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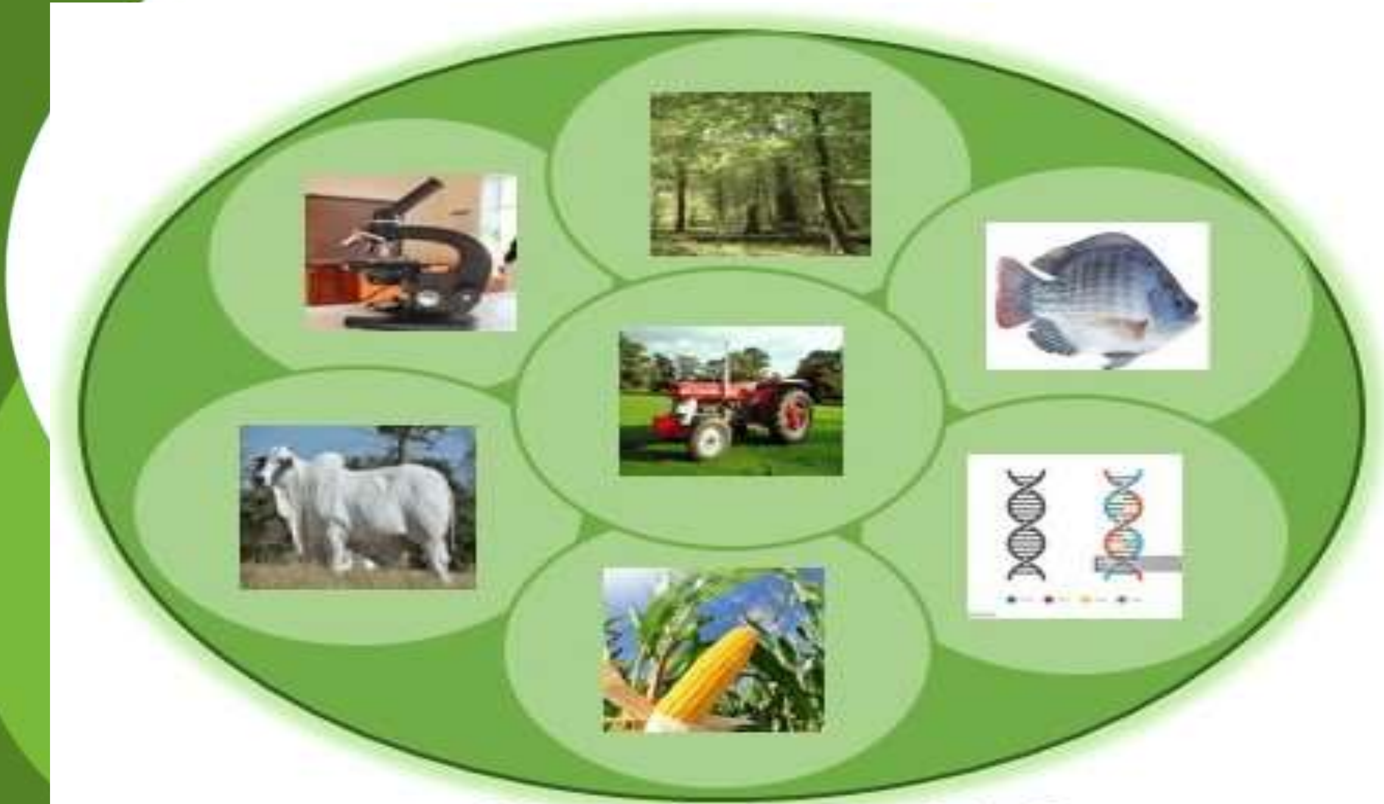

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This official scientific publication of the Faculty of Agriculture, Abdullahi Fodiyo University of Science and Technology Aliero, is a non-profit, open access, double-blind peer-reviewed Journal publishing four issues (January, April, July and October) per annum. The Journal is a platform open to collaborations with researchers, authors, institutions, research agencies and private companies related to Agriculture. The Mission of the Journal is to disseminate scientific knowledge through the publication of original research articles, research notes, book reviews, letters to the editor and reviews of Literature, representing a contribution to scientific and technological knowledge in respective areas covered by the Journal. The Kebbi Journal of Agriculture and Natural Sciences seeks to validate and disseminate new knowledge, making it public in order to strengthen the human capacity, constitute a link in the scientific community to the society and encouraging the expansion of University and academic researches.

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The first page of the manuscript should contain the title of the article, which should be concise and explicit, typed with upper-case, bold, 14 font size, TNR and not more than 21 words. The surname and forenames (in full) of authors, affiliation of each author should be provided. Phone number and email address of the corresponding author (identified by an asterisk) should be provided. Superscripts should be used to relate authors to their affiliations.

