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POPULATION CORRELATES AND CRITICAL PEST LEVEL (CPL) OF THE LEAFHOPPER, *AMRASCA BIGUTTULA* AND ASSOCIATED INSECT PESTS ATTACKING OKRA, *HIBISCUS ESCULENTUS* (L.)

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ABSTRACT

This study was conducted in two locations; San Manuel and Capas, Tarlac from 2008-2010. It aimed to determine the population density of major insect pests attacking okra as affected by time of planting, establishment of critical pest level (CPL) of *Amrasca biguttula* and other associated insect pests, and to assess phenologically the rate of first instar larval/nymph emergence from an eggmass. Feeding tests of insect pests with host were conducted in an experiment nethouse with sufficient batches of trials which had established the critical pest level. *Amrasca sp*. and *Dysdercus cingulatus* were found with high population density during the dry seasons planting of 2009-2010, while *Spodoptera litura* registered a population mean ranging from 11.75 to 23.66 regardless of observation sites. High population of *Amrasca sp.* was evident during January and onwards as affected by temperature and as shown from the gathered population data which confirmed that planting of okra during dry seasons would entail significant damage of the crop. With a series of feeding interaction tests conducted for *Amrasca biguttula,* its critical threshold level was established with a population ratio of 45.53 per 50 plants with an allowable yield reduction threshold of 10 percent (%). The generated data is recommended for adoption which contributes to reduced frequency of chemical application and production of quality exportable green okra. Moreover, phenological forecast on the hatchability of the eggs of two major insect pests; *Amrasca bigutula* and *Dysdercus cingulatus* were found correlated with temperature while *A. biguttula* was found correlated with crop age and temperature.

Key words: *Dysdercus cingulatus, Heliothis armigera, Spodoptera litura,* phenological forecast, feeding test

INTRODUCTION

Okra is a vegetable crop under the Malvaceae family, scientifically known as *Hibiscus esculentus* L. Some agricultural studies and literatures underscored the nutritional importance of okra due to its valuable nutrients. It has been recognized as an important food crop due to its high seed protein content of 21% and abundant essential nutrients. It has been noted as a good source of vitamin, phosphorus, and iron. Mature okra seed contains 20% edible oil.

For the last thirteen years, this crop has been intensively cultivated by farmers, particularly in the Province of Tarlac, due to its export potential as well as the contribution to the economy of the province. Although farmer-cultivators have enjoyed and are continuously enjoying the gains from okra production, they have been facing with problems like pest resurgence and development of insecticide resistance in okra leafhopper (*Amrasca biguttula*) which becomes a major problem in okra production due to the calendar spraying practice by the growers. In 2005, information gathered from the okra growers revealed that pesticide detectable residues from okra fruits sampled from foreign market access were beyond acceptable limit due to the effect of calendar spraying (OPPA, 2005).

Amrasca biguttula is also considered as one of the major pests of legumes in Southeast Asia. This pest was originally under the genus *Empoasca*, but Gapud (1995) and Caasit-lit (1989) confirmed that this genus was renamed to *Amrasca*. Both nymphs and adults feed on the lower surface of the leaves. They suck the sap and cause hopper burn. Heavy damage is shown by yellowing of the leaf margin and curling of the leaves. High infestation during the vegetative stage ultimately causes stunting followed by the death of the plant (Scheirner, 2000).

Okra leafhopper is also known as eggplant leafhopper, cotton leafhopper, green jassid and Indian cotton leafhopper. This pest is difficult to control and it was found very destructive. Various strategies like alternate use of pesticides had been done by farmers themselves to control this pest but did not emerged as sustainable control strategy. Moreover, it is not economical but causes environmental pollution instead. This could be the reason why farmers should be guided with workable and viable control measures, through reduced frequency of pesticide application.

Relatively, the result of this study is an imminent component of the export scheme such as production of quality green okra with tolerable/acceptable pesticide residue, as a market assurance for foreign consumers.

