Application of fertilizer type and dosage toward brown planthopper (*Nilaparvata lugens* Stall.) attack level on several paddy (*Oryza sativa* L.) varieties

A B Tarigan, Marheni* and J Ginting

Faculty of Agriculture, Universitas Sumatera Utara, Padang Bulan, Medan 20155, Indonesia

Email: *marheni.sembiring@yahoo.com

Abstract. Usage management of inorganic fertilizers into organic fertilizers can reduce the attack level of brown planthopper. The organic matter can increase tolerance of plants to pest attacks. The objective of this research was to determine the cow manure dosage against the attack level of brown planthopper on several paddy plants varieties. This research was conducted on paddy fields in Serdang Village, Beringin Sub-District, Deli Serdang District from March to July 2018. This study used a two-factor randomized block design (RBD) with three replications. The First Factor was the dosage of fertilizer which consisted of 4 treatments (inorganic fertilizer, 50 kg/plot of manure, 100 kg/plot of manure and 150 kg/plot of manure). The second Factor was the varieties which consisted of 2 varieties treatment (Ciherang and Inpari 10). Result showed that P2 fertilizer dosage (100 kg/plot) was able to reduce the percentage of brown planthopper attack. V2 variety (Inpari 10) was a treatment that can reduce the percentage of brown planthopper attack. The interaction between fertilizer dosage and variety of V2P2 (Inpari 10 + 100 kg/plot) was the best treatment in suppressing the percentage of brown planthopper attack.

1. Introduction

Nowadays, brown planthopper has become an important and endemic pest in paddy plants in Indonesia. In 2010, the area of brown planthopper attack reached 30,000 ha in the period of January to April 2010 [1]. The main contribute factor to the population and attack of brown planthopper increasement in recent years are the high biotic potential of brown planthopper, abiotic factors and paddy cultivation systems that support the development of brown planthopper populations. These three factors work together [2].

The brown planthopper was included as a secondary pest previously. However, it changed into an important pest due to improper spraying of pesticides which resulted resistance. Malignancy of the brown planthopper is caused by its ability to adapt to the environment, including the adaptability to resistant varieties [3].

The usage of a responsive new superior varieties toward fertilization encourages farmers to apply a high dosage of inorganic fertilizers and does not apply the organic matter to the soil. This condition causes the soil organic matter content to decrease which results land fertility degradation which is one of the limiting factors to obtain high yields [4].

Efforts that can be made to reduce the level of brown planthopper attacks can be conducted by regulating the usage of inorganic fertilizers management by replacing with organic materials. Addition of organic matter is an alternative to reduce the negative impact of inorganic fertilizers usage. Besides
being able to provide a balanced nutrition for plants, organic matter can also increase plant tolerance to pest attacks. Organic materials can be in the form of manure, compost (city garbage compost, rice straw compost), etc. Organic materials have different nutrients and quality, moreover, each of them has limited quantities and procurement. However, it can be helped by the organic ingredients which is combined with resistant varieties usage. In this study organic matter in the form of cow manure was combined with two resistant varieties namely Ciherang and Inpari 10. The objective of this study was to determine the type and dosage of fertilizer that could reduce the level of brown planthopper pest attack on several paddy plant varieties

2. Materials and Method

2.1. Research design
This research was conducted in Serdang Village, Beringin Sub-District, Deli Serdang District on paddy field. This study used a two-factor randomized block design (RBD) with three replications. Factor 1 was the dosage of fertilizer consisted of 4 treatments (inorganic fertilizer, 50 kg/plot of manure, 100 kg/plot of manure and 150 kg/plot of manure). Factor 2 was the variety consisted of 2 varieties treatments (Ciherang and Inpari 10). Application of manure was carried out in a week before planting time using the treatment dosage, while application of inorganic fertilizer was carried out in the day 7th after planting (HST) and the day 42nd HST. The fertilizers used were in accordance with the Center for Rice Research (2016) recommendation.

2.2. Analysis of plant nutrient content
The plant nutrient content observed in this study were N and K nutrients, where the nutrient content analysis was carried out in the laboratory of PT. Socfindo, Medan. The number of samples analyzed was 24 (representing each experimental plot). The N and K nutrient contents were analyzed to determine the effect of manure application to plants.

