Efficiency of Cultural Practices of Mulching and Nipping in the Management of Eggplant Infestation and Damage by Leucinodes orbonalis Gueéne (Lepidoptera: Pyralidae)

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Abstract
The objective of the study was to evaluate the effectiveness of cultural practices of mulching and nipping in the management of eggplant infestation and damage by *Leucinodes orbonalis* Guenée (Lepidoptera: Pyralidae). Therefore, a field experiment using six eggplant varieties was carried out under tropical mean ambient temperature (30.4 °C) and relative humidity (73.3 %). The experimental site was Teaching and Research Farm of Faculty of Agriculture, University of Port Harcourt, Nigeria. Each bed measured 2 m x 1.3 m and eggplant varieties were planted at a distance of 0.3 m x 0.4 m. The experiment was arranged in a randomized complete block design, left to natural infestation and had three replications. The eggplants were mulched and nipped every two weeks in the study. The results revealed that all the test varieties were susceptible to attack by the insect pest under the two management techniques. Fruit weight of all varieties increased progressively (25.06 g) up to the third week after planting and declined thereafter (18.09 g) probably due to damaging effect of *L. orbonalis*. Mulching and nipping supported good fruit weight but were not highly effective in protecting eggplants against *L. orbonalis* infestation and damage. There was no significant difference ($P > 0.05$) in their individual ability to manage *L. orbonalis* attack irrespective of resistance status except at second-week after maturity in the number of exit holes/fruit and number of larvae/fruit ($P < 0.001$).

Key words: Eggplant, Mulching, Nipping, Integrated pest management, Varietal resistance.

Introduction

Eggplant is a culturally important vegetable in the tropics; its fruits are often presented to guests as a demonstration of hospitality demanded by the customs of the people. Recently, it has been reported that the fruit is arousing a growing interest in the exotic vegetable markets of the world and the plant represents potential new crop for subtropical climates (Onekutu and Omoloye, 2015). Unfortunately, fruit production in eggplant is hampered by *Leucinodes orbonalis* Guenée commonly known as eggplant fruit and shoot borer found virtually everywhere the crop is grown and causing significant reduction in the amount of marketable fruits (Chakraborti and Sarkar, 2011; Onekutu and Omoloye, 2015). The pest has been reported to be a major problem in eggplant cultivation. The larva bores into the shoots and fruits culminating in diminished fruit production, loss of visual appeal and consequent financial losses from poor sales or outright rejection at the local and international markets. In the field, yield loss as high as 85 – 90 % has been reported (Jagginavar *et al*., 2009; Chakraborti and Sarkar, 2011). Yield reduction apart, the borer is now known to reduce up to 80 % vitamin C content of the fruit (Sharma, 2002) and this raises nutritional concern.

Many strategies are used for the management of *L. orbonalis* infestation and damage in eggplants (Chakraborti and Sarkar, 2011). These include mechanical, cultural, biological, biotechnical and chemical tactics. The growing of resistant varieties of eggplants is one useful approach to solving the problem of attack by *L. orbonalis*. However, this is often undermined by the unavailability of resistant eggplant varieties. Most farmers deploy chemical method because of its quick action and effectiveness (Chakraborti and Sarkar, 2011; Onekutu and Omoloye, 2015). Different cultural practices have been suggested for eggplants (Chen *et al*., 2001). These include mulching, staking, pruning, weed control and irrigation. Use of cover crop residues as organic mulches and nipping to disturb prolific breeding of insect pests has a number of merits to farming systems including insect pest management (Udikeri *et al*., 2004; Gill *et al*., 2011). Prasifka *et al*. (2006) had indicated that mulches increased predatory populations to manage European corn borer (*Ostrinia nubilalis* Hübner) while Udikeri *et al*. (2004) recommended nipping as effective cultural measure in insect pest management of cotton. Undoubtedly, using cultural practices such as mulching and nipping in the management of pest infestations is highly beneficial. They are safer and cheaper than conventional synthetic insecticides. Therefore, it is in the light of the reorientation for safer and cheaper control tactics that the present study was designed to evaluate the efficiency of mulching and nipping in managing *L. orbonalis* infesting eggplants in a humid tropical environment. Also, the study sought to determine the varietal response of eggplants to *L. orbonalis* attack under the two field management techniques.