MATERIALS AND METHODS

Determination of correlates on major insect pest populations of okra as affected by time of planting

The establishment of trial plots were done to generate information on monthly population trend of major insect pests attacking okra. It aimed to serve as basis for planting guide and enable farmers to avoid the damage particularly caused by *Amrasca sp.* and ultimately reduce the effect of pesticide residue. Clusters of farms in four sites in San Manuel and Capas, Tarlac planted with okra in January planting 2009 and January planting 2010 were identified as observation sites. An area of 2,500 m^2 per trial was used for data collection. In each observation unit, data were gathered at 30, 45, 60 and 75 days after planting on 100 tagged plants randomly selected across the test plots in an X pattern. Correlation of determinants; crop age and temperature in relation to major insect pests abundance were determined. The results were tabulated and analyzed statistically.

Feeding Test and Determination of Critical Pest Level (CPL)

Collection and mass rearing of *A. biguttula*

Egg colonies of *Amrasca biguttula* were collected from the field and mass reared in a room temperature using ball jars. Disinfected fresh okra leaves, honey and wetted cotton balls were provided in the rearing jars from egg up to adult stage. The rearing media were replaced daily until enough supply of leafhopper adults was attained. The rearing set-ups were the source of insects for test replicates. Initial observations and recording were made to determine the susceptible stage of *Amrasca* and to assess the duration of each stadium from egg to adult and validated in nethouse experiment.

The Critical Pest Level (CPL) of *Amrasca* sp. was determined through feeding tests. Three hundred polyethylene bags size #9 were planted with susceptible okra plants arranged in Completely Randomized Design (CRD) replicated three times. The treatments were as follows:

T1 - 2 egg cluster with 100 eggs
T2 - 2 egg cluster with 150 eggs
T3 - 2 egg cluster with 200 eggs
T4 - 2 egg cluster with 250 eggs
T5 - Control Check

Egg clusters deposited on leaves of okra taken from reared *A. biguttula* sp. were pinned on the leaves of an identified center plants in the assigned experiment treatments, done for five set up; dry seasons from January 2009 to June 2010. Data collections were made at 30, 45, 60 and 75 days after crop emergence. Cost of control and the value of the product were determined based on the tolerable yield reduction (TYR) caused by crop response with *Amrasca* sp.

Theoretical critical pest level was equated with equivalent crop damage from the total incidence of hopper burn. Reduction of pest by parasites, entomopathogen, competitors, antagonists and environmental conditions were estimated. The computation of the action critical pest level (ACPL) was made based on the ratio of insect population and equivalent crop damage using the method of Cadapan *et al.* (1996).

Fabrication and installation of net house

A net house was fabricated and constructed using steel materials. The structure has a measurement of 10 m x 10 m equivalent to an area of 100 m^2; with 4.5 m in height .Flat thin narrow steel reinforcement was used across the perimeter of the fabrication, structurally enclosed with a white fine mesh cloth. Trenches were established around edge-ends, with 6.5 inches depth purposely to prevent the entrance of pest other than the test insect. Ten steel net cages were framed separately as an enclosure material on control check treatments made up of steel post measuring 1.5 meters in height with four sides containing a diameter of 0.5 meter installed through acetylene machine with its corner ends enclosed with fine mesh cloth.

Preparation of host plant and layout of the experiment

Three hundred #9 thick black polyethylene bags were planted with highly susceptible okra variety secured from Biotech UPLB using a sterilized soil media following the peri-urban cultural requirements according to the method of Ulrichs (2001). Individual bags were planted with the rate of 5 seeds per bag and thinned to 3 plants at 10 days after crop emergence. Five treatments in a set were laid in a Completely Randomized Design, arranged in 3 replicates. One week after seed emergence, control check(s) were provided with steel cages which enclosed the test plants free from other insect pests.

