Effects of Different Systemic Insecticides in Carotenoid Content, Antibacterial Activity and Morphological Characteristics of Tomato (Solanum lycopersicum var Diamante)

LEXTER R. NATIVIDAD, MARIA FATIMA T. ASTRERO, LENARD T. BASINGA, MARIA KARYSA G. CALANG
lexter_natividad@yahoo.com
Central Luzon State University Science High School, Science City of Muñoz, Nueva Ecija
PHILIPPINES

Abstract *- This study aimed to determine the effects of different systemic insecticides in tomato (Lycopersicon esculentum var. Diamante). The study also assessed different systemic insecticides used in other plants in their effectiveness and suitability to tomato by evaluating the carotenoid content and antibacterial activity of each insecticide. Morphological characteristics such as the weight, the number and the circumference of tomato fruits and the height of the plant were also observed. Moreover, the cost effectiveness was computed. Treatments were designated as follows: Treatment 1- plants sprayed with* active ingredient (a.i.) cartap hydrochloride; Treatment 2 - plants sprayed with a.i. indoxacarb; Treatment 3- plants sprayed with *a.i. chlorantraniliprole and thiamethoxam; Treatment 4 - plants sprayed with a.i. dinotefuran (positive control); and Treatment 5 - no insecticide applied. The experimental design used was Randomized Complete Block Design (RCBD) with three replications. The first three systemic insecticides with such active ingredient were not yet registered for tomato plant. Statistical analyses show that there were no significant differences among the weight, the number and the circumference of tomato fruits and the height of the plant for each treatment. Results showed that treatments 1, 2, 3, 4 and 5 extracts have 49.74, 44.16, 48.19, 52.57 and 50.60* $^{\mu g}/g$ *of total carotenoids (TC), respectively. Statistical analysis shows that there no significant differences in the TC content of each treatment. The antibacterial activity of each plant sample showed no significant differences among treatments. Thin layer chromatographic analysis revealed that there were equal numbers of spots for all the plant samples.The study concluded that systemic insecticide with* a.i. cartap hydrochloride be introduced to the farmers as insecticide for tomato plant since it shows comparable effect with the registered insecticide *(T_4) based on the morphological characteristics, total carotenoid content, antibacterial activity and found to be the most cost-effective.*

Keywords: Systemic Insecticides, Antibacterial Activity, Tomato

I. INTRODUCTION

Tomato *(Solanum lyopersicum* L.*)*, commonly known as "kamatis" in Filipino belongs to the family Solanaceae. They are cultivated annually in most regions of the world and serve as a valuable source of food minerals and vitamins, particularly vitamins A and C. Tomatoes are propagated from seeds. They grow best in well-fertilized, sandy loams, but they also thrive in almost any type of fertile, well-drained soil (van Wyk, 2005).

Because of the weather, tomatoes were easy to grow in the country Philippines preferably from May to September. Tomatoes become one of the most widely grown and commercially important vegetable crops for off-season production (Spicer, 2012). According to Mercola (2013), tomatoes are one of the low-calorie vegetables containing just 18 calories per 100 g. Tomatoes are also very low in any fat contents and have zero cholesterol levels and they are excellent sources of antioxidants, dietary fiber, minerals, and vitamins. Because of their all-round qualities, dieticians and nutritionists often recommend them to be included in cholesterol controlling and weight reduction programs.

Many pests or diseases may occur in tomatoes. Some of the pests are tomato fruitworm (*Heliothis armigera*), cutworm (*Spodoptera exigua*), late blight (*Phytophthora infestans*), early blight (*Alternaria solani*) and white fly (*Bemisia tabaci*). Hence, the growers should maintain proper protection for the tomato plant (DuPont, 2010).

Systemic insecticide is a type of insecticide in which the active ingredient is taken up primarily by the plant roots, and transported to locations throughout the plant, such as growing points, where it can affect plant-feeding pests (Cloyd, 2002). Compared with contact insecticide, systemic insecticide works by spreading through all the tissues of a plant instead of on the surface. Insects ingest the insecticide while feeding on the plants. Compared with contact insecticide, systemic insecticide works by spreading through all the tissues of a plant instead of just staying on the surface. Insects ingest the insecticide while feeding on the plants. It lasts longer than a surface application of insecticide. Surface applied pesticides wash away with rain and irrigation and diminish in effectiveness with exposure to sunlight. Also, systemic insecticide protects an entire plant, from root tip to leaf tip. Moreover, these insecticides are not subject to ultraviolet light degradation or "wash off" during watering. There is less unsightly residue on foliage or flowers and harmful effects to workers and customers are minimal.