2.3. Percentage of the brown planthopper attack
The attacked parts of plants were observed and compared with a non-attacked part of plants, then calculated using equation [5].

\[ I = \left( \frac{a}{b} \right) \times 100\% \]  

Where:
I: Percentage of attacks (%)
a: The number of the attacked parts of plant by pests from the sample observed
b: The number of the observed parts of plant

3. Results and Discussion

3.1. The N nutrient content in plants
Based on the variance test result showed that the treatments, including the fertilizer dosage, the variety and the interaction of both, gave a significant effect on the total N nutrient content in plants. The average different test of total N nutrient content of several paddy varieties with fertilizer dosage application can be seen in Table 1.
Table 1. Total N nutrient content of several paddy varieties with fertilizer dosage applications.

| Dosage of Fertilizer | Varieties          | Mean  |
|----------------------|--------------------|-------|
|                      | V₁ (Ciherang)      | V₂ (Inpari 10) |       |
|                      | Mean               | Mean  |   |
| P₀ (Inorganic fertilizer) | 2.88a              | 2.28de | 2.58a |
| P₁ (50 kg/plot)      | 2.27e              | 2.33cd | 2.30d |
| P₂ (100 kg/plot)     | 2.20f              | 2.52b  | 2.36c |
| P₃ (150 kg/plot)     | 2.39c              | 2.51b  | 2.45b |
| Mean                 | 2.44a              | 2.41b  |   |

From Table 1, it can be seen that the P₀ (Inorganic Fertilizer) was 2.58% and significantly different from the other treatments. Where the application of urea fertilizer increased the N nutrient content in plants. The addition of urea fertilizer would reduce or eliminate immobilization of N therefore the N requirement of plant were fulfilled [6].

The highest N nutrient content with a dosage of P₀ fertilizer (Inorganic Fertilizer) on plant was found in V₁ (Ciherang) variety. The highest total N nutrient content with a dosage of P₁ fertilizer (50 kg/plot) on plant was found in V₂ (Inpari 10) variety. The highest total N nutrient content with a dosage of P₂ fertilizer (100 kg/plot) on plant was found in V₂ (Inpari 10) variety. The highest total N nutrient content with a dosage of P₃ fertilizer (150 kg/plot) on plant was found in V₂ (Inpari 10) variety. This happened due to the interaction between the varieties and fertilizers. There was an interaction between the paddy varieties and the recommended fertilizer dosage [7].

The highest total N nutrient content with variety of V₁ (Ciherang) on plant was found in the dosage of P₀ fertilizer (Inorganic Fertilizer). The highest total N nutrient content with variety of V₂ (Inpari 10) on plant was found in the dosage of P₂ fertilizer (100 kg/plot). The total N nutrient content occured due to the inorganic fertilizer application. The application of inorganic fertilizer into the soil could increase a fast nutrient availability for plants [8].

3.2. The K Nutrient Content in Plants

Result of variance test showed that the treatment of fertilizer dosage, variety and interaction of both gave a significant effect to the total K nutrient content on plants. The average different test of total K nutrient content of several paddy varieties with application of fertilizer dosage can be seen in Table 2.

From Table 2 it can be seen that the P₂ (100 kg/plot) was 2.48% and significantly different from the other treatments. Moreover, the treatment of V₂ variety (Inpari 10) was 2.32% which was significantly different from the other treatments. The P₂V₂ interaction (100 kg/plot + Inpari 10) was 2.66% and significantly different from the other treatments. This indicated that the dosage of P₂V₂ fertilizer had the best ability in the total K nutrient content increasement on plant. There was a difference in response of plant to the fertilizer dosage which also seen in total K nutrient content. The difference was occured due to the different plant responses due to the genetic nature of a variety. The effect on plant growth was not only due to the fertilizer but the varieties were very influential, because each variety had a different genetic, morphological, and physiological properties [9].

The highest total K nutrient content with the dosage of fertilizer P₀ (inorganic fertilizer) on plant was in V₂ (Inpari 10) variety. Moreover, the highest total K nutrient content with the dosage of fertilizer P₁ (inorganic fertilizer) on plant was in V₂ (Inpari 10) variety. The highest total K nutrient content with the dosage of fertilizer P₂ (100 kg/plot) on plant was in V₂ (Inpari 10) variety. The highest total K nutrient content with the dosage of fertilizer P₃ (150 kg/plot) on plant was in V₂ (Inpari 10) variety. There were differences between varieties in total K nutrient content, which indicated that each variety showed
different genetic variations in nutrient absorption. Genetic variation was caused by inheritance of characteristics/genetic and environmental factors [10].