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Avoid the use of figures /numbers at the beginning of a sentence. Write out one through nine unless a measurement, a designator, or a range (e.g five seeds, 8cm, 3yr, 5-11 flowers)

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ASSESSMENT OF MORPHOLOGICAL RESPONSES IN EGGPLANT (*SOLANUMMELONGENA* L.) TO WHITEFLY (*BEMISIA TABACI* GENN.) INFESTATION STRESS

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ABSTRACT

Whiteflies (Bemisia tabaci Genn.) are destructive sugar-robbing insect pests that depend primarily on plant leaf tissue for their nourishment thus, causing direct and indirect infestation effects in different fruits and vegetables. In this study, the effect of whitefly infestation on the green round eggplant (Solanum melongena L.) cultivar was evaluated in an indoor condition using standard experimental methods. The trial was carried out using completely randomized design (CRD) with four treatments (T_1 = 15, T_2 = 30, T_3 = 45 and T_4 ((control) = 0 whiteflies/plot) and four replications. The experiment consists of 16 plots, each measuring 1x1m^2 with 0.5 m space between the plots, thus measuring 5.5x5.5m^2 wide and length respectively. The results revealed the level of leaf damage and its effects on the morphological features of eggplant due to whitefly infestation. The infestation led to the emergence of multiple symptoms, such as leaf discoloration, deformation, reduced plant growth, the presence of holes, the deposition of honeydew and the formation of sooty mold, which collectively resulted in substantial leaf damage. Plants in T_3 were most affected with 90.10 and 93.18% leaf damage while the least (70.00 and 68.00%) were found in $T_{1,}$ 12 weeks after infestation during the 2022 and 2023 experiments. Among the morphological parameters assessed, leaf fresh weight was most affected (11.9g/leaf and 11.7g/leaf) in T_1 and T_3 respectively, representing 47.6 and 55.3% reduction at 90 days after infestation (DAI). It was followed by plant height (37.6 and 38.9cm) representing 46.7 and 46.5% reduction in the year 2022 and 2023 respectively. The least effect was observed in leaf area recording 32.1 and 31.9% reduction in the respective cropping seasons at 90 DAI. The lowest yield was recorded in T_3 (40.0 and 31.8kg/ha) compared to 367.9 and 318.1kg/ha in the control group, representing 89.1 and 90.0% reduction in yield at 90 DAI.These indicate the high level of whitefly feeding effect on eggplant, demonstrating the need for providing sustainable whitefly control methods to protect and enhance the productivity of the crop.

*Keywords**:** Whiteflies, eggplant, damage assessment, plant yield and infestation.*

Introduction

Eggplant (*Solanummelongena* L.) is among the most popularly grown vegetables in the family solanaceae (Chapman, 2019), as it was ranked 5th following tomatoes, onions, cucumbers and cabbages with regards to total universal production (Alam and Salimullah, 2021). The members of this family provide good number of nutrients and other substances that are beneficial to human health, which explains in

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part why it has a high variety of species utilized for food or medication (Meyer *et al*., 2015; Chapman, 2019). Eggplant is also recognized as a rootstock for tomatoes due to its tolerance to waterlogging and pathogenic attack (Bletsos *et al*., 2003; Meyer *et al*., 2015).

Despite the benefits, eggplant growth has been hindered by whitely infestations (Islam *et al*., 2011; Lee *et al*., 2018). Decrease in the fresh leaf area, leaf fresh and dry weights were reported as 26.6, 21.8 and 19.27% respectively due to whitefly feeding effects (Islam and Shunxiang, 2009). Similarly, the chlorophyll content and photosynthetic activity were negatively affected and reduced by 9.7 and 65.9% respectively (Islam and Shunxiang, 2009). Furthermore, infestation by large population of whiteflies leads to dropoff of immature leaves, and release of sugary excreta (honeydew) thatprovides breeding ground sooty mold. Sooty mold turns the leaves black, decrease the rate of photosynthesis, affects plant vigor and consequently the quality of farm produce (Perring *et al*., 2018). Whiteflies feeding also lead to leaf mosaic and wrinkling, which cause stunting and disfigured fruits (Sani *et al*., 2020).

Eggplant growth faces significant challenges due to whitefly infestations (Islam *et al*., 2011; Lee *et al*., 2018) as it has been shown to reduce fresh leaf area, leaf fresh weight, and leaf dry weight by 26.6%, 21.8%, and 19.27%, respectively (Islam and Shunxiang, 2009). Additionally, chlorophyll content and photosynthetic efficiency are negatively affected, decreasing by 9.7% and 65.9%, respectively (Islam and Shunxiang, 2009). High populations of whiteflies also cause premature shedding of young leaves and release honeydew, a sugary excretion that fosters the growth of sooty mold. This mold darkens the leaves, impairs photosynthesis, reduces plant vitality, and decreases the overall quality of the crop (Perring *et al*., 2018). Whitefly feeding also leads to leaf mosaic patterns, leaf wrinkling, stunted plant growth, and the formation of deformed fruits (Sani *et al*., 2020).

Beside the physiological effects, whitefly infestation also affects eggplant structural tissues causing multiple necrotic rings on the leaves (Abubakar *et al*., 2022), blanching of vegetative structures, and irregular ripening or other abnormalities of fruiting structures. As a phloem feeder, *B. tabaci* can also reduce the eggplant productivity by directly consuming the carbohydrates along with other nutrients through the plant's vascular system. Islam and Shunxiang (2009) reported that leaf anatomy particularly the vascular tissue of eggplant was negatively affected by whitefly infestation, where they demonstrated that the xylem of damaged vascular bundles of infested leaf could not transport water and dissolved ions from the roots to the leaves as they are composed of various cell types including tracheids and vessel elements. The phloem was unable to transport synthesized organic substances such as carbohydrates and other products of photosynthesis from the leaves to other regions of the plant. However, they reported that the eggplant epidermis and mesophyll were not damaged by whitefly infestation but there were some damage tissue observed in the vascular bundle of infested leaf (Islam and Shunxiang, 2009).

