Vol. 12, No. 3 (2023) : 676 - 683
DOI : http://dx.doi.org/10.23960/jtep-l.v12i3.676-683
JURNAL TEKNIK PERTANIAN LAMPUNG
ISSN 2302-559X (print) / 2549-0818 (online)
Journal homepage : https://jurnal.fp.unila.ac.id/index.php/JTP

The Effect of Various Concentrations of Both Lime Juice and Synthetic Citric Acid Solutions to Protect *Capsicum frutescens* L. against Yellow Leaf Curl Disease

Rejo Wagiman[1]✉, Yohanes Hendro Agus[1], Bistok Hasiholan Simanjuntak[1]

[1]Department Agricultural Science, Faculty of Agriculture and Business, Universitas Kristen Satya Wacana, Salatiga, Central Java, INDONESIA

Article History :
Received : 26 January 2023
Received in revised form : 17 March 2023
Accepted : 14 April 2023

Keywords :
Citric acid,
Chili pepper,
Gemini virus diseases,
Whitefly.

✉Corresponding Author:
532022702@student.uksw.edu

ABSTRACT

The yellow leaf curl (YLC) disease is one of plant disease generally found in chili pepper. The aim of the research was to know various concentrations of lime juice and synthetic citric acids to protect chili pepper (Capsicum frutescens L.) against YLC disease. The research used a randomized completely block design using seven treatments and three replications. The treatments tested were spraying lime juice of 0.1%, 0.2%, and 0.3% volume per volume (v/v); citric acid solution of 0.1%, 0.2%, and 0.3 % weight per volume (w/v). Control was used water only. The data result were analyzed using the honestly significant different test at the 95% confidence level. The treatment of both lime juice and citric acid solutions 0.2% and 0.3% could decreased whitefly population on chili pepper compared with control. The lime juice and citric acid solutions 0.3% was able to reduce the incidence and intensity of YLC disease. Lime juice and citric acid solution of 0.2% and 0.3% increased fruit numbers and fruit weights compared with control. The lower whitefly population decreased disease incidence of YLC (with regression Y = 5.7505x – 48.029). Intensity of YLC disease decreased fruit numbers and fruit weight (correlation value of -0.949 and -0.912).

1. INTRODUCTION

The potential productivity for some varieties of chili pepper reached 12-20 tons per hectare (Sujitno, 2015). One reason of the low productivity of chili pepper is caused by disease pathogens. One pathogen that caused losses in both the quality and quantity of chili pepper plant is yellow leaf curl disease.

This yellow leaf curl disease is caused by the Gemini virus. According to (De Barro *et al.*, 2011; Thakur *et al.*, 2018), Gemini virus is persistently transmitted by whitefly, *Bemisia tabacci* Genn. (Hemiptera: Aleyrodidae). Gemini virus spreads within plants and inhibits the growth of plant tissue. DNA of the Gemini virus replicates in the host plant's body, utilizing the host metabolisms so that the host is unable to form chlorophyll (Kumar,

2019). Gemini virus spreading rapidly across the country especially in Central Java, West Java, Yogyakarta, and Lampung, this location is in the region of chili pepper production area (Selangga *et al*., 2019).

Up to now, the method of controlling to the spread yellow leaf curl disease in chili pepper are: (1) planting resistant varieties, (2) controlling vector insects, (3) planting barrier plant, (4) used intercropping system and trap crops (Hilje *et al*., 2001; Kenyon *et al*., 2014; Lapidot *et al*., 2014; Friarini, 2016).

Based on literature, citric acid has a capability to repel aphids (*Aphis craccivora*) (El-kady *et al*., 2010). Citric acid could be obtained naturally and synthetically. One of fruit contain natural citric acid content can be found in lime fruit.

To decrase of whitefly infestation on chili crop, the treatments were tested in this research. The objective of this research is to know the effect of both natural citric acid (from lime juice) and synthetic citric acid concentrations were used as treatment tested.