Phenological forecast of *Amrasca biguttula* and *D. cingulatus*

Phenological forecast from egg to nymph emergence of the leafhopper, *Amrasca biguttula* and *Dysdercus cingulatus* was predicted. Basically, this is an important approach in the timing of chemical control. Temperature was used to correlate the determinants as it exerted dominance on developmental rate of the insect pests. The computation was done by using the electronic model established by Mols (1989) that evaluates the monitored daily temperature, oviposition and the rate of development of insect (in days) specifically on emergence of the first nymphal stadium from an egg. The forecast equation used, viz:

$$Y=a+b.X. \qquad \text{(Equation a)}$$

The value of X is the prevailing temperature T and Y is the rate of development r, then: r=a+b.T; TS=D.(T-Td) (Equation b)
where:

Ts = the temperature sum appropriate to the particular event
D = the duration in time units
T = the prevailing temperature
Td = the threshold temperature for development of insect
T-Td = the effective temperature
Tmin = the temperature in a given period of the effective temperature of each day
Tmax = is the temperature that exceeds the threshold temperature that would initiate emergence of a insect stadium from egg.

The constant a and b is transformed 1/D=(T-Td) / Ts, 1/D=(1.Ts).T-Td/Ts. (Equation c)

Thus r=1/D, b=1/Ts, a=Td/Ts. (Equation d)

Using temperature sum of several days on this study with the equation:

Ts=Σï (Tmin +Tmax) /2-Td. (Equation e)

The generated output of this study establishes a sustainable control based on judicious decision making in as much that *Amrasca* and other major insect pests attacking okra are unpredictable as to their population and feeding habits.

RESULTS AND DISCUSSION

Determination of major insect pest populations in okra as affected by time of planting

The leafhopper attacking okra, *Amrasca biguttula*, and other associated insect pests of the crop were studied, particularly on their periodic occurrence across okra farms located in San Manuel, Tarlac City, Tarlac Province. The occurrence of the identified insect pests shows that there was a consistent population occurrence of *Amrasca biguttula* during the assessment period, dry season of 2009 – 2010 (Tables 1 to 5). The mean population of the two major insect pests, *Helicoverpa armigera* and *Dysdercus cingulatus* has comparably with slight differences with mean population ranging from 4.97 to 16.04 except for *Spodoptera* with mean population which ranges from 11.75 to 23.66 regardless of observation sites.

On the other hand, there was sudden increase in the population of existing insect pests noted 30 up to 75 days after crop emergence. Consistency in the population density of *Amrasca species* was noted as this pest behaves persistently on its feeding habit from vegetative to maturity of the host. Its high population density is attributed to its biological growth potential and its multiple generation capacity (Esguerra, 1989).

Slow population build-up of *Helicoverpa sp.* was observed (Tables 1 – 5), registered which ranges from of 0.44 to 4.66 at 30 days after planting (DAP) increasing slightly at 45 days after planting (DAP) ranging from 0.86 to 17.50. This explains that intensive feeding of the pest starts as the crop reaches fruit bearing stage (Martin *et al*, 1978; Markose *et al*, 1990).

As to periodic occurrence of *Amrasca*, the month of January planting has registered high population density which has exceeded the critical threshold and damage threshold level. This indicates that planting of the crop within January of the planting period of the years with low precipitation would entail significant damage and increases cost of control.

