

Susceptibility Status of *Bemisia tabaci* Biotypes to Pyrethroid Insecticides in North-Eastern Nigeria

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Abstract: A study was conducted to assess the effect of treatments with the recommended application rate of α -Cypermethrin, Permethrin, Allethrin, Tetramethrin, Cyhalothrin and Deltamethrin pesticides on *Bemisia tabaci* biotypes. Two localities each were selected from three States of North-eastern Nigeria for sample collections and determination of susceptibility to the insecticides. The localities include Toro and Wuro wasse in Bauchi State, College of Agric farm center (COAG) and Tudun wada in Borno State, Dadin kowa and Kwadon in Gombe State. The insecticides were applied against adult *B. tabaci* using a leaf-dip bioassay. Insect population that survived any of the insecticides after 24 hours post exposures were considered resistance to the insecticide and their biotypes were determined using Polymerase Chain Reaction (PCR). Overall mean mortality response was 88.89%, 91.27%, 88.09%, 96.83%, 93.65%, and 96.05 for α -Cypermethrin, Permethrin, Allethrin, Tetramethrin, Cyhalothrin and Deltamethrin respectively and all were significantly different from control ($P < 0.05$). Populations from Kwadon showed high resistant factor to α -Cypermethrin, Tetramethrin and Cyhalothrin (RF = 221.99, 128.05 and 98.8-folds respectively). All populations displayed significant resistance to Allethrin (RF ranging from 7.01-fold in Tudun wada to 78.93-fold in Kwadon. Tetramethrin resistant was followed by Dadin kowa and Tudun wada (RF = 13.43 and 13.33) respectively and Cyhalothrin resistant was followed by population from Dadin kowa (RF = 82.94-folds) while Deltamethrin resistant was found to be insignificant between almost all locations. Biotype B exhibited higher resistance for all the evaluated insecticides compared to Q in all locations.

Keywords: *Bemisia tabaci*, Biotypes, Susceptible, Resistance, Pyrethroids, North-East Nigeria

1. Introduction

B. tabaci is among the damaging insect pest of many crops globally. Its population structure is said to be highly cryptic species complex that are morphologically indistinguishable, with 24 described biotypes [16]. It has been shown to transmit 111 virus species, some of which are of high economic importance, causing a significant crop loss. World-wide, growers routinely use insecticides against *B. tabaci* and these have included broad-spectrum chemicals such as organophosphate, carbarnates and pyrethroids. The use of these chemicals for the control of this insect species in the past has shown to have a significant impact on crop production. However, failures to control the pest have been

reported recently in many parts of the world probably due to development of insecticide resistance [3]. *B. tabaci* have shown resistance to over 40 active ingredients of the major synthetic insecticide groups in many countries of world [8, 2, 1, 3]. Synthetic insecticides therefore if not continuously monitored might not retain its efficacy indefinitely even in areas where resistance have not been reported or investigated. Overdependence on a particular group of chemicals is one of the most important reasons for the rapid development of resistance among insects [5]. Similarly, the over use and increase dosages of insecticides against resistant insect pest populations could lead to disruption of natural enemies of both the target and secondary pest species, thereby generating the notorious "pesticide treadmill" effect. On the other hand, the use of the chemicals pesticides is also

becoming more problematic in many areas of crop production and insect vector control due to the accumulation effects of these pesticides on human health and the environment. In lieu of this therefore, there is an urgent need for routine monitoring of the efficacy of recommended pesticides that are in use for control of pests. The aim of this study was to evaluate whether populations of *B. tabaci* from north-east arid zone of Nigeria were susceptible to commonly used pyrethroid insecticides to control pest in the region.

2. Materials and Methods

2.1. Study Area

The study was conducted in three States of the Sudano-Sahelian ecological zone of north-east,

Nigeria *viz*: Bauchi, Borno and Gombe States. In each State, two major areas of farming activities were selected *viz*: Wuro wasse and Toro (Bauchi); Tudun wada and COAG farms (Borno); and Kwadon and Dadin kowa (Gombe).