Table 2. Total K nutrient content of some paddy varieties with fertilizer dosage applications.

| Dosage of Fertilizer | Varieties | Mean |
|----------------------|-----------|------|
|                      | V₁ (Ciherang) | V₂ (Inpari 10) |      |
| P₀ (Inorganic Fertilizer) | 1.82g | 2.01f | 1.92d |
| P₁ (50 kg/plot) | 2.18e | 2.27d | 2.22c |
| P₂ (100 kg/plot) | 2.31c | 2.66a | 2.48a |
| P₃ (150 kg/plot) | 2.18e | 2.34b | 2.26b |
| Mean | 2.12b | 2.32a |

The highest total K nutrient content with variety of V₁ (Ciherang) on plant was found in P₂ (100 kg/plot) fertilizer dosage. Furthermore, the highest total K nutrient content with variety of V₂ (Inpari 10) on plant was found in P₂ (100 kg/plot) fertilizer dosage. The increasement of nutrient content was caused by application of manure which could increase the total K nutrient content. The addition of organic matter into paddy fields had several benefits for physical, chemical and biological fertility of soil [11].

Result of the variance test showed that at the 2nd week after planting, the treatment of fertilizer dosage gave a significant effect on the attack percentage. The treatments including fertilizer dosage, varieties and interactions of both have a significant effect on the attack percentage on 3rd–7th week after planting. At the 8th week after planting, treatment of fertilizer dosage and varieties had a significant effect on attack percentage. The average different test of attack percentage of several paddy varieties with application of fertilizer dosage can be seen in Table 3.

From Table 3. the application of inorganic fertilizer could increase the attack percentage compared to the other treatments. This was caused by the available elements in inorganic fertilizers were absorbed faster by plants. This rapid absorption was also able to increase the N nutrient content in P₀ treatment faster than other treatments (Table 1). A high N nutrient on plants could make the plants susceptible to be attacked, because the high N elements attracted pests. As well as other organisms, pests needed specific nutrients, and were needed for stability and development of life. The existence of changes in soil conditions due to fertilization efforts, would affect the soil conditions which indirectly affect the plants that were directly related to pests. In brown planthopper, the increasement of nitrogen fertilizer usage could accelerate the development of planthopper populations [12]. The absorption rate of nutrients from organic fertilizer by plants was longer than the nutrients absorption from inorganic fertilizers [13].

Table 3. showed that the attack percentage of brown planthopper on Ciherang variety was the highest attack and significantly different to the other treatments at the 3rd–8th week after planting. Differences in the level of planthopper attacks in both varieties indicated that there were resistant and less resistant varieties towarded a planthopper biotype. The Brown planthopper that lived on pest resistant paddy varieties experienced a high mortality, a low egg laying due to natural biophysical and biochemical reactions that could cause non-preference, antibiotic, and tolerant effects [14].
Table 3. Attack percentage of 2-8 weeks after planting of several paddy varieties with fertilizer dosage applications.

