olugbire et al., 2020). It can be sliced with a little onion and pepper and eaten with a local dish known as "danwake" or eaten with a little oil and chilies as spices. It can be processed into paste or puree, and used in cooking or the production of fruit drinks and ketchup (Chula et al., 2017; Ghaderi et al., 2017). In Nigeria, tomatoes are sundried and ground into powder (Olugbire et al., 2020) for use in preparations of different soups.

Nutritionally, tomatoes are filled with a variety of nutrients like fiber, potassium, and vitamins A and C. Medium, red, ripe tomatoes provide 22 calorie diet (Ghaderi et al., 2017; Yasser et al., 2019), and contain 8 percent of dietary potassium and 7 percent of recommended dietary allowance (RDA) of iron for women and 10 percent for men (Olugbire et al., 2020). Tomato contains high levels of lycopene which is a very powerful antioxidant that prevents the development of many forms of cancer (Hussaini et al., 2016). The leaves have also been used widely as a natural antiseptic agent because of their narcotic acid content (Ugonna et al., 2015).

Nigeria was ranked the second largest producer of tomatoes in Africa, and 16$^{th}$ largest producer in the world (Ghaderi et al., 2017), and about 1.8 million metric tonnes of tomatoes were produced in Nigeria, which accounts for about 68.4% of West Africa, 10.8% of Africa's total output and 1.28% of world output (Umar et al., 2015). Production in Nigeria spread all over the country, the total arable land under tomato production was estimated to be 1,000,000 ha with an estimated output of 1.8mm tones per annum (Umar et al., 2017). The major producing areas in Nigeria lies within the area with a temperature range of 25-34$^{0}$C (Ugonna et al., 2015), these areas include most states (Bauchi, Benue, Borno, Kaduna, Kano, Plateau, Sokoto, Jigawa and Yobe) in the Northern region.

Tomato production is affected negatively by numerous pests which result in poor yield, low quality, and financial loss. Ahmed et al. (2022) reported about 200 species of insect pests attacking tomatoes in Egypt. The major pests include aphids (*Aphis gossypii*), white flies (*Bemisia tabaci*), thrips (*Thrips tabaci*), leaf miners *(Lyriomyza spp* and *Tuta absoluta*), and the fruit worms (*Helicoverpa armigera*) (Kollie et al., 2014; Brévault et al., 2014).

*Helicoverpa armigera* is one of the most serious insect pests of tomatoes worldwide. It is widely distributed in Asia, Europe, Africa, and Australasia. The larvae are the destructive stage, they prefer to feed and develop on reproductive structures in general, feed on buds, flowers, and fruit which are rich in nitrogen (Liu et al., 2004); leading to severe yield loss in greenhouse and open-field tomato crops (Compolo et al., 2017). This moth has a high reproductive potential, completing up to 13 generations per year (Tropea Garzia et al., 2012).

In Nigeria, the use of synthetic pesticides has been reported to be the main control measure used for the management of fruit borer infestation on tomatoes and other crops (Olugbire et al., 2020). However, Nigerian farmers lack knowledge about safety and do not have access to appropriate training that could help them cope with pesticide hazards (Sule et al., 2020).

Lack of monitoring of insect pests may increase the unwarranted frequency of pesticide application by our local farmers, exacerbating the manifestation of the drawbacks of synthetic insecticides on the environment. There is a consensus among pest control specialists that insecticides should be applied as a last resort and should be based on the established threshold levels; which can only be economically estimated when there are reliable data on population dynamics, distribution, and dispersion of insect pests among others. There is currently some paucity of information in literature on most of the above insect population parameters particularly for *H. amigera* in this part of the world. Therefore, this study aims to determine the population distribution and dispersion indices of *H. armigera* on tomato plants in some selected tomato-producing areas of Kano and Yobe State in Nigeria to generate information on the same that can be harnessed in the development of IPM systems for its management.

## Methods

### Study location

The study was conducted in two states (Kano and Yobe) in Northern Nigeria. Two Local Governments were randomly selected from each State. Thereafter, six villages (Lamba-Burji, Takaraste, Doka, Gada, Gadana, and Ngalda) across the four LGs (Madobi, Tofa in Kano State, Nangere, and Fika in Yobe state) that are known for both dry and rainy season tomato cultivation were purposefully selected for the study. The mean annual rainfall in Kano and Yobe State during the sampling at rainy season is 178.33±6.20 and 210.15±3.20 mm respectively.