Whiteflies are known to vector over 350 plant viruses (Lu *et al*., 2019; Estefanía Rodríguez *et al*., 2019), with crops such as eggplant, tomato, potato, and soybean being particularly susceptible to these viral infections (Kedar *et al*., 2014). Begomoviruses, in particular, are a major cause of reduced crop productivity, leading to yield losses ranging from 20% to 100%, resulting in millions of dollars in economic damage (Gangwar*et al*., 2018). Whiteflies transmit several important viruses, including Eggplant mild leaf mottle virus

(EMLMV) (Lapidot *et al*., 2014), Tomato torado virus (ToTV) (Amari *et al*., 2017), Tomato chlorosis virus (ToCV), and Tomato yellow leaf curl virus (TYLCV), which affect both tomatoes and eggplants (Fidan and Sarikaya, 2020). In summary, whiteflies are among the most destructive agricultural pests, causing both direct and indirect damage to a wide range of vegetables and food crops, with potential crop losses reaching up to 100% (Barkman, 2013; Singh and Aggarwal, 2023).

Gaining an understanding on the level of damage caused by whitefly vectors is essential for developing and implementing effective control strategies to reduce their detrimental effects on various vegetables. Such knowledge will also enhance our ability to predict how plants will grow under whitefly infestation by offering a deeper insight into the morphological responses of eggplants to the stress caused by these pests. Therefore, this study was conducted to assess the morphological changes in the green round eggplant variety resulting from whitefly infestation stressin Aliero Local Government Area, Kebbi State, Nigeria.

Materials and Methods

Study area

The experimental works were carried out in agricultural research farm of the Kebbi State University of Science and Technology, Aliero, Nigeria. The area is on the latitude 12° 13' 19.88" N, longitude of 4° 22' 46.67'E." The area has dry and wet seasons. The wet season begins in May and extended to late September while dry season lasts from October to May. The mean annual rainfall is of the area 500 mm and that of temperature is 31°C respectively. Most of the occupants in the area are farmers cultivating different food and vegetable crops for their sustenance (Abubakar *et al*., 2020).

Plant culture and insect collection

The seedlings of the green round eggplant variety were raised using standard procedure and used for this experiment (Ghosh, 2022; Abubakar and Koul, 2023), being the most cultivated cultivar in the area. The insects used for the study (*Bemisia tabaci* Genn.) were collected from the vegetables (watermelon, eggplants and tomatoes) in the farmers' field using aspirators. The required number of whiteflies for each plot was counted as they were being caught from the field and they were released gently by slightly shaking the aspirator at the lower surface of the eggplant leaves in the experimental plots.

Experimental design and procedure

Indoor experiment was conducted using completely randomized design (CRD) consisting of four treatments (T_1= 15, T_2= 30, T_3= 45 and T_4= control with 0 whiteflies/plots) replicated four times. The experiment consisted of sixteen (16) plots, each measuring $1x1m^2$ with 0.5 m space between the plots, thus measuring $5.5x5.5m^2$ wide, length respectively. In each plot, three earthen pots were installed in a triangular setting at 60x60cm spacing and each pot was transplanted with a single eggplant plantlet and the plots were demarcated with mosquito nets. The required number of whiteflies for each plot (15, 30, and 45 whiteflies) were counted as they were caught from the vegetable fields using aspirator and then released into the demarcated plots by gently shaking the aspirator at the lower surfaces of the eggplant leaves, a week after transplanting (Padilha *et al*., 2021). The recommended agronomic practices which include irrigation, weeding, and fertilizer application were provided uniformly in all the plots during the trials. The data on the symptoms of whitefly infestations (leaf cholorosis, honey dew deposition, leaf yellowing, distortion, darkening and stunting,

as well as sooty mold development) were observed and recorded weekly. Three leaves (from the top, middle and bottom regions) of each plant were selected randomly for data collection. To assess the leaf damage caused by whiteflies per plant, a visual rating scale of 1 – 5 was adopted; where 1 = 0 – 20%, 2 = 21 – 40%, 3 = 41 – 60%, 4 = 61 – 80% and 5 = 81 – 100% of foliage damaged by whiteflies (Anjorin *et al*., 2013). The data on the effect of whitefly infestations on the growth parameters of eggplant were recordedat an interval of 30 days (approximate time for single whiteflies life cycle) throughout the plant growth period. Plant height (cm) was measuredusing a measuring tape,
leaf area (cm^2) using the formula, F (L x W); (where F= constant factor, L= leaf length and W = width of the leaf), leaf fresh weight (g) using digital weighing device (M-METLAR digital balance) and number of leaves per plantby counting the total number of leaves per each plant. Plant yield per plot was determined at harvest, while the reduction (%) in growth parameters was determined using following equation: Reduction (%) = (control – infested)/control x100 (Islam *et al*., 2011; Saeedi and Ziaee, 2020).