Materials and Methods

Experimental site and attributes

The study was conducted in the year 2013 and repeated in 2014 and 2015 at the Teaching and Research Farm of Faculty of Agriculture, University of Port Harcourt, Rivers State, Nigeria, situated on latitude 4.54^0 North and longitude 6.55^0 East with an elevation of 20 m above sea level of the humid tropics. The area is characterized by a wet and dry season with a bimodal rainfall pattern. The wet season lasts from April to October with peaks in June and September. The dry season commences in November and ends in March with occasional interruptions by sporadic rainfall. Annual rainfall ranges from 2,000 to 2,680 mm while temperature is between 20 to 33 °C (GEM, 2011).

Eggplant varieties

The six eggplant varieties used in the study were two hybrids, Barbetene and F1 African beauty and four Nigerian local varieties- Yallow white oval with green stripes, Yallow white oval, Yallow big white and Gauta. All the varieties were obtained from Jos Main Market, Plateau State, Nigeria and their seeds were used for the study.

Pre-nursery and nursery preparations

The seedlings were raised under a shed in a 25 cm x 35 cm plastic basket filled with top soil. After a period of 21 days, seedlings were removed and placed singly into a plastic cup fitted with top soil and kept in the nursery for 3 weeks to enable establishments of roots and further development. Seedlings grown in cells or containers are ideal for easy field-planting without disturbance to the root system (Chen *et al*., 2001).

Site preparation, transplanting, treatment and data collection

The land area was cleared mechanically using a tractor, ploughed with a disc plough and tilled with a fork tiller. The layout covered a total land area of 288 m^2. The experiment was set out in a randomized complete block design with each bed measuring 2 m x 1.3 m. Three replications were done. Forty-two-day-old seedlings were transplanted (in the evening between 1700 and 1800 hours to minimize shock and heat stress) on each bed at a spacing of 0.3 m x 0.4 m. The soil was pressed firmly around the plant, irrigated immediately and then, left to natural rains. Standard agronomic practices were followed to ensure a good crop stand (Chen *et al*., 2001). The plants were left to natural infestation. The treatments were mulching and nipping. Organic type of mulch was used and applied manually at the base of the plants, monitored every two weeks and got ultimately augmented when necessary. Nipping was done every two weeks and briefly, the older (sometimes, rotten) leaves from the lower portions of the eggplants were cut off every two weeks to allow for more air circulation and lightning within the canopy. Eggplant fruits were harvested immediately the fruits reached one-third of their full growth and when their skins turned glossy (Udoh *et al*., 2005) and the parameters measured in order to determine the efficiency of mulching and nipping were fruit weight, number of *L. orbonalis* exit holes per fruit and number of *L. orbonalis* larvae per fruit. The parameters were measured at interval of 7 days up to 4 weeks in the study.

Statistical analysis

Data on eggplant fruit weight, number of insect exit-holes and number of larvae per fruit were analyzed using one-way analysis of variance. The statistical software used to run the analysis is SPSS (Statistical Package for the Social Sciences) version 19.0. Upon significance of the F-test, means were separated using LSD (Least Significant Difference) at α level of 0.05. The student t-test was statistically used (at n-1 degrees of freedom) to compare the pooled effects of mulching and nipping.