Tomatoes contain carotenoids. Carotenoid refers to any group of red, orange, or yellow pigmented polyisoprenoid hydrocarbons synthesized by prokaryotes and higher plants and concentrating in animal fat when eaten (The Free Dictionary).

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com

Higdon (2005) described carotenoids as organic pigments that are found in the chloroplasts and chromoplasts of plants and some other photosynthetic organisms like algae, some bacteria, and some fungi. She added that carotenoids can be produced from fats and other basic organic metabolic building blocks by all these organisms. They serve two key roles in plants and algae: they absorb light energy for use in photosynthesis, and they protect chlorophyll from photo damage. The most common carotenoids include lycopene and the vitamin A precursor β-carotene. In plants, the xanthophyll lutein is the most abundant carotenoid and its role in preventing age-related eye disease is currently under investigation.

Antibacterial properties of a certain plant refer to its ability to inhibit the growth and potentially kill bacteria of a certain kind. This is used widely in the production of antibiotics. Some plants that are found to have antibacterial properties include garlic (*Allium sativum*), ginger (*Zingiber officinale*) and many other known herbs (White, n.d.).

Morphological characteristics of a plant refer to its external form and structure without regard to its function. This covers the height of the plant, number of leaves, number of flowers, number of fruits and other external features of the tomato plant (The Free Dictionary).

OBJECTIVES OF THE STUDY

The purpose of this study is to determine the effect of the four different systemic insecticides—systemic insecticide with active ingredient (a.i.) cartap hydrochloride, systemic insecticide with a.i. indoxacarb, and systemic insecticide with a.i. chlorantraniliprole and thiamethoxam, which are not yet proven or registered for tomato and systemic insecticide with a.i. dinotefuran which is registered for tomato. Specifically, the study aimed to determine the effects of different systemic insecticides in the total carotenoid content and antibacterial activity of tomato in each treatment; to determine the effects of different systemic insecticides in the morphological characteristics (number, mass, circumference of the fruits, and height of the plant) of tomato in each treatment; to identify the most cost effective systemic insecticide for tomato and to determine the best systemic insecticide for tomato from the four treatments.

Hypotheses of the Study

The following are the hypotheses of the study:

1. There is no significant difference on the total carotenoid content.
2. There is no significant difference on the antibacterial activity of the tomatoes.
3. There is no significant difference on the number of fruits produced.
4. There is no significant difference on the mass of tomato fruits.
5. There is no significant difference on the average circumference of the fruits.
6. There is no significant difference on the height of the plants.

MATERIALS AND METHODS

Experimental Design

Five treatments which were replicated three times and arranged in Randomized Complete Block Design by draw lots were used in this study. Figure 1 show the experimental layout used in the experiment.

BLOCK 1	T_1R_2	T_5R_3	T_4R_2	T_2R_1	T_3R_2
BLOCK 2	T_2R_2	T_4R_1	T_5R_2	T_3R_3	T_1R_3
BLOCK 3	T_1R_1	T_2R_3	T_3R_1	T_4R_3	T_5R_1

Figure 1. Experimental Layout

Materials

The following materials and equipment were used in this study: a) tomato seeds (Diamante), b) clay loam soil, c) seedling tray, d) 5 sprayers, e)fungicide, f) systemic insecticide with active ingredient (a.i.) cartap hydrochloride, g) systemic insecticide with a.i. indoxacarb, h) systemic insecticide with a.i. chlorantraniliprole and thiamethoxam and i) systemic insecticide with a.i. dinotefuran.

Procedures

Seedling Production

Seedlings were produced in a seedling tray. There were 2-3 seeds sown in each cell filled with clay loam soil. Plants were watered every day. One week after the sowing, thinning of the seedlings was done.

Transplanting

Twenty eight days after sowing, 15 seedlings were transplanted in the experimental plots and sprayed with fungicide. To reduce transplanting shock, this was done late in the afternoon.

Water Management

Each tomato plant was watered daily between 7:00 to 8:00 in the morning. During rainy days, no watering was employed to the experimental plots.

Weed Control

Weeds that grow in the bags were controlled immediately by regular hand pulling to prevent competition for water, sunlight and nutrients.