Statistical analysis
The data was analyzed using a statistical tool for agricultural research (STAR version 2.0.1) by means of ANOVA and means were separated using least significant difference (LSD) at 5% level of significance.

Results
Symptoms development and leaf damage
Whitefly infestation caused a number of symptoms (leaf mosaic, stunting, darkening, honeydew deposition and sooty mold emergence) on the eggplant variety examined **(**Fig 1**)**. The accumulation of such effects led to substantial leaf damage (%) with treatments differing significantly from week 2 to 12 in the respective cropping periods. The highest leaf damages were recorded at week 12 with plants in T_3 (90.1 and 93.2%) while the least (0.4 and 0.3%) were recorded in T_4 at week 4 after infestation in 2022 and 2023 trials **(**Fig 2 and 3).

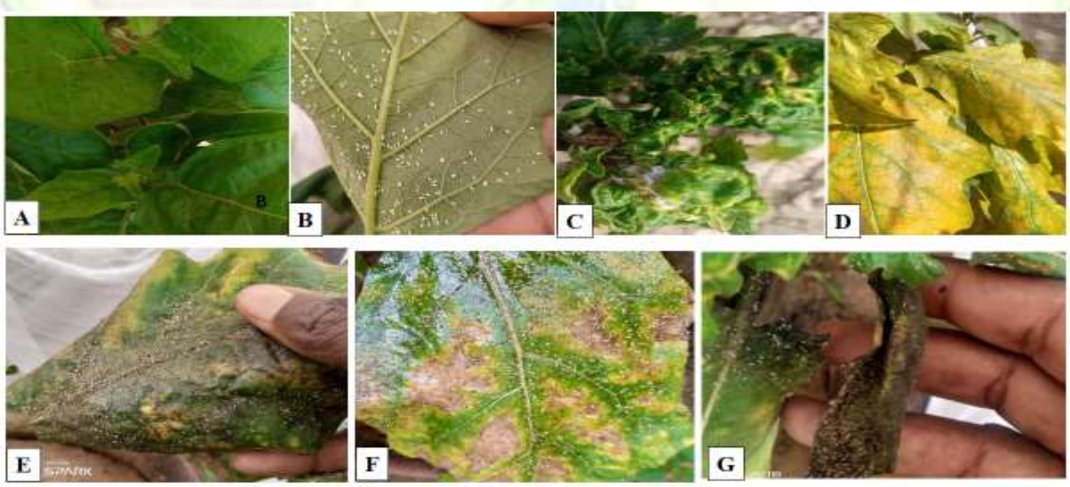

Fig 1: Symptoms development due to whitefly infestation and on the eggplant leaf during the 2022 and 2023 cropping seasons. A: Healthy leaves; B: Whiteflies on the leaf; C: Folded/stunted leaves; D: Leaf yellowing; E: Darkening of leaf; F: Leaf mosaic; G: Reduced blacken leaves with honey dew and sooty mold