| Age  | Dosage of Fertilizer | Varieties | Mean   |
|------|----------------------|-----------|--------|
|      |                      | V (Ciharam) | V (Inpari 10) |        |
|      |                      | Mean       | Mean    |        |
| 2 WAP | $P_0$ (Inorganic Fertilizer) | 2.10       | 1.40    | 1.75a  |
|       | $P_1$ (50 kg/plot)    | 0.00       | 0.00    | 0.00b  |
|       | $P_2$ (100 kg/plot)   | 0.00       | 0.00    | 0.00b  |
|       | $P_3$ (150 kg/plot)   | 0.00       | 0.00    | 0.00b  |
|       | Mean                  | 0.52       | 0.35    |        |
| 3 WAP | $P_0$ (Inorganic Fertilizer) | 2.76a      | 1.17b   | 1.96a  |
|       | $P_1$ (50 kg/plot)    | 0.00c      | 0.00c   | 0.00b  |
|       | $P_2$ (100 kg/plot)   | 0.00c      | 0.00c   | 0.00b  |
|       | $P_3$ (150 kg/plot)   | 0.00c      | 0.00c   | 0.00b  |
|       | Mean                  | 0.69a      | 0.29b   |        |
| 4 WAP | $P_0$ (Inorganic Fertilizer) | 4.16a      | 2.36b   | 3.26a  |
|       | $P_1$ (50 kg/plot)    | 1.66c      | 0.79d   | 1.22b  |
|       | $P_2$ (100 kg/plot)   | 0.39e      | 0.00f   | 0.20c  |
|       | $P_3$ (150 kg/plot)   | 0.00f      | 0.00f   | 0.00d  |
|       | Mean                  | 1.55a      | 0.79b   |        |
| 5 WAP | $P_0$ (Inorganic Fertilizer) | 8.12a      | 5.36b   | 6.74a  |
|       | $P_1$ (50 kg/plot)    | 2.95c      | 2.17d   | 2.56b  |
|       | $P_2$ (100 kg/plot)   | 1.26e      | 0.53f   | 0.89c  |
|       | $P_3$ (150 kg/plot)   | 0.53f      | 0.52f   | 0.52d  |
|       | Mean                  | 3.21a      | 2.15b   |        |
| 6 WAP | $P_0$ (Inorganic Fertilizer) | 11.49a     | 9.09b   | 10.29a |
|       | $P_1$ (50 kg/plot)    | 6.73c      | 6.30d   | 6.51b  |
|       | $P_2$ (100 kg/plot)   | 4.60e      | 1.72g   | 3.16c  |
|       | $P_3$ (150 kg/plot)   | 1.97f      | 1.95f   | 1.96d  |
|       | Mean                  | 6.20a      | 4.77b   |        |
| 7 WAP | $P_0$ (Inorganic Fertilizer) | 4.20a      | 2.44b   | 3.32a  |
|       | $P_1$ (50 kg/plot)    | 2.43b      | 1.39c   | 1.91b  |
|       | $P_2$ (100 kg/plot)   | 1.31c      | 0.87de  | 1.09c  |
|       | $P_3$ (150 kg/plot)   | 0.96d      | 0.83e   | 0.89d  |
|       | Mean                  | 2.23a      | 1.38b   |        |
| 8 WAP | $P_0$ (Inorganic Fertilizer) | 1.96       | 1.67    | 1.82a  |
|       | $P_1$ (50 kg/plot)    | 1.00       | 0.63    | 0.82b  |
|       | $P_2$ (100 kg/plot)   | 0.00       | 0.00    | 0.00c  |
|       | $P_3$ (150 kg/plot)   | 0.00       | 0.00    | 0.00c  |
|       | Mean                  | 0.74a      | 0.58b   |        |
Moreover, Table 3 showed that the usage of inorganic fertilizer could increase the attack of planthoppers in the 6th week. This was because the application of inorganic fertilizer increased the N nutrient content than the other treatments, which was 2.58% (Table 1). Nitrogen was needed for plant growth and development, but high content of N could cause plants to be sensitive to insect attacks. High content of N could cause plants to be sensitive to water stress and sensitive to insect attacks [15]. The nitrogen element correlated very closely with the development of meristem tissue, so that it determined the growth of plants. In addition, the N element acted as a constituent of all proteins, chlorophyll, nucleic acids and formation of coenzymes [16].

The highest attack occurred at the 6th week after planting, this was due to the initial attack occurred at 2-3rd week after planting. Attacks at the first week of planting made the planthopper would be able to multiply and the peak occurred at 6th week after planting (according to its life cycle). If the migration occurred at 2-3rd week after planting, the immigrants would breed for up to two generations. So that when viewed from the life cycle of the first and second generation, nymph population peaks appeared at the 5-6th week after planting paddy [17]. The number of eggs placed by adult insects was very diverse, in one group between 3-21 grains. The eggs hatched between 7-11 days with an average of 9 days. The young insects that hatched from eggs were called nymphs, the food was the same as the mother. Nymphs experienced skin changes (instar). The nymph length was 12-15 days with the average to complete the nymph stage was 12.8 days. Adult stadia were between 18-28 days [18].