Results

Impact of mulching and nipping at week-one post maturity evaluation stage

There were significant differences in the mean weight of fruits, number of insect exit-holes and number of larvae of *L. orbonalis* in different eggplant varieties at week-one post maturity evaluation stage under the two field management techniques (Table 1a). The result further indicates that fruit weight was significantly higher ($P < 0.05$) in Barbetene that were both mulched (66.31 g) and nipped (73.60 g) while the fruit weight (g) of other varieties under the management techniques did not differ from each other. Number of exit holes of *L. orbonalis* recorded in eggplant fruits were highest in Barbetene varieties (1.36 and 1.37 in mulched and nipped, respectively), significantly higher ($P < 0.05$) than mulched F1 African beauty, but without statistical difference ($P > 0.05$) with nipped F1 African variety. The least *L. orbonalis* exit holes (0.71) was recorded in F1 African beauty which did not differ statistically ($P > 0.05$) from Yallow big white. Significantly higher number of larvae (1.25) was recorded on Barbetene that was mulched which did not differ from Yallow big white and the least number of larvae (0.66) was on variety Yallow big white that was nipped which also did not differ ($P > 0.05$) from F1 African beauty that was mulched. Pooled comparative impact of mulching and nipping in the management of eggplant fruit and shoot borer are shown in Table 1b. The result revealed no statistical differences ($P > 0.05$).

Impact of mulching and nipping at week-two post maturity evaluation stage

There were significant variations in the mean weight of fruits, number of insect exit-holes and number of larvae of *L. orbonalis* in the eggplant varieties two weeks after maturity (Table 2a). The result indicates that fruit weight was significantly higher in Barbetene eggplants that were both mulched (106.93 g) and nipped (82.39 g) while the other varieties under the management techniques did not differ from each other ($P > 0.05$). The number of exit holes was significantly higher in variety F1 African beauty that were mulched (1.65 holes/fruit) and nipped (1.77 holes/fruit). This was followed by variety Yallow white oval with green stripes that was mulched. The least exit holes (0.33) were recorded on Yallow big white that was nipped; though it did not differ from same variety that was mulched. The weight of fruits (at harvest) (25.71 g versus 24.20 g) did not differ statistically ($P > 0.05$) between the two treatments (mulching and nipping), but the mean number of insect exit holes (1.26) and larvae (1.02) were significantly higher for mulched varieties in week two (Table 2b).

Impact of mulching and nipping at week-three post maturity evaluation stage

The mean weight of fruits, number of insect exit-holes and number of larvae of *L. orbonalis* in the eggplant varieties as influenced by mulching and nipping during week-three post maturity assessment stage are shown in Table 3a. For fruit weight, the result was as in week two evaluation. Exit holes (1.55) of *L. orbonalis* were significantly highest ($P < 0.05$) in F1 African beauty varieties that were mulched but did not differ statistically ($P > 0.05$) with its nipped samples and with the rest of the varieties that were both mulched and nipped, except Barbetene. All the varieties (mulched and in the number of larvae infesting the fruits. In week three, there was no comparative difference (P > 0.05) in *L. orbonalis* management evoked by mulching and nipping (Table 3b).

Impact of mulching and nipping at week-four post maturity evaluation stage

In week four stage of evaluation (after fruit maturity), eggplant fruits weighed significantly highest (P < 0.05) in Barbetene that were both mulched (25.14 g) and nipped (40.14 g) in the field and the fruit weight of the other varieties did not vary significantly (P > 0.05) (Table 4a). The number of exit holes (1.66) made by the moth was significantly highest in variety Yallow white oval with green stripes that received mulch. However, this was statistically the same with the amount of holes in varieties Yallow white oval (mulched and nipped), Yallow big white (mulched) and Gauta (nipped). Mulched and nipped Barbetene eggplants had lowest number of larvae (0.33) in their fruits and differed significantly (P < 0.05) with the others. Mulching and nipping in week four showed no significant difference (P > 0.05) in their individual ability to manage *L. orbonalis* infestation and damage (Table 4b). The same trend was observed in weeks one and three (Tables 1b and 3b).

