ECONOMIC INJURY LEVELS OF *Dysdercus volkeri* F. (HETEROPTERA: PYRRHOCORIDAE) ON COTTON IN SAMARU ZARIA, NIGERIA

Musa*, N., Onu, I., Bamaiyi, L. J. and Adamu, R. S.
Department of Crop Protection, Institute for Agricultural Research, Ahmadu Bello University, Zaria
*Email: musanuradeen@gmail.com; +2348 06507 6850

SUMMARY

Field trials were carried out during 2019 and 2020 cropping seasons at Samaru, Zaria to study the Economic Injury Levels (EIL) of Dysdercus volkeri on cotton. Nymphs instar at levels 0 (control), 5, 10, 15, 20 and 25 per meter row of cotton variety (SAMCOT- 9) were released at boll forming stage into caged cotton. The treatments were arranged in a Randomized Complete Block Design (RCBD) replicated four times. Parameters assessed included, number of bolls produced, damaged bolls, weight of damaged bolls and of undamaged bolls and the rate of association between nymph density and weight of lint. The result obtained showed decreased yield in cotton with increase in number of nymphs infested in the caged cotton. Infestation with 5 and 25 nymphs per caged plant during 2019 and 2020 cropping seasons caused decrease in yield of 16.215 kg ha^{-1}, 15.382 kg ha^{-1} and 16.04 kg ha^{-1}, 9.618 kg ha^{-1} respectively. EIL for D. volkeri nymphs were determined as 2.30 and 2.91 nymphs when cypermethrin insecticide was used in 2019 and 2020, respectively. Therefore, control measures should be applied when the D. volkeri nymph populations reaches at least two nymph per meter row length in cotton plant.

Key words; Cotton, *Dysdercus volkeri*, Economic Injury Levels

COTTON, *Gossypium hirsutum* L, belongs to the family *Malvaceae* (Paterson, 2009). It is a shrub, native to tropical and subtropical regions of the world. Cotton is one of the most important commercial and economically viable crops in the world (Naveed *et al*., 2015). The total global area under production is about 35 million hectares with a production of approximately 238.57 million bales in 2019 (FAO, 2020). It is an important fiber crop, which is cultivated in more than 80 countries of the world (Kutama *et al*., 2015). Despite the strategic importance of cotton in national economic development, its productivity in most parts of the world is steadily declining (James, 2007; Anonymous, 2013). However, primary among these production constraints is insect pests infestation which many times necessitated control through intensive use of synthetic chemicals and the use of high yielding cultivars geared at managing insect pests that are a major problem in cotton production (Naranjo *et al*., 2008; Rafiq, 2014; Akhtar, 2016). Several insect species that belongs to the order Pyrrhocoridae are serious pests of cotton worldwide (Gutierrez *et al*., 2005; Sontakke, *et al*., 2013; Jaleel, *et al*., 2013) with cotton stainers causing significant losses of between 30-50% in Nigeria if not controlled (Amatobi, 2007, Horna, *et al*., 2009). The biology and economic injury levels of *D. volkeri* on sunflower has been studied extensively (Mani, 2013), but there is still inadequate information on the biology and the level at which they cause damage on cotton (SAMCOT -9) in Nigeria and this could hinder the development of effective integrated pest management strategies against the pest in the country. A better understanding of pest populations is needed to integrate these and other pest control options into an overall integrated pest management (IPM) plan to maximize cotton production. Therefore, the objective of the study was to determine the economic injury level of *D. volkeri* on SAMCOT-9

MATERIALS AND METHODS

Field experiments were conducted during 2019 and 2020 cropping seasons at the Institute for Agricultural Research (IAR) Farm Samaru, Zaria (11^{o} 11, 7^{o}38 E) in the northern Guinea Savanna of Nigeria. The fields were ploughed, harrowed and ridged. Single Super Phosphate fertilizer was applied prior to planting at 31.5 kg P_2O_5 ha^{-1} for proper root development. SAMCOT 9 variety of cotton was used for both years. This variety of cotton is characterized by reddish stem, no petal colour, adapted to northern cotton growing zone, medium maturing (130-150 days), with estimated yield of 1.5-2.0 tons per ha, medium staple, fine lint with good luster, erect 120-150 cm and resistant to Bacteria Blight (Anonymous, 2015)

