Entomology

The effect of weed species on the survival and reproduction of green leafhopper *Nephotettix virescens* (Distant)

Nurjannah Hasibuan[1] and B. Manurung[1*]

[1] Biology Study Program, Faculty of Mathematics and Natural Sciences, State University of Medan, Jl. Willem Iskandar Psr. V, Medan Estate, Medan, Indonesia

Correspondence Author: B. Manurung

Received 12 Dec 2024; Accepted 24 Jan 2025; Published 3 Feb 2025

Abstract

This study aimed to assess the effect of different weed species on the survival and reproductive success of the green leafhopper *Nephotettix virescens* and to determine which weed species that can to supports leafhopper survival. The study was carried out in randomized complete block design with three replications across three weed types (*Leersia hexandra*, *Cyperus rotundus*, *Echinochloa crusgalli*) and rice (*Oryza sativa*) as a control. Research results showed that *N. virescens* has the longest survival on rice, followed by the weeds of *Leersia hexandra*, *Cyperus rotundus*, and *Echinochloa crusgalli* (Fc = 23.79; P= 0.01). The highest of offspring number was observed on rice, be followed on *Cyperus rotundus*, *Leersia hexandra*, and *Echinochloa crus-galli* (Fc = 8.45; P = 0.01). *Cyperus rotundus* and *Leersia hexandra* could supported the survival and reproduction of *N. virescens*.

Keywords: Green leafhoppers, Weeds, Survival rates

1. Introduction

The relationship between insects and plants is mutual, benefiting both; however, insects typically derive nourishment from plants, which can be detrimental to the plants. Over 50% of insects are herbivores, with the rest feeding on other insects or plant and animal remains (Hadi *et al.*, 2009) [3].

In rice ecosystems, the relationship between rice plants (*Oryza sativa*) and leafhoppers is particularly significant. Leafhoppers utilize rice plants for food and shelter, feeding on various plant parts, including leaves, stems, and sap (Jumar, 2000) [5]. Research by Manurung (2012) [7] identified at least 10 species of leafhoppers in Serdang Bedagai Regency, such as *Recilia dorsalis*, *Nehotettix nigropictus*, *Nephotettix virescens*, *Nilaparvata lugens*, *Cofana spectra*, *Sogatella furcifera*, *Cicadulina sp.*, *Cicadella sp.*, *Oliarus sp.*, and *Thaia sp.* Further research by Manurung (2014) [8] reported the presence of 10 leafhopper species on rice plants in Deli Serdang Regency, including the green leafhopper.

The green leafhopper (*Nephotettix virescens*) poses a serious threat to rice cultivation as a potential primary pest. With a life cycle of 23-33 days, a single female can lay up to 1,000 eggs under laboratory conditions, though environmental factors in the field typically reduce this number to 100–600 eggs (Basri *et al.*, 2012) [2].

After the rice harvest, leafhoppers can no longer rely on rice as their primary food source and instead turn to weeds. Weeds serve as an alternative food source, shelter, and breeding ground, sustaining leafhoppers until the next rice planting season (Aminatum, 2012) [1]. According to Nurhasanah's (2016) [9] research in Percut Sei Tuan District, Deli Serdang Regency, various weed species are found in rice fields, including *Limnocharis flava*, *Fimbristylis miliacea*, *Alternanthera sessilis*, *Panicum repens*, *Cyperus rotundus*, *Echinochloa crus-galli*, and *Bidens pilosa*. Heinrichs (1989) [4] found that the weed *Leersia hexandra* is a suitable host for leafhoppers and provides an ideal habitat for adult leafhoppers (Oka, 1979) [10].

Limited research exists on how weeds influence the survival rates of the green leafhopper *(Nephotettix virescens)*. Consequently, a study was conducted to examine the influence of several weed species on the survival of the green leafhopper, with rice (*Oryza sativa*) as the control.

2. Research methods

This research was conducted in Asam Jawa Village, Torgamba District, Labuhanbatu Selatan Regency, North Sumatra Province, and the Biology Laboratory of the State University of Medan from March to June 2018. Samples were collected from rice fields in Mampang Village, Kotapinang District, Labuhanbatu Selatan Regency, North Sumatra Province.

