**INTRODUCTION**

*Nilaparvata lugens* (Stål) (Hemiptera: Delphacidae) is known as the Green Revolution pest. The research conducted by national and international research institutions from 1979 to 1986 proved that the explosion of brown planthopper population was triggered by excessive use of pesticides. Indonesia’s crop protection policies, which promote the use of pesticides, had caused two pest outbreaks in 1979 and 1986. Philippines, Thailand, Vietnam, Cambodia and Malaysia also experienced similar pest outbreaks. The population ecologists explain this mechanism of the BPH pest explosion in detail (Kenmore, Carino, Perez, Dyck, & Gutierrez, 1984). The disruption by insecticide in ‘ecological’ balance between BPH and natural enemies, has been accused to be the cause of BPH outbreaks, though the methods contributed to the incline high-yielding output in tropical paddy ecosystem (Sogawa, 2015). Several factors have been alleged to be the pathways in inducing BPH outbreaks, such as the limitation of spray range into the plant basis which BPH are feeding, the residual effects in hatching nymphs weakened, and insecticide resistance; declining numbers of natural enemies; the alteration of chemical components in paddy field which affect BPH nutrition; and insecticide as an oviposition booster, feeding and hatching stimulators.

To prevent the BPH explosion, Indonesian Government issued INPRES Number 3, 1986, which established the IPM Program as a national pest control strategy and banned certain pesticide formulations and active ingredients for rice cultivation (Sutrisno, 2014). Sutrisno (1989) reported that BPH population in the field showed cross-resistance to insecticides such as Carbamate and Organophosphate. Thus, Imidacloprid as the new insecticide in Indonesia was introduced for paddy. From 2005 to 2006, Gorman, Liu, Denholm, Brüggen, & Nauen (2008) investigated 24 BPH samples collected from China, India, Indonesia, Malaysia, Thailand and Vietnam. Samples that were collected in 2005
are susceptible to Imidacloprid while those were collected in 2009 in some regions from Central Java and East Java is resistant. Nevertheless, the resistant BPH population to Imidacloprid, was reported to be still susceptible to Etiprol-based insecticides. The insect resistances to insecticide were through several mechanisms and one of them is BPH mechanism. Those involving mechanisms were declining the Acetylcholinesterase Enzyme (AChE) sensitivity, inclining the Aliesterase Enzyme (AliE) or non-specific Aliesterase activity, the Glutathione S-transferase activity, and also inclining the microsomal oxidase enzyme (Heong, Tan, Garcia, Fabellar, & Lu, 2011). Currently, Indonesian government gives permission to distribute 28 active ingredients of insecticide for BPH management program (Ditjen PSP, 2016). From those 28 insecticides, Carbosulfan is prohibited in Europe, and Abamectin is banned in Thailand (IRRI, 2011). Furthermore, IRRI also recommends that Deltamethrin is not used in BPH management control program since it induced resurgence (Bouman & Heong, 2014).

IPM training for farmers was established in the form of IPM Field School, massively conducted in 14 rice-producing provinces in Indonesia from 1989 to 2000 (Horgan, 2017). This program aims to alleviate the negative entanglements of the Green Revolution and alter the paradigm, from encouraging farmers to uplifting crop intensification targets to enhance their knowledge, improve their learning ability, increase their dignity, as well as empower them in life. Based on the observation in the last decade, farmers’ knowledge and skill were improved as well as the upsurge of the training program, called Farmer Field Schools (FFS). The IPM Program was explained in detail and gave the farmers opportunity to learn the problems that they face every day in their fields. On this day, farmers should be more educated in terms of technology, politics, markets and society (Pontius, Dilts, & Bartlett, 2002). Indonesian Pest Forecasting Institute estimated that in the 2014/2015 rice planting season, BPH would attack around 36,000 ha rice plantations (BBPOPT, 2014). Besides, the Indonesian government also banned the use of pyrethroid-based insecticides on rice fields in early 2000. The program was able to suppress the use of insecticides indiscriminately by farmers and prevented the BPH explosions at least until 2009.