Table 1. Insect Pests Attacking Okra and their Population Means as Affected by Time of Planting and Plant Age (Observation Site 1) Dry Season November plantings 2008 and 2009

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	50.00	47.00	58.00	95.50	250.50	62.63
Spodoptera litura	15.00	12.00	11.00	9.00	47.00	11.75
Helicoverpa armigera	2.56	2.00	8.00	11.00	23.56	5.89
Dysdercus cingulatus	0.23	2.23	7.50	10.00	19.96	5.00

[1/] DAP = days after planting

Table 2. Insect Pests Attaching Okra and their Population Means as Affected by Time of Planting and Plant Age (Observation Site 2) Dry Season January planting 2009 and January planting 2010

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	59.50	57.00	83.00	114.50	314.00	78.50
Spodoptera litura	19.00	12.00	11.50	7.00	49.50	12.38
Helicoverpa armigera	1.86	1.33	1.06	13.40	17.65	4.41
Dysdercus cingulatus	1.66	1.06	1.53	15.67	19.89	4.97

[1/] DAP = days after planting

Table 3. Insect Pests Attacking Okra and their Population Means as Affected by Time of Planting (Observation Site 3) Dry Season February planting 2009 and February planting 2010

Insect Pests	Population Density (Individual pest species per 100 plants)				Total	Mean
	30 DAP[1/]	45 DAP	60 DAP	75 DAP		
Amrasca biguttula	18.00	87.00	86.50	100.00	291.50	72.88
Spodoptera litura	22.33	21.06	28.00	23.26	94.65	23.66
Helicoverpa armigera	1.66	1.78	20.00	21.50	44.94	11.24
Dysdercus cingulatus	1.82	2.08	9.00	20.00	32.90	8.23

[1/] DAP = days after planting

Table 4. Insect Pests Attaching Okra and their Population Means as Affected by Time of Planting (Observation Site 4) Dry Season March planting 2009 and March planting 2010.

Insect Pests	**Population Density (Individual pest species per 100 plants)**				**Total**	**Mean**
	30 DAP[1/]	**45 DAP**	**60 DAP**	**75 DAP**		
Amrasca biguttula	50.00	28.50	64.00	79.00	221.50	55.38
Spodoptera litura	20.00	19.00	25.00	24.00	88.00	22.00
Helicoverpa armigera	4.66	17.50	20.00	22.00	64.16	16.04
Dysdercus cingulatus	9.00	2.23	3.36	11.50	26.09	6.52

[1/] DAP = days after planting

Table 5. Insect Pests Attaching Okra and their Population Means as Affected by Time of Planting (Observation Site 5) Dry Season April planting 2009 and April planting 2010.

Insect Pests	**Population Density (Individual pest species per 100 plants)**				**Total**	**Mean**
	30 DAP[1/]	**45 DAP**	**60 DAP**	**75 DAP**		
Amrasca biguttula	56.00	29.00	78.00	89.00	252.00	63.00
Spodoptera litura	18.00	14.00	17.00	18.50	67.50	16.88
Helicoverpa armigera	0.44	0.86	7.00	14.00	22.30	5.58
Dysdercus cingulatus	0.66	1.08	4.00	8.47	14.20	13.55

[1/] DAP = days after planting

Table 6 and Figure 1 show the summarized population means of major insect pests as affected by time of planting. *Amrasca biguttula* exhibited high population among insect pests, followed by *Spodoptera litura* with a mean population range of 11.75 to 23.66. Planting season in February 2009 has the highest population mean followed by crop sown in March 2009, with the least population density of 11.75. Insignificant differences were noted among planting time comparing November and January planting time from February and March planting season. *Helicoverpa armigera* and *Dysdercus cingulatus* registered the low population means of all planting months.

Table 6. Summary of population means of major insect pests of okra, *Hibiscus esculentus* L., as affected by time of planting taken November 2008 to March 2009 planting months of the cumulative years.

Time of Planting	***Amrasca biguttula***	***Spodoptera litura***	***Helicoverpa armigera***	***Dysdercus cingulatus***
November 2008	52.63 b	11.75 b	5.89 c	6.00 b
January 2009	78.50 a	12.38 b	4.41 c	4.97 c
February 2009	72.88 a	23.66 a	11.24 b	8.23 a
March 2009	55.38 b	22.00 a	16.04 a	6.25 b
April 2009	63.00 b	16.88 b	5.58 c	3.55 c
Mean	66.48	17.33	8.63	5.60

* Means followed by the same letter(s) within the same column of individual species are not significantly different at 5% level of DMRT.