Table 1a: Fruit weight of eggplants and number of holes and larvae of *L. orbonalis* per fruit as influenced by mulching and nipping assessed first-week after maturity (in all cases, df = 11,24)

Eggplant varieties	Mean fruit weight (g)	Mean No. of holes/fruit	Mean No. of larvae/fruit
Barbetene	66.31±5.24^{a}	1.36±0.01^{a}	1.25±0.77^{a}
Barbetene	73.60±3.21^{a}	1.37±0.12^{a}	1.16±0.10^{ab}
Ywowgs*	20.02±1.26^{b}	1.24±0.04^{a}	1.00±0.00^{ab}
Ywowgs*	13.18±1.56^{b}	1.32±0.05^{a}	1.00±0.00^{ab}
Yallow white oval	19.40±2.22^{b}	1.11±0.01^{a}	1.00±0.00^{ab}
Yallow white oval	13.72±4.12^{b}	1.18±0.31^{a}	1.11±0.01^{ab}
F1 African beauty	16.82±0.98^{b}	0.71±0.22^{b}	0.66±0.11^{c}
F1 African beauty	19.32±2.34^{b}	1.12±0.42^{a}	1.00±0.00^{ab}
Yallow big white	8.20±1.78^{b}	1.31±0.01^{a}	1.22±0.02^{a}
Yallow big white	8.42±2.20^{b}	0.71±0.05^{b}	0.66±0.01^{c}
Gauta	6.24±0.34^{b}	1.31±0.11^{a}	0.88±0.01^{bc}
Gauta	10.74±0.55^{b}	1.27±0.56^{a}	1.04±0.01^{ab}
F	17.7	2.4	3.0
P	< 0.05	< 0.05	< 0.05

Data are means ± standard errors of three replications

Figures followed by same letter(s) in a column did not differ significantly at 0.05 α level on the basis of LSD (Least Significant Difference) *Yellow white oval with green stripes

Table 1b: Comparative efficacy of mulching and nipping in the management of eggplant varieties infested with *Leucinodes orbonalis* Gueéne during week one following maturity

Assessment indices	Mulching	Nipping	t-value	Remarks
Fruit weight	22.83	23.16	0.934	Not significant
No. of exit holes/fruit	1.14	1.13	0.268	Not significant
No. of larvae/fruit	0.99	0.99	0.239	Not significant

In all cases df = n-1; P > 0.05

Table 2a: Fruit weight of eggplants and number of holes and larvae of *L. orbonalis* per fruit as influenced by mulching and nipping assessed second week after maturity (in all cases, df = 11,24)

Eggplant varieties	Mean fruit weight (g)	Mean No. of holes/fruit	Mean No. of larvae/fruit
Barbetene	106.93±2.32^{a}	1.07±0.15^{bcd}	1.04±0.50^{abc}
Barbetene	82.39±10.76^{b}	1.08±0.01^{bcd}	0.94±0.12^{abc}
Ywowgs*	10.10±1.27^{c}	1.53±0.02^{ab}	1.21±0.13^{a}
Ywowgs*	15.29±3.33^{c}	1.11±0.02^{bcd}	1.04±0.26^{abc}
Yallow white oval	11.40±2.50^{c}	1.40±0.23^{ab}	1.12±0.34^{ab}
Yallow white oval	9.66±2.55^{c}	0.82±0.01^{cd}	0.82±0.12^{bc}
F1 African beauty	10.01±2.89^{c}	1.65±0.03^{a}	1.01±0.22^{abc}
F1 African beauty	21.29±2.01^{c}	1.77±0.40^{bcd}	1.04±0.05^{abc}
Yallow big white	5.78±1.01^{c}	0.71±0.01^{de}	0.74±0.24^{c}
Yallow big white	3.49±0.50^{c}	0.33±0.01^{e}	0.33±0.01^{d}
Gauta	10.04±1.80^{c}	1.20±0.70^{abc}	1.04±0.01^{abc}
Gauta	13.11±1.56^{c}	1.28±0.35^{abc}	1.00±0.00^{abc}
F	21.6	4.4	3.5
P	< 0.05	< 0.05	< 0.05