Bauchi is the Capital city of Bauchi State and is located in the Sudan-Savannah region of north-east Nigeria at Latitude 10°18'N and Longitude 9°50'E. Gombe on the other hand is the capital city of Gombe State and is located at Latitude 10°17' N and Longitude 11°10' E while Maiduguri is the Capital city of Borno State and is located in the Sahel Savannah region of North-East Nigeria at Latitude 11°55' N and Longitude 13°05' E and at about 350 m above sea level [7]. The weather condition for the three States varies with time and location of an area. In Bauchi for instance the mean daily maximum temperatures range from 29.2°C in July and August to 37.6°C in March and April. While in Gombe temperature ranges between 22 and 34°C and has similar pattern of monthly distribution like Bauchi. In Maiduguri, the rainy season months are May to September with its peak in August. Humidity ranges from about 28 per cent to 46 per cent. Monthly rainfall ranges from 0.0 mm in December - April, to about 343 mm in August. Onset of the rains varies but more often in April while they end virtually by October. The sunshine hours range from about 5.1 hours in July - September to about 10-12 hours in the remaining months [7].

2.2. Field Collection of Sample for Pyrethroid Susceptibility Test

B. tabaci were sampled randomly from cotton (*Gossypium hirsutum*) and tomato (*Solanum lycopersicum*) plant hosts in six locations that constituted the study area using modified plastic vials by vacuuming plant foliage with a Makita® Cordless Vacuum (Model 4071D) and custom made battery operated suction sampler [6]. Sampling for the whitefly was performed for 2 hours for each sample day from 6: 00 – 7: 00 am and 5:00 - 6:00 pm on monthly bases for six months. In each sample location, two sunken beds 10 m by 20 m were prepared side by side 100 m away from farmers planting fields to avoid being sprayed with insecticides during routine farm spray. On each side of bed was planted tomato and cotton respectively for sampling of the whitefly for the study.

2.3. Bioassay Procedure and Biotype Determination

Three concentrations (0.25µg/ml, 0.75 µg/ml and 1.00 µg/ml) of each of Cypermethrin, Permethrin, Allethrin, Tetramethrin, Cyhalothrin and Deltamethrin insecticides were tested as treatments for the control of *B. tabaci* following the manufacturer's recommendations. Formulations of test compounds were prepared in distilled water as parts per millions of active ingredients. All the insecticides were tested using a leaf-dip bioassay [17, 11]. Briefly, six leaves were obtained from seedlings of tomato plants measuring between 15-20 cm tall. Each leaf was dipped into each of the aqueous concentrations of each of the insecticides listed above for fifteen seconds and were allowed to air dry on a paper towel and then placed into petri dishes containing moistened filter papers to avoid desiccation of leaves as described by [9] and one, (untreated control), was dipped into deionized water, and also allowed to air dry for fifteen seconds. Seven adults of *B. tabaci* from each sample site were released into each petri dish containing the treatment leaves per concentration. Each treatment was replicated 3 times for each set of experiment for each concentration per location along with an untreated control under complete randomized design. Each set of experiment was further replicated three times throughout the study. Knock down resistance (KDR) for an insect sample was recorded at time intervals of 10 minutes for 1 hour while mortality was recorded at 24 hours post exposure treatment. Insects were considered dead after 24 hours when such insects no longer able to move wholly or partially on the treatment leaves. Insect population that showed resistance to any of the insecticides after 24 hour exposures were isolated and subjected to PCR for biotype identification by Random Amplified-length Polymorphism DNA (RAPD) [4, 16, 12, 14, 18] using esterase markers.

2.4. Data Analysis

Mortality data were analyzed using the Two-Way Analysis of Variance and significant means were differentiated by the Duncan Multiple Mean (DMRT) Comparison using the SPSS, (2004) version.

3. Results

3.1. Susceptibility to α -Cypermethrin Insecticide

Of the total 126 white flies assayed for each concentration across the study locations, the overall mean mortality for the control, 0.25 µg/l, 0.75 µg/l and 1.00 µg/l were 7.94%, 57.14%, 69.05 and 88.89% respectively, (Table 1). Samples collected from Toro and Wuro wasse Farm (Bauchi State) and COAG farm in Borno State were found to be susceptible to α -Cypermethrin at the highest recommended dose of 1.00 µg/l (Mortality >95%), however α -Cypermethrin resistance was slightly observed in Tudun wada (Mortality = 90.47) and higher resistance was detected in Whitefly population from Kwadon and Dadin kowa (Mortality = 71.43 and 80.95 respectively). The overall mean percentage mortality of

88.89 indicated that *B. tabaci* within the study areas have developed resistance to α -Cypermethrin.