The tools used in the study included an insect net for capturing leafhoppers, plastic bags for storing weeds collected from the field, polybags for planting weeds, glass tubes to enclose weeds to prevent leafhoppers from escaping, tubes for storing captured leafhoppers, hoes for weed collection, a hand lens for leafhopper identification, and various other items like pens and paper.

The study materials included three types of weeds: Cyperus rotundus, Leersia hexandra, and Echinochloa crus-galli. Weed selection was based on the findings of Nurhasanah (2016) [9] and Oka (1979) [10]. Rice plants were used as the control host plant, and the study included both male and female green leafhoppers.

The experimental design used was a Completely Randomized Design (CRD). In this setup, the independent variable was the type of weed (including rice as a control). In contrast, the

dependent variables were the mortality rate and the number of leafhopper offspring in each treatment.

The research procedure was divided into three main stages:

a) Weed sample collection procedure

The steps for collecting weed samples were as follows:

- Selecting a sampling location within a rice field.
- Collecting weeds of the specified types using a hoe to avoid damaging the plant roots.
- Planting the collected weeds in polybags filled with soil.
- Transporting the planted weeds to Asam Jawa Village, Torgamba District, Labuhanbatu Selatan Regency, North Sumatra.
- Maintaining the weeds until they grew well.

b) Leafhopper collection procedure

The steps for collecting rice leafhoppers were as follows:

- Selecting a sampling location within a rice field.
- Capturing rice leafhoppers using an insect net.
- Extracting the leafhoppers from the net using an aspirator.
- Placing captured leafhoppers into prepared tubes.
- Identifying the captured leafhoppers using a stereo microscope, based on Wilson and Claridge's (1991) [14] leafhopper identification key. The primary identification parameter was the shape of the aedeagus (male reproductive organ).
- Cover the top of each tube with gauze to allow airflow for the leafhoppers.

c) Observing the effect of weeds on leafhopper survival rates

The method for observing the effect of weeds on leafhopper survival rates and number of offspring was adapted from Manurung (2014) [8] using glass tube cages placed over the soil in polybags. The steps were as follows:

- Ensuring the weeds had grown well and then covering them with glass tubes.
- Each glass tube was stocked with 10 pairs of rice leafhoppers.
- Monitoring the development of the leafhoppers over 28 days.
- Recording the number of dead leafhoppers in each glass tube.
- The surviving leafhoppers were moved to a fresh glass tube with new weeds after 14 days.
- Recording the number of surviving or dead leafhoppers, as well as the number of offspring, in a data table for further analysis.

3. Data analysis techniques

a) Leafhopper survival rate

Data on leafhopper survival rate were gathered by observing the number of live and dead leafhoppers in each treatment group (weeds and rice) on a daily basis. The influence of weed types on leafhopper survival rate was tested using a one-way ANOVA (Zar, 2013) [18], with IBM SPSS Statistics 20 software.

To determine the difference in survival rates across weed types, a Tukey's Honestly Significant Difference (HSD) test or Least Significant Difference (LSD) test was conducted using the following formula:

$$LSD\ (\alpha) = t\ \alpha\ (dB\ error) \times \sqrt{\frac{2MSE}{r}}$$

Note:
MSE = Mean Square Error
r = Number of repetitions
t = value from the t-table

b) Leafhopper offspring count

The data on the number of leafhopper offspring in each treatment were recorded after a 28-day observation period, with the offspring counted for each treatment. To determine the effect of weed species on the number of leafhopper offspring, a one-way ANOVA was applied using IBM SPSS Statistics 20.

To examine differences in offspring counts between weed types, Tukey's HSD test or the LSD test was conducted using the following formula:

$$LSD\ (\alpha) = t\ \alpha\ (dB\ error) \times \sqrt{\frac{2MSE}{r}}$$

Note:
MSE = Mean Square Error
r = Number of repetitions
t = value from the t-table.