The experiments were laid out in Randomized Complete Block Design (RCBD) with four replications. Three seeds were sown per hole at the spacing of 90 cm by 40 cm, later thinned to two per stand. The plants on one-meter length ridge were covered with screen mesh cages of size 1.0 m x 0.5 m x 1.0 m as adapted from Musa (2016) for each treatment before square initiation to avoid natural infestation. During artificial infestation, *D. volkeri* at the nymph instars stage were placed directly on the bolls at between 6.00 and 7.00 am. A camel hairbrush was used to transfer the different nymph densities (0, 5, 10, 15, 20 and 25 per two plants) from a holding container to the cotton. This was done at boll and boll breaking stages of growth. The total number of boll produced, and the number of damaged bolls were recorded. Weight of total lint from all the covered plants in each cage was determined. The relationship between the nymph density and lint yield was determined by regression analysis. Yield data were extrapolated to kg ha^{-1} and yield losses due to different nymph rates were derived by deducting the yield of respective nymph rates from the yield of untreated control (where no nymphs were released). The monetary values of yield losses were determined according to the prevailing market price of cotton lint at Zaria just after harvest. Cypermethrin at two litres was considered for calculating the cost of insecticidal application. Three spray applications of Cypermethrin at two litres per hectare according to Musa, (2016) were done for calculating the cost of insecticidal applicationsThe economic injury level for cotton stainer nymphs were calculated by regression equation Y= a + bx, Where, Y = yield per cage, a = a constant (the y intercept), b = yield loss per nymph, x = number of nymph per cage.

$$\text{EIL} = \frac{\text{Gain threshold}}{\text{Yield reduction per larva}}$$

$$\text{Gain threshold} = \frac{\text{Management cost ₦ha}^{-1}}{\text{Market value (price)₦kg}^{-1}}$$

RESULTS

Effect of *D. volkeri* infestation on boll production, boll damage and weight of lint during 2019 cropping season

The result showed that among the treatments, cotton plants caged with varying levels of *D. volkeri* nymph produced higher number of bolls when compared with caged with 0, 5, and 10 nymphs recorded significantly higher number of boll compared with10, 15 and 25 which were at par with each other. On the other hand, there was significant difference (P≤0.05) between 25 and 10 nymph densities. Similarly, among the nymph levels caged, significant difference was observed between 15, 25 and 5 nymph densities. The least number of bolls damaged was recorded with 0 nymphs per cage (Table 1). However, there was significant difference (p≤0.05) among the nymph densities on total weight of lint produced. Untreated control had higher weight of lint compared with 5, 10 and 25 nymph densities. The least weight of lint was obtained on the cotton caged with 15 and 25 nymph densities. However, there were significant differences ($p \leq 0.05$) between 25 and 20 nymph densities on damaged lint. Similarly, among the nymph treatments, significant differences were observed between 10 and 15 nymph densities. The least weight of damage lint was recorded on plant in untreated control. A strong positive correlation was found ($R^2 = 0.901$) between nymph density and percentage boll damage (Fig. 1).

Table 1: Effect of *D. volkeri* infestation on Cotton boll production and damage during 2019 cropping season at Samaru, Kaduna State

Density of nymph	Number of bolls produced	Number of bolls damaged	Total weight of lint (kg/ha)	Weight of damaged lint (kg/ha)	Yield loss (%)
0	58.5000a	0.00e	24.167a	0.1736f	0.000c
5	53.5000abc	9.000d	16.215b	0.9722e	32.193b
10	49.000bcd	18.750b	15.521b	2.4653c	35.145b
15	42.500d	12.500c	11.771c	1.9098d	50.917a
20	55.750ab	31.000a	10.694c	3.0209b	55.160a
25	45.250cd	14.250c	15.382b	4.6875a	35.677b
Mean	50.7500	14.7917	15.6249	2.2048	34.8486
SE ±	2.2877	0.9556	0.8253	0.0919	2.8581

Means within the same column followed by the different letter(s) are significantly different at ($P \leq 0.05$) of Student Newman Keuls (SNK) Test.