Table 1. % Mean \pm S. D mortality response of *B. tabaci* to (α -Cypermethrin).

Sample location	Concentration				RF
	Control	0.25 μ g/l	0.75 μ g/l	1.00 μ g/l	
Toro	14.29 \pm 5.40 ^a	57.14 \pm 5.63 ^a	75.23 \pm 2.66 ^a	95.23 \pm 2.63 ^a	0.33
Wuro wasse	0.00 \pm 0.00 ^b	42.86 \pm 5.80 ^b	68.23 \pm 3.82 ^a	95.23 \pm 3.80 ^a	3.82
Tudun wada	19.05 \pm 6.77 ^a	66.67 \pm 3.64 ^c	70.47 \pm 3.21 ^a	90.47 \pm 3.12 ^b	68.82
COAG	4.76 \pm 5.83 ^c	76.9 \pm 1.67 ^c	80.00 \pm 0.58 ^b	100 \pm 0.00 ^c	*
Kwadon	9.50 \pm 3.92 ^c	42.86 \pm 3.66 ^b	51.43 \pm 2.53 ^c	71.43 \pm 1.63 ^d	221.99
Dadin kowa	0.00 \pm 0.00 ^b	57.14 \pm 8.88 ^a	68.95 \pm 4.89 ^a	80.95 \pm 5.88 ^c	111.83
N	126	126	126	126	
Mean	7.94 \pm 3.22	57.14 \pm 11.2	69.05 \pm 4.76	88.89 \pm 0.42	

Mortality < 95% for 1.00 μ g/l is resistance to α -Cypermethrin, Means in the column with the same letters are not significantly different at P = 0.05 using DMRT.

3.2. Susceptibility to Permethrin Insecticide

The overall mean mortality for the control, 0.25 μ g/l, 0.75 μ g/l and 1.00 μ g/l were 6.35 \pm 3.22, 57.94 \pm 11.2, 79.69 \pm 4.52, 91.27 \pm 0.42 respectively, (Table 2). The detail results shown in table 2 indicated that, *B. tabaci* population collected from Wuro wasse, COAG farm and Tudun wada exhibited absolute

susceptibility to Permethrin at field recommended diagnostic concentration of 1.00 μ g/l (mortality = 100%). Kwadon and Dadin kowa population showed resistance to field recommended concentration of 1.00 (mean mortality = 76.19% and 71.43% respectively). The overall mean mortality of 91.27 (< 95%) also indicates permethrin resistance.

Table 2. % mean \pm S. D Mortality response of *B. tabaci* to Permethrin.

Sample location	Concentration				RF
	Control	0.25 μ g/l	0.75 μ g/l	1.00 μ g/l	
Toro	14.29 \pm 5.40 ^a	71.43 \pm 5.63 ^a	75.23 \pm 4.18 ^a	95.23 \pm 4.11 ^a	39.62
Wuro wasse	0.00 \pm 0.00 ^b	42.86 \pm 5.80 ^b	80.00 \pm 5.62 ^{ab}	100 \pm 0.00 ^b	*
Tudun wada	9.50 \pm 4.71 ^b	66.67 \pm 3.64 ^a	71.43 \pm 3.02 ^a	100 \pm 0.00 ^b	*
COAG	4.76 \pm 5.83 ^c	76.9 \pm 1.67 ^a	89.44 \pm 5.32 ^b	100 \pm 0.00 ^b	*
Kwadon	9.50 \pm 3.92 ^b	42.86 \pm 3.66 ^b	73.19 \pm 2.64 ^a	76.19 \pm 2.68 ^c	135.05
Dadin kowa	0.00 \pm 0.00 ^b	47.62 \pm 8.88 ^b	88.83 \pm 4.32 ^b	71.43 \pm 3.12 ^c	248.8
N	126	126	126	126	
Mean	6.35 \pm 3.22	57.94 \pm 11.2	79.69 \pm 4.52	91.27 \pm 0.42	

Mortality < 95% for 1.00 is resistance to Permethrin, Means in the column with the same letters are not significantly different at P = 0.05 by DMRT.

