International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 9, No. 1, p. 178-202, 2016

RESEARCH PAPER OPEN ACCESS

Growth responses of *Solanum melongena L.* treated with *Carica papaya* L. crude latex extract at different concentrations

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Key words: *Aspergillus niger*, Fungicide, Larvicide, *Leucinodes orbonalis*, *Solanum melongena* L.

http://dx.doi.org/10.12692/ijb/9.1.178-202 Article published on July 29, 2016

Abstract

Carica papaya latex is reported to be insecticidal, bacteriocidal, molluscicidal and fungicidal which are beneficial in agriculture. A complete randomized design (CRD) experiment was conducted to determine the growth responses of *Solanum melongena* treated with *Carica papaya* crude latex extract at different concentrations. Field results show that the mean stem height (*sh)* was 40.7 cm trial 1 (T1) antifungal activity (AFA) and 35.0 cm (T3) for larvicidal activity (LA); stem diameter (*sd)* was 3.2 cm (T3 and T5) for AFA and 3.1 cm (T4, T3 and T2) for LA. The total number of leaves (*L*) were 122 (T1: AFA) and 100 (T2: LA). For AFA, the mean number of damaged or infested leaves (*diL*) was 3.0 for T2, T3 and T5 and 2.0 for all treatments in LA. The mean number of damaged or infested shoots (*dish)* was 2 (T5) for AFA and 1 for all treatments for LA. The total means number of flowers (*fl*) were 3 flowers for AFA and 2 flowers for LA. The mean number of fruits (*ft)* yielded 7*ft* with only 3 marketable fruits (*Mft)* for AFA (T2) and 1 *Mft* for LA (T1, T3 and T4). The mean fruit weights (Wft) were 30.56 g for AFA (T2) and 11.11 g for LA (T3 and T4). *Carica papaya* crude latex extract could potentially mitigate *S. melongena* pests such as *L. orbonalis* larvae (as larvicide) and *A. niger* (as fungicide) based on the results.

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Introduction

Carica papaya latex is reported to be insecticidal, bacteriocidal, molluscicidal and fungicidal which are beneficial in agriculture. Fully grown but unripe fruits constitute the source of latex that is produced at the rate of several thousand metric tons each year (El Moussaoui *et al*., 2001). Fruits weighing 0.5 to 1.0 kg are those containing the largest amounts of latex with a mean value of 9 g per fruit (Monti *et al*., 2000).

The presence of papain, a cysteine protease in the latex of papaya tree (*C. papaya*, Caricaceae) functions in defense of the papaya tree against lepidopteran larvae, namely: Oligophagous *Samiaricini* (Saturniidae), two notorious polyphagous *brassicae* (Noctuidae), and *Spodoptera litura* (Noctuidae), (Konno *et al*., 2004). The cysteine proteases evidently provide in these plants with general defence mechanisms against herbivorous insects (Konno *et al*., 2004) and as sources of natural fungicides (Barkai-Golan, 2001).

Eggplant (*Solanum melongena* L.); Division Anthophyta; Class Dicotyledoneae; Order Solanales) is an agronomically important non-tuberous solanaceous crop grown primarily for its large oval fruit. Eggplant is one of the most important vegetables in Asia, where more than 90% of the world's eggplant production occurs (Srinivasan, 2009). Eggplant supplies vital vitamins, minerals, and dietary fiber to the human diet, especially in the rainy season, when other vegetables are in short supply for the rural and urban poor (Srinivasan, 2009). However, it is susceptible to numerous diseases and parasites, particularly the bacterial wilt, *Fusarium* and *Verticillium* wilts, nematodes and insects (Collonnier *et al*., 2001). Some fungi are common threat to agricultural production by causing huge economic losses to agriculture. In the tropics, eggplant production is severely constrained by several insect and mite pests. The major pests include eggplant fruit and shoot borer, leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer, blister beetle, red spider mite, and little leaf disease.

Growers rely heavily on chemical pesticides to protect their eggplant crop. For instance, farmers in certain areas of Philippines spray chemical insecticides up to 56 times during a cropping season. The total quantity of pesticide used per hectare of eggplant was about 41 liters of different brands belonging to the four major pesticide groups (Gapud and Canapi, 1994; Orden *et al*., 1994). In Bangladesh, some farmers spray about 180 times during a cropping season (SUSVEG-Asia, 2007). Pesticide misuse has adverse effects on the environment and human health and also increases the cost of production. Exploration of chemical constituents of different parts of the plants and pharmacological screening may provide the basis for the development of novel agents (Pandey and Dushyant, 2011). Botanical insecticides break down readily in soil and are not stored in animal and plant tissues. Often their effects are not as long lasting as those of synthetic insecticides and some of these products may be very difficult to find. Plant parts used for extraction or assay have included leaves, roots, tubers, fruits, seeds, flowers, bark, sap, pods and wood (Begum *et al*., 2013). Naturally occurring plant products are important sources of antifungal compounds with low toxicity to mammals. These plant products are safe to the environment which may serve as substitutes for synthetically produced fungicides (Knight *et al*., 1997).

This study focuses on the affectivity of *Carica papaya* crude latex extract as a potential alternative for larvicide and fungicide. The use of the *C. papaya* crude latex extract may reduce the farmer's dependency on the use of synthetic chemicals to depopulate farm pests which negatively affect agricultural production. This study specifically aims to determine the effects of *Carica papaya* L. crude latex extract at different concentrations on the growth of *Solanum melongena* L.

Materials and methods

Study area

The study area is located in Pagawan, Manticao, Misamis Oriental which is 1.5 km from the national highway (Fig. 1). Pagawan is one of the outlying areas among the 13 barangays covering the municipality of Manticao, Misamis Oriental.

It is a rural area having 1,748 residents as of 2007. It has a dry and wet climate. The area is composed partly of sandy loam soil which is mostly planted with papayas, coconut, bananas, trees and bamboos (Macalood *et al.*, 2013).

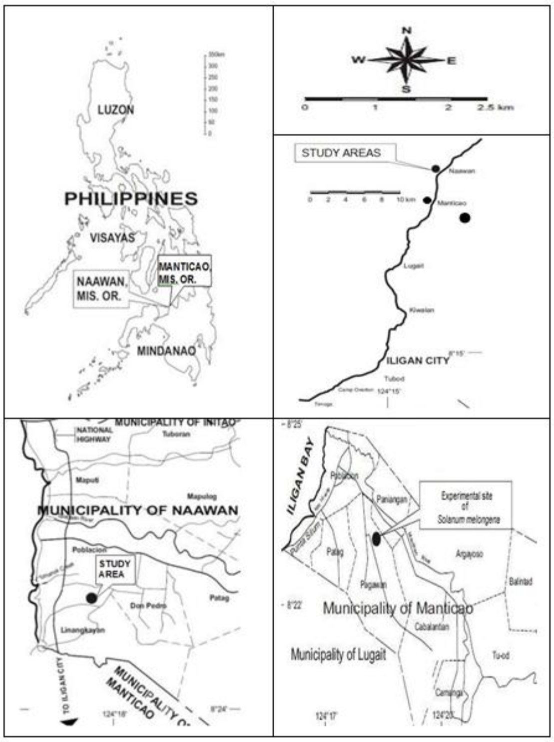

Fig. 1. Location of *Carica papaya* L. plantation at Tiwi-Simanok, Linangkayan, Naawan, Misamis Oriental and *Solanum melongena* L. garden, experimental site in Pagawan, Manticao, Misamis Oriental.

Fig. 2. *Carica papaya* plantation at Tiwi-Simanok, Linangkayan, Naawan, Misamis Oriental (Actual site).

Collection of latex

Fresh latex of *C. papaya* L. CX variety from Del Monte, Philippines was collected from Tiwi-Simanok, Linangkayan, Naawan, Misamis Oriental (Fig. 1 and 2). Initially, 4 to 6 longitudinal incisions at 3 mm deep were made on the unripe mature fruit surface from the fruit stalk end to the tip of the fruit by using a stainless steel knife between 6:00 AM and 8:00 AM during bright sunshine (Nitsawang *et al.*, 2006; Kamalkumar *et al.*, 2007). The incisions were repeated 4 times at 3 days interval. The exuded latex was allowed to run down the fruit and drip into collecting devices or aluminum trays raised in the trunk (Fig. 3 and 4). The procedures specified in the flowchart (Fig. 5) were strictly followed (Macalood *et al.*, 2013).

Fig. 3. *Carica papaya* latex collection by incision.

Fig. 4. *Carica papaya* latex allowed to drip in the aluminum tray raised in the trunk.