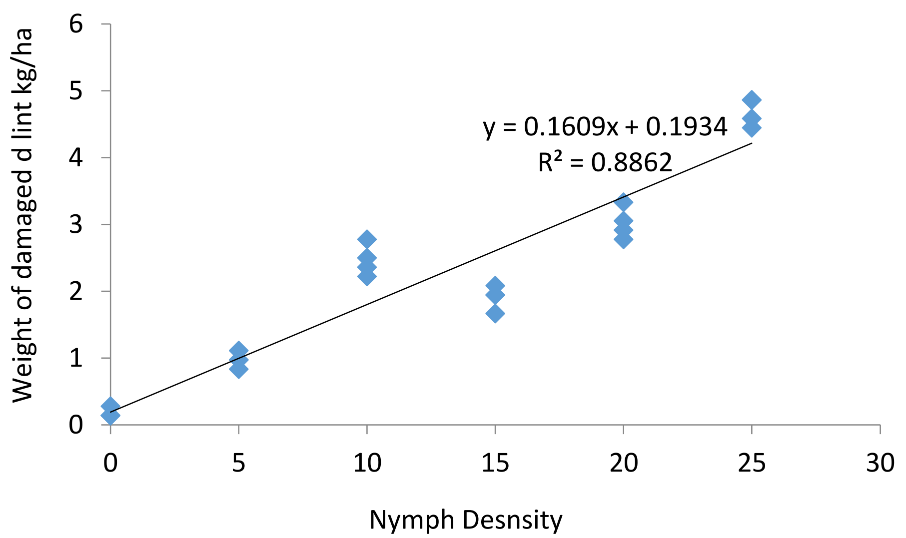

Figure 1: Relationship between *D. volkeri* Nymph density and weight of damaged lint in 2019

Effect of *D. volkeri* infestation on boll production, boll damage and weight of lint during 2020 cropping season

Untreated control and 5 nymphs significantly produced highest number of bolls compared with other nymph densities, but no significant differences were recorded among the plants caged with 10, 15, 20 and 25 nymph densities (Table 2). However, cotton plants cage with 25 nymph densities significantly had higher ($P \leq 0.05$) number of bolls damaged compared with 15 and 25 nymph densities. Similarly, among the treatments, significant difference was observed between 5 and 10 nymph densities. The least number of bolls damaged was recorded with untreated control cage.

On the other hand, untreated control had higher ($P \leq 0.05$) total weight of lint compared with 5 and 10 nymph density. However, there was no statistical difference among the cotton caged with 15, 20 and25 nymph densities. Similarly, plants caged with 25 nymph densities significantly produced more damaged lint when compared with 20 nymph densities. The least damaged lint was recorded with untreated control cage. The percentage yield loss was statistically higher on cotton caged with 15, 20 and 25 nymph densities compared with 5 and 10 nymph densities. The least percentage yield loss was recorded on the untreated control cage. A strong positive correlation was found ($R^2 = 0.815$) between nymph density and damaged lint (Fig. 2). Table 2 was brought up after the interpretation of table 1 above for the flow of point.

Table 2: Effect of *D. volkeri* infestation on boll Production and damage during 2020 cropping season at Samaru, Kaduna State

Density of Nymph	Number of bolls produced	Number of bolls damaged	Total weight of lint (kg/ha)	Weight of damaged lint (kg/ha)	Yield loss (%)
0	53.000a	0.000e	24.491a	0.2084f	0.000c
5	49.500ab	6.000d	16.041b	1.0763e	35.115b
10	43.000b	12.250c	15.104b	1.8405d	36.638b
15	42.750b	18.250b	13.126bc	2.5000c	44.895ab
20	40.500b	21.000b	12.222bc	3.2988b	48.768ab
25	44.750b	32.250a	9.618c	4.4095a	59.560a
Mean	45.5833	15.1667	15.1003	2.2222	37.4958
SE ±	2.3118	1.2888	1.1064	0.1040	3.1900

Means within the same column followed by the different letter(s) are significantly different at ($P \leq 0.05$) of Student Newman Keuls (SNK) Test.

To calculate the EIL it was necessary to know not only the rate of yield reduction in question but also the cost of controlling the insect and market price of the crop. In the year 2019 and 2020 one liter of Cypermethrin was selling at ₦ 1,900.00. The field was sprayed three times at the rate of 2 liter / spray. For spraying two liter three times (₦1, 900.00 × 3 = N11, 400.00). Application cost of five laborers for the three applications = ₦250.00 × 5 × 3 = ₦3, 750.00. Therefore cost of insecticides and application cost = N11, 400.00 + ₦3, 750.00 = ₦ 15,150.00. The market price of cotton/kg in 2019 and 2020 was ₦400.00 and ₦420.00 per kg, respectively with a grand mean of ₦410.00 per kg for these two years. Therefore the market price of cotton per kg = ₦410.00.