3.3. Susceptibility to Allethrin

The results of Susceptibility status of *Bemisia tabaci* to Allethrin insecticide at three diagnostic concentrations is presented in table 3. As indicated the overall mean mortality at concentration 0.25 μ g/l, 0.75 μ g/l and 1.00 μ g/l are 60.32%, 72.22% and 88.09% respectively (Table 3). The range mortality for each concentration was 42.86-76.19%,

61.90 – 80.95% and 80.95 – 100% respectively across the study sites. Samples collected from Tudun wada farm and Dadin kowa were susceptible to Allethrin (mortality > 95%), however, the overall mean of 88.09% mortality which is < 95% signifies that the generality of the white flies are not susceptible to Allethrin.

Table 3. % Mean \pm S. D. mortality response of *B. tabaci* to Allethrin.

Sample location	Concentration				RF
	Control	0.25 μ g/l	0.75 μ g/l	1.00 μ g/l	
Toro	4.76 \pm 3.20 ^a	66.67 \pm 6.02 ^a	71.42 \pm 4.62 ^a	90.47 \pm 5.63 ^a	72.06
Wuro wasse	19.05 \pm 5.56 ^b	47.62 \pm 7.23 ^b	66.67 \pm 4.58 ^b	85.71 \pm 4.57 ^{ab}	10.03
Tudun wada	0.00 \pm 0.00 ^c	76.19 \pm 6.84 ^c	76.19 \pm 3.62 ^a	95.23 \pm 3.33 ^a	7.01
COAG	9.52 \pm 2.58 ^a	61.90 \pm 9.63 ^a	76.19 \pm 7.22 ^a	76.19 \pm 8.23 ^c	26.73
Kwadon	14.29 \pm 3.65 ^b	42.86 \pm 7.78 ^b	61.90 \pm 2.61 ^b	80.95 \pm 2.89 ^d	78.93
Dadin kowa	0.00 \pm 0.00 ^c	66.67 \pm 9.54 ^a	80.95 \pm 3.02 ^c	100 \pm 0.00 ^c	*
N	126	126	126	126	
Mean	7.93 \pm 6.67	60.32 \pm 12.1	72.22 \pm 3.33	88.09 \pm 10.6	

Mortality < 95% for 1.00 is resistance to Allethrin, Means in the column with the same letters are not significantly different at P = 0.05 by DMRT.

3.4. Susceptibility to Tetramethrin

With the exception of population collected from Kwadon which exhibited high resistance where only 66.67% mortality was

recorded, all other population exhibited high susceptibility to tetramethrin. The overall mean mortality of 96.83% recorded against tetramethrin at 1µg/l indicated that the overall population was susceptible to the insecticide. White flies from Toro, Wuro wasse and COAG farms had no detectable resistance to tetramethrin (mortality = 100%) (Table 4).

Table 4. % Mean \pm S. D mortality response of *B. tabaci* to tetramethrin.

Sample location	Concentration				RF
	Control	0.25 µg/l	0.75 µg/l	1.00 µg/l	
Toro	9.52 \pm 2.76 ^a	47.62 \pm 4.40 ^a	77.15 \pm 4.81 ^a	100 \pm 0.00 ^a	*
Wuro wasse	0.00 \pm 0.00 ^b	66.67 \pm 2.56 ^b	66.67 \pm 2.91 ^b	100 \pm 0.00 ^a	*
Tudun wada	9.52 \pm 3.26 ^a	57.14 \pm 2.52 ^c	76.19 \pm 2.50 ^a	95.23 \pm 2.36 ^a	13.33
COAG	0.00 \pm 1.50 ^b	71.43 \pm 7.08 ^b	71.43 \pm 7.04 ^b	100 \pm 1.39 ^a	78.01
Kwadon	4.76 \pm 6.22 ^a	33.33 \pm 5.75 ^d	52.38 \pm 5.89 ^c	66.67 \pm 4.76 ^b	128.05
Dadin kowa	0.00 \pm 0.00 ^b	52.38 \pm 9.78 ^c	52.38 \pm 13.70 ^c	95.23 \pm 2.08 ^a	13.43
N	126	126	126	126	
Mean	3.97 \pm 1.14	54.76 \pm 14.3	66.03 \pm 5.24	96.83 \pm 0.34	

Mortality < 95% for 1.00 is resistance to tetramethrin, Means in the column with the same letters are not significantly different at P = 0.05 by DMRT.