4. Research result

A. Survival rates of green leafhopper (*Nephotettix virescens*) on different weeds

The results of observations on the effects of different weed types on the survival rates of the green leafhopper (*Nephotettix virescens*) are presented in Table 4.1.

Table 4.1. The survival rates of green leafhopper (*Nephotettix virescens*) on different weeds

No	Treatment	Replication			Total	Average	Contribution
		1	2	3			
1.	*Oryza sativa* (as control)	10	10	8	28	9,33	-
2.	*Cyperus rotundus L*	6	5	5	16	5,33	57%
3.	*Leersia hexandra*	8	6	7	21	7	75%
4.	*Echynochloa crus-galli*	4	4	4	12	4	43%

Based on Table 4.1, the survival duration of the green leafhopper (*Nephotettix virescens*) varied depending on the treatment. The shortest survival duration was observed on the weed *Echinochloa crus-galli*, with an average survival time of four days, while the longest survival duration, at an average of 10 days, was recorded in the control treatment using rice

(*Oryza sativa*). Among the weed species, *Leersia hexandra* supported the longest survival time, averaging eight days.
Leersia hexandra contributed 75% to the survival of the green leafhopper (*Nephotettix virescens*) when rice was unavailable in the field (post-harvest). Meanwhile, *Cyperus rotundus* and *Echinochloa crus-galli* contributed 57% and 43%, respectively.
In order to determine the effect of different weed types on the survival rates of the green leafhopper, statistical analysis using one-way ANOVA was conducted and its result is displayed in Table 4.2.

Table 4.2. Analysis of variance (ANOVA) survival rates of green leafhopper (*Nephotettix virescens*) on different weeds

Source of variation	Degrees of freedom	Sum of squares	Mean square	F calculated (fc)	F tab. 0,05	F tab. 0.01
Treatment	3	47,58	15,86	23,79	4,07	7,59
Error	8	5,33	0,67			
Total	11	52,91	15,53			

Based on the results that be presented in Table 4.2, it showed that there was very significantly effect of weeds on the survival rates of the green leafhopper (Fh = 23.79 > F table 0.01 = 7.59).
A post hoc Tukey's HSD test was done to examine the differences between treatments, as shown in Table 4.3.

Table 4.3. Tukey's LSD test results for green leafhopper (*Nephotettix virescens*) Survival rates on different weeds

Treatment	Treatment average	Significant difference			
		1	2	3	4
Echynochloa crus-galli (1)	4	-	-	-	-
Cyperus rotundus (2)	5,33	$1,33^{ns}$	-	-	-
Leersia hexandra (3)	7	3^{**}	$1,67^{*}$	-	-
Oryza sativa (4)	9,33	$5,33^{**}$	4^{**}	$2,33^{*}$	-

Note:
* = significant
** = very significant
ns = not significant
Where:

- LSD $_{(0.05)}$ = 1,54
- LSD $_{(0,01)}$ = 2,24

According to the results of Tukey test shown in Table 4.3, there were highly significant differences in the survival duration of green leafhoppers between rice (*Oryza sativa*) and *Echinochloa crus-galli*, rice and *Cyperus rotundus*, as well as rice and *Leersia hexandra*. Additionally, there was a significant difference in survival duration between *Leersia hexandra* and *Echinochloa crus-galli*, and between *Cyperus rotundus* and *Leersia hexandra*. However, no significant difference was observed between *Cyperus rotundus* and *Echinochloa crus-galli*.

B. Number of green leafhopper (*Nephotettix virescens*) offspring on different weeds

Table 4.4 presents the observational results on the impact of various weed types on the number of the green leafhopper offspring after 28 days.