The amount of yield loss that constitutes economic damage is referred to as gain threshold. The following formula was used to calculate gain threshold;

$$\text{Gain threshold} = \frac{\text{management cost ₦ha}^{-1})}{\text{Market value of cotton ₦kg}^{-1})}$$

In this particular case the gain threshold $= \frac{15{,}150 \text{ ₦ha}^{-1})}{410 \text{ ₦kg}^{-1})} = 36.951 \text{ kg ha}^{-1}$

EIL is the number of infesting *D. volkeri* that would reduce the yield by 36.951 kg/ha. Because Y= a + bx, it followed that bx = y –a (a – y)
But a – y is the reduction (the intercept minus the expected yield).
Therefore, bx = 36.951
For 2019 (Fig. 3) bx = (16.059) x = 36.951
Therefore, x = 36.951 ÷ (16.059) = 2.30 ≈ 2 consequently, the EIL for 2019 infestation of 2 nymphs per plants is economically significant.
For 2020 infestation (Fig. 3), bx = 12.709x = 36.951.
Therefore, x = 36.951 ÷ (12.709) = 2.91 ≈ 3.0

The EIL for 2020 cropping season infestation is three *D. volkeri* per plants. The aspect of benefit cost ratio was removed from material and methods therefore; table 3 has also been removed. All other aspects remained same in the above calculation