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com

Pest Control

Different systemic insecticides were used in this study. For the first treatment, systemic insecticide with active ingredient (a.i.) cartap hydrochloride was applied, systemic insecticide with a.i. indoxacarb for the second treatment and systemic insecticide with a.i. chlorantraniliprole and thiamethoxam for the third treatment. These systemic insecticides were not yet registered for tomatoes. Registered systemic insecticide, with a.i. dinotefuran was applied in the fourth treatment and no systemic insecticide was applied in the fifth treatment.

Spraying of systemic insecticides in the tomato plants with their respective treatments was repeated after 5-6 days and was stopped as the fruit arise and begin to mature. This was done to avoid too much chemicals in the fruit.

The quantity given by the manufacturer in every 16 L of water was converted for the amount of water needed in the study which is 400 mL.

Harvesting

Tomato fruits were harvested 110 days after the day the seeds were sowed by picking the fruits in each plant manually.

Collection and Preparation of Samples

The tomato fruits harvested were cut in halves and were air-dried for four (4) weeks. The samples were pulverized after air-drying. Each sample was placed in a plastic bag and sealed.

Total Carotenoid and Thin Layer Chromatographic Analyses

Methods used in the study of Natividad and Rafael (2013) for total carotenoid and thin layer chromatographic analyses were followed in this study.

Antibacterial Assay

Antibacterial assay of the samples was done at the Center for Tropical Mushroom Research and Development (CTMRD), Central Luzon State University, Science City of Muñoz, Nueva Ecija.

RESULTS AND DISCUSSIONS

Total Carotenoid Content of the Plant Samples

The total carotenoid (TC) content of the tomato fruits is presented in Table 1. The TC content of the samples ranged from 44.16 to 52.57 $^{\mu g}/g$ (dry weight).

Table 1. Total Carotenoid content of the plant samples.

Treatments	total carotenoid content ($^{\mu g}/g$)
active ingredient (a.i.) cartap hydrochloride	49.74^a
a.i. indoxacarb	44.16^a
a.i. chlorantraniliprole and thiamethoxam	48.19^a
a.i. dinotefuran	52.57^a
No systemic insecticide applied	50.60^a

Note: *Means having the same letter of superscript in the same column are not significantly different from each other at 5% level of significance.*

From the computed data, Treatment 4 (active ingredient dinotefuran), the registered systemic insecticide for tomato has the largest TC content while Treatment 2 (a.i. indoxacarb) has the lowest among the samples.

Analysis of Variance (ANOVA) and Duncan's Multiple Range Test (DMRT) revealed that there are no significant differences among the treatments in terms of their TC content (Table 1).

The researcher also tried to compare the computed TC content to other literatures and studies. Gama *et al.* (2006) stated that the carotenoid content of tomato, tomato pulp and tomato ketchup using high performance liquid chromatography ranges from 67-71 $^{\mu g}/g$ (fresh weight basis). This means that the computed content is close to the values written in literature.

Thin Layer Chromatographic Analysis

Based on the method of Rodriguez-Amaya (2001), the solvent system used in the thin layer chromatography (TLC) was 5% methanol in xylene with some modifications. The spots on the TLC plates were visualized using iodine vapour and ultraviolet (UV) lamp and were marked using pencil. TLC results showed a diversity of phytochemicals contained in the plant samples.

There were 6 spots identified in all the treatments of tomato extracts (Table 2), but extra spot was found in T_1R_1 and T_4R_2. Retention factor (*Rf*) values obtained ranged from 0 to 0.98 which indicate that the spots were of varying polarities for each plant extract. The lowest *Rf* value of 0.00 means that the spot is a very polar compound and has great affinity for the polar silica gel plate. These spots could be oxygenated carotenoids. The spots with *Rf* value of 0.98 have the lowest polarity among the spots.

Thus, these have strong affinity for the mobile phase which has greater proportion of nonpolar solvent, xylene. Table 2 revealed that all the treatments obtained similar spots which could imply the presence of similar compounds of carotenoids in the samples tested.

According to Rodriguez-Amaya (2001), monohydroxy carotenoids will be situated in the middle, trihydroxy carotenoids will remain in the origin, and dihydroxy carotenoids will be located between the other two groups. High performance liquid chromatography and other methods can specify the carotenoids.

Table 2. *Rf* values of the plant samples separated by thin layer chromatography.