Table 4.4. Green leafhopper (Nephotettix virescens) offspring number on different weeds after 28 days

No.		Replication			Total	Average	Contribution
		1	2	3			
1.	*Oryza sativa*) (control)	16	11	9	36	12	-
2.	*Cyperus rotundus*	6	10	8	24	8	66%
3.	*Leersia hexandra*	6	3	3	12	4	33%
4.	*Echynochloa crus-gall*	1	3	5	9	3	25%

According to Table 4.4, the number offspring of the green leafhopper (*Nephotettix virescens*) varied depending on the treatment. The lowest number of offspring was observed on *Echinochloa crus-galli*, while the highest was found on rice (*Oryza sativa*).
Among the weeds, *Cyperus rotundus* supported the highest number of offspring, contributing 66% to the total offspring count, while *Leersia hexandra and Echinochloa crus-galli* contributed 33% and 25%, respectively.
The one-way ANOVA test results for the effect of different weed types on green leafhopper offspring number is shown in Table 4.5.

Table 4.5: Analysis of variance reen leafhopper (*Nephotettix virescens*) off spring number on different weeds and rice

Source of variation	5	Sum of squares	Mean square	F calculated (F_h)	F tab. 0,05	F tab. 0,01
Treatment	3	152,25	50,75	8,45	4,07	7,59
Error	8	48	6	-	-	-
Total	11	200,25	56,75	-	-	-

The results in Table 4.5 indicated that weed type have a highly significant effect on the number of green leafhopper offspring (Fc = 8.45 > F table 0.01 = 7.59). In order to determine the differences of offspring number between treatments, a post hoc Least Significant Difference (LSD) test was conducted, and the results are presented in Table 4.6.

Table 4.6: Results of the least significant difference (LSD) test for the number of offspring of green leafhopper (*Nephotettix virescens*) on different weeds

Treatment	Treatment average	Significant difference			
		1	2	3	4
Echynochloa crus-galli (1)	3	-	-	-	-
Leersia hexandra (2)	4	1^{ns}	-	-	-
Cyperus rotundus (3)	8	5*	4^{ns}	-	-
Oryza sativa(control) (4)	12	9^{**}	8^{**}	4^{ns}	-

Note:
* = significant
** = very significant
ns = not significant
Where:

- LSD $_{(0.05)}$ = 4,61
- LSD $_{(0,01)}$ = 6,71

Based on the results of the Least Significant Difference (LSD) test as presented in Table 4.6, it can be stated that there is a highly significant difference in the number of offspring of leafhoppers raised on rice (*Oryza sativa*) compared to *Echinochloa crus-galli* and between rice (*Oryza sativa*) and *Leersia hexandra*. There is a significant difference in the number of offspring between *Cyperus rotundus* and *Echinochloa crus-galli*. However, there is no significant difference in the number of offspring between leafhoppers raised on *Leersia hexandra* and *Echinochloa crus-galli*, *Cyperus rotundus* and *Leersia hexandra*, or between rice (*Oryza sativa*) and *Cyperus rotundus*.

The combined data on the survival rates and offspring count of the green leafhopper on different weeds are presented in Table 4.7.

Table 4.7: Survival (survival rates and number of offspring) of green planthopper (*nephotettix virescens*)

No.	Weed type	Average survival rate (days)	Average offspring count
1.	*Cyperus rotundus*	5,33	8
2.	*Leersia hexandra*	7	4
3.	*Echynochloa crus-galli*	4	3

Based on the data presented in Table 4.7, it is clearly evident that the best weed for supporting the survival rate of the green leafhopper (*Nephotettix virescens*) is *Leersia hexandra*, while the weed that supports the highest number of offspring is *Cyperus rotundus*.

5. Discussion

a) Differences in survival rates of green leafhopper (*Nephotettix virescens*)

The survival rates of the green leafhopper (*Nephotettix virescens*) varied depending on the treatment. Based on the findings in this study, the green leafhopper had the longest survival on the weed *Leersia hexandra* and the shortest on *Echinochloa crus-galli*. This suggests that these weeds can serve as host plants (providing food sources, shelter, and breeding grounds) for leafhoppers during periods when rice plants are not available in the field. These results align with Oka's (1979) [10] findings, which indicated that *Leersia hexandra* is a suitable host plant for adult leafhoppers but not for their larval stages. The effect of weeds presence especially Poaceae family on diversity and population level of insect has been reported by Thanou *et al.* (2021) [12]. Kay and Brown (2007) [6] reported that there was a good association between *Nephotettix malayanus* and *N. nigropmaculatus with Leersia hexandra* whereas there was no *Nephotettix spp* that be found on *Echinochloa colona.*