### Survey and Sampling Methodology

Field visit to tomato farms in the study area was done from July - September 2019 (rainy season), December -2019 through March -2020 (dry season). The surveys were conducted each field starting from six weeks after transplanting up to harvest since the activities of *H. armigera* are high during this period in the tomato plant phenology. In total, there were seven (7) samplings in the rainy season and nine (9) in the dry seasons in each location.

In each of the selected villages, one farm was randomly selected from which ten plants were subsequently randomly selected and tagged for data collection. Each plant was divided into two equal parts (upper and lower parts). Observation for the presence of *H. armigera* larvae on the upper and lower parts of the tagged plants was made early in the morning (6:00-7:30 a.m.). Number of H. *armigera* found on each plant was collected, counted, recorded with dates and killed.

**Statistical data analysis**

To determine whether the mean population of *H. armigera* larvae differed significantly between the upper and lower parts of the tomato plant, the number of *H. armigera* larvae counted on the upper and lower parts of the tomato plants during each sampling visit were subjected to analysis of variance using computer software Genstat Discovery Edition for Windows. The least significant difference (LSD) at a 0.05% level of probability was used to separate significant means.

Also, based on *H. armigera* larvae counts from upper and lower parts of tomato plants, a mean number of *H. armigera* larvae per tomato plant over time was calculated, and used in calculating the various dispersion indices. Furthermore, the spatial distribution of *H. armigera* larvae was determined by different methods. The simplest method is the variance to mean ratio, $S^2/m$ where the value of $S^2/m<$ 1 indicates a uniform dispersion, while $S^2/m=$ 1 indicates random dispersion and $S^2/m>$ 1 indicates an aggregated dispersion.

Lloyd's index of patchiness is described as the ratio of the mean of mean crowding ($m^*$) to mean density ($m$). The mean crowding was calculated using the formula as described by Queiroz-Santos et al. (2018) and Sule et al. (2012):

$$m^* = x + \left[\left(\frac{S^2}{x}\right)\right] - 1 \qquad (1)$$

Where
$x$ is the mean density
$S^2$ is the variance,
Lloyd's ($m^*$) index =1 indicates a random dispersion; Lloyd's index > 1 indicates aggregated dispersion, and Lloyd's index < 1 indicates regular dispersion.

The degree of aggregation was determined by the most commonly used dispersion indices, i.e., the Greens coefficient (*Cx*). The Greens coefficient was calculated as described by (Sule et al., 2012; Wade et al., 2018) using the formula:

$$Cx = \frac{\left(S^2/m\right) - 1}{\Sigma x - 1} \qquad (2)$$

Where
$S^2$= variance of mean,
$m$= mean number of *H. armigera* per shoot and
$\Sigma x$ = total number of *H. armigera,* where
$Cx$= 1, the coefficients indicate a random dispersion; $Cx$>1, it indicates aggregated dispersion; where $Cx$<1, indicates regular dispersion

**Table 1**
*Abundance of H. armigera Larvae on Tomato Plants during Dry and Rainy Seasons in Kano and Yobe States*

| | Mean number of larvae | |
|---|---|---|
| Season | Kano | Yobe |
| Dry | 6.5$^b$ | 5.3$^b$ |
| Rainy | 0.8$^a$ | 0.8$^a$ |
| SE± | 1.85 | 4.10 |

Mean followed by different letters in the same column are significantly different at *p* = .05 level of probability according to the least significant difference (LSD) test.

## Results

### Abundance of *H. armigera* Larvae on Tomato Plants during Dry and Rainy Season in Kano and Yobe State

Table 1 shows the abundance of *H. armigera* larvae per plant in both dry and rainy season in the Kano and Yobe states. The result indicates that there is a significant difference (p< 0.05) between the dry and rainy season for both states. Significantly high numbers of *H. armigera* larvae were recorded during the dry season compared to the rainy season in both States.

**Table 2**
*Abundance of H. armigera Larvae on Upper and Lower Part of Tomato Plant at 6, 8, 10 and 12 weeks after planting in Kano State.*

| WAP | Upper | Lower |
|---|---|---|
| 6 | 1.7$^{ab}$ | 0.7$^a$ |
| 8 | 1.7$^{ab}$ | 3.8$^b$ |
| 10 | 3.5$^b$ | 0.8$^a$ |
| 12 | 0.2$^a$ | 0.3$^a$ |
| SE± | 1.44 | 0.99 |

*Mean followed by different letters in the same column are significantly different at p =.05 level of probability according to the least significant difference (LSD) test.*

### Abundance of *H. armigera* Larvae on Upper and Lower Parts of Tomato Plant at 6, 8, 10 and 12 Weeks After Planting (WAP) in Kano State