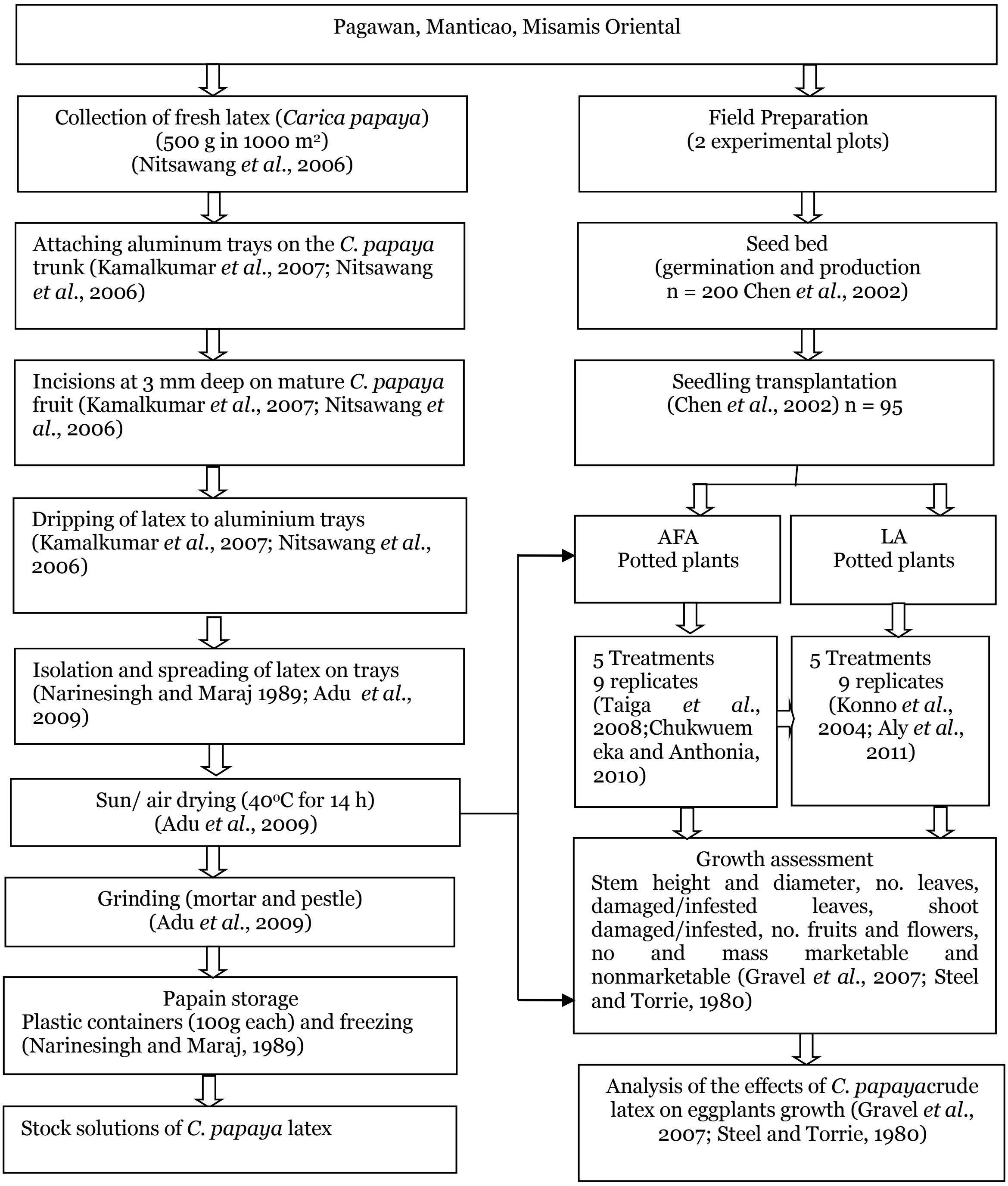

Fig. 5. Flow chart of the methods involved in the study.

Isolation of latex from C. papaya

Following collection, the latex was simply spread on trays and left for sun and air drying (Macalood *et al.*, 2013) at 40°C for 14 (Fig. 6 and 7). With the aid of mortal and pestle, the latex was ground producing a greenish or grey powder known as papain (Adu *et al.*, 2009). Papain is known to have a proteolytic activity slightly higher than that of the fresh latex (Narinesingh and Maraj, 1989).

Fig. 6. Spreading of *Carica papaya* crude latex on aluminum tray.

Fig. 7. Sun and air drying of *Carica papaya* crude latex at 30-40^{o}C.

Papain storage

The dried products were packed in air-tight plastic containers and stored in a cool, dry place (Macalood *et al*., 2013). Four plastic containers at 100 g capacity were used to pack the crude papain powder since metal containers would result in loss of enzyme activity (Fig. 8). These were kept and stored in a freezer at –20^{o}C (Nitsawang *et al*., 2006) in order to avoid reduction of its shelf life (Fig. 9) With proper storage and handling, the shelf life of the flakes or powder is 5-6 mo from the start of storage.

Fig. 8. Dried crude latex of *Carica papaya* in plastic container.

Fig.9. *Carica papaya* dried crude latex extract freeze-stored in plastic containers.

Disposal

All trays and other materials used in the latex collection and drying were cleaned with detergent soap, washed thoroughly with water, and kept dried. Waste water was allowed to run to the sink.

Potted plant preparation

The 45 potted *S. melongena* were treated with *Carica papaya* L. crude latex extract for fungicidal activity and 45 another potted *S. melongena*, for larvicidal activity. Forty five pots were prepared and filled with soil from a 2 kg m^{-2} of compost which was fertilized at 40 g m^{-2} ammonium sulphate and 30 g m^{-2} potassium chloride. A seed bed flat form of about 6 m x 1 m was made by using bamboo sticks and covered on the side with a nylon net (Fig. 10) to protect the seedlings from damage.

Fig 10.A seed bed flatform at 6 m^{2} made of sticks with a nylon net placed around the side.

Variety used

One can of commercial Morena F1 variety of *S. melongena* seeds was bought (Fig. 11) from the agrivet store in the locality.

Fig. 11. Selected *Solanum melongena* seeds of Morena F1 variety.

Seed treatment, germination and seedling production

About 10-30 g of *S. melongena* seeds was soaked in warm water (50 °C) for 30 min, rinsed in cold water and dried (Fig. 12). Seeds were sown at 0.5 cm deep at 24 to 29°C and allowed to germinate in the rolled banana leaves filled with fertile soil which was previously prepared and finally placed in the prepared seedling bed (Fig. 10). Two hundred seedlings out of 700 seeds in a can of *S. melongena* of Morena F1 variety germinated. Seedlings were planted at 6 cm apart in rows and 0.5 cm deep at 24 to 29°C (Chen *et al.*, 2002).

Fig. 12. Seeds of *Solanum melongena* soaked in warm water (50°C) for 30 min.

Transplanting

Ninety five healthy and fully grown *S. melongena* seedlings of about 5 to 6 wks old with 3 to 4 true leaves were transplanted individually in plastic pots filled with 5 kg soil (Fig. 13). Transplanting was done by digging a hole deep enough to bury a plant so that the first true leaf was just above the soil surface. After transplanting, the soil was pressed firmly around the root and watered immediately. Chicken manure was added at 3 to 4 tablespoons into a hole about 2 to 3 inch deeper than the plant root and about 4 inch to the side of the eggplant. Every 4-6 wks during the growing season the plants were fertilized with complete fertilizer 14-14-14. Watering the newly transplanted seedlings was done daily at 6:00 AM to attain the established requirement for seedlings of about 1 inch of water week^{-1} (Chen *et al.*, 2002).

Field experimental Set-up

Forty five potted *S. melongena* were arranged in column in the field treated with *C. papaya* latex at different concentrations and properly labelled for fungicidal activity (Fig. 14). Another 45 potted *S. melongena* were arranged similarly treated with *C. papaya* crude latex at different concentrations and also labelled properly for larvicidal activity (Fig. 14). In the field, a CRD experiment was done with the following treatments in 3 replicates: T1 = 0.2, T2= 0.26, T3 0.33, T4= 0.4 and T5=0 g ml^{-1} for AFA and T1= 0.025, T2= 0.050, T3= 0.075, T4= 0.1 and T5= 0 g ml^{-1} for LA. Each replicate were planted with three *S. melongena* (n = 9 plants treatment^{-1}). Application of treatments to *S. melongena* was done at 2-wk interval by using respective plant sprayer. Growth and observations of *S. melongena* were done every week (Fig. 15) after 2 wk of transplantation for the duration of 2.5 mo (Gravel *et al.*, 2007). The variables measured in cm and counted were 1) stem height (*sh*), 2) stem diameter (*sd*), 3) number of leaves (*L*), 4) number of damaged/infested leaves (*diL*), (5) number of damaged/infested shoot (*dish*), 6) number of fruits (*ft*), 7) number of marketable fruits (*Mft*), 8) number of non-marketable fruits (*NMft*), 9) weight of marketable fruits (*WMft*), 10) weight of non-marketable fruits (*WNMft*) and 11) number of flowers (*fl*). Older leaves were removed from the lower portions of plants to allow for more air circulation and lighting within the canopy (Chen *et al.*, 2002). Marketable yield includes fruits with fresh weight whereas total yield includes all fruits harvested with rot and misshaped fruits.