3.5. Susceptibility to Cyhalothrin

Of the total population exposed to each concentration of 0.25 µg/l, 0.75 µg/l and 1µg/l, the mean mortality for each concentration was 61.91%, 65.88% and 93.65% respectively. Resistance to Cyhalothrin was observed in population collected from COAG farm and Kwadon (Mortality < 95%) (Table 5). Population from Toro (Bauchi State) and Tudun wada farm (Borno State) had no detectable resistance to Cyhalothrin insecticides at 1µg/l.

Table 5. % Mean \pm S. D Mortality response of *B. tabaci* to Cyhalothrin.

Sample location	Concentration				RF
	Control	0.25 µg/l	0.75 µg/l	1.00 µg/l	
Toro	19.05 \pm 1.03 ^a	61.91 \pm 12.14 ^a	66.67 \pm 12.00 ^a	100 \pm 0.00 ^a	*
Wuro wasse	9.52 \pm 7.43 ^b	76.19 \pm 11.33 ^b	66.67 \pm 11.46 ^a	95.24 \pm 3.20 ^b	0.03
Tudun wada	0.00 \pm 0.00 ^c	52.38 \pm 12.63 ^c	76.19 \pm 11.60 ^b	100 \pm 0.00 ^a	0.04
COAG	4.76 \pm 6.06 ^d	66.67 \pm 6.68 ^a	66.67 \pm 6.62 ^a	90.48 \pm 2.56 ^c	28.52
Kwadon	19.05 \pm 2.88 ^a	47.62 \pm 10.10 ^d	52.38 \pm 11.08 ^c	80.92 \pm 1.99 ^d	98.8
Dadin kowa	23.81 \pm 5.61 ^a	66.67 \pm 13.25 ^a	66.67 \pm 17.20 ^a	95.24 \pm 3.14 ^b	82.94
N	126	126	126	126	
Mean	12.69 \pm 8.61	61.91 \pm 19.3	65.88 \pm 8.58	93.65 \pm 11.65	

Mortality < 95% for 1.00 µg/l is resistance to Cyhalothrin, Means in the column with the same letters are not significantly different at P = 0.05 by DMRT.

3.6. Susceptibility to Deltamethrin

The results revealed that only Kwadon populations showed resistance to Deltamethrin insecticide at recommended concentration of 1µg/l. 85.71% of the total population exposed died of Deltamethrin which indicated resistance (mortality < 95%). On the contrary population from Wuro wasse farm, COAG farm, and Dadin kowa had no detectable resistance (mortality = 100%) to Deltamethrin (Table 6).

Table 6. % Mean \pm S. D Mortality response of *B. tabaci* collected to Deltamethrin.

Sample location	Concentration				RF
	Control	0.25 µg/l	0.75 µg/l	1.00 µg/l	
Toro	0.00 \pm 0.00 ^a	52.38 \pm 13.00 ^a	90.58 \pm 4.82 ^a	95.24 \pm 4.11 ^a	34.85
Wuro wasse	0.00 \pm 0.00 ^a	71.43 \pm 42.5 ^b	90.58 \pm 4.04 ^a	100 \pm 0.00 ^b	0.05
Tudun Wada	0.00 \pm 0.00 ^a	80.95 \pm 10.5 ^c	95.24 \pm 2.81 ^b	95.24 \pm 2.81 ^a	40.30
COAG	9.52 \pm 3.78 ^b	47.62 \pm 11.8 ^d	100 \pm 0.00 ^c	100 \pm 0.00 ^b	89.50
Kwadon	4.76 \pm 5.56 ^b	80.95 \pm 11.5 ^c	71.43 \pm 5.29 ^d	85.71 \pm 0.07 ^c	132.82
Dadin kowa	9.52 \pm 3.61 ^b	61.91 \pm 25.2 ^c	80.95 \pm 3.42 ^c	100 \pm 0.00 ^b	0.02
N	26	26	26	26	
Mean	7.60 \pm 7.40	65.87 \pm 19.6	88.13 \pm 6.32	96.03 \pm 4.06	

Mortality < 95% for 1.00 µg/l is resistance to Deltamethrin, Means in the column with the same letters are not significantly different at P = 0.05 by DMRT.

3.7. Comparative Susceptibility Between Population Biotypes

Of the total 756 *B. tabaci* analyzed for susceptibility, the frequency distribution of resistance population between biotypes is presented in table 7

Table 7. Table showing the frequency distribution of resistance among whitefly biotypes.