Table 2 shows the abundance of *H. armigera* larvae on the upper and lower part of tomato plants in Kano state at 6, 8,10 and 12 WAP. The result reveals a significant difference ($p$ <.05) in the number of larvae obtained at different WAP in the upper and lower part of the tomato plant. On the upper part of the tomato plant, significantly high numbers of *H. armigera* larvae were recorded at 10 WAP, but this number was not statistically different from the number of larvae obtained at 6 and 8 WAP and the least number *H. armigera* larvae were obtained at 12 WAP, however, this number was not different statistically from the number of *H. armigera* larvae obtained at 6 and 8 WAP. When the lower part of the plant is been considered, a significantly high number of *H. armigera* larvae was obtained at 8 WAP compared to the remaining WAP, and the least number of *H. armigera* larvae was obtained at 12 WAP but was at par with the number of *H. armigera* larvae obtained at 6 and 10 WAP.

**Table 3**

*Abundance of H. armigera Larvae on Upper and Lower Parts of Tomato Plant at 6, 8, 10 and 12 weeks after planting in Yobe state*

| WAP | Upper | Lower |
|---|---|---|
| 6 | $3.7^{a}$ | $1.0^{ab}$ |
| 8 | $2.7^{a}$ | $3.3^{b}$ |
| 10 | $1.2^{a}$ | $0.2^{a}$ |
| 12 | $0.2^{a}$ | $0.0^{a}$ |
| SE± | 2.75 | 1.55 |

Mean followed by different letters in the same column are significantly different at p = .05 level of probability according to the least significant difference (LSD) test.

### Abundance of *H. armigera* Larvae on Upper and Lower Parts of Tomato Plant at 6, 8, 10 and 12 Weeks After Planting (WAP) in Yobe State

Table 3 shows the abundance of *H. armigera* larvae on upper and lower parts of tomato plants in Yobe State at 6, 8,10 and 12 WAP. The result reveals that there is no significant difference ($p$ <.05) in the number of *H. armigera* larvae at the different WAP on the upper part of a tomato plant. When the lower part of the plant is being considered significant difference was observed between the different WAP. A significantly high number of *H. armigera* larvae was recorded at 8WAP but was different statistically from the number of *H. armigera* larvae recorded at 6 WAP, and the least number of *H. armigera* larvae was obtained at 12 WAP but was at par with the number of *H. armigera* larvae obtained at 6 and 10 WAP.

**Table 4**

*Distribution Statistics and Dispersion Indices of H. armigera Larvae on Tomato*

| S/No. | Mean (X) | Variance ($S^2$) | ($S^2$/ X) | Mean/ shoot | GC ($C_x$) | Lloyds (M*) |
|---|---|---|---|---|---|---|
| 1 | 0.75 | 28 | 37.33 | 0.16 | 177.95 | 49.19 |
| 2 | 1.38 | 93.63 | 68.09 | 0.30 | 324.30 | 50.17 |
| 3 | 0.50 | 12.75 | 25.50 | 0.10 | 122.60 | 49.50 |
| 4 | 0.63 | 19.63 | 31.40 | 0.13 | 150.70 | 49.27 |
| 5 | 0.75 | 28.25 | 37.67 | 0.16 | 180.54 | 49.63 |
| 6 | 0.88 | 38.63 | 44.14 | 0.18 | 211.41 | 50.18 |
| 7 | 0.88 | 38.13 | 43.57 | 0.18 | 208.70 | 49.53 |
| 8 | 1.25 | 77.75 | 62.20 | 0.26 | 297.50 | 50.21 |
| 9 | 1.13 | 63.63 | 56.56 | 0.24 | 270.58 | 50.51 |
| 10 | 1.00 | 50.75 | 50.75 | 0.21 | 242.90 | 50.75 |
| 11 | 0.38 | 7.38 | 19.67 | 0.08 | 94.74 | 50.15 |
| 12 | 0.38 | 7.88 | 21.00 | 0.08 | 101.10 | 53.71 |
| 13 | 0.13 | 0.88 | 7.00 | 0.03 | 34.37 | 48.13 |
| 14 | 0.75 | 28.50 | 38.00 | 0.16 | 182.13 | 50.08 |
| 15 | 0.38 | 7.38 | 19.67 | 0.08 | 94.74 | 50.15 |
| 16 | 0.63 | 19.63 | 31.40 | 0.13 | 150.70 | 49.27 |
| 17 | 0.50 | 12.75 | 25.50 | 0.10 | 122.55 | 49.50 |
| 18 | 0.38 | 7.13 | 19.00 | 0.08 | 91.57 | 48.38 |
| 19 | 0.68 | 20.13 | 32.20 | 0.13 | 154.50 | 50.55 |
| 20 | 0.25 | 3.25 | 13.00 | 0.05 | 62.97 | 48.25 |
| 21 | 0.50 | 12.50 | 25.00 | 0.10 | 120.20 | 48.50 |
| 22 | 0.625 | 20.125 | 32.20 | 0.13 | 154.50 | 50.55 |
| 23 | 0.13 | 0.88 | 7.00 | 0.03 | 34.37 | 48.13 |
| 24 | 0.75 | 28.00 | 37.33 | 0.16 | 178.96 | 49.19 |
| 25 | 0.75 | 28.50 | 38.00 | 0.16 | 182.13 | 50.083 |
| 26 | 0.25 | 3.25 | 13.00 | 0.05 | 62.97 | 48.25 |
| 27 | 0.13 | 0.88 | 7.00 | 0.026 | 34.37 | 48.13 |
| 28 | 0.50 | 12.75 | 25.50 | 0.10 | 122.55 | 49.50 |
| 29 | 0.38 | 7.38 | 19.67 | 0.08 | 94.74 | 50.15 |
| 30 | 0.38 | 7.38 | 19.67 | 0.08 | 94.74 | 50.15 |