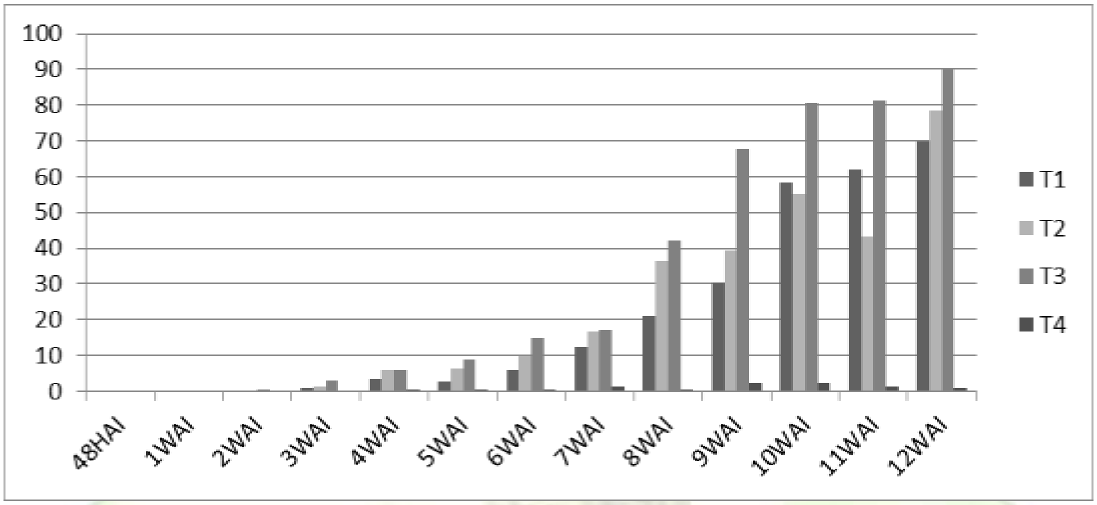

Fig 2: Leaf damage (%) due to whitefly infestation during the 2022 experiments

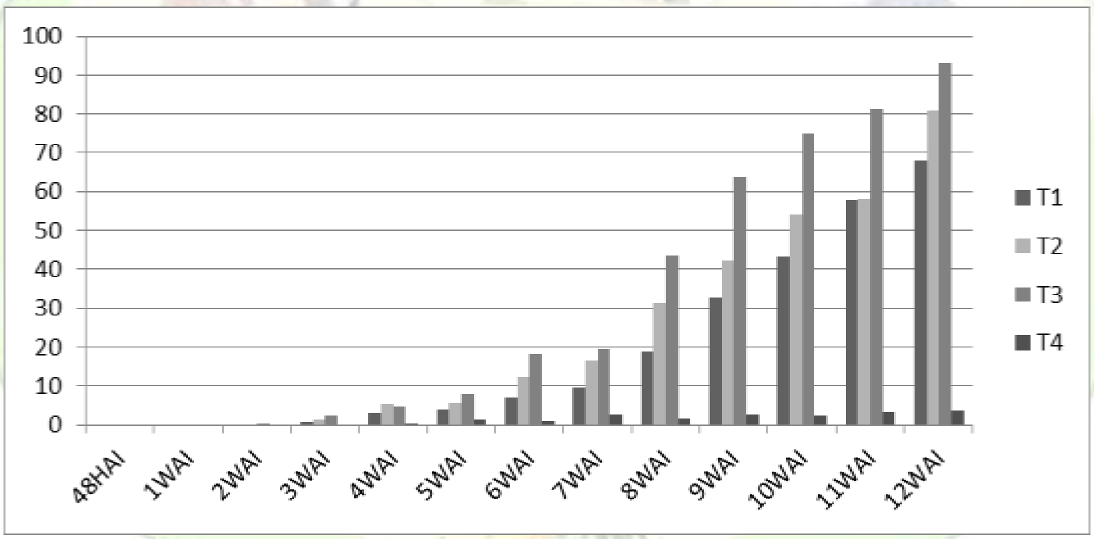

Fig 3: Leaf damage (%) due to whitefly infestation during the 2023 experiment. WAI= Week after infestation, HAI= Hours after infestation, T=Treatment (T1= 15, T2= 30, T3= 45 and T4= control with 0 whiteflies/plot).

Effect of whitefly infestation on the morphological features of eggplant

Plant height (cm)

The whitefly feeding effects on the plant height during the two consecutive cropping periods (2022 and 2023) in the pot experiment were presented in table 4.11. At 48 h, there was no significant difference between all the treatments (P=0.871) with plant height being highest inT_3 (14.3 cm) after the control plot (T_4) (14.8 cm), while T_1 had the least (13.9cm) in 2022. At 30 and 90 days, significant differences were observed (P<0.0001) with plants in T_3also having lesser effects (27.1 and 37.6 cm) while those in T_1 had the highest (35.6 and 54.8 cm). Similar result was also recorded (P=0.102) at 60 days after infestation, with plants in T_3 having the least (42.4 cm) and those in T_1having the highest (51.9 cm) in

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2022. In 2023, no significant differences were found at 48 h (P=0.059) and 60 (P=0.221) days after infestation, but at 30 (P=0.003) and 90 (P<0.0001) days, the treatments differed significantly with plants in T_3 being more affected (29.1 and 38.9 cm) and those in T_1 being less affected (37.0 and 52.5 cm) compared to the control plots (38.5 and 72.9 cm) **(**Table 1).

Table 1: Effect of whitefly infestation on the plant height (cm) during the 2022 and 2023

Treatments	Year							
	2022				2023			
	48HAI	30DAI	60DAI	90DAI	48HAI	30DAI	60DAI	90DAI
T1	13.9^a	35.6^b	51.9^a	54.8b	12.2^b	37.0^a	48.1^a	52.5^a
T2	14.2^a	31.3^c	46.6 ^{a}	41.6c	15.0^a	32.7^b	44.8^a	43.4^{bc}
T3	14.3^a	27.1^d	42.4 ^{a}	37.6c	13.1^b	29.1^c	40.9^a	38.9^c
T4	14.8^a	39.1^a	54.5^a	70.6a	13.2^a	38.5^a	52.0^a	72.9^a
C.D.	0.0	2.9	0.0	6.3	0.0	3.0	0.00	11.5
SEM±	1.0	1.3	4.7	2.9	0.9	1.6	2.3	4.7
C.V. (%)	9.6	5.7	13.8	7.9	9.6	6.6	15.7	12.8
P-value (5%)	0.871	<0.0001	0.102	<0.0001	0.059	0.003	0.221	<0.0001

Means with the same common letter in the same column are not significantly different from each other (P< 0.05). C.D. = Critical difference, C.V.= Coefficient of variance, SEM =Standard error means, HAI=Hours after infestation, DAI= Days after infestation, T=Treatment (T1= 15, T2= 30, T3= 45 and T4= control with 0 whiteflies/plot).