Insecticide	No. tested	% resistance	% frequency of resistance by Biotypes		
			B	Q	Unknown
α -Cypmt	126	12.69	50.00	37.50	12.5
Permt	126	9.52	50.00	41.66	8.33
Allt	126	11.91	60.00	33.33	6.66
Tetm	126	7.14	66.66	22.22	11.11
Cyht	126	7.94	80.10	10.00	10.00
Delt	126	1.59	60.00	40.00	0.00
mean	126	8.47	61.13	30.79	8.10

Values in brackets are percentage resistance, α -Cypmt= α -Cypermethrin, Permt= permethrin, Allt= Allethrin, Tetm=Tetramethrin, Cyht= Cyhalothrin, Delt=Deltamethrin.

Table 7 above revealed that *B. tabaci* resistance to α -Cypermethrin was found to be marginally higher (12.69%) population, followed by permethrin, Allethrin and the least was resistance to Deltamethrin (1.59%). Similarly, Biotype B exhibited higher resistance (>50%) for all the evaluated insecticides, followed by biotype Q and UK in that order.

4. Discussion

This study has revealed variation in the level of insecticide resistance in *B. tabaci* collected in cultivated fields of some parts Bauchi, Borno and Gombe states all located in the Sudan Savannah Ecological Zone of North-eastern Nigeria. The susceptibility status varies with location and biotypes. Generally, the population collected from Kwadon in Gombe State showed a high resistance to all the evaluated insecticide at average recommended field application (ARFA) (1 μ g/l) mortality <95% as compared to standard recommended percentage mortality (\geq 95%) for control of insect pest.

Mortality response of *B. tabaci* was highest in Cyhalothrin, Deltamethrin and tetramethrin in all the average recommended field application of 1 μ g/l (mean mortality = 93.65%, 96.03% and 96.83%) respectively as against Cypermethrin, Permethrin and Allethrin (88.89%, 91.27% and 88.09%) respectively and is significantly different ($P < 0.05$). However, the overall mean performance of all the six pyrethroid insecticides of 92.25% which is less than recommended standard mortality of >95% might be an indication of resistance of the white flies to pyrethroids.

Different levels of resistance were recorded among individual populations from different locations to the different pyrethroid insecticides evaluated. α -Cypermethrin resistance was found to be highest in population collected from Kwadon and Dadin kowa in Gombe State (RF = 221.99 fold and 111.83) respectively, followed by Tudun wada farm from Borno State (RF =168.82 fold). No detectable resistance to α -Cypermethrin was observed in population collected from COAG farm (mortality response was 100%) (Table 1). Similarly, Permethrin resistance was not detected in population collected from Wuro wasse, Tudun wada and COAG (mortality = 100%). However, resistance was observed to be very high in populations collected from Dadin kowa and Kwadon both in Gombe State which exhibited a

resistance factor of 248.8 and 135.05-fold respectively as compared to populations Toro (RF = 39.62).

Evaluation of Allethrin on the Whitefly showed that all populations except Dadin Kowa and Tudun wada displayed significant resistance (mortality <95%) with resistance factor ranging from 7.01-fold in Tudun wada farm to 78.93-fold in Kwadon). High slope values (>4) were observed for all whitefly populations from all collection sites, suggesting a high homogeneity of the populations against the Allethrin insecticide. Comparison of resistance of whitefly between biotypes revealed that biotype B exhibited higher resistance for all the insecticides evaluated and accounted for >50% of the total population of whitefly found to be resistance to the insecticides. This result seem to disagree with the report of Nauen and Delnholm [9] who reported higher resistance in Q biotypes compare to B biotypes. However, the differences observed could attribute to variation responses to insecticide active ingredients acting on different target sites [13]. In this study, pyrethroid insecticides were used which targets voltage gated sodium channel of nerve cell membrane [9] as compared to Nauen and Delnholm [15] who used organophosphate and carbomates insecticides which both target acetyl cholinesterase in the nerve cell synapse.

5. Conclusion

This study has shown that *Bemisia tabaci* in north-eastern Nigeria have shown to have developed resistance to pyrethroid insecticides at the recommend dose. The resistance was low to moderate depending on location and biotype. For effective utilization of the evaluated insecticides, there is need for upward review of the recommended concentration. Biotype B exhibited more resistance than Q while population from Gombe State were more resistance to insecticides compare to other locations.

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