At the 6th week, the highest attack percentage occurred at V1 (Ciherang) variety which was significantly different from V2 (Inpari 10). This happened because ciherang variety was an old superior variety, while the inpari was a new superior variety. Ciherang itself was released in 2000 while Inpari 10 was in 2009. The old superior variety was thought to have been vulnerable to planthoppers compared to Inpari 10 which was a new superior variety. The use of the same variety continuously would cause resistance to certain pests, especially against r-strategic pests including the brown planthopper [3].

The interaction between fertilizer dosage on paddy varieties had a significant effect of the attack percentage at 6th week after planting. Where the P0/V1 treatment (Inorganic Fertilizer + Ciherang) was the highest and significantly different from the other treatments. This occured due to the highest total N nutrient content (Table 5) also found in the combination of these treatments.Increasement of nitrogen in paddy plants resulted more susceptible paddy to pest’s attack [19]. The number of planthoppers and the dry mass of a pair of adult planthopper were significantly higher on plants with a high nitrogen content. The body weight and number of planthoppers increased by adding the nitrogen fertilizer dosage to susceptible and resistant paddy varieties [20].

Interaction of P2/V2 at 6th week after planting had the lowest attack percentage level (1.72%). This was supported by the highest K nutrient content on plants (Table 6) found in the combination treatment (2.66%). The application of K for paddy plants showed an increasement in plant tolerance to pests that altered several other chemicals such as lower levels of soluble proteins and free sugars in plant tissues, thus created an environment that was not beneficial for insects. Dissolved sugar levels, organic acids and amino acids tended to increase on plants with K nutrient deficient [21]. Most of plants that lacked of potassium showed symptoms of weak plant stems therefore the plants became easily to collapse. The availability of K on plants affected the plants quality and played an important role in the development of pest populations [22].

At 7-8th week after planting there was a decreasement of the attack percentage on each treatment. This was closely related to the age of plants that had entered the generative phase and were having an old age. During the generative phase, plant stems became harder and less suitable to the planthopper environment. Hard stems were also close to the K content on plants that could increase the stem strength. Brown planthopper would usually start to attack (migrate) when rice began to be planted [17]. The movement of individuals was triggered by the brown planthopper behavior which left the old plant. The resistant varieties had a hard stems and rather rough leaf surfaces [23]. Such things were generally not liked by the brown planthopper pests. A hard stems and rough leaves complicated the brown planthopper while inserting a tool in its mouth to sucked on plant fluids and could also cause death in nymphs due
to starving. The stem strength could become the criteria for resistance to fall, therefore the application of potassium fertilizer could increase the fall resistance [24].

4. Conclusions

Results showed that P$_2$ fertilizer dosage (100 kg/plot) was able to reduce the percentage level of brown planthopper attacks. Moreover, V$_2$ variety (Inpari 10) was a treatment that could reduce the percentage level of brown planthopper attacks. The interaction between fertilizer dosage and V$_2$P$_2$ variety (Inpari 10 + 100 kg/plot) was the best treatment in suppressing the percentage of brown planthopper attacks.