Number of leaves

The effects of whitely feeding on the number of leaves were shown in Table 2. The results were statistically similarat 48 h (P=0.093) and 60 days (P=0.457) between all the treatments. Plants in T_1 had the highest (5.1 leaves/plant) followed by those in T_4 (5.0leaves/plant) while those in T_2 recorded the lowest (4.2 leaves/plant) at 48 h after infestation. At 60 days, plants in T_3 were most affected (34.3 leaves/plant) while those in T_1 were less affected (37.1 leaves/plant) in 2022 trial. Similar results were found at 30 and 90 days with plants in T_3 being more affected while those in T_1 and T_2 were less affected on the respective days (30 and a 90) after infestation. In the 2023, T_4 has the highest number of leaves (5.7 leaves/plant) with T_2 having the least (4.7 leaves/plant) 48 h after infestation as there is no significant difference (P=0.598) between the treatments. At 30 days, T_3differed significantly (0.013) from the remaining treatments with 7.4 leaves/plant while T_2 had the highest (11.0leaves/plant) as compared to the control (12.8 leaves/plant). At 90 days, plants in treated plots were similar, but differed significantly (P=0.001) with those in control plots in 2023 trial. The control plots maintained the highest number of leaves at 60 (41.9 and 41.2 leaves/plant) and 90 (54.5 and 56.1 leaves/plant) days after infestation, with T_3 and T_2 having the least recording 32.3 leaves/plant each, in the year 2022 and 2023 respectively.

Table 2: Whitefly infestation effect on the number of leaves in 2022 and 2023 experiments

Treatments	Year							
	2022				2023			
	48HAI	30DAI	60DAI	90DAI	48HAI	30DAI	60DAI	90DAI
T1	5.1^{a}	11.0^{a}	37.1^{a}	33.2^{b}	5.1^{a}	9.4^{bc}	38.9^{a}	32.3^{b}
T2	4.2^{a}	8.9^{b}	36.7^{a}	39.7^{b}	4.7^{a}	11.0^{ab}	35.1^{a}	41.3^{b}
T3	4.6^{a}	7.2^{c}	34.3^{a}	32.3^{b}	5.6^{a}	7.4^{c}	33.8^{a}	33.4^{b}
T4	5.0^{a}	10.8^{a}	41.9^{a}	54.5^{a}	5.7^{a}	12.8^{a}	41.2^{a}	56.1^{a}
C.D.	0.0	1.7	0.0	10.2	0.0	3.1	0.0	9.8
SEM±	0.3	0.6	2.8	3.3	0.6	1.0	4.4	3.1
C.V. (%)	11.5	11.8	12.3	16.4	21.2	19.5	16.5	15.4
P-value (5%)	0.093	0.001	0.547	0.002	0.598	0.013	0.345	0.001

Means with the same common letter in the same column are not significantly different from each other (P<0.05). C.D. = Critical difference, C.V.=Coefficient of variance, SEM =Standard error means, HAI=Hours after infestation, DAI=Days after infestation, T=Treatment (T1= 15, T2= 30, T3= 45 and T4= control with 0 whiteflies/plot).

Leaf area (cm^2)

Table 4.13 presents the result of whitefly feeding effects on leaf area in the pot trials during the 2022 and 2023 cropping seasons. The results showed that there was no significant difference among all the treatments at 48 h (P=0.085and 2023 (P=0.679) in 2022 and 2023 respectively. The results differed significantly at 30 (P=0.0003) and 90 (P<0.0001) days after infestation, with plants in T_3 being most affected with 67.6 and 191.2 cm^2 respectively during the year 2022. In 2023, significant differences were also observed with plants in T_3 having the least leaf area at 30 (67.8 cm^2), 60 (226.7cm^2) and 90 (191.2 cm^2) days after infestation. The untreated controls (T_4) had the highest leaf area at all the data recording periods in the respective experiments with the highest leaf number found at 90 days (281.5 and 280.7 cm^2) in T_4 and lowest (17.7 and 19.8 cm^2) were recordedin T_1 at 48 h after infestation in the respective cropping seasons **(**Table 3**)**.

Fresh weight of leaves (g)

The whitefly infestation also affected the fresh weight of eggplant leaves in the pot experiments. At 48 h, the treatments were not significantly different from each other and from the control (P=0.190 and 0.740) in 2022 and 2023 experiments. Plants in T_4 recorded the higher fresh weight value (3.8 g), followed by T_2 (3.2g) while T_1 has the least (2.3g) in 2022. In 2023, T_4 has the highest (3.6g) followed by T_1 (3.1g) with T_2 having the least (2.8g). At 30, 60 and 90 days, the control plots had higher fresh weight values (8.3, 22.1 and 22.7g) with T_3 having the least (4.8 and 16.4g) at 30 and 60 days while T_2 recorded the least (11.9g) at 90 days after infestation in 2022 trial. In 2023, T_3 had the least fresh weight values (4.9, 14.4 and 11.7g) while T4 had the highest (7.2, 24.7 and 26.2g) at 30, 60 and 90 days respectively. The results differed significantly between T_1 and the rest of the treatments at 90 days after infestations in 2022, while in 2023, the control (T_4) differed significantly (P<0.0001) from the remaining plots at 90 days after infestation (Table 4**)**.