Fig. 13. Selected *Solanum melongena* of Morena F1 variety seedling with 3-4 primary leaves.

Fig. 14. Treated *S. melongena*for anti-fungal activity (AFA) and larvicidal activity (LA).

Harvesting

Eggplant fruits were harvested once a week when they reached sufficient size for marketing, i.e. from 3 to 4 wk after flowering (Chen *et al.*, 2002). Harvesting was done manually by using a sharp knife or clippers, leaving the calyx attached to the fruit. High quality eggplant was firm, heavy, glossy with a desirable color, and free of cuts and scars (Fig. 16). Once the color of the skin begins to dullen, the seeds darken and the flesh becomes spongy and bitter.

Fig. 15. Weekly observation of the treated *Solanum melongena* with *C. papaya* crude latex extract at different concentrations.

Fig. 16. Marketable *Solanum melongena* fruit characterized with glossy, desirable color, free of cuts and scars.

Identification of test organisms

Ten larvae of *L. orbonalis* were collected from *S. melongena* at Pagawan, Manticao, Misamis Oriental and placed in the designed plastic container for identification at the College of Agriculture and Forestry, MSU-Naawan, Naawan, Misamis Oriental (Fig. 17). Fully grown spore-producing *A. niger sp*. (Fig. 18) in Petri dish was sent to the Philippine National Collection of Microorganisms (PNCM), UP BIOTECH, Los Baños, Laguna for identification. Photographs of *S. melongena* fruit, flowers and whole plant were taken from the field and sent to the National Museum of the Philippines, Manila for identification. Likewise, flowers, fruits and whole plant pictures of *Carica papaya* CX variety were sent to the National Museum of the Philippines, Manila for verification.

Data analysis

Formula for the concentrations used for larvicidal activity.

Density formula

$$\text{Density} = \frac{\text{m (g)}}{\text{Vf} - \text{Vi (ml)}}$$

Where:

M is the mass of crude papaya latex

V_f is the final volume of H_2O (ml)

V_i is the initial volume of H_2O (ml)

Formula for dilution concentration

Concentration = Mass crude latex / (volume latex + volume water)

= weight crude latex / (Weight crude latex/density of crude latex)

volume water = weight crude latex/ volume soluti

Fig. 17. *Leucinodesorbonalis* larvae placed in the designed plastic container identified at the College of Agriculture and Forestry, MSU-Naawan, Naawan, Misamis Oriental.

Fig. 18. Cultured *Aspergillus niger* identified at National Institute of Molecular Biology and Biotechnology, (BIOTECH), University of the Philippines, *Los Baños,* Laguna, Philippines.

Statistical analysis

Mean values of the various growth parameters of *S. melongena* treated with the different concentrations of *C. papaya* crude latex were determined such as; stem height (*sh*), stem diameter (*sd*), no. of leaves (*L*), damaged/infested leaves (*diL*), damaged/infested shoot (*dish*), flowers (*fl*), fruits (*ft*), marketable fruits (*Mft*), nonmarketable fruits (*NMft*), weight of marketable fruits (*WMft*), weight of nonmarketable fruits (*WNMft*). Coefficient of correlation (r) and ANOVA were computed at 5% significant level (Steel and Torrie, 1980). Coefficient of correlation was also computed for 2 variables.

Documentation

Assessment of *S. melongena* growth and morphological responses of *L. orbonalis* larvae and *A. niger* to the treatments of *C. papaya* crude latex were documented by using a DSC-S950 Sony digital camera.

Results

Growth and yield of Solanum melongena

Stem height (sh)

Fig. 19[th] *sh* difference of *S. melongena* treated with *Carica papaya* crude latex extract at different concentrations for AFA and LA. For the antifungal activity (AFA), *S. melongena* L. treated with 0.20 g ml^{-1} (T1) gave the highest *sh* (40.7 cm) followed by T3 (38.0 cm), T2 (37.7 cm), T5 (36.9 cm) and T4 (35.7 cm). For larvicidal activity (LA), the greatest *sh* was obtained in T3 (35.0 cm) and T5 (33.6 cm), T4 (33.2 cm), T2 (32.9 cm) and T1 (32.8 cm). For AFA, the *sh* was negatively correlated with *L*, r = -0.614; *fl*, r = -0.303 and positively correlated to *ft*, r = 0.233 in T1. Positive correlation was shown between *sh* and *L*,; *sh* and *fl*,; and *sh* and *WNMft*, in T2. There was a pronounced positive correlation between *sh* and *L*,; *sh* and *fl*, and *sh* and *WNMft*, in T3. T4 *sh* was positively correlated to *L*, *fl*, *WNMft*, while T5 showed positive correlation between *sh* and *L*,; *fl* and *WMft* as revealed in table 1 and 2 on the correlation coefficient (r) values between the growth parameters of *S. melongena* as affected by *A. niger*for antifungal activity (AFA) and Larvicidal activity (LA) determination. For LA, negative correlation existed between *sh* and *dish* (Tables 1 and 2): (T1), (T2), (T3) and (T4). The stem height for AFA plants was higher at beyond 40 cm in comparison to LA plants that most had not reached to 35 cm (Fig. 19).

Table 1. Correlation coefficient (r) values between the growth parameters of *S. melongena* as affected by *A. niger* for antifungal activity (AFA) determination.

Variables	*sh*	*sd*	*L*	*fl*	*ft*	*Mft*	*NMft*	*WMft*	*WNMft*
T1									
Number of leaves (*L*)	-0.614**								
Number of flowers (*fl*)	-0.303**		0.315**						
Number of fruits (*ft*)	0.233*		0.222*						
Weight of marketable fruits (*WMft*)						0.990**			
Weight of nonmarketable fruits (*WNMft*)							0.999**		
Number of damaged or infested shoot (*dish*)			0.230*	0.336**					
Number of damaged or infested leaves (*diL*)		0.323**							

Variables	*sh*	*sd*	*L*	*fl*	*ft*	*Mft*	*NMft*	*WMft*	*WNMft*
T2									
Number of leaves (*L*)	0.559**								
Number of flowers (*fl*)	0.292**		0.393**						
Number of fruits (*ft*)				0.512**					
Number of nonmarketable fruits (*NMft*)				0.504**	0.995**				
Weight of nonmarketable fruits (*WNMft*)	0.349**		0.418**						
Number of damaged or infested shoot (*dish*)						0.999**			
Number of damaged or infested leaves (*diL*)			0.285**						
T3									
Number of leaves (*L*)	0.692**								
Number of flowers (*fl*)	0.377*								
Number of fruits (*ft*)				0.364**					
Number of nonmarketable fruits (*NMft*)				0.364**	0.999**				
Weight of nonmarketable fruits (*WNMft*)	0.421**		0.353**						
T4									
Number of leaves (*L*)	0.672xx		0.226**						
Number of flowers (fl)	0.305**								
Number of fruits (ft)				0.365**					
Number of nonmarketable fruits (*NMft*)				0.365**	0.990**				
Weight of nonmarketable fruits (*WNMft*)	0.403**		0.371**						
Number of damaged or infested leaves (*di L*)		0.344**							
T5									
Number of leaves (*L*)	0.606**		0.243*						
Number of flowers (*fl*)	0.387**								
Number of marketable fruit (*Mft*)									
Weight of marketable fruits (*WMft*)	0.309**								
Weight of nonmarketable fruits (*WNMft*)	0.309**		0.290**	0.304**		0.999**			
Number of damaged or infested leaves (*diL*)			0.223*	0.245*					

** Correlation is significant at the 0.01 level (2 tailed),

* Correlation is significant at the 0.05 level (2 tailed).

Table 2. Correlation coefficient (r) values between the growth parameters of *S. melongena* by *L. orbonalis* larvae for larvicidal activity (LA) determination.