Correlation of determinants

Figure 1 shows the relationship between the crop age of *H. esculentus* and population of *Amrasca biguttula* 10 days after emergence up to 60 days of growth of the crop. There was a consistent and persistent feeding by *Amrasca* sp. on the crop regardless of the age. There was a linear correlation observed with r = 0.81 which indicates that the feeding interaction as affected by the crop age is not a determinant on feeding preference of the insect pest, as the same, consistently caused damage during the growth cycle of the crop, which is indicative that the insect is a serious pest of okra, as confirmed by Agsaoay and Briones (2010).

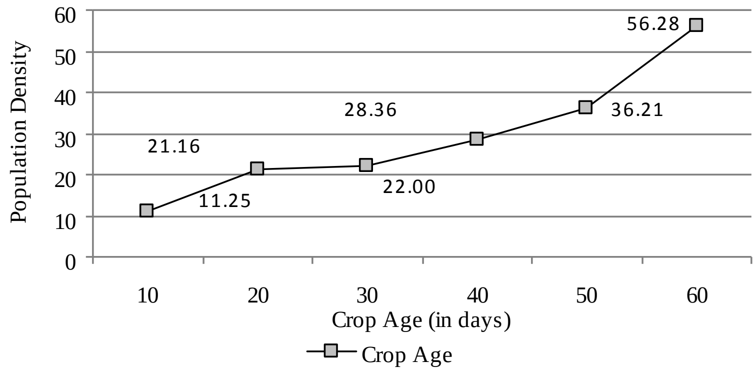

Fig. 1. Correlation between *Amrasca biguttula* population and age of the crop 10 days after emergence up to 60 days after planting.

On the other hand, Figure 2 reveals the relationship of four insect pests of the crop, namely: *A. biguttula*, *S. litura*, *H. armigera* and *D. cingulatus*. Feeding performance of the *A. biguttula* exceeded other associated pests. There was an inverse relationship on abundance as affected by temperature for *S. litura*. This insect pest exhibited slight damage during the early stage of the crop and leveled off as the age of the crop increased. Correspondingly, *D. cingulatus* population increased, and feeding performance started at 45 DAP up to the maturity of the crop.

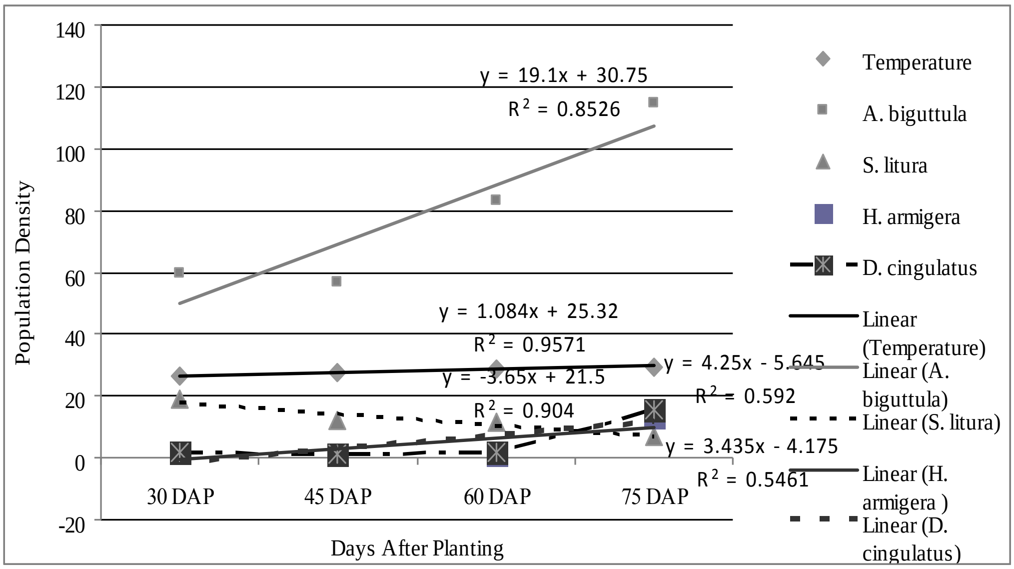

Fig. 2. Relationship between temperature and population of insect pests attacking okra as affected by time of planting (November 2009 – January 2010).