The increasing BPH populations began to return in the 2009 planting season in most rice production centers in Java, Indonesia. The symptoms affected by BPH such as burning or hopperburn spreaded widely, and the threat of pest explosion became more serious (Darmadi & Alawiyah, 2018). In 2011, the BPH attack resulted in 0.9 million tons of rice losses in Java (Heong, Wong, & Reyes, 2015). The occurrence of the BPH explosion was allegedly due to excessive and blind-use of insecticide as if the farmers had forgotten about IPM (Iswanto, Rahmini, Nuryanto, & Baliadi, 2016). This research aims to examine the relationship between the level of crop damage due to BPH attacks with pesticide use schemes in Java, Indonesia.

MATERIALS AND METHODS

Sampling and Observation Method

The research was carried out at the end of 2013-2014 rice planting season. The surveys on the scheme of pesticide use by rice farmers was conducted in 15 districts in Java island that were reported to have severe BPH attacks, namely Banyuwangi, Jember, Blitar, Kediri, Lamongan, Tuban, Bojonegoro (East Java), Pati, Demak, Pekalongan, Tegal, Klaten, Sukoharjo (Central Java) and Indramayu, Subang (West Java).

The research was conducted based on a purposive sampling method by choosing 5 relatively unaffected and 5 BPH-damaged rice fields. Those ten plots were determined from each district and interviews were carried out on the farmers that grew the rice paddies. Ten farmers were interviewed from each district. Thus, 150 farmers were interviewed for 15 sampled districts. Information about cultivation techniques, especially on farmer approaches in managing BPH attacks i.e. number of pesticide, application types of pesticide, number of pesticides mixed and other pertinent information were collected using structured-questionnaire.

Direct observations were also conducted on the selected rice fields. The damage level observation was carried out in the rice field of every plot. In every selected plot, there are 5 categories to estimated damage level i.e. damage category 1 (0%), 2 (about 25%), 3 (about 50%), 4 (about 75%), 5 (hopperburn). Table 1 presented damage levels and symptoms caused by BPH.
Special attention was given on the relation between the control approaches and the damage levels. Correlation between number of pesticide application types of pesticide, number of pesticides mixed, and other measures with damage level were investigated.

Data Analysis

Data gained from interview were presented using descriptive statistics and the data were analyzed using Chi-Square tests for investigating the correlation between number of pesticide application types of pesticide, number of pesticides mixed, and other measures with damage level.

RESULTS AND DISCUSSION

The Relationship Between BPH Attacks and Insecticides Use Pattern in Java

The data was collected from 150 farmers that were spread over 15 districts in Java Island. The backgrounds of the farmers were varied on the ownerships, size of rice fields, rice ages, rice varieties and rice varieties. The size of rice fields ranged from 50 m$^2$ to 3 ha. The rice ages were also varied from 14 to 90 days after planting. The rice varieties planted by farmers are Ciherang, Campedak, Ketan, Metek Wangi, Bagendit, IR 42, IR 64, Mekongga, Membramo, Way Apu, Serang 2, Sintanur and Pandan Wangi. The stated varieties were planted in various spacing i.e. from a very short distance 18 x 18, 30 x 30 and 25 x 75 cm$^2$.

Direct observations in 15 districts revealed that the rice plants that have free damage from from BPH attacks were very few. Fig. 1 shows the distribution of selected sample plot damage conditions. The number of rice plots that were free from the BPH attacks was very small, approximately only 4%. Most of the sample plots were damaged in the category of 2 and 3.

Sample plots that were free from BPH attacks were managed by implementing an integrated management program. These farmers did not use synthetic insecticides but applied biological agents such as Lecanicilium sp., Beauveria sp. and Corynebacterium sp. As found in Lamongan District, plots with IPM implementation are free from BPH attacks, even though the adjacent plots experienced hopperburn (Fig. 2). In all districts, the plots were majority sprayed with pesticides where rice plots attacked by BPH. Farmers had limitation in accessing information regarding the use of pesticides could trigger a BPH explosion. In one season, the frequency of pesticide application was varied among farmers. Farmers having rice damage in category 2 applied pesticides up to 8 times application. While those category 3 applied 6 times, category 4 applied 5 times, and on plant damage of category 5, the farmer applied 4 times (Fig. 3). This happens because the lower attack rate induced a longer time for farmers to apply pesticides. On the other hand, if the BPH attack rate is high and resulting hopper burn, the farmer tends not to take care of their crops. Chi-square test based on the level of alpha 0.05 indicates that there is a relation between the level of damage to rice crops with the number of applications of pesticides by farmers ($\chi^2$count = 29.17 and $\chi^2$tables = 28.87).