Treatment	a.i. cartap hydrochloride	a.i. indoxacarb	a.i. chlorantraniliprole and thiamethoxam	a.i. dinotefuran	No systemic insecticide applied
Rf values	0.00	0.00	0.00	0.00	0.00
	0.08	0.09	0.09	0.12	0.07
	0.28	0.28	0.32	0.33	0.20
	0.39	0.40	0.39	0.37	0.57
	0.89	0.81	0.67	0.50	0.79
	0.98	0.95	0.96	0.92	0.97

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com

Antibacterial Assay

The results of antibacterial assay of the five plant sample extracts towards *Staphylococcus aureus*, a gram positive bacterium and *Escherichia coli*, a gram negative bacterium are shown in Tables 3 and 4.

The highest antibacterial activity against *S. aureus* was observed in Streptomycin, the positive control, with mean zone of inhibition of 31.67 mm. Six millimeters (6 mm) mean zone of inhibition was recorded in the negative control and experimental treatments.

Table 3. Mean zone of inhibition (mm) of the plant extracts against *Staphylococcus aureus.*

Treatments	Zone of inhibition (mm)
active ingredient (a.i.) cartap hydrochloride	6[b]
a.i. indoxacarb	6[b]
a.i. chlorantraniliprole and thiamethoxam	6[b]
a.i. dinotefuran	6[b]
No systemic insecticide applied	6[b]
Streptomycin (positive control)	31.67[a]
Ethanol (negative control)	6[b]

Note: *Means having the same letter of superscript in the same column are not significantly different from each other at 5% level of significance.*

Duncan's Multiple Range Test (DMRT) shows that the mean zone of inhibition of the plant extracts is significantly different from Streptomycin (positive control).

Table 4 presents the results of the antibacterial activity of the plant extracts against *E. coli*. Mean zone of inhibition with 29.67 mm was recorded in the positive control.

Table 4. Antibacterial activity of the plant samples extract against *Escherichia coli.*

Treatment	Zone of inhibition (mm)
active ingredient (a.i.) cartap hydrochloride	6[b]
a.i. indoxacarb	6[b]
a.i. chlorantraniliprole and thiamethoxam	6[b]
a.i. dinotefuran	6[b]
No systemic insecticide applied	6[b]
Streptomycin (positive control)	29.67[a]
Ethanol (negative control)	6[b]

Note: *Means having the same letter of superscript in the same column are not significantly different from each other at 5% level of significance.*

Morphological Characteristics

The morphological characteristics observed in each treatment were shown in Table 5. In terms of the number of pieces, Treatment 1 (active ingredient (a.i.) cartap hydrochloride) gave the highest mean of 22 while Treatment 5 (no insecticide applied) gave the lowest with 19.33.

Treatment 1 obtained the heaviest harvest in grams with a mean of 763.33 followed by Treatments 2, 4, 3 (a.i. chlorantraniliprole and thiamethoxam) and 5 in increasing order with means of 750, 720, 718.33 and 651.67 respectively.

Table 5. Morphological Characteristics

Treatments	No. of fruits (pc)	Mass (g)	Ave. Circumference of fruits (cm)	Height of the plant (cm)
active ingredient (a.i.) cartap hydrochloride	22[a]	763.33[a]	12.25[a]	149.17[a]
a.i. indoxacarb	21.67[a]	750[a]	12.23[a]	162.13[a]
a.i. chlorantraniliprole and thiamethoxam	21.67[a]	718.33[a]	11.89[a]	155.80[a]
a.i. dinotefuran	19.67[a]	720[a]	12.36[a]	149.73[a]
No systemic insecticide applied	19.33[a]	651.67[a]	12.5[a]	160.13[a]

Note: *Means having the same letter of superscript in the same column are not significantly different from each other at 5% level of significance.*

The circumference (cm) of each fruit was measured and computed its average by dividing the total to the number of pieces in each treatment. Treatment 5 gave the highest mean and Treatment 3 gave the lowest with a mean of 11.89.

The height (cm) of the plant was measured from the highest part up to the soil or the ground. Treatment 2 gave the highest mean with 162.13 followed by Treatments 5, 3, 4, 1 in decreasing order with means 160.13, 155.80, 149.73 and 149.17.

However, Analysis of Variance and Duncan's Multiple Range Test showed that there is no significant difference between and among treatments. Treatments showed comparable effect with the positive control.

Cost Effectiveness

The cost effectiveness of the different systemic insecticides was shown in Table 6. The price of PhP45/kg of tomatoes was used based on the selling price of tomato in the market of Science City of Muñoz, Nueva Ecija last October 2013. Systemic insecticide with active ingredient (a.i.) cartap hydrochloride gave the highest profit with PhP102.45. Systemic insecticide with a.i. dinotefuran, the one that is registered gave only a profit of PhP95.95. T_2-a.i. indoxacarb gave a profit of PhP100.00, T_3-a.i. chlorantraniliprole and thiamethoxam with PhP94.23 and T_5-no systemic insecticide applied with PhP87.98. Since this is only in a pilot scale, it is not imperative to think that using Treatment 1 will have significant profit if used in a tomato plantation.