During growth and development, weeds also produce secondary metabolites. These secondary metabolites may support leafhopper survival. According to Zhao *et al.* (2010) [19], secondary metabolites are non-essential metabolic compounds for plant growth. These compounds are not always produced; they appear only when required or during specific growth phases. The composition and presence of these secondary metabolites correlate with plant resistance. They function as chemical signals in ecosystems and may sometimes act as antibiosis against insects and pathogens. Volatile secondary metabolites play a role in plants' responses to insect presence.

Rice plants contain tricin, a flavonoid compound found in rice stems, leaves, and husks. This flavonoid serves as a repellent, inhibitor, and toxin to insects (Xu, 2001) [16].

Besides rice plants, *Cyperus rotundus* also contains flavonoids. Additionally, *Cyperus rotundus* possesses alkaloids, which function as natural insect repellents. However, specific information on the compounds in *Leersia hexandra* and *Echinochloa crus-galli* remains limited. Apart from chemical properties, morphological features, such as plant surface hair, can also contribute to plant resistance against insect pests (Woodhead and Padgham, 1988) [15]. Such characteristics directly interfere with insect behavior, affecting activities like egg-laying, feeding, and colonization.

The green leafhopper (*Nephotettix virescens*), which serves as an active vector for transmitting the tungro virus, poses a threat to rice crops. The tungro disease in rice is caused by rod-shaped and spiral-shaped tungro viruses. The presence and spread of the tungro virus in the field also rely on the availability of virus inoculum sources, with weeds potentially acting as alternative hosts for the tungro virus.

Several researchers have studied the association between weeds and tungro disease. Yulianto *et al.* (1999) [17] reported that *Jussiaea repens*, *Trianthema portulacastrum*, *P. niruri*, *Cyperus rotundus*, *M. vaginalis*, and *Leersia hexandra* could serve as alternative hosts for the tungro virus, thus providing a breeding ground for the virus.

b) Differences in offspring of green leafhopper (*Nephotettix virescens*)

The study results showed differences in the number of green leafhopper offspring across the weed treatments, including rice (*Oryza sativa*) as a control. Among the weeds, *Cyperus rotundus* contributed the most to the number of green leafhopper offspring. Yulianto *et al.* (1999) [17] previously highlighted the role of weeds in facilitating insect reproduction, explaining that weeds can supply food, shelter, and breeding areas for insects, as well as for nematodes, pathogens, and other pests. Weeds such as *Jussiaea repens*, *Trianthema portulacastrum*, *P. niruri*, *Cyperus rotundus*, *M. vaginalis*, and *Leersia hexandra* have been identified to support these functions. Viswanathan & Kalode (1986) [13] reported that *N. nigropictus* preferred *Leersia hexandra* both for its settling and egg laying, whereas *N. virescens* preferred rice plant. Furthermore, it was stated that *N. virecens* could survive and breed only on susceptible rice variety, while *N. nigropictus* host range consisting of rice, sugarcane and five graminaceous weeds. According to Patel *et al*. (2018) [11] *N. virescens* can feed on *Eleusine indica*, *Cynodon dactylon* and *Cyperus rotundus*. *N. virescens* preferred rice to grassy weeds but *N. nigropictus* preferred grassy weed, especially *L. hexandra* over rice.

Therefore, the presence of weeds in rice fields, both during the rice crop's vegetative phase and post-harvest or fallow periods, can serve as a source of food, shelter, mating sites, and breeding grounds for the green leafhopper. Consequently, if farmers aim to reduce the green leafhopper population—which can harm future rice crops as a tungro virus vector—they should eradicate all weeds in the field after harvest or during fallow periods. Such measures can disrupt the life cycle of the green leafhopper, minimizing its abundance in the field.