Farmers’ decisions for pesticide application in the field was varied. Some of them used single type of pesticide, while others applied mixture of pesticides. The results show that there are several pesticide mixtures found in the field. The amount of pesticide mixture used by farmers ranged from 1 to 8 types. In the damage categories of 2, 3 and 5. Most of farmers use single type of pesticide. While in the damage categories of 4, farmers prefer to use the combination of 3 different kinds of pesticides (Fig. 4).

Table 1. Scale of damage due to BPH attacks

| Damage Categories | Description of Damage |
|-------------------|-----------------------|
| 1 (0%)            | No damage             |
| 2 (0 < X ≤ 25%)   | Plants turn a little yellow, but there are no symptoms of hopperburn |
| 3 (25 < X ≤ 50%)  | The leaves turn yellow; growth is stunted or withered, have hopperburn or are stunted |
| 4 (50 < X ≤ 75%)  | More than half of plants wither or with hopperburn or very dwarf plants |
| 5 (75 < X ≤ 100%) | Perfect withered, dead plants |

Copyright © 2020 Universitas Brawijaya
Fig. 1. Distribution of plots damage conditions due to BPH attack on Java, 2013/2014 planting season

Fig. 2. Plots of rice that are managed conventionally using pesticides (A) and integrated pest control pest (B) in Lamongan, East Java, 2013/2014 planting season
**Fig. 3.** Frequency of pesticide application during within season

**Fig. 4.** Percentage of use of pesticide mixtures at several categories of plant damages
The Relationship Between the Level of Damage to Rice Crops with Insecticides Status in Java

The data shows that the pesticides used by farmers consists of 25 groups of pesticides (Table 2), 43 active ingredients (Table 3) from 66 trademarks of Organophosphate and Pyridine. Those are groups with the highest frequency used in the field. Several groups of these pesticide have been prohibited, but farmers still used these prohibited pesticides for rice. Heong, Wong, & Reyes (2015) stated that insecticides, especially the Pyrethroids and Organophosphates groups, could influence predators and parasitoids because they have destructive effects.