Variables	*sh*	*sd*	*L*	*fl*	*ft*	*NMft*	*WNMft*
T1							
Number of damaged or infested shoots (*dish*)	-0.274*	0.317**	-0.234*				
T2							
Number of damaged or infested shoots (*dish*)	-0.227*	0.264*			0.297*	0.470**	0.508*
Number of damaged or infested leaves (*diL*)				0.499**	*	0.232*	*
T3							
Number of damaged or infested shoots (*dish*)	-0.353**	0.281*					

Variables	*sh*	*sd*	*L*	*fl*	*ft*	*NMft*	*WNMft*
T4							
Number of damaged or infested shoots (*dish*)	-0.344**	0.226*	-0.234				
Number of damaged or infested leaves (*diL*)		-0.080					
T5							
Number of damaged or infested shoots (*dish*)		0.451**					

Legend:
sh= stem height, *sd*=stem diameter, *L*=number of leaves, *fl*=number of flowers, *ft*=number of fruits
Mft= number of marketable fruits, *NMft*= number of nonmarketable fruits, *WMft*= weight of marketable fruits
WNMft= weight of nonmarketable fruits, *dish*= number of damaged or infested shoots,
diL= number of damaged or infested leaves
** Correlation is significant at the 0.01 level (2 tailed), * Correlation is significant at the 0.05 level (2 tailed).

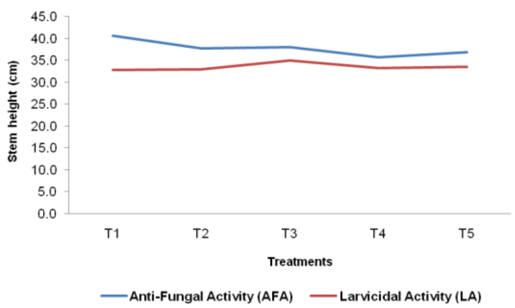

Fig. 19. The stem height (*sh*) of *S. melongena* treated with *Carica papaya* crude latex extract at different concentrations for AFA and LA.

Stem diameter (sd)

Fig. 20 revealed the stem diameter variation of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA. *Solanum melongena* L. AFA showed the same mean highest *sd* in T3 and T5 with 3.2 cm followed by T1 and T2 (3.1 cm) and T4 (3.0 cm). The *sd* of *S. melongena* for LA got slightly higher value of 3.1 cm in T4, T3 and T2 and lower value of 3.00 cm in T1 and T5 during the 2.5 mo after 2wk of seedling transplantation. Between the *sd* and *diL*, positive correlation was obtained in T1 and T4 for AFA. Likewise, between the *sd* and the *dish* showed positive correlation for all treatments: T5,; T1,; T3,; T2,; and T4, and negative correlation between *sd* and *diL*, was obtained. The variations in *sd* of *S. melongena* treated at different concentrations showed no significant differences (P>0.050) of *C. papaya* crude latex for AFA and LA. T3 and T5 for AFA had *sd* values fluctuating with greatest effects in T3 and T5 and for LA, *sd* values were lower than AFA with slight effects in T1 and except for T5.

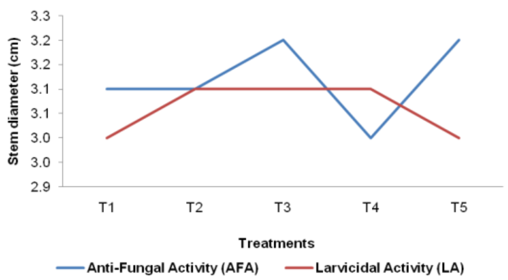

Fig. 20. The stem diameter (*sd*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

Number of leaves (L)

In *S. melongena* treated with *C. papaya* latex for antifungal activity (AFA) as shown in Fig. 21, the total *L* was highest with 122 in T1 followed by T5, 108; T3, 101; T4, 98; and T2, 94. Considering, the mean *L*treatment^{-1} T1 was the highest with 14 followed by T5, 13; T3, 12; and T2 and T4 11 (Fig. 26). Between the *L* and *fl* positive correlations existed, (T1), (T2), (T4), and (T5) as well as between *L* and *ft* (T1) and between *L* and *dish*, (T1). Positive correlations also were obtained between *L* and *WNMft* (T2); (T3);

(T4); (T5) and between total L and *diL*, (T2) and (T5) for AFA. In treatments for larvicidal activity (LA), T2 yielded the highest number of leaves (100) with T5 (99), T3 (94), T1 (92) and T4 (90) following closely. Considering the mean number of leaves treatment^{-1}, T2 still got the highest number of leaves with 12 followed by 11 in T5, T1 and T3 11 and 10 in T4. Positive correlation (r) was obtained between *L* and *dish*, (T1 and T4, Tables 1 and 2). The treatments showed significantly similar effects (P>0.05) of *C. papaya* crude latex on *S. melongena* in all treatments for AFA and LA.

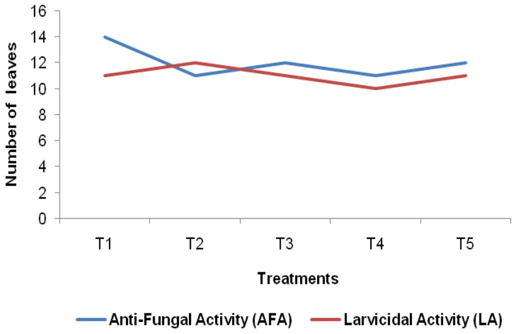

Fig. 21. Number of leaves (*L*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

Number of flowers (fl)

Fig. 22 showed the difference in the number of flowers (*fl*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA. The highest mean value of the total *fl* was obtained in T1 and T2 with 3.0 flowers (AFA). This value was closely followed by T3, T4, and T5 with 2 flowers. In treatments for (LA), T5 got 2 flowers and the rest of the treatment got 1 flower. Tables 1 and 2 on the Correlation coefficient (r) values between the growth parameters of *S. melongena* as affected by *A. niger*for antifungal activity (AFA) and *L. orbonalis* larvae for larvicidal activity (LA) determination respectively.As shown, there was a positive correlation occurred between *fl* and *dish*, (T1) in treatments for AFA as well as between *fl* and *ft*, (T2); (T4) and (T4); and between *fl* and *NMft*, (T2); (T3) and (T4) .Similarly positive correlation was obtained between *fl* and *WNMft*, (T5) and between *fl* and *diL*, (T5). In treatments for LA, only T2 got positive correlation of between *fl* and *diL* (Tables 1 and 2). However, variations in the *fl* of *S. melongena* were not significantly different (P>0.05) in all treatments of *C. papaya* crude latex for AFA and LA (Table 3).

Table 3. ANOVA results on the mean values of the growth parameters of *Solanum melongena* treated with *Carica papaya* crude latex extract at different concentrations for antifungal activity (AFA).

Growth parameters	Source of Variation	df	SS	MS	F	P-value	F crit	Remarks
Stem height (*sh*)	Between Groups	4	38.3707	9.5926	0.0977	0.9826	2.606	Ns
	Within Groups	40	3928.65	98.2162				
	Total	44	3967.02					
Stem diameter (*sd*)	Between Groups	4	0.043	0.0107	0.1564	0.959	2.606	Ns
	Within Groups	40	2.7506	0.0687				
	Total	44	2.7937					
No. Leaves (*L*)	Between Groups	4	8.4444	2.1111	0.0741	0.9896	2.606	Ns
	Within Groups	40	1138.67	28.4667				
	Total	44	1147.11					
Damaged/ Infested Leaves (*diL*)	Between Groups	4	2.2222	0.5556	0.4132	0.7981	2.606	Ns
	Within Groups	40	53.7778	1.3444				
	Total	44	56					
Damaged/ infested shoot (*dish*)	Between Groups	4	0.8	0.2	0.5538	0.6973	2.606	Ns
	Within Groups	40	14.4444	0.3611				
	Total	44	15.2444					
No. flowers (*fl*)	Between Groups	4	1.6444	0.4111	0.1163	0.9759	2.606	Ns
	Within Groups	40	141.333	3.5333				
	Total	44	142.977					

Growth parameters	Source of Variation	df	SS	MS	F	P-value	F crit	Remarks
No. fruits (*ft*)	Between Groups	4	1.4222	0.3555	0.9014	0.4722	2.606	Ns
	Within Groups	40	15.7777	0.3944				
	Total	44	17.2					
Marketable fruits (*Mft*)	Between Groups	4	1.4222	0.3556	0.9014	0.4722	2.606	Ns
	Within Groups	40	15.7778	0.3944				
	Total	44	17.2					
Weight marketable fruits (*WMft*)	Between Groups	4	888.534	222.133	0.9997	0.419	2.606	Ns
	Within Groups	40	8887.58	222.189				
	Total	44	9776.11					
Nonmarketable fruits (*NMft*)	Between Groups	4	0.5777	0.1444	0.7878	0.5399	2.606	Ns
	Within Groups	40	7.3333	0.1833				
	Total	44	7.9111					
Weight nonmarketable fruits (*WNMft*)	Between Groups	4	2024.44	506.111	0.3706	0.8282	2.606	Ns
	Within Groups	40	54633.3	1365.83				
	Total	44	56657.8					

ns = not significant.