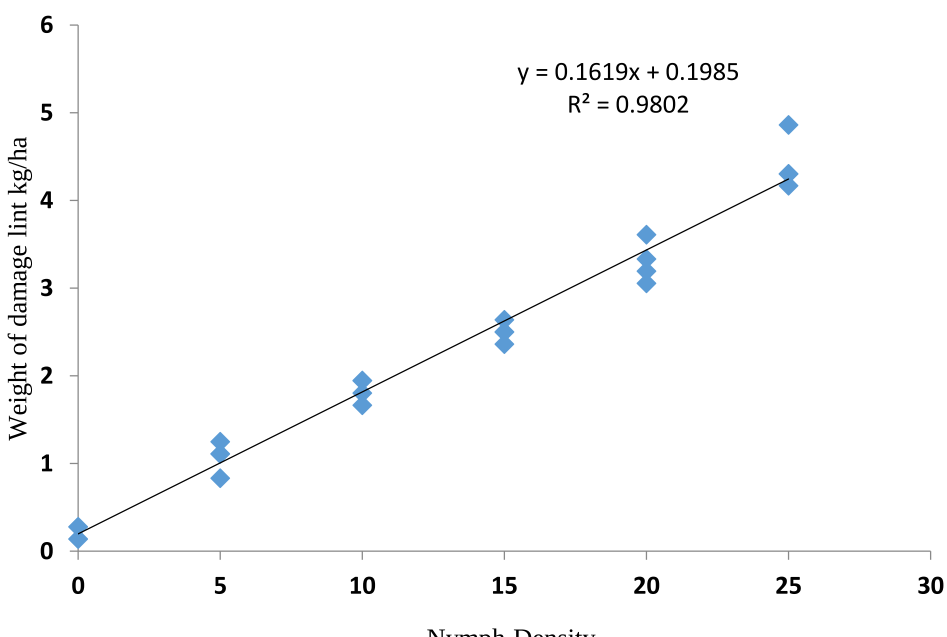

Figure 2: Relationship between Nymph and weight of damaged lint kg/ha in 2020

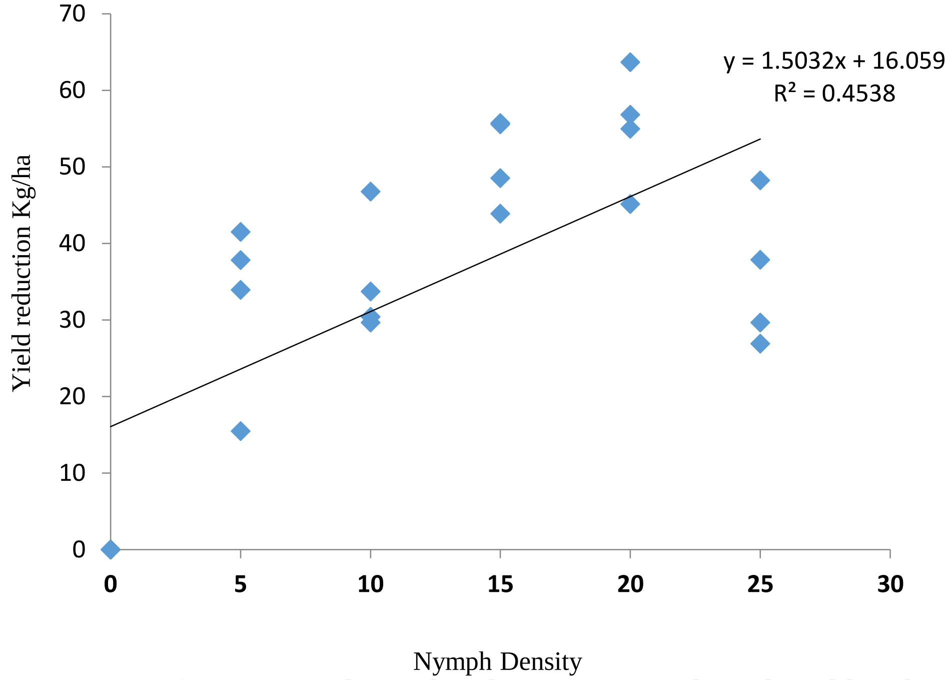

Figure 3: Relationship between Nymph and yield reduction kg/ha in 2019

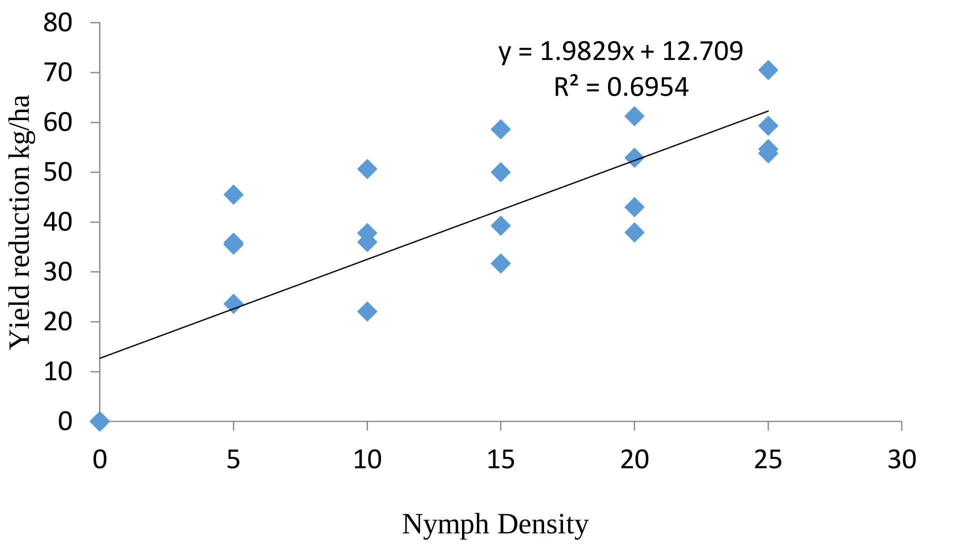

Figure 4: Relationship between Nymph and yield reduction kg/ha in 2020

DISCUSSION

The knowledge of economic threshold (ET) is used to determine whether an insect is to be classified as a pest or not (Pedigo, 1996). ET is the pest density at which control measures should be applied to prevent an increasing pest population reaching the Economic Injury Level (EIL). The concept has been described as the pest population level which causes damage equals to the gain threshold which is the ratio of protection cost and price of produce (Zahid *et al*., 2008). In the present study the values of coefficient of determination (R^2) were high for both 2019 and 2020 cropping seasons and this offered a more reliable explanation for the nature of the association. This also implied that the *Dysdercus* damage significantly influenced lint yield with the increasing number of nymph. The linear relationship indicates a yield reduction proportional to infestation and lack of compensation following the nymph attack.

In this study, gain threshold was based on the ratio of cost of pest control to the market price of produce. The results of this study showed that the total weight of lint per plant in the cages ranged from 24.167kg/ha to 15.382 kg/ha and from 24.491 kg/ha to 9.618 kg/ha during 2019 and 2020, respectively. In both years the difference among the various treatments were found significant indicating the effect of nymph density on lint formation. The percentage lint damaged increased with increasing nymph density. This corroborated the reports of Mani (2013) who observed proportionate increase in damage of sunflower heads with increase in the adult population levels of *D. volkeri*. The regression between the number of nymph per plant and total lint weight was negative and significant (R^2= 0.477 and R^2= 0.697) in 2019 and 2020, respectively. Statistical analysis showed that the regression between the nymph population and reduction in lint weight per plant was positive and significant (R^2=0.453 and R^2= 0.695) in both 2019 and 2020, respectively.