References

[1] Gaib A 2010 Attack status of brown planthopper in Indonesia and the control efforts Inside (Bogor, Lokakarya Pengelolaan Wereng Cokelat: Kemitraan Petani, Pemda, Kementan, dan IPB Bogor 15 Juni 2010 Bogor IPB)
[2] Untung K and Trisyono A 2010 Brown Planthopper Threaten Paddy Self-Sufficiency (Indonesia: Executive Summary)
[3] Baehaki 2012 The development of brown planthopper pest biotypes on paddy plants Iptek Tanaman Pangan 7 1 pp 8-17
[4] Ikeda R and D A Vaughan. 2004 The distribution of resistance genes to the brown planthopper in the germplasm Paddy Genetic Newsletter 8 pp 125-27
[5] Ginting C 2013 Plant Science (Lampung: Lembaga Penelitian Universitas Lampung Bandar Lampung) p 245
[6] Sugiyanta F, Rumawan, Chozin M A, Mugnisyah W Q and Ghulamahdi M 2008 Study of nutrient uptake of N, P, K and potential results of five varieties of rice paddy (Oryza sativa L) in Inorganic and Organic Fertilization Bul Agron 36 3 196-203
[7] Dahlan D, Musa Y and Ardah M I 2012 The growth and production of two rice varieties on various fertilization recommendation treatments Jurnal Agrivigor 11 2 262-74
[8] Sutejo M 2002 Fertilizer and fertilization method (Jakarta: Rineka Cipta)
[9] Rahayu A Y and Harjoso T 2011 Application of husk ash in gogo rice (Oryza sativa L) on silicate and leaf proline content as well as amylase and protein seeds Biota 16 1 pp 48-55
[10] Welsh J P and Mogen J P 1991 Fundamental of genetic and plant breeding (Jakarta: Erlangga) pp 44-7
[11] Sisworo W R 2006 Swasembada Pangan dan Pertanian Berkelanjutan Tantangan Abad XXI [Self-Sufficiency in Food and Sustainable Agriculture Challenges The XXI Century] (Batan-Jakarta, Approach to Soil, Plant and Nuclear Science and Technology Utilization)
[12] Dyck V A, Misra B C, Alam S, Chen C N, Hsieh C Y and Rejesus R S 1979 Ecology of The Brown Planthoppers in The Tropics (Phillipines, IRRI Brown Planthoppers Threat to Paddy Production in Asia Laguna Phillipines) pp 61-100
[13] Pamata A 2010 Meningkatkan Hasil Panen dengan Pupuk Organik [Increasing the harvesting results with organic fertilizers] (Jakarta: Agro Media Pustaka)
[14] Kartohardjono A 2011 Penggunaan musuh alami sebagai komponen pengendalian hama padi berbasis ekologi [The use of natural enemies as ecological based rice pest control components] Balai Besar Penelitian Tanaman Padi Sukamandi [Sukamandi Rice Research Center] J. Pengembangan Inovasi Pertanian 4 1 pp 29-46
[15] Winarso S 2005 Kesuburan Tanah; Dasar Kesehatan dan Kualitas Tanah [Soil fertility; Basic Health and Quality of Soil] (Yogyakarta: Gava Media)
[16] Sauge M H, Grechi I, and Poëssel J L 2010 Nitrogen fertilization effects on Myzus persicae aphid dynamics on peach: Vegetative growth allocation or chemical defense? Entomol Exp Appl 136 2 pp 123–33

[17] Baehaki S E and Widiarta I N 2008 Hama Wereng dan cara pengendaliannya pada tanaman padi [The planthopper pest and its control method are on rice plants] (Jakarta: LIPI Press.)

[18] Nurbaeti B, Diratmaja I G P A and Putra S 2010 Hama wereng coklat (Nilaparvata Lugens Stal) dan pengendaliannya [Brown planthopper pests (Nilaparvata Lugens Stal) and their controls] (Lembang-West Java, Balai Pengkajian Teknologi Pertanian (BPTP) [Center for Agricultural Technology Assessment (BPTP)])

[19] Salim M 2002 Effects of potassium nutrition on growth, biomass and chemical composition of rice plants and on host-insect interaction Pak J Agric Res 17 1 pp 14–21

[20] Prasad B R, Pasalu I C, Raju N B T and Lingaiah T 2005 Effect of nitrogen levels and rice varieties on brown planthopper adult weight and amount of honeydew excretion Ann Plant Prot Sci 13 1 pp 243–45

[21] Amtmann A, Troufflard S and Armengaud P 2008 The effect of potassium nutrition on pest and disease resistance in plants Physiol Plant 133 4 pp 682–91

[22] Rosmarkam, A dan N W Yuwono 2002 Ilmu kesuburan tanah [Soil fertility science] (Yogyakarta: Kanisius)

[23] Rozakurniati 2010 Inpari 13 padi sangat genjah dan tahan wereng cokelat [Inpari 13 rice is very early and resistant to brown planthopper] Warta Penelitian dan Pengembangan Pertanian [News of Agricultural Research and Development] 32 6 pp 7-9

[24] Yamin M and Moentono M D 2005 Seleksi Beberapa Varietas Padi Untuk Kuat Batang dan Ketahanan Rebah [Selection of several rice varieties for stem strength and fall resistance] Jurnal Balai Penelitian Tanaman Padi. Subang [Journal of Rice Crops Research Institute Subang]