Data are means ± standard errors of three replications
Figures followed by same letter(s) in a column did not differ significantly at 0.05 α level on the basis of LSD (Least Significant Difference) *Yellow white oval with green stripes

Table 2b: Comparative efficacy of mulching and nipping in the management of eggplant varieties infested with *Leucinodes orbonalis* Gueéne during week two following maturity

Assessment indices	Mulching	Nipping	t-value	Remarks
Fruit weight	25.71	24.20	-0.754	Not significant*
No. of exit holes/fruit	1.26	0.97	3.691	Significant**
No. of larvae/fruit	1.02	0.86	2.857	Significant**

In all cases df = n-1; *P > 0.05; **P < 0.001

Table 3a: Fruit weight of eggplants and number of holes and larvae of *L. orbonalis* per fruit as influenced by mulching and nipping assessed third-week after maturity (in all cases, df = 11,24)

Eggplant varieties	Mean fruit weight (g)	Mean No. of holes/fruit	Mean No. of larvae/fruit
Barbetene	83.57±1.97^{a}	0.75±0.24^{c}	0.93±0.05^{ab}
Barbetene	89.90±8.26^{a}	0.75±0.01^{c}	1.02±0.01^{ab}
Ywowgs*	30.67±2.58^{b}	1.43±0.11^{a}	1.18±0.46^{a}
Ywowgs*	15.42±3.11^{b}	1.30±0.01^{a}	1.08±0.20^{ab}
Yallow white oval	13.97±4.19^{b}	1.12±0.02^{abc}	1.07±0.30^{ab}
Yallow white oval	13.72±2.20^{b}	1.27±0.03^{ab}	1.04±0.22^{ab}
F1 African beauty	13.36±1.65^{b}	1.55±0.50^{abc}	1.08±0.10^{ab}
F1 African beauty	20.18±2.50^{b}	1.04±0.04^{abc}	1.00±0.00^{ab}
Yallow big white	13.01±1.66^{b}	1.00±0.00^{abc}	1.04±0.07^{ab}
Yallow big white	9.06±1.27^{b}	0.84±0.05^{bc}	0.71±0.01^{b}
Gauta	12.56±2.39^{b}	1.24±0.09^{ab}	1.00±0.00^{ab}
Gauta	11.36±4.33^{b}	1.30±0.55^{a}	1.08±0.78^{ab}
F	6.9	2.0	0.6
P	< 0.05	< 0.05	< 0.05

Data are means ± standard errors of three replications
Figures followed by same letter(s) in a column did not differ significantly at 0.05 α level on the basis of LSD (Least Significant Difference)
*Yallow white oval with green stripes

Table 3b: Comparative efficacy of mulching and nipping in the management of eggplant varieties infested with *Leucinodes orbonalis* Gueéne during week three following maturity

Assessment indices	Mulching	Nipping	t-value	Remarks
Fruit weight	27.85	26.6	0.519	Not significant
No. of exit holes/fruit	1.11	1.08	1.104	Not significant
No. of larvae/fruit	1.05	0.99	0.851	Not significant

In all cases df = n-1; P > 0.05

Table 4a: Fruit weight of eggplants and number of holes and larvae of *L. orbonalis* per fruit as influenced by mulching and nipping assessed fourth-week after maturity (in all cases, df = 11,24)