Table 2. Frequency of pesticide groups at various levels of damage

| Pesticides Group | Damage Categories |
|------------------|-------------------|
|                  | 2      | 3      | 4      | 5      |
|                  | F*     | F      | F      | F      | F      |
|                  | Rf*    | F      | Rf     | F      | Rf     |
| Avermectin       | 12     | 0.09   | 5      | 0.02   | 3      | 0.02   | 2      | 0.07   |
| Benzimidazol     | 1      | 0.01   | 4      | 0.02   | 0      | 0.00   | 0      | 0.00   |
| Bipiridilium     | 0      | 0.00   | 1      | 0.00   | 0      | 0.00   | 0      | 0.00   |
| Difenil          | 6      | 0.05   | 2      | 0.01   | 1      | 0.01   | 3      | 0.10   |
| Ditiokarbamat    | 1      | 0.01   | 4      | 0.02   | 0      | 0.00   | 0      | 0.00   |
| Fenil-pirazol    | 10     | 0.01   | 1      | 0.00   | 4      | 0.02   | 4      | 0.13   |
| Fenoksi          | 5      | 0.04   | 3      | 0.01   | 3      | 0.02   | 0      | 0.00   |
| Gisin            | 0      | 0.00   | 1      | 0.00   | 1      | 0.01   | 0      | 0.00   |
| Karbamat         | 8      | 0.06   | 10     | 0.04   | 16     | 0.08   | 6      | 0.20   |
| MBC              | 5      | 0.04   | 4      | 0.02   | 0      | 0.00   | 0      | 0.00   |
| Neonicotinoid    | 6      | 0.05   | 17     | 0.07   | 9      | 0.05   | 4      | 0.13   |
| Nertoksin        | 1      | 0.01   | 25     | 0.11   | 3      | 0.02   | 2      | 0.07   |
| Organofosfat     | 10     | 0.08   | 13     | 0.06   | 52     | 0.26   | 0      | 0.00   |
| Organomangan     | 20     | 0.16   | 4      | 0.02   | 0      | 0.00   | 0      | 0.00   |
| Organoseng       | 1      | 0.01   | 1      | 0.00   | 0      | 0.00   | 0      | 0.00   |
| Piretroid        | 9      | 0.07   | 15     | 0.06   | 3      | 0.02   | 3      | 0.10   |
| Piridin          | 13     | 0.10   | 12     | 0.05   | 50     | 0.25   | 0      | 0.00   |
| Pirimimidin      | 1      | 0.01   | 2      | 0.01   | 0      | 0.00   | 0      | 0.00   |
| Sulfonil Urea    | 5      | 0.04   | 2      | 0.01   | 27     | 0.14   | 0      | 0.00   |
| Triadiazin       | 1      | 0.01   | 3      | 0.01   | 6      | 0.03   | 2      | 0.07   |
| Triadiazol       | 2      | 0.02   | 2      | 0.01   | 5      | 0.03   | 2      | 0.07   |
| Triazin          | 0      | 0.00   | 20     | 0.09   | 1      | 0.01   | 0      | 0.00   |
| Triazol          | 0      | 0.00   | 7      | 0.03   | 5      | 0.03   | 0      | 0.00   |
| Trifluorometil   | 8      | 0.06   | 37     | 0.16   | 5      | 0.03   | 2      | 0.07   |
| Urea             | 2      | 0.02   | 38     | 0.16   | 5      | 0.03   | 2      | 0.07   |

Remarks: *Frequency; ** Relative Frequency
Table 3. Frequency of active ingredients pesticides at various damage categories

| Active Materials                  | Damage Category |          |          |          |          |          |
|----------------------------------|-----------------|----------|----------|----------|----------|----------|
|                                  | 2               | 3        | 4        | 5        |          |          |
|                                  | F   | Rf  | F    | Rf  | F    | Rf  | F    | Rf  |
| 2,4 D metilmetsulfuron           | 0   | 0.00 | 2 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| 2,4 D Natrium                    | 5   | 0.03 | 0 | 0.00 | 0   | 0.00 | 0   | 0.00 |
| 2,4 D Isopropilamina             | 5   | 0.03 | 1 | 0.01 | 1   | 0.01 | 0   | 0.00 |
| Abamectin                        | 12  | 0.08 | 5 | 0.03 | 4   | 0.03 | 2   | 0.07 |
| AlfaMetrin                       | 0   | 0.00 | 2 | 0.01 | 1   | 0.01 | 1   | 0.04 |
| Alfa Siprometrin                 | 0   | 0.00 | 3 | 0.02 | 0   | 0.00 | 0   | 0.00 |
| Asibenzolare-metil               | 1   | 0.01 | 2 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 11  | 0.07 | 0   | 0.00 |
| Azoxistrobin                     | 12  | 0.08 | 5 | 0.03 | 4   | 0.03 | 2   | 0.07 |
| AlfaMetrin                       | 0   | 0.00 | 2 | 0.01 | 1   | 0.01 | 1   | 0.04 |
| Alfa Siprometrin                 | 0   | 0.00 | 3 | 0.02 | 0   | 0.00 | 0   | 0.00 |
| Asibenzolare-metil               | 1   | 0.01 | 2 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 11  | 0.07 | 0   | 0.00 |
| Azoxistrobin                     | 12  | 0.08 | 5 | 0.03 | 4   | 0.03 | 2   | 0.07 |
| AlfaMetrin                       | 0   | 0.00 | 2 | 0.01 | 1   | 0.01 | 1   | 0.04 |
| Alfa Siprometrin                 | 0   | 0.00 | 3 | 0.02 | 0   | 0.00 | 0   | 0.00 |
| Asibenzolare-metil               | 1   | 0.01 | 2 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 11  | 0.07 | 0   | 0.00 |
| Azoxistrobin                     | 12  | 0.08 | 5 | 0.03 | 4   | 0.03 | 2   | 0.07 |
| AlfaMetrin                       | 0   | 0.00 | 2 | 0.01 | 1   | 0.01 | 1   | 0.04 |
| Alfa Siprometrin                 | 0   | 0.00 | 3 | 0.02 | 0   | 0.00 | 0   | 0.00 |
| Asibenzolare-metil               | 1   | 0.01 | 2 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 11  | 0.07 | 0   | 0.00 |
| Azoxistrobin                     | 12  | 0.08 | 5 | 0.03 | 4   | 0.03 | 2   | 0.07 |
| AlfaMetrin                       | 0   | 0.00 | 2 | 0.01 | 1   | 0.01 | 1   | 0.04 |
| Alfa Siprometrin                 | 0   | 0.00 | 3 | 0.02 | 0   | 0.00 | 0   | 0.00 |
| Asibenzolare-metil               | 1   | 0.01 | 2 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 0 | 0.00 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 0   | 0.00 | 0   | 0.00 |
| Asfalt                           | 0   | 0.00 | 1 | 0.01 | 0   | 0.00 | 0   | 0.00 |