Critical Pest Level (CPL) of *Amrasca biguttula*

The critical pest count, yield (tons ha^{-1}) differences and damage threshold (%) were determined during the dry season, January to June 2009 and October 2009 to May 2010 in an experiment nethouse. Assessment was done at 30, 45, 60, and 75 days after planting. Significant differences were observed among treatments (Table 7). Treatments 1 and 2 released with 100 and 150 eggs, respectively did not differ significantly on the assessed critical pest level. A comparison among treatments showed Treatments 1 and 2 differ significantly from the rest of the Treatments; 3, 4 and 5. Yield differences and damage threshold did not vary significantly as shown by the damage threshold except when compared to the control.

Table 7. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1–2 egg clusters with 100 eggs	57.00	31.00	57.00	79.00	224.00	56.00a	10	6.90	3.10	31.0 a
T2 – 2 egg clusters with 150 eggs	68.50	57.50	70.00	36.00	232.00	58.00a	10	6.56	3.44	34.0 a
T3 – 2 egg clusters with 200 eggs	36.00	50.00	31.00	78.50	195.50	48.88c	10	6.75	3.25	32.5 a
T4 – 2 egg clusters with 250 eggs	41.00	56.50	60.50	86.50	244.50	61.13b	10	7.00	3.00	30.0 a
T5 - Control Check	8.00	9.00	7.50	10.00	34.50	8.63d	10	9.83	0.17	0.02 b

[1] First Trial
[2] Critical Pest level = 45.53
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Table 8 showed the critical pest count on Trial 2. The mean count shows insignificant differences among treatments 1, 2, and 3, while significant differences were noted when compared to treatments 4 and 5. Damage threshold on the other hand registered almost insignificant differences except when compared to the control check (T5). The highest damage threshold was noted in treatment 4, with the highest mean pest population of 73.37. Critical pest level registered 45.30.

Insignificant differences were noted in Tables 9 and 10. Damage threshold did not differ among treatments which ranges from 25 to 30% although mean pest count varies significantly among treatments. Control check (T5) has the lowest population with 7.75, but the damage threshold registered the highest value compared from among treatments.

Table 8. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	12.50	22.00	93.33	95.00	222.83	55.71 b	10	7.00	3.00	30 .0 a
T2 – 2 egg clusters with 150 eggs	16.67	13.75	75.00	87.50	192.92	48.23 b	10	7.00	2.50	25.0 b
T3 – 2 egg clusters with 200 eggs	20.50	75.00	11.67	75.00	182.17	45.54 b	10	7.19	2.81	28.1 a
T4 – 2 egg clusters with 250 eggs	18.00	87.50	86.67	101.33	293.50	73.37 a	10	6.40	3.60	36.0 a
T5 – Control Check	8.00	7.50	9.00	10.00	34.50	8.63 c	10	8.83	1.17	0.96 c

[1] Second Trial

[2] Critical Pest level = 45.30

[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Table 9. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	25.67	28.00	100.00	54.25	207.92	51.98 a	10	7.00	3.00	30.0 a
T2 – 2 egg clusters with 150 eggs	32.33	37.33	63.67	10.50	143.83	35.96 c	10	7.19	2.81	28.1 a
T3 – 2 egg clusters with 200 eggs	27.00	62.33	32.00	66.50	187.83	55.21 a	10	6.90	3.10	31.0 a
T4 – 2 egg clusters with 250 eggs	33.00	33.00	2.75	56.33	125.08	36.27 b	10	7.19	2.81	28.10 a
T5 – Control Check	6.50	7.00	8.50	9.00	31.00	7.75 d	10	7.50	2.5	25.0 a