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Table 3: Effect on the leaf area (cm^2) of eggplant during the 2022 and 2023 experiments

Treatments	Year							
	2022				2023			
	48HAI	30DAI	60DAI	90DAI	48HAI	30DAI	60DAI	90DAI
T1	20.8[a]	91.2[a]	249.3[b]	200.8[b]	20.5[a]	90.4[a]	242.0b	225.8[b]
T2	22.4[a]	72.0[b]	234.8[c]	198.3[bc]	22.1[a]	72.9[b]	230.5[bc]	197.3[c]
T3	17.7[a]	67.6[b]	241.3[c]	191.2[c]	19.8[a]	67.8[b]	226.7c	191.2[c]
T4	23.8[a]	103.5[a]	257.9[a]	281.5[a]	22.6[a]	97.4[a]	262.0[a]	280.7[a]
C.D.	0.0	0.9	8.72	7.71	0.0	14.30	13.86	11.9
SEM±	1.6	0.3	3.6	2.38	1.9	4.4	4.27	4.9
C.V. (%)	14.0	10.6	2.1	2.7	17.4	9.7	3.6	3.1
P-value (5%)	0.085	0.0003	0.002	<0.0001	0.679	0.001	0.0004	<0.0001

Means with the same common letter in the same column are not significantly different from each other (P< 0.05). C.D. = Critical difference, C.V.=Coefficient of variance, SEM =Standard error means, HAI=Hours after infestation, DAI= Days after infestation, T=Treatment (T1= 15, T2= 30, T3= 45 and T4= control with 0 whiteflies/plot).

Table 4: Effect on the fresh weight (g) of leaves during the 2022 and 2023 experiments

Treatments	Year							
	2022				2023			
	48HAI	30DAI	60DAI	90DAI	48HAI	30DAI	60DAI	90DAI
T1	2.3[a]	7.1[b]	18.9[a]	14.2[b]	3.1[a]	5.9[a]	16.7[b]	17.1[b]
T2	3.2[a]	5.9[c]	17.3[a]	11.9[b]	2.8[a]	6.2[a]	18.5[ab]	14.0[c]
T3	2.8[a]	4.8[d]	16.4[a]	13.8 [b]	2.9[a]	4.9[a]	14.4[b]	11.7[c]
T4	3.8[a]	8.3[a]	22.1[a]	22.7[a]	3.6[a]	7.2[a]	24.7[a]	26.2[a]
C.D.	0.0	0.9	0.0	3.8	0.0	0.0	5.9	3.7
SEM±	0.6	0.3	1.7	1.5	0.5	0.6	1.9	0.9
C.V. (%)	29.4	8.8	15.0	13.9	35.0	20.5	15.7	10.8
P-value (5%)	0.190	<0.0001	0.226	0.0004	0.740	0.117	0.017	<0.0001

Means with the same common letter in the same column are not significantly different from each other (P< 0.05). C.D. = Critical difference, C.V.=Coefficient of variance, SEM =Standard error means, HAI=Hours after infestation, DAI= Days after infestation, T=Treatment (T1= 15, T2= 30, T3= 45 and T4= control with 0 whiteflies/plot).

Plant yield (kg/ha)

The infestation by whiteflies also affected the crop yield in pot experiments. The highest yield (367.9 and 318.1kg/ha) were recorded in the control plots (T_4) while the least were found in T_3 (40.0 and 31.8 kg/ha) during 2022 and 2023 experiments. The results differed significantly (P<0.0001) between the control and treated plots in 2022 trial. Similar results were recorded in 2023, with T_4 differing significantly (P<0.0001) from all the treated plots **(**Table 5).

Table 5: Plant yield (kg/ha) during the 2022 and 2023 pot experiments

Treatments	2022	2023
T1	66.3[b]	68.6[b]
T2	54.5[c]	56.8[c]
T3	40.0[d]	31.8[d]
T4	367.9[a]	318.1[a]
C.D.	14.0	14.4
SEM$\pm$	4.5	4.6
C.V. (%)	4.3	4.9
P-value (5%)	<0.0001	<0.0001

Means with the same common letter in the same column are not significantly different from each other (P< 0.05). C.D. = Critical difference, C.V. = Coefficient of variance, SEM =Standard error mean, g= gram, T=Treatment (T1= 15, T2= 30, T3= 45 and T4= control with 0 whiteflies/plot).

Discussion

The present study revealed that whitefly feeding had significant detrimental effects on the morphology of eggplant leaves, resulting in a range of symptoms such as chlorosis, stunting, leaf holes, curling, yellowing, darkening, honeydew secretion, and sooty mold growth. These symptoms negatively impacted the overall growth and yield of the eggplant cultivar. The damages appeared gradually, with leaf yellowing and mosaic being the first observable signs, followed by honeydew secretion, dehydration, and darkening of the leaves. The cumulative effects of these symptoms led to severe leaf damages and near-total crop destruction. The results indicated that plants in T3, which had the highest whitefly density, were the most affected, while those in T1 experienced minimal damage. The control plots (T4) remained healthy throughout the trial. This suggests that the extent of damage is dependent on the density of whitefly populations, with higher populations resulting in more severe damages. In all treatments, the cumulative effects and leaf damages were minimal during the first 30 days after infestation. However, by day 60, the damage increased significantly, with leaves in treated plots becoming crumpled, dehydrated, and nutrient-deficient, highlighting the impact of prolonged infestation periods on whitefly damage in controlled environments. This aligned with the results Ghosh (2022) who reported leaf and fruit deformation, defoliation, early wilting, reduced growth, and lower yield in different vegetables. due to whiteflies infestations. Similarly, Calvo *et al*. (2009) demonstrated that tomato leaf morphology was negatively affected by whiteflies resulting in multiple infestation symptoms including necrotic rings on the leaves.