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com

Table 6. Cost effectiveness of using different systemic insecticides

TREATMENT	COMPUTATION	PROFIT
active ingredient (a.i.) cartap hydrochloride	(2.290kg × PhP45.00) - PhP0.60 =	PhP102.45
a.i. indoxacarb	(2.250kg × PhP45.00) - PhP1.25 =	PhP100.00
a.i. chlorantraniliprole and thiamethoxam	(2.155kg × PhP45.00) - PhP2.75 =	PhP94.23
a.i. dinotefuran	(2.160kg × PhP45.00) - PhP1.25 =	PhP95.95
No systemic insecticide applied	(1.955kg × PhP45.00) – PhP0.00 =	PhP87.98

CONCLUSIONS AND RECOMMENDATIONS

There were no significant differences among the total carotenoid content of the tomato fruits, Treatment 4 gave the highest TC content; antibacterial activity each treatment showed no significant differences to each other; morphological characteristics such as the number and mass of fruits produced, average circumference of fruits (cm) and height of the plant (cm) also showed insignificant differences among each other; and, it was determined that T_{1-} systemic insecticide with a.i. cartap hydrochloride was the most cost effective among the treatments.

It is therefore concluded that T_{1-} systemic insecticide with a.i. cartap hydrochloride be introduced to the farmers as insecticide for tomato plant since it shows comparable effect with the registered insecticide (systemic insecticide with a.i. dinotefuran) based on total carotenoid content, antibacterial activity and morphological characteristics but found to be the most cost-effective.

Based from the present findings, it is suggested to examine the chemical residue in the tomato or how many days they are able for human consumption when sprayed. Also, the same parameters will be applied on the second harvest, third harvest, and so on.

REFERENCES

Cloyd, R. (2002, November 27). Systemic, Local Systemic, or Translaminar Insecticides: What's the Difference?. *University of Illinois extension: Home, yard and garden pest.* Retrieved from http://hyg.ipm.illinois.edu/pastpest/200220e.html

DuPont™, (2010). *Guide to Effective Pest & Disease Management TOMATO* [Brochure].

Higdon, J. (2005). Carotenoids. *Linus Pauling Institute*. Retrieved from http://lpi.oregonstate.edu/infocenter/phytochemicals/carotenoids/#biological_activity

Mercola. (2013, March 25). *Organic Tomatoes, While Smaller, are More Nutritious than Conventional Counterpart, Study Shows*. Retrieved from http://articles.mercola.com/sites/articles/archive/2013/03/25/organic-tomatoes.aspx

Natividad, L.R. & Rafael R.R. (2013). Carotenoid Analyses and Antibacterial Assay of annato (*Bixa orellana* L.), Carrot (*Daucus carota* L.), Corn (*Zea mays* L.) and Tomato (*Solanum lycopersicum* L.) Extracts. *Research Journal of Recent Sciences* 3(3):40-45.

Rodriquez-Amaya, D.R. (2001). *A guide to carotenoid analysis in foods*. Washington D.C.

Spicer, J. (2012). *Tomatoes Grown Upside Down*. Retrieved from http://ecop.pbworks.com/w/page/40489664/Tomatoes%20Grown%20Upside%20Down

United States Environmental Protection Energy. (2000). *Pesticide Fact Sheet.* Office of Prevention, Pesticides and Toxic Substances (7505C).

United States Environmental Protection Energy. (2004). *Pesticide Fact Sheet.* Office of Prevention, Pesticides and Toxic Substances (7501C).

United States Environmental Protection Energy. (2008). *Pesticide Fact Sheet.* Office of Prevention, Pesticides and Toxic Substances (7505P).

van Wyk, B.-E. (2005). *Food Plants of the World.* Briza Publications, South Africa.

Webster's Desk Dictionary of the English Language. Avenel, NJ: Gramercy Books.

White, L. (n.d.). Infection-Fighting Herbs. *Monterey Bay Spice Company: Newsletter Archive.* Retrieved from www.herbco.com/t-herbs-infection.aspx

P-ISSN 2350-7756 | E-ISSN 2350-8442 | www.apjmr.com