6. Conclusion

The green leafhopper (*Nephotettix virescens*) had the longest survival rate on the weed *Leersia hexandra*, followed by *Cyperus rotundus*, and the shortest on *Echinochloa crus-galli*. The highest number of green leafhopper (*Nephotettix virescens*) offspring was found on *Cyperus rotundus*, followed by *Leersia hexandra*, with the lowest on *Echinochloa crus-galli*.

Among the weeds tested, *Cyperus rotundus* proved to be the most favorable for the survival (survival rate and offspring count) of the green leafhopper *(Nephotettix virescens*).

References

1. Aminatum. Pola Interaksi Serangga dan Gulma pada Ekosisttem Sawah Surjan dan Lembaran dalam Mendukung Pengendalian Hayati. Sekolah Pascasarjana Universitas Gadjah Mada, Yogyakarta, 2012.
2. Basri AB, Nazariah, Ferizal M. Mengenal Wereng Coklat. Serambi Pertanian, 2012, 6(2).
3. Hadi M, Tarwotjo U, Rahadian R. Biologi Insekta Entomologi. Graha Ilmu, Yogyakarta, 2009.
4. Heinrichs EA. Leersia hexandra, a Weed Host of the Rice Brown Planthopper, Nilavarpata lugens (Stal). Department of Entomology, International Rice Research Institute, Manila, Philippines. 1989;3(1):77-85.
5. Jumar. Entomologi Pertanian. Rineka Cipta, Jakarta, 2000.
6. Kay IR, Brown JD. Nephotettix species (Hemiptera, Cicadellidae) on rice and weeds in Queensland. Aust J Entomol. 2007;31(4):303-304.
7. Manurung B. Biodiversitas, Distribusi dan Biologi Perkembangan Wereng Padi (Auchenorrhynca) di Kabupaten Serdangbedagai, Laporan Hasil Penelitian Dosen Sesuai KDBK, 2012.
8. Manurung B. Entomologi. Medan: FMIPA Unimed Press, 2014.
9. Nurhasanah, Manurung B. Kajian morfometri wereng putih (Cofana spectra) dan Gulma pada ekosistim padi sawah di kecamatan Percut Sei Tuan Sumatera Utara. J Biosains. 2016;2(2):112-117.
10. Oka IN. Cultural Control of the Brown Planthopper, Nilaparvata lugens. Central Research Institute for Agriculture, Bogor, Indonesia, 1979.
11. Patel SKP, Rajeswari B, Khrishnavei D. Weed host range of rice tungro virus disease. Plant Arch. 2018;18(1):382-386.
12. Thanou ZN, Kontogiannis EG, Tsagkarakis AE. Impact of weeds on Auchenorhyncha incidence and species richness in citrus orchards. Phytoparasitica. 2021;49:333-347.
13. Viswanathan K, Kalode MB. Host specificity of rice green leafhoppers Nephotettix virescens (Distant) and Nephotettix nigropictus (Stahl). Proc Anim Sci. 1986;95:227-236.
14. Wilson MR, Claridge MF. Handbook for the identification of leafhoppers and planthoppers of rice. Wallingford, UK: C.A.B. International, 1991.
15. Woodhead S, Padgham DE. The effect of plant surface characteristics on resistance of rice to the brown planthopper, Nilaparvata lugens. Entomol Exp Appl. 1988;47:15-22.
16. Xu HH. Insecticide Plant and Botanical Insecticide. Beijing: Chinese Agriculture Press, 2001.
17. Yulianto A, Hasanuddin, Sutisna E. Uji Eradikasi Selektif Gulma Sebagai Sumber Inokulum Virus Tungro. In: Kongres Nasional XV dan Seminar Ilmiah Perhimpunan Fitopalogi Indonesia, Purwokerto, 1999, 286-289.

18. Zar JH. Biostatistical Analysis. Singapore: Prentice-Hall, 2013.
19. Zhao YFK, Huang ZL, Tong, Pang XP. HPLC Analysis of Rice Variety Resistance to Different Biotype of Nilaparvata lugens. J South. 2010;26(2):53-56.