The study also found that whitefly infestation negatively affected the growth parameters of eggplant, including plant height, leaf number, area, fresh and dry weights, dry matter and yield. Control plots showed no damage in most of these parameters, while infested plants exhibited significant reductions in growth. Previous studies (Li *et al*., 2013) reported significant reduction in the growth parameters of tobacco in which plant height, internode length and photosynthesis rate were decreased by 32.7, 4.0 and 81.5 % respectively. The largest reduction in plant height was observed in T3, with the highest whitefly density, at 90 days after infestation during both the 2022 and 2023 cropping seasons. This indicates the combined effect of longer infestation periods and higher whitefly density on plant damage. Plants in the pot trials were more severely affected than those in the field trials, likely due

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to the different climatic conditions that influence whitefly activity.The observed reduction in plant height was higher than reported by other studies, which found reductions of 16.15%, 20.6%, and 32.7% (Isalm and Shuxang, 2009; Li *et al*., 2013; Farina *et al*., 2022). The difference may be attributed to variations in infestation periods and the specific variety under investigation as demonstrated by Abubakar *et al*., 2024).

Similarly, the number of leaves was significantly reduced, with control plots having the highest leaf count in both the field and pot trials. Plants in the pot trials had fewer leaves than those in the field, which could be due to limited sunlight and temperature differences in the pots. Whitefly feeding also reduced the leaf area in both field and pot trials, with control plots having the largest leaf areas. In contrast, plants in T3 saw reductions of 48.8% to 70.6% in leaf area, which significantly affected light absorption, photosynthesis, and yield. Similar reductions in leaf area have been reported in previous studies, ranging from 12.7% to 61.01%. Whitefly sap feeding induces leaf chlorosis and distortion, which negatively impacts photosynthesis and growth. This is similar to the previous findings (Al-shereef, 2011) who demostrated significant reduction of photosynthetic pigments to 0.87, 1.12, and 0.54 in cucumber, zucchini and cantaloupe compared to the control with 1.13, 2.09 and 1.05 respectively Li *et al*., 2018) also reported a reduction in chlorophyll A levels by 42.36%, 56.96%, and 81.43% at 11, 14, and 20 days respectively after the whitefly infestation in tobacco plants. .

Furthermore, the fresh and dry weights of eggplant leaves were adversely affected by whitefly feeding. Fresh weight was reduced by 43.9% and 47.6% in the field and pot trials, respectively, while dry weight decreased by 69.1% and 70.6%. These reductions were higher than those observed in earlier studies, which reported 21.8% and 19.3% reductions in one whitefly life cycle. The greater reductions observed in this study may be due to the longer infestation period, covering multiple whitefly life cycles. These findings contrast with Farina *et al*. (2022), who found no significant impact on dry weight, possibly because of lower whitefly density and a shorter experimental duration.

Repeated growth analysis showed that all morphological parameters in whitefly-infested eggplants were lower than those in control plants, indicating nutrient stress. This suggests the negative impact of whitefly feeding on chlorophyll content and photosynthesis, which ultimately suppressed plant growth. Similar effects on chlorophyll content and photosynthesis have been reported in other crops, such as tomatoes and squash, where whitefly feeding led to chlorosis and reduced photosynthetic capacity. In eggplants, infestation by *B. tabaci* resulted in a 9.7% reduction in chlorophyll content and a 65.9% reduction in photosynthesis, as reported by Islam and Shunxiang, (2009). The deposition of eggs by female whiteflies also reduced stomatal conductance, further limiting access to sunlight and carbon dioxide, essential for photosynthesis. As a result, the yield of eggplantswas observed to be negatively impacted by whitefly infestation, recording lower fruit yields in infested plots compared to the control. Previous research has reported similar reductions in yield in crops like zucchini and soybeans due to whitefly infestation. These findings highlight the significant economic impact of whiteflies on various vegetables, including eggplant, emphasizing the need for effective, sustainable management strategies to mitigate whitefly damage.

Conclusion

In conclusion, our findings indicate that whitefly infestations on eggplant can lead to severe leaf damage, significantly impacting growth parameters and crop yield. The infestations caused approximately 90.1% and 93.2% leaf damage in 2022 and 2023, respectively, resulting in yield losses of up to 89.1% and 90.0% in the same years. Given the high susceptibility of the green round eggplant variety to whitefly damage, it is crucial for policymakers, scientists, and farmers to collaborate in finding sustainable control measures to whitefly infestation stress. One promising approach is the development and application of biopesticides derived from plants and animals, which are known to be safe, cost-effective, eco-friendly, and sustainable, offering a viable means to mitigate the impact of whitefly infestations and improve eggplant productivity.

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