Remarks: *Frequency; **Relative Frequency
Pesticides that are prohibited based on the 1986 Presidential Decree yet still be used to control pests are Abamectin, Alfamethrin, Deltamethrin, Cypermethrin, Alpha Cypermethrin, Imidacloprid, Chlorpyrifos and Fipronil. These pesticide groups were also known to have resurgence effects in high BPH attacks, the frequency of Abamectin, Imidacloprid, Fipronil and Cypermethrin increased. These were observed from their active ingredients left in the field. Reissig, Heinrichs, & Valencia (1982) reported that the use of pyrethroid deltamethrin on rice plants with different resistancy levels i.e. susceptible, moderate and resistant. In the end of observation, they observed that all plants turned into susceptible to BPH.

BPH resistance to deltamethrin, metal parathion and diazinon greatly influenced the biological factors of BPH on their eating behavior, reproduction and survival rate. The application of these pesticide led to the emergence of new individuals that would be resistant so that there was an increasing tendency for rice damage in the next period (Chelliah & Heinrichs, 1980). Imidacloprid and Etofenprox have been reported to be the causal agent of pest resistance in China, Malaysia and Japan (Nagata, 2002). In India, there are several levels BPH resistance to insecticides, from low to high i.e. quinalphos, carbofuran, monocrotophos, carbaryl phorate, phosphamidon, chlorpyriphos and BPMC. IRRI also recommends that deltamethrin should not be for BPH control because it causes resurgence (Surahmat, Dadang, & Prijono, 2016). Furthermore, Basanth, Sannaveerappanavar, & Gowda (2013) conducted research using several insecticides and they found that the level of insecticide resistance was varied in each region.

In the field, farmers often put less attention on pesticide status, such which are allowed or not permitted for rice plants. Fig. 5 shows that many farmers use pesticides which were prohibited in rice cultivation. Chi-square with confidence level of 95% indicates that there is no relation between the BPH damage level and pesticides status ($\chi^2_{\text{count}} = 2.44$ and $\chi^2_{\text{tables}} = 7.82$). The following bar chart illustrated that the damage occurred in every category, both in permitted pesticide application and also in illegal pesticides. It means that damage categories or even hopper burn case do not depend on the pesticide status, permitted or not.

![Fig. 5. The use of pesticides is permitted (■) and are not allowed for rice (□)](image)
The Impact of Insecticides Application in Rice Field

Rice ecosystem remains stable and balance, but the usage of insecticides weakens the system the population of beneficial organisms, including natural enemies of insect pests becomes lower and unable to protect the system. Currently, Indonesian rice farmers generally use chemical pesticides as pest control and only few farmers apply IPM systems on their paddy field. Since there are various types of pesticides available in the market, farmers tend to mix several pesticides expecting higher effects of the applied pesticides. Such erroneous practices finally become regular habit regardless the presence of the pests (Minarni, Suyanto, & Kartini, 2018).