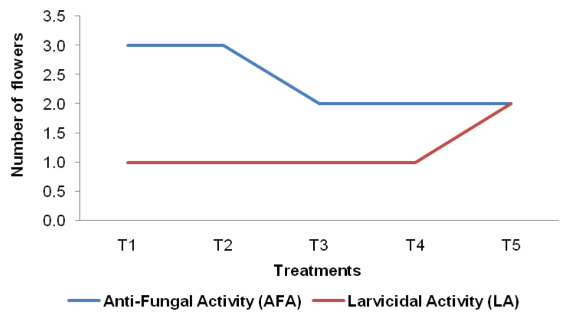

Fig. 22. Differences in the number of flowers (*fl*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

Fruit yield (ft)

On Fig. 23 referring to the number of fruits (*ft*) of *S. melongena* produced with the treatments of *C. papaya* crude latex extract for AFA and LA, the total number of *S. melongena* fruit, yielded 7 fruits (T2) which was the highest, followed by 6 fruits (T1), 5 fruits (T5), 3 fruits (T3) and 2 fruits (T4) for AFA.. As to LA, the greatest total *ft* was 7 (T1), followed by 4 fruits (T3, T4 and T5) and 2 fruits (T2). However, for the mean fruit yield, only one fruit was produced for both AFA and LA. High production of *ft* resulted to high production of *NMft* with (T1), (T3) and (T4) for AFA. For LA, increase in fruit production is correlated to increase in dish (T2: (Tables 1 and 2). The variations in the fruit production of *S. melongena* treated with *C. papaya* crude latex at different concentrations were not significant (P>0.05) for both AFA and LA based on the ANOVA results on the mean values of the growth parameters of *Solanum melongena* treated with *Carica papaya* crude latex extract at different concentrations for antifungal activity (AFA) and larvicidal activity (LA) as reflected on table 3 and 4.

Table 4. ANOVA results on the mean values of the growth parameters of *Solanum melongena* treated with *Carica papaya* crude latex extract at different concentrations for larvicidal activity (LA).

Growth parameters	Source of Variation	df	SS	MS	F	P-value	F crit	Remarks
Stem height (*sh*)	Between Groups	4	121.219	30.3049	0.2743	0.8928	2.606	Ns
	Within Groups	10	4,419.24	110.481				
	Total	44	4,540.46					
Stem diameter (*sd*)	Between Groups	4	0.2583	0.0646	0.4611	0.7638	2.606	Ns
	Within Groups	40	5.6028	0.1400				

Growth parameters	Source of Variation	df	SS	MS	F	P-value	F crit	Remarks
	Total	44	5.8611					
Number of leaves (*L*)	Between Groups	4	53.6888	13.4222	0.5429	0.7051	2.606	Ns
	Within Groups	40	988.888	24.7222				
	Total	44	1042.57					
Damaged/Infested leaves(*diL*)	Between Groups	4	1.8666	0.4667	0.5637	0.6903	2.606	Ns
	Within Groups	40	33.1111	0.8278				
	Total	44	3 34.9778					
Damaged/infested shoot (*dish*)	Between Groups	4	2.2222	0.5556	0.3105	0.8692	2.606	Ns
	Within Groups	40	71.5556	1.7889				
	Total	44	73.7778					
No. flowers (*fl*)	Between Groups	4	6.9777	1.7444	0.3485	0.8434	2.606	Ns
	Within Groups	40	200.222	5.0056				
	Total	44	207.2					
No. fruits (*ft*)	Between Groups	4	1.9111	0.4778	1.4333	0.2407	2.606	Ns
	Within Groups	40	13.3333	0.3333				
	Total	44	15.2444					
Marketable fruits (*Mft*)	Between Groups	4	0.5333	0.1333	1.1428	0.3504	2.606	Ns
	Within Groups	40	4.6667	0.1167				
	Total	44	5.2					
Weight of marketable fruits (*WMft*)	Between Groups	4	4483.33	1 1120.83	1.1395	0.3519	2.606	Ns
	Within Groups	40	39344.4	983.611				
	Total	44	43827.7					
Nonmarketable fruits (*NMft*)	Between Groups	4	0.1333	0.0333	0.5	0.7358	2.606	Ns
	Within Groups	40	2.6666	0.0667				
	Total	44	2.8					
Weight of nonmarketable fruits (*WNMft*)	Between Groups	4	867.222	216.805	0.5373	0.7091	2.606	ns
	Within Groups	40	16138.8	403.472				
	Total	44	17006.1					

ns = not significant.

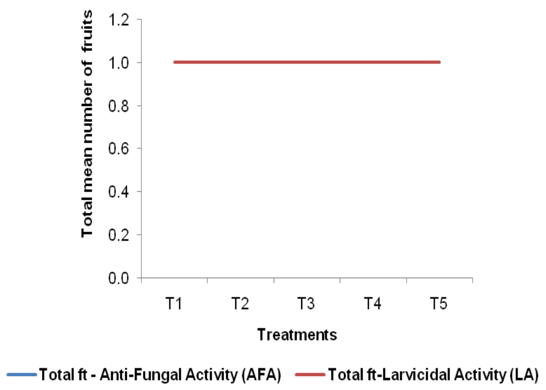

Fig. 23. Number of fruits (*ft*) of *S. melongena* with the treatments of *C. papaya* crude latex extract for AFA and LA.

Number of marketable fruits (Mft)

Fig. 24 disclosed the number of marketable fruits (*Mft*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

There was a production of 3 marketable fruits (*Mft*), in T2, one fruit in T1, T3, T4 and no fruit production in T5 for AFA. The mean *Mft* production for all treatments was 1 fruit and none in T5 (control) for AFA. In LA, only one *Mft* was produced in T3 and T4 and none in T1, T2 and T5 with means of one fruit in T3 and T4 and none in T1, T2 and T5. There were very high positive correlation obtained between variables, namely; between *Mft* and *WMft*, in T1 AFA; between *Mft* and *dish*, in T2; and between *Mft* and *WMft*, in T5 (Tables 1 and 2). However, ANOVA showed that these variations on the *Mft* production of *S. melongena* with the different treatments of *C. papaya* crude latex had no significant difference (P>0.05) for both AFA and LA (Table 3).

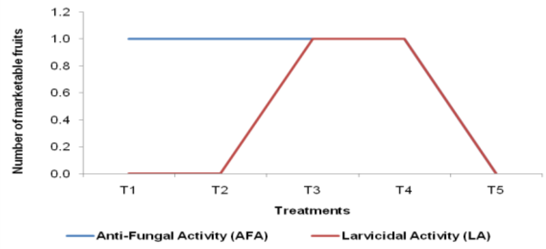

Fig. 24. Number of marketable fruits (*Mft*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

Number of nonmarketable fruit (NMft)

As to the number of non marketable fruits (*NMft*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA, Fig. 25 showed that the mean number of nonmarketable fruits (*NMft*) produced by *S. melongena* was one fruit for T5 and zero fruit for T1, T2, T3 and T4 in AFA (Fig. 25). As to LA, T1, T2, T4 and T5 had one fruit and zero fruit for T3. The *NMft* was positively correlated with the *WNMft*, (T1) for AFA treatments. For LA, the *NMft* was also positively correlated with *dish*, between *NMft* and *diL*, (T2) and between *WNMft* and *dish*, (T2) (Tables 1 and 2). However, the (T2) *NMft* production of *S. melongena* with the treatments of *C. papaya* crude latex showed no significant difference (P> 0.05) in all treatments (Table 3).

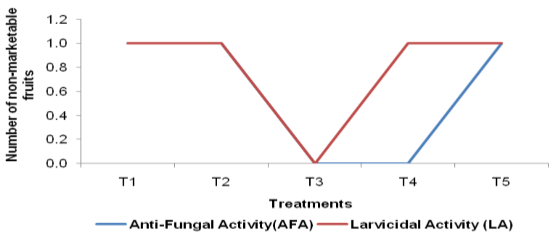

Fig. 25. Number of nonmarketable fruits (*NMft*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

Weight of marketable fruits (WMft)

Fig. 26 showed the weights of marketable fruits (*WMft*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

The yield in terms of weight of marketable fruits (*WMft*), AFA treatments showed higher values, namely: T2= 275 g, T4= 95 g, T1 and T3= 90 g in comparison to LA which only gave 100 g for T3 and T4 and zero g for the rest of the treatments. As to mean values of AFA treatments, T2 showed as the highest with 30.56 g followed by T4 with 10.56 g, T1 and T3 with 10.00 g and zero g in T5. For the LA, treatments T3 and T4 showed only 11.11 g and none in the other treatments. There was no significant difference (P>0.05) on the weight of marketable fruits of *S. melongena* with the treatments of *C. papaya* crude latex for AFA and LA (Tables 3 and 4).