In the present study the yield reduction per nymph was 32.193 and 35.115 % per plant for both 2019 and 2020 seasons, respectively. These findings are also in conformity with that of Baloch *et al*. (2001) who reported a yield reduction of 1.61 g per plant for every increase in the cottonhead bug. The EIL of the study was found to be 2.30 and 2.91 for 2019 and 2020 cropping seasons, respectively. Zahid *et al*. (2008) had also reported a linear relationship between *Maruca* larval density and percentage grain yield in Mungbean and added that the EIL during 2006 and 2007 was 1.45 and 1.34, respectively when Cypermethrin was sprayed. The authors concluded that the two year EIL mean of the borer was 1.08 larvae per meters row respectively. The relationship between EIL and market value (price) was inversely related such that as market value increased EIL decreased and vice versa. EIL calculation should be based on current market value of crop (Adamu *et al.*, 2006). However, the market value of cotton lint in January 2020 and 2021 at Samaru, Zaria was ₦ 400.00/kg and ₦420.00 per kg respectively with a grand mean of ₦410.00 per kg for these two years. Therefore the market price of cotton per kg = ₦410.00.

Egwurube (2004) showed that EIL differed across season, stage of crop development cultivars and efficacy of insecticides used. In this study the values of EIL in the 2019 and 2020 cropping seasons were found to be 2.30 and 2.91 using cypermethrin insecticide. There seems to be no much difference between the 2019 and 2020 cropping seasons using same insecticide. These findings are in agreement with that of Memon, (2011) who reported EIL of plant sucking bugs in cotton 0.78 to 0.80 insects per plant. Similarly, in this study, the 2020 cropping season had higher observed EIL estimates than 2019 cropping season. This might be associated with the lower damage potential in 2019 compared to 2020 and higher management costs. Thus, EIL value increased with increase in the cost of protection. The EIL may change for the same pest in a different crop, or for the same crop in a different environment or for different market demands (Wazire and Patel, 2016). The lowest EILs were associated with a low control cost, high control efficacy, and a high potential yield. As expected, the highest EILs were associated with high control costs, lower control efficacy, and lower potential yields.

CONCLUSION

From the economic injury level values obtained in this study the infestation of *Dysdercus* nymphs at low population level can cause significant yield loss. Control measures should be initiated when the *D. volkeri* population reached at least two nymphs per cotton plants. This can be done by regular monitoring the insect population and judicious sound use of insecticides.
Recommendation was added to the above conclusion

REFERENCES

Adamu, R. S. 2006. Economic injury levels and control of *Eurystalis oldi* Pop. on *Sorghum bicolor*. Moench Ph. D. Thesis, Department of Crop Protection. Ahmadu Bello University, Zaria, Nigeria. 243 pp.

Akhtar, M. F., Tariq, H. Raza, A. Nadeem, I.; Yousaf, J. M., Ahmed, R. and Niaz, T. 2016. Evaluation of different insecticides for the management of red cotton bug *Dysdercus* spp. via flooding and foliar methods of application *International Journal of Entomology Research* Vol. 1 P.16-18

Amatobi, C. I. 2007. *Arthropod pests of crops in Nigeria; General biology, natural enemies and control*. P. A. Ndahi printing. Zaria, Nigeria. 124 pp.

Anonymous. 2017. Agricultural Statistics of Pakistan, Government of Pakistan Ministry of Food and Agriculture (Economic wing), Islamabad, Pakistan. 29-30

Baloch, A. A., Rasool, G. Naz, M. A., and Baloch, A. H. 2001. Cotton pest and their natural enemies as observed under habitation of Nasirabad and certain other parts of Balochistan. Sindh, BaL *Journal of Plant Science* 3:31-36

Egwurube, E. A. 2004. Bioeconomics of *Empoasca dolichi* Paoli (Homoptera; Cicadellidae) on groundnut in northwestern Nigeria. M. Sc Thesis, Department of Crop Protection, Ahmadu Bello University Zaria. 142 pp.

FAO. 2020. Agricultural production status worldwide web sites pages, http:www.fao.org/faostat.