Pyrethroid and Organophosphates were still widely used by farmers, though both groups were considered not allowed for rice cultivation. Pyrethroids act as contact and stomach poisons for sucking and piercing-types insects, like pest borer. The way pyrethroids work is by killing insects that directly exposed by pesticide or those that consume plants contaminated with insecticide. The mechanism resulted in the death of both targeted pests and their natural enemies. BPH eggs are mostly found in sheaths or rice midribs. If predators and parasitoid of BPH eggs are absent, then BPH population would grow excessively in the next generation. In addition, predator populations decline because their preys, the BPH eggs were no longer available. Behavioral resistance is the performance of resistant insects that could detect or recognize the danger and avoid poison. Resistance mechanisms occur in several insecticide types, including Organochlorines, Organophosphates, Carbamates, and Pyrethroids. Insects could only stop eating if they find certain insecticides, or leave the area where the insecticide sprays occurred. For example, pests can move to the underside of the sprayed leaf, move into the plant canopy or fly from the target area (Baehaki et al., 2017).

The mode of action of Organophosphate is binding the enzyme cholinesterase in the insects’ nervous systems. It works by inhibiting the action of cholinesterase on acetylcholine in the insect’s body. This would cause the insects’ body to experience seizures, paralyzed, and eventually die. Organophosphate is toxic to insects. BPH resistance has developed against many insecticides with various modes of action due to different biological and behavioral characteristics such as short life cycles, high fertility, and high spread capacity (Khoa, Thang, Van Liem, Holst, & Kristensen, 2018).

Excessive pesticides application could bring out BPH with a new race that can break the resistance of varieties to BPH. According to Krishnaiah (2016), BPH the most important insect pest of rice has developed high level of resistance to almost all the insecticides so far used and also could overcome the barrier imposed by many resistant varieties. Tanaka & Matsumura (2000) reported that the development of resistance-breaking ability in wild BPH against resistance rice varieties carrying resistance gene Bph1 or Bph2 has reported in many Asian countries. Rice research in the tropics conducted for 25 years by Indonesian national and international institutions such as IRRI and FAO never prove that insecticides contribute to the inclining of rice production or farmer profits (Thorburn, 2015). Unwise insecticides usage could result in dramatic yield losses due to the impact of pest resurgence, as happened in 1975 to 1979 so that rice production is experiencing a crisis due to the BPH attack.

Rice farmers also use pesticides that are not supposed to be used in rice cultivation. Pesticides that are prohibited for use under the 1986 Presidential Decree are still used to control pests. The extensive, inappropriate and indiscriminate of insecticides uses are likely driven by aggressive pesticide companies’ promotion, inadequate pesticide regulations, and weak extension services. Therefore, the question arises, “Could we learn from the history of BPH pest control in our own homeland?” For this reason, we need to review the history of the issuance of INPRES 3/86 and the implementation of the IPM National Program in the period 1989-1999, during which it is Indonesia’s food self-sufficiency.

CONCLUSION

There is a significant influence between pesticide use schemes and BPH attack rates in the field. The increasing of BPH attacks in line with the increasing of pesticide use, both in the frequency of application, the various types of pesticides, and the number of sprayed pesticide mixtures. Many farmers use pesticides that are prohibited for rice plants, such as the Pyrethroid and Organophosphate groups. However, the incidence of BPH attacks still occur even though there are
differences in legality pesticide status. Most farmers do not use the principle of IPM in managing plant pests and diseases. Efforts were needed to revive the integrated pest control system to farmers as were done in Indonesia during 1989 to 2000.

ACKNOWLEDGEMENT

Acknowledgments to students of the Plant Protection Department, Faculty of Agriculture, IPB University, which has helped respondents to observe and interview during vacation time in their hometowns.