Eggplant varieties	Mean fruit weight (g)	Mean No. of holes/fruit	Mean No. of larvae/fruit
Barbetene	25.14 ± 3.57^{ab}	0.33 ± 0.02^{d}	0.33 ± 0.01^{b}
Barbetene	40.14 ± 13.87^{a}	0.33 ± 0.01^{d}	0.33 ± 0.11^{b}
Ywowgs*	16.40 ± 1.89^{b}	2.00 ± 1.00^{a}	1.23 ± 0.01^{a}
Ywowgs*	15.70 ± 3.55^{b}	1.43 ± 0.03^{bc}	1.12 ± 0.05^{a}
Yallow white oval	16.87 ± 2.98^{b}	1.66 ± 0.06^{ab}	1.28 ± 0.02^{a}
Yallow white oval	20.31 ± 3.45^{ab}	1.53 ± 0.24^{abc}	1.21 ± 0.03^{a}
F1 African beauty	16.47 ± 2.20^{b}	1.46 ± 0.04^{bc}	1.25 ± 0.01^{a}
F1 African beauty	17.40 ± 2.34^{b}	1.35 ± 0.51^{bc}	1.04 ± 0.01^{a}
Yallow big white	14.41 ± 2.50^{b}	1.54 ± 0.01^{abc}	1.21 ± 0.50^{a}
Yallow big white	11.34 ± 1.10^{b}	1.10 ± 0.01^{c}	0.97 ± 0.01^{a}
Gauta	13.12 ± 4.77^{b}	1.47 ± 0.02^{bc}	1.20 ± 0.03^{a}

Discussion

The presence of larvae of *L. orbonalis* and exit-holes in all the varieties evaluated indicate that none was immune to the borer. This agrees with report of Darekar *et al*. (1991) that all varieties of eggplant are susceptible to the eggplant fruit and shoot borer. Pest population varying across the varieties under field management techniques of mulching and nipping demonstrated that eggplant varieties possess different levels of resistance to *L. orbonalis* and this was evident on the hybrid eggplants (Barbetene and F1 African beauty) which had lower infestations. Krishnaiah and Vijay (1975) reported that only two (Beckwai and Musk) out of thirty-seven eggplant varieties (local and hybrids) showed moderate resistance to *L. orbonalis* in India. Therefore, it is not surprising that the test eggplants differed in terms of varietal-response to *L. orbonalis* infestations under mulching and nipping as management tactics.

Field observations revealed that *L. orbonalis* (after appearance) persisted up to the end of the harvest cycle of the eggplants. As also revealed *L. orbonalis* increased in number with advancing time and reduced towards the end of the harvest. This is in agreement with the observations of Dhamdhere *et al*. (1995) that *L. orbonalis* activity commenced after transplanting of the seedlings and persisted up to the end of the harvest. The analysis of result further showed that the number of larvae obtained from a single eggplant fruit ranged from 0 – 10 and this is rated low compared to 50 % infestation rate recorded by Dhamdhere (1995). Field observations revealed a progressive increase in fruit weight in all the varieties under treatment conditions of mulching and nipping suggesting that the two management measures have the capacity to ensure good fruit weight. Therefore, the decline in fruit weight recorded after the third week could be attributable to the physiological state of the plant where yield declined after reaching its peak and the activity of the insect pest in question. From the results, it is obvious that mulching and nipping did not prevent infestation and damage of eggplants by *L. orbonalis*. However, the cultural practices achieved low infestation and damage rates throughout the period of investigation and the current impact made by mulching and nipping is not surprising. This is because it has been demonstrated that populations of small plant-feeding insects such as Aphididae, Thripidae and Aleyrodidae were adversely affected by organic mulch (Gill *et al*., 2011). In apple orchards, compost mulch reduced incidence of leafminer (*Phyllonorycter blancardella*) and migratory wolly apple aphid (*Eriosoma lanigerum*) nymphs (Brown and Tworkoski, 2003) whereas, nipping has already been shown to effectively manage insect pests of cotton (Udikeri *et al*., 2004). So, mulching and nipping have been culturally applied against certain insect pest infestations with encouraging results. The present extension to *L. orbonalis* with regard to eggplant protection is necessary.

In conclusion, this study revealed that *L. orbonalis* infested and damaged both local and hybrid eggplant varieties tested in humid tropical Nigeria probably due to low resistance. Therefore, an integrated pest management system using high varietal resistance and cultural practices of mulching and nipping is recommended for managers seeking to reduce eggplant infestation and damage by *L. orbonalis*.

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