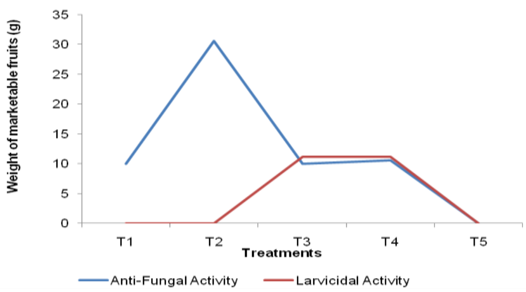

Fig. 26. Weights of marketable fruits (*WMft*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

Weight for nonmarketable fruits (WNft)

The yield in terms weight for nonmarketable fruits (*WNMft*) showed higher values of 100 g for T5, 67.50 g for T1 and 60 g for T2 and none for T3 and T4 for AFA treatments as revealed in Fig. 27. Mean values, obtained were 11.10 g for T5 as the highest, followed by 7.50 g for T1, 6.70 g for T2 and zero for T3 and T4. For LA, 240 g was the highest mean nonmarketable weight obtained in T1, followed by 145 g for T2, 90 g for T3, 87.50 g for T4, 80 g for T5 and the lower mean values of 26.70 g for T1, followed by 16.10 g for T2, 10 g for T3, 9.70 g for T4 and 8.90 g for T5. The *WNMft* was positively correlated to the *dish*, in T2 (Tables 1 and 2) for the LA treatments. However, no significant difference (P>0.05) was obtained between and among treatments means of the *WNMft* of *S. melongena* treated with *C. papaya* crude latex extract for AFA and LA (Tables 3 and 4).

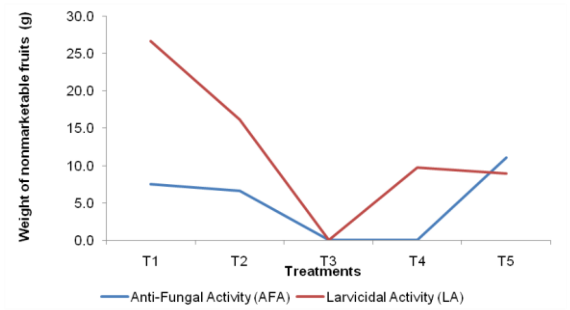

Fig. 27. Weights of nonmarketable fruits (*WNMft*) of *S. melongena* treated with C. *papaya* crude latex extract at different concentrations for AFA and LA.

Number of damaged or infested leaves (diL)

Fig. 28 exhibited the number of damaged or infested leaves (*diL*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.In AFA treatments, the mean value of 3 was obtained in T2, T3 and T5 while 2 was obtained in T1 and T4. For LA, all treatments had the same mean value of 2. There was no significant difference (P>0.05) on the *diL* of *S. melongena* with the treatments of *C. papaya* crude latex extract. Fig. 29 revealed the percentage results of *diL* that for AFA, 21.26% (T2) was the highest, followed by 19.79 (T3), 17.58 (T5), 16.35 (T4) and the least, 13.13% (T1). For LA., percentage of *diL* was highest at 18% (T2), followed by 17.80% (T4), 16.00% (T3), 15.26% (T1) and 12.09% (T5).

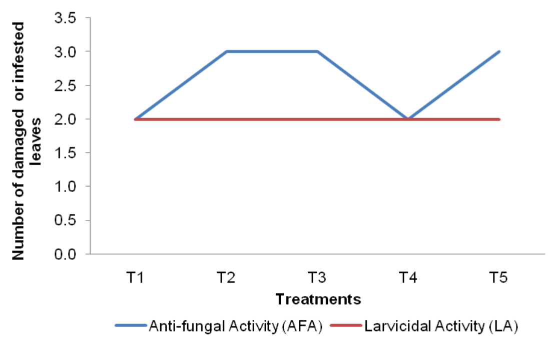

Fig. 28. Number of damaged or infested leaves (*diL*) of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

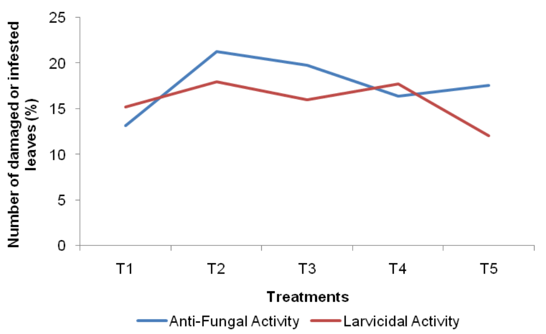

Fig. 29. Number of *S. melongena* damaged or infested leaves (*diL*) (%) treated with *C. papaya* crude latex extract at different concentrations for AFA and LA.

Number of damaged or infested shoots (dish)

On Fig. 30, the number of damaged or infested shoots (*dish*) of *S. melongena* treated *C. papaya* crude latex extract at different concentrations for AFA and L was displayed. The means of the number of *dish*, gave the highest mean value of 2 in T5 (control) and all treatments AFA had 1.0 for the AFA treatments. In the case of LA treatments, the extent of shoot damage or infestation showed that all treatments including the control had the same mean value of 1.0. There was no significant difference (P>0.05) on the *dish* of *S. melongena* treated with *C. papaya* crude latex extract at different concentrations (Tables 3 and 4).

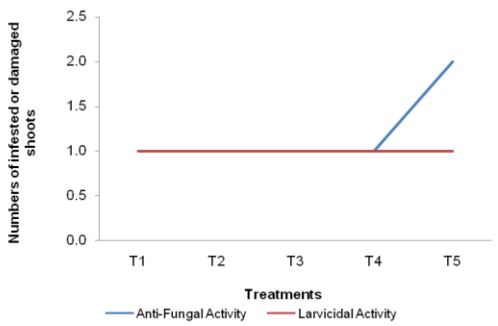

Fig. 30. Number of damaged or infested shoots (*dish*) of *S. melongena* treated *C. papaya* crude latex extract at different concentrations for AFA and LA.

Discussion

Growth and yield of Solanum melongena

Stem height (sh)

Stem height (*sh*) of *S. melongena* T5 (Control) had lower with mean value as compared to those treated with *C. papaya* crude latex.

T1 AFA had higher *sh* while LA treated *S. melongena* had higher *sh* mean value specifically T3 and T5. For AFA, the analysis of correlation revealed that *sh* had a negative significant correlation to *L*, *fl* and positive significant correlation to the *ft* yield in T1 AFA. LA *sh* had a negative significant correlation to *dish*, (T1), (T2), (T3) and in T4. The negative correlation AFA between the *sh* and *L* and *fl* signified that the increase in *sh* corresponded to the reduction in the *L* and *fl* of *S. melongena*. This has a beneficial effect to the growth of host plant because having higher *sh* with less *L* and *fl* would mean less infestation as in T1 AFA. The results agree with other related studies, higher plant height and more number of leaves increased infestation of BSFB (Brinjal shoot and fruit borer) because more leaves may be suitable for oviposition by young larvae (Ahmad *et al*., 2009). On the other hand, there was a positive significant correlation on *sh* with *L*, *fl* and *WNMft* in T2. Another positive significant correlation existed between *sh* and *L*, *fl* and *WNMft*, in T3. *S. melongena sh* in T4 had a positive significant correlation to *L*, *fl* and *WNMft*. T5 *sh* showed more positive significant correlation such as *L*, *fl*, *Mft* and *WMft*. This means that the increase in *sh* had simultaneously corresponded for increase in *L*, *fl*, *WNMft* and *Mft*. These results are in disagreement on the study of the infection of cork oak plants with three pathogenic fungi, the common plant responses were characterized by a decrease in daily stem shrinkage and growth, stomatal conductance and air-leaf temperature (Luque *et al*., 1999). In this present study, *S. melongena* was slightly infested due to the treatments of *C. papaya* crude latex. For LA, *sh* had negative significant correlation to the shoot infestations. Meaning there was a significant effect of the treatment of *C. papaya* crude latex by reducing infestation which resulted to an increase in *sh* for the treated *S. melongena*. This effect was reversed in the control host plant. Evidently, the degree of infestation on the untreated *S. melongena* was higher which negatively affected the *sh* growth. Besides, pest attacks generally accelerate a complicated series of metabolic disturbances in the host. Infestation often brings changes in normal development, and abnormal growth forms can result.