REFERENCES

Baehaki, S. E., Zulkarnain, I., Widawan, A. B., Vincent, D. R., Dupo, T., & Gurulingappa, P. (2017). Baseline susceptibility of brown planthopper, Nilaparvata lugens (Stål) to mesoionic insecticide triflumezopyrim of some rice areas in West and Central Java of Indonesia. *Scholars Journal of Agriculture and Veterinary Sciences*, 4(12), 570–579. Retrieved from http://saspjournals.com/wp-content/uploads/2018/01/SJAVS-412570-579.pdf

Basanth, Y. S., Sannaveerappanavar, V. T., & Gowda, D. K. S. (2013). Susceptibility of different populations of Nilaparvata lugens from major rice growing areas of Karnataka, India to different groups of insecticides. *Rice Science*, 20(5), 371–378. https://doi.org/10.1016/S1672-6308(13)60147-X

BBPOPT. (2014). Perkiraan luas serangan OPT utama padi MT 2014/2015. In *Laporan Tahunan* Balai Besar Peramalan Organisme Pengganggu Tumbuhan, Direktorat Jenderal Tanaman Pangan. Retrieved from https://www.google.com/url?sa=t&source=web&rct=j&qurl=http://sakip.pertanian.go.id/admin/tahunan/LAPORAN%2520TAHUNAN%2520BALAI%2520BESAR%2520OPT%2520JATISARI%2520TAHUN%25202014.pdf&ved=2ahUKEwiHh9bswp7QAhXX-SH0KHRNYCrMQFJAAeQIGBxAC&usg=AOvVaw1Xt3RpgA1s2t0pThV-89j&cid=1593141668003

Bouman, B., & Heong, K. L. (2014). Preventing planthopper outbreaks in rice. Retrieved from http://books.iri.org/Preventing_planthopper.pdf

Chelliah, S., & Heinrichs, E. A. (1980). Factors affecting insecticide-induced resurgence of the brown planthopper, Nilaparvata lugens on rice. *Environmental Entomology*, 9(6), 773–777. https://doi.org/10.1093/ee/9.6.773

Darmadi, D., & Alawiyah, T. (2018). Respons beberapa varietas padi (*Oryza sativa* L.) terhadap wereng batang coklat (*Nilaparvata lugens* Stoll) koloni Karawang. *Agrikultura*, 29(2), 73–81. https://doi.org/10.24198/agrikultura.v29i2.19249

Ditjen PSP. (2016). *Pestisida pertanian dan kehutanan tahun 2016*. Direktorat Pupuk dan Pestisida, Direktorat Jenderal Prasarana dan Sarana Pertanian, Kementerian Pertanian RI. Retrieved from http://203.190.36.171/index.php/page/newsdetail/296

Gorman, K., Liu, Z., Denholm, I., Brüggen, K. U., & Nauen, R. (2008). Neonicotinoid resistance in rice brown planthopper, Nilaparvata lugens. *Pest Management Science*, 64(11), 1122–1125. https://doi.org/10.1002/ps.1635

Heong, K. L., Tan, K. H., Garcia, C. P. F., Fabbellar, L. T., & Lu, Z. (2011). Research methods in toxicology and insecticide resistance monitoring of rice planthoppers. Los Baños, Philippines: International Rice Research Institute. Retrieved from https://books.google.co.id/books?id=en&hl=ai&id=SciJXh28xxEC&oi=fnd&pg=PR5&q=Research+methods+in+toxicology+and+insecticide+resistance+monitoring+of+rice+planthoppers&ots=ZjBBknqZ&sig=gV5N8GZEr7YOf1AnxSPP0JwvoCA&redir_esc=y#v=onepage&q=Research&f=false

Heong, Kong Luen, Wong, L., & Reyes, J. H. D. (2015). Addressing planthopper threats to Asian rice farming and food security: Fixing insecticide misuse. In K. Heong, J. Cheng, & M. Escalada (Eds.), *Rice Planthoppers: Ecology, Management, Socio Economics and Policy* (pp. 65–76). Dordrecht: Springer. https://doi.org/10.1007/978-94-017-9535-7_3

Horgan, F. G. (2017). Integrated pest management for sustainable rice cultivation: a holistic approach (pp. 309–341). Burleigh Dodds Science Publishing Limited. https://doi.org/10.19103/as.2016.0003.23

IRRI. (2011). IRRI supports Thai move to stop insecticide use in rice. Retrieved from http://news.agropages.com/News/NewsDetail--4220.htm