X=Mean, $S^2$ =Variance, S2/ X=Mean/shoot, C x=Greens coefficient and M*=Lloyds

### Population Dispersion of *H. armigera* Larvae

The distribution patterns of *H. armigera* larvae on tomato plants were established by various indices of dispersion. Our result reveals the dispersion pattern of *H. armigera* larvae to be highly aggregated within tomato plants. All the tomato plants sampled, show variance to mean ratio ($S^2/m$) of greater than one with values ranging from 68.09 to 7.00 (Table 4). Furthermore, the Greens coefficient ($C_x$) values and the Lloyd's mean crowding ($m^*$)values of all the tree sampled were greater than one confirming the distribution of *H. armigera* larvae on tomato plant to be aggregative.

## Discussion

The Abundance of *H. armigera* larvae on tomato plants depends on the season, cropping system, and developmental stage of the plant. A significantly high number of *H. armigera* larvae was observed during the dry season compared to the rainy season in both states. This may be due to the low quantity of eggs hatching as rainfall might have washed away the eggs. The high population of *H. armigera* larvae obtained at 8 and 10 WAP may be attributed to the presence of fully grown unripe tomato fruit, which coincides with 8 and 10 WAP. It was reported that *H. armigera* larvae prefer unripe fruits to leaves and ripe fruits (Czepak et al., 2013; Queiroz et al., 2018). Our findings agree with Murúa et al. (2014) who reported that *H. armigera* larvae prefer green fruits, as well as that of Mondal et al. (2019) *H. armigera* larvae reach their peak period during the fruiting stage. However, our findings contradict reports of Chula et al. (2017) who observed a high larval population of *H. armigera* during the entire crop period and the finding of Perkin et al. (2010) which reveals that *H. armigera* larvae prefer the vegetative part of plants over fruits.

The dispersion pattern of *H. armigera* larvae depends on the egg-laying habit of the female moths, the age of the larvae, variation in growth among the host plants, and the occurrence of natural enemies, among other biotic and abiotic factors (Khaing et al., 2002). The result shows that the dispersion pattern of *H. armigera* larvae on tomato plants is aggregated. This suggests their preference for the upper parts of the plant over the lower parts. This outcome conforms with Khaing et al. (2002), who reported an aggregate distribution pattern of *H. armigera* larvae on cotton plants. Mallampulli & Isaacs (2002) also reported the aggregate distribution of *H. armigera* on high-bush blueberries.

Abundance and dispersion of individuals are important characteristics of populations, affecting their spatial pattern of resource use and their effect on community and ecosystem attributes. Thus, the results of this study may come in handy for developing a successful management strategy for *H. armigera,* particularly if IPM is desired, where monitoring is an essential component to reduce unnecessary insecticide application. However, since this study was conducted in an open field in a savannah agro-ecological zone, its application to other agro-ecological zones needs to be investigated

## Conclusion and Recommendations

The findings of this study showed that the population of *H. armigera* larvae is aggregated on the upper part of tomato plants at 8 WAP, exhibits higher densities during the dry season, and prefers developed fruits. The dispersion pattern of *H. armigera* larvae on tomato plants is aggregated. Based on the findings, it is recommended that when managing *H. armigera*, farmers should spray on a plant-by-plant basis and concentrate their efforts on the upper parts of the plant.

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