These include epinasty (leaf and stem distortions), hypertrophy (cell enlargement), hyperplasia (cell proliferation), internode shortening, proliferation of adventitious buds, unusual rooting, flowering or fruiting patterns, abnormal organ development, and irregular bud abscission (Allen 1947; Carter, 1973). For this reason, the more highly evolved plant parasites become intimately involved with the physiology of the host plant (Southwood, 1972). In this case, parasites seldom destroy their food source, but they remove nutrients and photosynthesis which inevitably lead to reduced growth rate or altered growth form of the host. The untreated *S. melongena* (T5) in the present study was not able to evade infestation which resulted to slow growth. However, there was no significant difference ($P>0.05$) on the *sh* of *S. melongena* with the treatments of *C. papaya* crude latex for AFA and LA (Tables 3 and 4). This indicates that AFA of *C. papaya* crude latex had greater effect on the *sh* than LA.

Stem diameter (sd)

Growth responses of *S. melongena* for *sd* revealed that the control (T5) had smaller mean value as compared with T2, T3 and T4 (3.1) in LA. With this, a positive significant correlation was found between the *sd* and *dish*, 1 for T2, T3 and T4, respectively, for LA. AFA *sd* was also correlated to *diL* in T1 and T5 The correlation existed in both LA and AFA with due consideration on the diameter size and infestation in shoot and leaves had shown similarity and agreement to other studies, greater *sd* and more number of leaves increased infestation of BSFB because more leaves may be suitable for oviposition and thick stem associated with succulent, thin cuticle and soft parenchymatous cells may be suitable to bore easily by young larvae (Ahmad *et al*. 2009). In relation to the findings of the present study, rates of defoliation attributable to insect herbivores are traditionally considered to lie within the range of 5-10% of leaf area per year (Gradwell 1974; Marquis 1984; Blanton and Ewel 1985; Crawley 1985). Indirect effects of feeding by insect herbivores, leading to reduced plant vigor and impaired competitive ability (Wapshere 1985; Goeden and Kok 1986; Harris1986; Schroeder and Goeden 1986).

Defoliating insects, phloem-feeding aphids, whitefly or scale insects, various sap-feeding Heteroptera, and stem-boring flies, moths, and beetles have all been charged with reducing the vigor of their host plants sufficiently that the plants were unable to compete with more vigorous, unattacked, neighboring plants (Crawley 1989). Obviously, the control host plant (T5) was greatly affected by infestation which resulted to none production of marketable fruits. Additionally, insect attack is often the cause of reduced plant growth rate (Heichel and Turner 1984; Kappel and Proctor 1986). The resulting increase in the growth of *S. melongena* could be attributed to the larvicidal and fungicidal effect of *C. papaya* crude latex however increase in shoot and leaves infestation in LA and AFA could be due to undevelop shoots during treatments of the *C. papaya* crude latex extract within the 2 wk interval of treatments. In addition, reduced *sd* had lower infestation since thick stem associated with succulent, thin cuticle and soft parenchymatous cells could be suitable to bore easily by young larvae (Ahmad *et al*. 2009).

Number of leaves (L)

S. melongena mean number of leaves (*L*) in T5 (control) was lower in comparison to T1 for AFA. T1 and T2 were treated with *C. papaya* crude latex for AFA and LA, respectively. The result showed there was a positive significant correlation between the *L* and the *fl*, ; *ft*, ; and *dish*, in T1. Positive significant correlation between *L* and *fl*; *WNMft*, and *diL* in T2 and *WNMft*, in T3 for AFA. In T4, *L* had positive significant correlation to the *fl*, and *WNMft*,; while T5 positive significant correlation between *L* and *fl*, ; *diL*, ; and *WNMft*,. This result does not agree with other studies as there are more leaves, the more prone the plants are to infestation because leaves are the main target of defoliating pests stressing that more leaves may be suitable for oviposition (Ahmad *et al*. 2009). However, it proved how potential C. *papaya* crude latex in the treatments of AFA and LA. Because of the *C. papaya* crude latex effects which persisted overtime, the treated *S. melongena* was able to withstand despite infestation pressure. The treatment allowed the host plant to bear more flowers and fruits.

The higher weight of nonmarketable fruits in the treated was the result of improper timing of treatments while in the control this could be due to the lack of defense of the *S. melongena* since no treatment was given. However, for LA, treated *S. melongena* had a negative significant correlation in T1 and T4 with between *L* and *dish*. This means that the treated *S. melongena* had more leaves with reduced infestation on the leaves and shoots and the reverse result happened in the control, few leaves with high infestation. This could be attributed to the effectivity of the *C. papaya* crude latex treatments to *S. melongena* which held the infestation effects. However, the control was more infested resulting to growth reduction in agreement to other similar studies. It has been reported that the gall-making larvae settle only on the undifferentiated parts of the leaf and prevent the normal unfolding of the lamina (Dieleman 1969). This finding could prove that *C. papaya* crude latex could be a potential source of phytochemicals to inhibit fungi and insect larval attacks on *S. melongena*.

Number of flowers (fl)

Based on the results, *S. melongena* responses on the number of flowers (*fl*) showed that some treatments had more flowers T1 and T2 while few in T5 (control) for AFA. The analysis of coefficient of correlation revealed that there was a positive significant correlation (r) between the *fl* to the following, namely; *dish*, in T1; *ft*, and *NMft*,; *ft*, and *NMft*,; *ft*, and *NMft*, in T2, T3 and T4 respectively. In T5 positive significant correlation existed between *fl* with *WNMft*,; and between *fl* and *diL*, for AFA. In LA, the positive significant correlation established was between *fl* and *diL*, in T2. This means that the increased in the number of flowers had consequently increased the infestation since more number of shoots, leaves, fruits, nonmarketable fruits and including the corresponding weight of nonmarketable fruits were inflicted both in AFA and LA. This is because as pollination proceeds like in the case of *S. melongena,* some shoots were inflicted with *L. orbonalis* larvae resulting to the increase production of nonmarketable fruits with consequent increase in the weight and more damaged or infested leaves.

Moreover, insects are carriers of pathogens like fungi. It is possible that during flower feeding, some fungi were transferred to the host plant especially in the floral parts which resulted to production of more nonmarketable fruits. This is in agreement to the findings of other related studies as insect feeding affects flower production directly by the destruction of flowers and flower buds, and indirectly through various kinds of damage that reduce bud production or bud burst (Crawley 1989). This was demonstrated by the host-specific moth *Heliodines nyctaginea* which causes a great flower loss of small *Mirabilis hirsuta* since large plants flower early and thereby escape attack by the peak of the insect population (Kinsman and Platt 1984). In other species, larger plants may flower longer than small ones, and may thus suffer a lower rate of flower loss to insects (Solomon 1981). Likewise the present study showed that the treated *S. melongena* were larger and produced flowers at an early stage opposite to the control. Thus, the result obtained in the control was very similar to the study on *Heliodines nyctaginea* wherein the consequent production of nonmarketable fruits merely showed that flowers were destructed by pests in the early part of development. However, the treatments of crude latex from *C. papaya* had reduced the infestation effects since the treated *S. melongena* were able to produce marketable fruits. Besides the treated *S. melongena* with *C. papaya* crude latex had greater chance of survival being lowly infested than the untreated ones.

Number of fruits (ft)

Growth responses of *S. melongena* to the treatment of *C. papaya* crude latex in terms of the number of fruits (*ft*) produced showed that for AFA, there was a positive significant correlation between *ft* and the *NMft*, and in T2, T3 and T4 respectively. In LA, *ft* was significantly correlated to the *dish*, in T2. *t* This means that for AFA, *S. melongena* was already infested at early stage resulting to production of more nonmarketable fruits as in the case of T2, T3 and T4. However, in T1 production of nonmarketable fruits was found lower which implied for the effectivity of crude latex from *C. papaya* as antifungal activity.

The result implied that *S. melongena* treated for larvicidal activity had less shoot damaged or infestation while other fruits were still developing. Further, result manifested that crude latex from *C. papaya* was able to combat against the attacked of pest more particularly on the shoot part of *S. melongena*. In agreement to other similar studies, *Leucinodes orbonalis* larvae attack affected the quality and yield of the crop at about 20-60% to the fruits (Alam 1970; Maureal *et al.* 1982). Moreover, yield loss has been estimated up to 86% (Ali *et al.* 1980) in Bangladesh and up to 95% (Naresh *et al.* 1986) in India. Infestation generally proves detrimental to growth and productivity (Zelitch 1975). Herbivorous insects affect plant performance (Crawley 1989). Fruit rots incited by fungi have been reported to cause heavy losses of many fruits both in the field and during storage (Oludemokun, 1976).