2. MATERIALS AND METHODS

2.1. Experiment Design

A field experiment was conducted at the location of the chili plant center (Semowo village, Pabelan sub-district, Semarang district) from June 2020 until November 2020. The treatments tested consisted were spraying lime juice solution of 0.1%, 0.2%, and 0.3% v/v, synthetic citric acid solution of 0.1%, 0.2%, and 0.3 % w/v. Control used water only. Each treatment tested was replicated three times, treatment aplication was conducted with spraying every five days. Each treatment and replications consisted of five plants.

2.2. Data Collection

The parameters observed were (1) the number of whiteflys, (2) the percentage of disease incidence, (3) the percentage of Disease severity, (4) the fruit number and fruit weight, and (5) Corellation disease incidense and Disease severity with fruit number and fruit weight.

The data result by an analyzed of variance (ANOVA). If observation data has a significant results on the treatment, it was analyzed continue by Tukey's HSD (honestly significant difference) test with a significance level of at least p-value less than 0.05.

Disease Incidence is the percentage of the number of symptomatic plants compared to the number of sample plants observed. According to (Damiri, 2020), percentage of disease incidence is counted by using the formula as follows:

$$DI = \frac{n}{N} \times 100\% \quad (1)$$

where *DI* is the disease incidence (%), n is number of plants showed disease symptom, and N is number of plants observed.

Disease severity is the severity of the plant attacked by the disease pathogen (Maman *et al*., 2014). Percentage of disease severity is counted by using the formula as follows:

$$DS = \frac{\sum nxv}{NxV} \times 100\% \quad (2)$$

with *DS* is the disease severity (%), *n* is number of crop damage with certain score, based on symptom category, *v* is score of symptom in each plant observed (based on Table 1), *N* is number of plants observed and *V* is the highest score of the symptom category.

Table 1. The proportion symptoms of yellow leaf curl disease

Score	Symptoms of yellow leaf curl disease
1	Symptoms of yellowing the leaf shoots
2	Symptoms of yellowing on the leaves of half of the observed plants
3	Symptoms of yellowing on all leaves of the observed plants
4	Symptoms of yellowing on all leaves and plants become stunted

To observe the effect of the number of whitefly on the disease incidence of yellow leaf curl, a regression curve and its correlation were made. The number of whitefly as the x-axis and the disease incidence as the y-ordinate. To observe the effect of Disease severity on fruit weight per plant and weight per hectare of fruit, correlations were made.

3. RESULT AND DISCUSSIONS

3.1. The Number of Whitefly in Various Treatment

The observations at 8 WAP, 12 WAP, and 16 WAP showed the number of whitefly (*Bemisia tabaci*) on plants sprayed with lime juice and synthetic citric acid with concentrations of 0.2% and 0.3% was lower than the plants used as control (Table 2). The lime juice and synthetic citric acid solution both of 0.3% concentrations were significantly different compared with control and 0.1%, but not significantly different from 0.2% concentrations.

Table 2. Number of whitefly on various concentration lime juice and synthetic citric acid solution

Treatment	Number of whitefly per plant			
	4 WAP	8 WAP	12 WAP	16 WAP
Control	6.53 a	35.33 c	34.33 c	23.13 c
Lime juice solution 0.1% v/v	6.07 a	30.33 bc	31.93 bc	21.07 bc
Lime juice solution 0.2% v/v	5.87 a	27.00 ab	29.13 ab	17.67 ab
Lime juice solution 0.3% v/v	5.47 a	20.67 a	25.60 a	15.13 a
Synthetic citric acid 0.1% w/v	6.33 a	28.67 bc	31.87 bc	21.13 bc
Synthetic citric acid 0.2% w/v	6.47 a	24.33 ab	28.93 ab	18.73 ab
Synthetic citric acid 0.3% w/v	5.80 a	23.33 a	26.20 a	15.80 a

Note: v/v is volume per volume, w/v is weight per volume, and WAP is week after planting. The number followed by the different letter showed significant difference based Honestly Significant Different Test at 95% confidence interval

The use of citric acid from lime juice and synthetic citric acid can reduce the number of whitefly that attacks chilli pepper plants. (Lapidot *et al*., 2014) stated that the use of repellent compounds disrupts the behavior of whitefly in finding plants as food sources. Based on research of 10 to 30 whiteflys per chili pepper shoot, included in the moderate category (Dirjen Tanaman Pangan, 2015).