[1] Third Trial

[2] Critical Pest level = 36.38

[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Table 10. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	29.00	32.33	123.50	70.00	254.83	63.71 a	10	6.38	3.62	36.2 a
T2 – 2 egg clusters with 150 eggs	36.33	49.00	73.67	14.00	173.00	43.25 c	10	7.19	2.81	28.1 a
T3 – 2 egg clusters with 200 eggs	32.33	70.33	36.00	104.50	243.16	60.75 a	10	7.00	3.00	30.0 a
T4 – 2 egg clusters with 250 eggs	47.00	37.00	58.50	87.50	230.00	57.50 b	10	7.00	3.00	30.0 a
T5 – Control Check	8.00	7.50	9.50	4.50	29.50	7.38 d	10	7.50	2.50	25.0 a

[1] Fourth Trial
[2] Critical Pest level = 45.52
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

Similarly, Table 11 particularly Treatments 1–4, obtained a consistent insignificant differences, for both mean population and damage threshold except when compared to the control check. Critical pest levels registered with a value of 36.38 and 49.72, respectively.

Table 11. Critical pest count of leaf hopper, *Amrasca biguttula*, yield differences and damage threshold (%) (Dry seasons, 2009-2010)[1]

Treatments	Population Density Days After Planting				Total	Mean[3]	Attainable Yield (tons ha^{-1})	Actual Yield (tons ha^{-1})	Yield Difference (tons ha^{-1})	Damage Threshold[2] (%)
	30	45	60	75						
T1 – 2 egg clusters with 100 eggs	26.00	15.67	73.33	110.67	225.67	56.42 b	10	7.06	2.94	29.40 a
T2 – 2 egg clusters with 150 eggs	35.67	39.25	112.33	80.67	267.92	66.98 a	10	6.50	3.50	35.00 a
T3 – 2 egg clusters with 200 eggs	22.33	105.67	23.00	153.50	304.50	76.13 a	10	6.31	3.69	36.90 a
T4 – 2 egg clusters with 250 eggs	51.00	19.00	36.00	52.33	185.33	46.33 b	10	7.44	2.56	25.60 ab
T5 – Control Check	6.50	7.00	8.00	9.50	31.00	7.75 c	10	9.68	3.62	0.63 c

[1] Fifth Trial
[2] Critical Pest level = 49.72
[3] Means followed by the same letter(s) within the same column are not significantly different at 5% level of DMRT

The result of this study has established critical pest level for Amrasca, a potent guide on pest management. The research output serves as an action order for an alternative to calendar spraying and minimizing risk on pesticide residue on exportable and for local consumption green okra.

Phenological forecast for the two major insect pests of okra

Figures 3 and 4 show the result of correlation of determinants on nymphal and larval emergence from egg mass of the two major pests, *Amrasca biguttula* and *Dysdercus cingulatus*. With the mean daily temperature of $36^{O}C$ had caused simultaneous biological emergence of the two major pests from egg within 3 days. As the temperature increases, corresponding increase (in days) decreases. The increase of temperature (^{O}C) hastens the hatchability of the eggs of the two insect pests species.

The result indicated that temperature is related to the growth and development of the insect. The inverse relationship is important in insect pest management particularly phenological forecasting as basis of timed- application of pesticide.

The value indicates that there was reliability of the equation for determinants as indicated by its r equivalent to 0.968 which is significant at 5% level. This means that 96.8% development time of the insect was attributed to temperature.

The generated research output resulting from forecasting of *Amrasca species* of this study coupled with appropriate sampling method reduces frequency of pesticide application resulting to a reduced pesticide residue on green okra fruits. On the other hand, the established critical pest level (CPL) on this study serves as guide for the okra growers in controlling the pest (*A. biguttula*).