Iswanto, E. H., Rahmini, Nuryanto, B., & Baliadi, Y. (2016). Antisipasi ledakan wereng coklat (*Nilaparvata lugens*) dengan penerapan teknik pengendalian hama terpadu biointensif. *Iptek Tanaman Pangan*, 11(1), 9–18. Retrieved from http://pangan.litbang.pertanian.go.id/files/02-iptek11012016EkoHari.pdf
Kenmore, P., Carino, F., Perez, C., Dyck, V., & Gutierrez, A. (1984). Population regulation of the rice brown planthopper (Nilaparvata lugens Stal) within rice fields in the Philippines. *Journal of Plant Protection in the Tropics*, 1(1), 19–37. Retrieved from https://europepmc.org/article/agrind87070071

Khoa, D. B., Thang, B. X., Van Liem, N., Holst, N., & Kristensent, M. (2018). Variation in susceptibility of eight insecticides in the brown planthopper Nilaparvata lugens in three regions of Vietnam 2015-2017. *PLoS ONE*, 13(10), e0204962. https://doi.org/10.1371/journal.pone.0204962

Krishnaiah, N. V. (2016). Varietal resistance breaking ability and insecticide resistance developing ability of BPH- Is there any relation between the two? *Molecular Entomology*, 7(1), 1-9. Retrieved from http://www.aquapublisher.com/index.php/me/article/html/2205

Minarni, E. W., Suyanto, A., & Kartini, K. (2018). Potensi parasitoid telur dalam mengendalikan wereng batang cokelat (Nilaparvata lugens Stal) pasca ledakan populasi di Kabupaten Banyumas. *Jurnal Perlindungan Tanaman Indonesia*, 22(2), 132–142. https://doi.org/10.22146/jpti.28886

Nagata, T. (2002). Monitoring on insecticide resistance of the brown planthopper and the white backed planthopper in Asia. *Journal of Asia-Pacific Entomology*, 5(1), 103–111. https://doi.org/10.1016/S1226-8615(08)60138-7

Pontius, J., Dilts, R., & Bartlett, A. (2002). *From farmer field school to community IPM: Ten years of IPM training in Asia*. Bangkok, TH. Retrieved from http://www.fao.org/3/aac834a/e/ac834e00.htm

Reissig, W. H., Heinrichs, E. A., & Valencia, S. L. (1982). Insecticide-induced resurgence of the brown planthopper, Nilaparvata lugens, on rice varieties with different levels of resistance. *Environmental Entomology*, 11(1), 165–168. https://doi.org/10.1093/ee/11.1.165

Sogawa, K. (2015). Planthopper outbreaks in different paddy ecosystems in Asia: Man-made hopper plagues that threatened the green revolution in rice. In K. Heong, J. Cheng, & M. Escalada (Eds.), *Rice Planthoppers: Ecology, Management, Socio Economics and Policy* (pp. 33–63). Dordrecht: Springer. https://doi.org/10.1007/978-94-017-9535-7_2

Surahmat, E. C., Dadang, & Prijono, D. (2016). Kerentanan wereng batang cokelat (Nilaparvata lugens) dari enam lokasi di pulau Jawa terhadap tiga jenis insektisida. *Jurnal Hama Dan Penyakit Tumbuhan Tropika*, 16(1), 71–81. https://doi.org/10.23960/j.hptt.11671-81

Sutrisno. (2014). Resistensi wereng batang cokelat padi, Nilaparvata lugens Stål terhadap insektisida di Indonesia. *Jurnal AgroBiogen*, 10(3), 115–124. https://doi.org/10.21082/jbio.v10n3.2014.p115-124

Sutrisno. (1989). *Kajian resistensi wereng batang cokelat, Nilaparvata lugens Stål terhadap insektisida organofosfat dan karbamat* (Doctoral dissertation). Retrieved from repository UGM (https://repository.ugm.ac.id/51466/)

Tanaka, K., & Matsumura, M. (2000). Development of virulence to resistant rice varieties in the brown planthopper, Nilaparvata lugens Stål (Homoptera: Delphacidae), immigrating into Japan. *Applied Entomology and Zoology*, 35(4), 529-533. https://doi.org/10.1303/aez.2000.529

Thorburn, C. (2015). The rise and demise of integrated pest management in rice in Indonesia. *Insects*, 6(2), 381–408. https://doi.org/10.3390/insects6020381