Treatment lime juice and shyntetic citric acid solution 16 WAP with concentration 0.3% could result lower whiteflys population of chili pepper compared with 0.1% concentration of lime juice and shyntetic citric acid and control. The relationship the number of whitefly and disease incidence can be count with regression formula (Figure 1). The low number of whitefly causes a decrease in the incidence of yellow leaf curl (with the regression equation Y = 5.7505x – 48.029). The population of whitefly can reach 81.48% of all arthropods in chili plant (Ghosh, 2020). Other than citric acid treatment, (Al-Aloosi *et al*., 2020) states that the density of whitefly in chilies can also be influenced by certain morphological characteristics such as the height and trichomes density of leaves, leaf thickness, and leaf color.

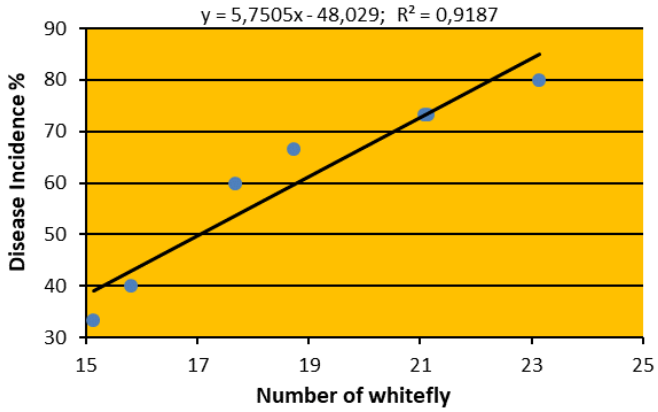

Figure 1. Regression of the relationship between the number of whitefly and the disease incidence of yellow leaf curl

3.2. Disease Incidence and Disease severity of Yellow Leaf Curl Disease on Chili Pepper

Disease incidence and attack intensity of yellow leaf curl disease on lime juice and synthetic citric acid solution with a concentration of 0.3% showed lower result compared to the control (Table 3). This was due to the number of whitefly per plant was lower in plants given a solution of lime juice and synthetic citric acid 0.3% compared to the control (Table 2).

Table 3. Disease incidence and Disease severity on various treatment lime juice and shyntetic citric acid solution

Treatment	Disease incidence (%)	Disease severity (%)
Control	80.00 a	32.80 a
Lime juice solution 0.1% v/v	73.33 ab	24.53 ab
Lime juice solution 0.2% v/v	60.00 ab	12.00 ab
Lime juice solution 0.3% v/v	33.33 b	9.20 b
Synthetic citric acid 0.1% w/v	73.33 ab	27.47 ab
Synthetic citric acid 0.2% w/v	66.67 ab	17.60 ab
Synthetic citric acid 0.3% w/v	40.00 b	10.47 b

Note: v/v is volume per volume, and w/v is weight per volume. The number followed by the different letter showed significant difference based Honestly Significant Different Test at 95% confidence interval

The disease incidence is closely related to the attack intensity of the yellow leaf curl. From this study shows a correlation of 0.895 (Table 5). The results research (Kiswoyo, 2019) also show a positive correlation between disease incidence and attack intensity

(0.897). (Gaswanto *et al*., 2016) stated that the discoloration of chili leaves infected with the Gemini virus occurred at ambient temperatures above 25ºC, and the attack intensity of disease increased up to ambient temperatures until 40ºC.

Based on research of Tricahyati *et al*. (2021), the disease severity on chili peppers plant of 0-25% was light catagory attack of whitefly. Disease severity of yellow leaf curl disease on spraying of both lime juice and synthetic citric acid solutions of 0.2% and 0.3% have light catagory (Table 3).