Number of marketable fruits (Mft)

S. melongena growth response on the production of marketable fruits showed that positive significant correlations on the *Mft* to the *WMft*, and in T1 and T5; and between *Mft* and *dish*, in T2 for AFA. Considering the results, the crude latex from *C. papaya* that was applied as treatment for *S. melongena* to ward off fungus and pest larvae proved its potential and effectivity. The treated *S. melongena* were able to produce quality fruits but the untreated failed, it may be due to the fungicidal and larvicidal effects of crude latex from *C. papaya* wherein pests were being inhibited so fruits were able to grow and develop normally free of infestation. In agreement with other similar studies, *L. orbonalis* larvae tunnel inside plant shoots (or fruit if available), adversely affecting marketable fruit yield (Owusu 2012) causing yield reduction ranges from 50-60% (Mehto *et al.* 1983) with damage to fruit in the field ranges from 47.6% to 85.8% (Patnaik2000). In addition, a single larva of *L. orbonalis* is enough to damage 4-6 healthy fruits (Anonymous 2010).

Number of nonmarketable fruits (NMft)

For AFA, there was a positive significant correlation between *NMft* and *WNMft,* in T1 and between *NMft* and *dish*, as well as between *NMft* and *dish*, in T2 for LA.

The result showed *S. melongena* T1 treated with *C. papaya* crude latex produced less *NMft* which corresponded for lower weight as compared to the control. For LA, *S. melongena* had produced few nonmarketable fruits (T2) with less infestation effects on the shoot and leaves. This signified that the treatment of crude latex from *C. papaya* to *S. melongena* served as defense against fungus and insect larvae. Obviously, crude latex from *C. papaya* was able to reduce the fruit damaged due to infestation. Thus, there was less production of nonmarketable fruits in the treated than the untreated. This study agrees to the results of other studies. On the study of the *Annona muricata* ethanolic leaf extract, it was reported to be fairly effective against *L. orbonalis* though the extract could not completely prevent damage to fruits of eggplant but significantly reduced the damage (Owosu 2012). The untreated set–up failed to produce marketable fruits because pests attacked on the fruits resulted to some malformations on the shape with noticed internal feeding due to the observed presence of small entrance holes.

Weight of marketable fruits (WMft)

S. melongena weight of marketable fruits (*WMft*) as response to the treatments of *C. papaya* crude latex revealed higher mean weight for the treated, particularly, T2 for AFA while T3 and T4 for LA. This indicates that *C. papaya* crude latex treatments may have ward off fruit attacking pests permitting fruits to grow bigger with minimal losses. The untreated set-up had zero or lower mean weight values for marketable fruits which could be attributed to the noticeable traces of internal fruit feeding and malformations while the fruits were growing and developing. These findings are in agreement with other related studies as it has been reported that caterpillars bore into fruits, rendering the fruit unfit for consumption and marketing (Anil and Sharma 2010). In this instance, the quality of fruits was affectedby fruit rottening which renders them unfit for marketing and human consumption (Islam and Karim 1994).

Weight of non marketable fruits (WNMft)

S. melongena weight of nonmarketable fruits response (*WNMft*) showed that T5 (control) had higher mean values for AFA and LA. *S. melongena* treated for AFA and LA had lower mean values. The *WNMft* was positively correlated to the *dish* in T2 LA. The result showed that *C. papaya* crude latex had contributed to the less production of *NMft* in the treated *S. melongena* resulting to lower mean *WNMft*. In agreement to other similar studies, this indicates that pests could not probably attack the *S. melongena* fruit easily due to the treatments *of C. papaya* crude latex. In T2, the mean value for *NMft* was high and was correlated to high *dish*. This is evidenced by the production of lesser number of fruits which were classified as nonmarketable. Besides, the timing of the *C. papaya* crude latex application may have been done after the infestation had struck earlier during pollination and the larvae were able to bore in the developing fruits that made the latex treatments less effective. Moreover, the entry point of the larvae is closed by their excreta and feeding is internal (Butani and Jotwani 1984) and in the later stages the larvae bore into young fruits through the soft calyx tissue leaving no sign of infestation. As reported, the most extensive pest of eggplant vegetable is the brinjal shoot and fruit borer, *Lucinodes orbonalis* Guenee, which reduces the yield and inflicts colossal loss in production of about 13% (Mall *et al.* 1992; Javed *et al.* 2011). Likewise, *L. orbonalis* pest is capable of causing significant level of damage in areas where it has become established (Owusu, 2012). An estimated crop losses due to animal pests is 18% and due to pathogen of about 15% which were attributed mostly to fungi (Oecke and Dehne 2004). Some reported on infestation causes 31-86% fruit damage in Bangladesh (Alam *et al.* 2003) which may reach up to 90% losses (Rahman 1997). The present result showed that *C. papaya* crude latex treatment could reduce the production of nonmarketable fruits due to reduction of number of damage or infected fruit.

Number of damaged or infested shoot (dish)

S. melongena treated with crude latex from *C. papaya* had less mean value of *dish* in comparison to the control for AFA.

In this case, *C. papaya* crude latex had apparently reduced the dish in all treatments while the untreated had seemingly having an accelerated dish. This could be due to the utilization of the crude latex from *C. papaya* as defense against pest attack by *S. melongena* which probably resulted to the evasion from the treated ones. However, the absence of crude latex from *C. papaya* in the control contributed to high dish in *S. melongena*. This agrees with the findings of other studies that the larvae of *L. orbonalis* cause 12-16 % damage to shoots (Alam 1970; Maureal *et al*. 1982) as the larvae bore into tender shoots in the early stage resulting in dropping shoots, which are readily visible in the infested fields (Anil and Sharma 2010).During infestation, the translocation mechanism of nutrients in the shoot was affected causing dropping and withering of shoots (Alam and Sana 1962) due to the larval activity.

Number of damaged or infested leaves (diL)

On the number of damaged or infested leaves (*diL*), T1 and T4 mean values was lower in comparison to T5 (control) for AFA. The control set-up for *S. melongena* had high *diL* in comparison to the treated set-up. This in agreement to other studies and implies further that *C. papaya* crude latex treatments has avoided high infestation effects in *S. melongena*. In this instance, *S. melongena* was relieved of severe infestation due to the infiltration of the *C. papaya* crude latex in the plant. Reports revealed that infestation is often caused by varied pests which ultimately affect the energy retained by the crop in 3 ways: by lowering light interception, by reducing photosynthetic efficiency and by altering normal distribution of assimilates within the plant. Any malformation of leaves would lead to the decrease in light interception (Hewett 1977) since photosynthesis per unit leaf area in plants with 'top-roll' was reduced by 50% (Gibson *et al*. 1976). In the present study, the effects of leaves infestation was noticeably reduced when crude latex from *C. papaya* was applied to *S. melongena* which had grown favorably in comparison to the untreated. These could prove that C. *papaya* crude latex had stored phytochemicals to potentially ward off infestations.

The infiltration of *C. papaya* crude latex treatments had improved the growth and normal development of *S. melongena*. Although, weather condition had slightly affected the result of the study, the overall results of the *C. papaya* crude latex treatments had enhanced favorably the growth of *S. melongena*.

Conclusion

1. For AFA, the overall increase in *L* and *fl* were correlated to the increase in *sh*. The growth increase in *sh* resulted to the increase in *ft* and *WNM ft* while the increase in *L* enhanced the production of *fl* but this has led to the corresponding increased in *dish*, *WNMft*, and *diL*. For the increase production of *fl,* it gave corresponding increase in *ft* though not all of these *ft* developed into *Mft*. The yield in terms of *Mft* developed was correlated to the increase in *WMft* and *dish*. Consequently, with the increase in *ft,* an increase in *NMft* and *WNMft* was noticed.

2. For LA, *dish* increased with increase in *sd*, *ft*, *NMft* and *WNMft*. The increase in *diL* corresponded to the increase in *fl* and *NMft*. However, the decrease in *dish* resulted to an increase in *sh*. Moreover, the increase in *diL* led to the decrease in *sd*. Likewise, the increase incidence of *dish* led to reduce *L*.

3. *Carica papaya* crude latex extract could potentially mitigate *Solanum melongena* pests such as *Leocinodes orbonalis* larvae and *Aspergillus niger* with proper timing and under favourable conditions.

4. The variations in all parameters determined are not significantly different (P>0.05). This was attributed to heavy rains which persisted throughout the duration of the study.

5. The results implied that some treatments of crude latex from *C. papaya* were found effective in reducing pest infestation damages to *S. melongena*. It is highly recommended that more related studies must be conducted in order to find more evidences on the stored potentials of *C. papaya* which are beneficial to agriculture and their consequent impact to the economy.

In addition, field studies included weather timing and time duration to verify the efficacy of *C. papaya* crude latex extract as larvicide and fungicide.

Acknowledgement
This work was supported by scholarship grants from the Department of Agriculture-Bureau of Agricultural Research (DA-BAR), Philippines, Exchange Visitor Program (EVP) Commission on Filipinos Overseas and the Department of Science and Technology - National Research Council of the Philippines (DOST-NRCP).

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