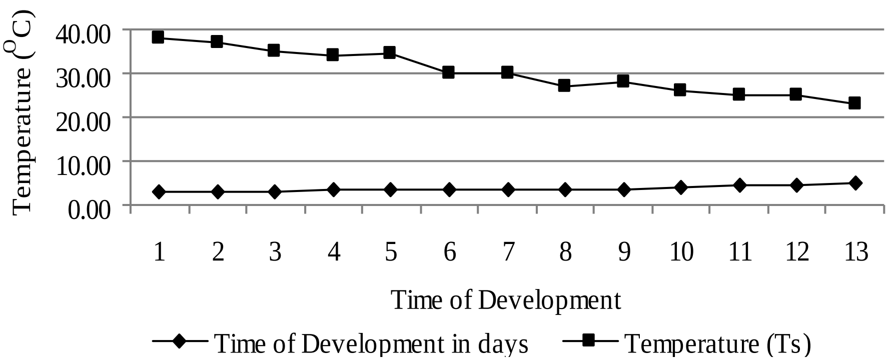

Fig. 3. The relationship between the time of nymph emergence from egg of *A. biguttula* and daily mean temperature (^{O}C).

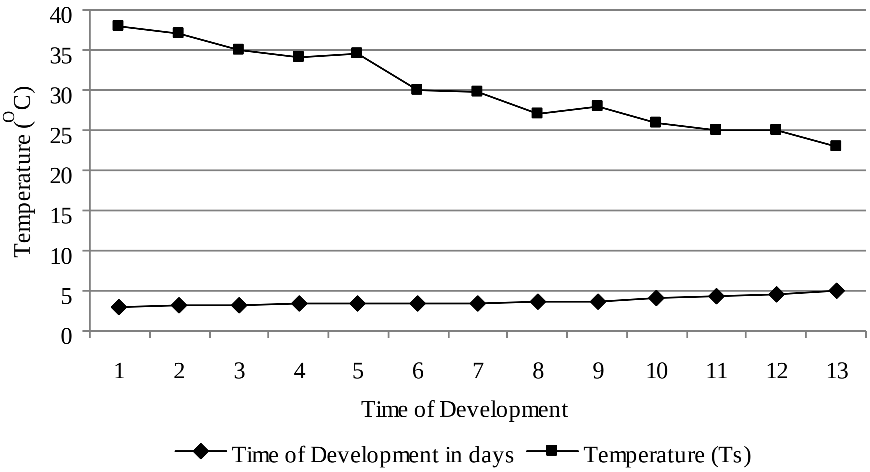

Fig. 4. The relationship between the time of development of *Dysdercus cingulatus* and the sum of temperatures (Ts ^{O}C) in days.

CONCLUSION

Result of this research work unraveled the concern for assessing damage caused by leafhopper, *Amrasca biguttula*, as one of the most diversed insect pest of okra.

Amrasca sp. and *Dysdercus cingulatus* were found with high population density during the dry seasons planting of 2009-2010, while *Spodoptera litura* registered a population mean ranging from 11.75 to 23.66 regardless of observation sites.

High population of *Amrasca sp.* was evident during January and onwards as affected by temperature and as shown from the gathered population data which confirmed that planting of okra during dry seasons would entail significant damage of the crop. With a series of feeding interaction tests conducted for *Amrasca biguttula*, its critical threshold level was established with a population ratio of 45.53 per 50 plants with an allowable yield reduction threshold of 10 percent (%). The generated data is recommended for adoption which contributes to reduced frequency of chemical application and production of quality exportable green okra.

Moreover, phenological forecast on the egg clusters hatchability of two major insect pests; *Amrasca bigutula* and *Dysdercus cingulatus* were found correlated with temperature while *A. biguttula* was found correlated with crop age and temperature.

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