3.3. Fruit Number per Plant and Fruit Weight per Plant at Various Concentrations of Spraying

Spraying lime juice and synthetic citric acidsolution (0.2% and 0.3%) was able to increase the fruit numbers and wight of fruit per plant which was significantly different compared to the control (Table 4). Spraying lime juice and synthetic citric acidsolution with a concentration of 0.1% produced the fruit numbers per plant and wight of fruit per plant which were not significantly different from the control (Table 4). Pepper Yellow leaf curl disease make the late growth stages of the plants, abscission of flower buds occurs and anthers sterile, which produces low quantity and quality of fruit (Kumar *et al*., 2015).

Table 4. Fruit number and weight number per plant on various treatment lime juice and shyntetic citric acid solution

Treatment	Fruit number per plant (furit)	Fruit Weight per plant (gram)
Control	24.80 a	55.79 a
Lime juice solution 0.1% v/v	28.18 ab	64.80 ab
Lime juice solution 0.2% v/v	35.08 bc	77.74 bc
Lime juice solution 0.3% v/v	41.13 c	97.43 c
Synthetic citric acid 0.1% w/v	29.77 ab	65.85 ab
Synthetic citric acid 0.2% w/v	37.00 bc	81.75 bc
Synthetic citric acid 0.3% w/v	43.13 c	101.39 c

Note: v/v is volume per volume, and w/v is weight per volume. The number followed by the different letter showed significant difference based Honestly Significant Different Test at 95% confidence interval.

Based on Sukada *et al.* (2014) research, plants showed chlorosis symptoms had an average yield of 8.42 tons/ha, yellow symptoms of 3.07 ton/ha, and the lowest was shown by mosaic symptoms (2.52 ton/ha) compared to the average yield the yield on healthy plants is 16.01 ton/ha.

Based on this research, resulted of chili pepper averages of 34.16 fruits per plant and 77.82 gram per plant. The used of 0.3% concentration of both lime juice and synthetic citric acid solution could result above the chili pepper averages.

3.4. Fruit Number and Fruit Weight

The use of both lime juice and synthetic citric acid solutions could result of low whiteflys population in field. The whitefly is vector of Gemini viruses, and Gemini viruses could impact disease incidence of yellow leaf curl disease of chili pepper. The results of the correlation test between the percentage of disease incidence and the attack intensity of yellow leaf curl disease attack on the fruit numbers per plant showed a strong and negative relationship (-0.897 and -0.949) (Table 5).

Table 5. The result of correlation disease incidence and attack intensity of yellow leaf curl disease toward fruit number and fruit weight per plant

Corelation	Disease incidence (%)	Disease severity (%)	Fruit number per plant (fruit)	Frui weight per plant (gram)
Disease incidence (%)	1	0.895	-0.897	-0.896
Disease Severity (%)		1	-0.949	-0.912
Fruit number per plant			1	0.909
Frui weight per plant (g)				1

Note: The number that was followed by negative sign (-) showed have invert correlation

The results of the correlation test between disease incidence and attack intesity of yellow leaf curl disease on wight of fruit per plant showed a moderate to strong and negative relationship (-0.896 and -0.912) (Table 5). This showed that the lower the disease incidence and the attack intensity of yellow leaf curl disease caused to increasing the fruit numbers per plant and fruit weight per plant. Barchenger *et al*. (2019) had been reported that chili plants infected with yellow leaf curl disease could cause economic losses, due to a yield loss of 95% compared to healthy plants, so the farmers have been forced to cultivate alternative corps.

The used both of lime juice and synthetic citric acid solutions could disturb whiteflys habbit to find out the hostplant. The used both of lime juice and synthetic citric acid solutions of 0.2% and 0.3% could result the low of whiteflys population in field.

4. CONCLUSION

The number of whitefly on plants sprayed with lime juice and synthetic citric acid solution at a concentration both of 0.2% dan 0.3% was lower than the control. Disease incidence and disease severity of yellow leaf curl disease attack on plants sprayed with a lime juice and synthetic citric acid solution at a concentration of 0.3% was lower than the control. Spraying a lime juice and synthetic citric acid at solution a concentration of 0.3% could result the fruit numbers per plant and fruit weight per plant. The disease incidence and disease severity of yellow leaf curl disease had a strong and negative correlation with the fruit numbers per plant and fruit weight per plant.

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