Gutierrez, A.; Paul, Ponti, L., Ellis, C. K. and Thibaud, O. 2005. Analysis of climate effects on Agricultural systems - *The California Climate Change Center Report Series*

Horna, D., Kyotalimye, M. and Falck-Zepeda, J. 2009. Cotton Production in Uganda: Would GM technologies the solution. A Paper presentation at the International Association of Agricultural Economists Conference, Beijing, China, August 16-22.

Anonymous. 2017. Institute for Agricultural Research Code and descriptors list of crop varieties released, IAR/ABU Samaru- Zaria 73pp

Jaleel, W., Saeed, S. and Naqqash, M. N. 2013. Biology and bionomic of *Dysdercus koenigii* F. (Hemiptera: Pyrrhocoridae) under laboratory conditions. *Pakistan Journal of Agricultural Science* 50: 373-378.

James, C. 2007. Global Status of Commercialized Biotech/GM Crops: 2006. ISAAA Brief No.35. International Service for the Acquisition of Ag-biotech Applications, Ithaca, NY.

Kutama, A. S., Sharif, U., Dangora, L. L., Umma, M., Salusu, A. and Rabiu, M. K. 2015. Yield of cotton and opinion of small- scale farmers on cotton production in Kano and

Katsina States Nigeria. *Global Advanced Research Journal of Agricultural Science.*4(8): 234-438

Mani, U. 2013. Bioecology and Economic Injury Levels (EIL) of *Dysdercus volkeri* F (Heteroptera: Pyrrhocoridae) on Sunflower *(Helianthus Annuus* L.) in Samaru Zaria, Nigeria.*Ph.D.Thesis* Department of Crop Protection, Ahmadu Bello University Zaria Nigeria Pp160

Memon, S. A., Rustamani, M. A., Sahito, H. A., Narejo, M. Mal, B. and Mahesar, T. G. 2011. Effect of Agrochemicals on Sucking Insect Pests of Cotton Crop. *Life Science International Journal* Vol.: 5(3), Pp2280-2287

Musa, N. 2016. Studies on economic injury level of legumes pod borer *M. vitrata* on cowpea (*Vigna unguiculata* (L.) Walp) in Zaria, Kaduna State Unpublished M. Sc. Thesis Department of Crop Protection Ahmadu Bello University, Zaria. Pp 104.

Naranjo, S.E., Ruberson, J. R., Sharma, H.C., Wilson, L., Wu, K.M. 2008. The present and future role of insect-resistant genetically modified cotton in IPM. ***In***: Romeis J, Shelton A. M., Kennedy, G. G. (ed). Integration of Insect-Resistant Genetically Modified Crops with IPM systems. *Springer*, Berlin, Germany; 2008. pp 159–94.

Naveed, H., Kanwer, S. A., Azhar A. H., Muhammad, A. and, Muhammad, Z. M. 2015. Field evaluation of different insecticides against spotted bollworm (*Earias* spp.) and comparative yield assessment for BT and non-Bt cotton. *Journal of entomology and zoology*

Paterson, A. H. 2009. *Genetics and Genomics of Cotton*. *Springer*. New York, USA.

Pedigo, L. P. 1996. *Entomology and Pest Management*, Macmillan Publishing Company, New York. pp. 107-119.

Rafiq, M., Shah, S. I. A., Jan, M. T., Khan, I. R., Shah, S. A. S., and Hussain, Z. 2014. Efficacy of different groups of insecticides against cotton stainer (*Dysdercus koenigii*) in field conditions. *Pakistan Entomology* 36(2):105-110

Sontakke, H., Baba, I., Jain, S.., Saxena, A., Bhagel, A. K. and Jadhaw, B. 2013. Fecundity and fertility control of red cotton bug (*Dysdercus cingulatus)* by the extract of *Psoralea corylifolia. International Journal of Research in Pharmaceutical and Biomedical Sciences*, 4 (2): 633-635.

Wazire, N. S. and Patel, J. I. 2016. Determination of Economic Injury Level (EIL) for leaf webber and capsule borer, *A. catalaunalis* (Duponchel) in sesamum. *International Journal for life science* pp169-172

Zahid, M. A., Islam, M. M. and Begume, M. R. 2008. Determination of economic injury levels of *M. vitrata* in Mungbean. *Journal of Agricultural Rural Development*, 6(1 and 2), 1-97.