Brown Planthoppers population in local rice varieties based on cellulose, hemicellulose and lignin content

R Wijayanti1,2, Sholahuddin2, Supriyadi2 and S H Poromarto2

1 Doctoral Program of Agriculture Science, Graduate School, Sebelas Maret University, Indonesia
2 Faculty of Agriculture, Sebelas Maret University, Indonesia

Email: retnowijayanti@staff.uns.ac.id

Abstract. Brown planthopper (BPH), Nilaparvata lugens, is insect pest in rice cultivation attack rice in all stages resulting growth retardation or stunting. In serious attack whole rice field can be lost. Some variety are resistant due to different plant cell walls. As known, cell wall components are cellulose, hemicellulose and lignin. For that, this research was aimed to evaluate BPH population in local rice varieties which have different content of cellulose, hemicellulose, and lignin. In this study, cellulose, hemicellulose and lignin content was analyzed using Cesson methods. The rice variety observed were aromatic (Rojolele, Pandanwangi, Mentikwangi, Mentiksusu), non-aromatic (Saudah/Klaten red rice, Slegreng/Wonogiri red rice, Rojopusur, Srikiti, Black rice/padi hitam Wonogiri), and Inpari 13 as control. The results showed that there were differences in cellulose, hemicellulose, and lignin content among the rice varieties. Cellulose content in local rice stems ranged from 24-27%, hemicellulose 22-31%, and lignin 10-14%. The highest cellulose content was in Inpari 13 and the lowest was in Rojopusur. Slegreng has highest hemicellulose, > 30%, and Pandanwangi has the highest lignin. According to the results, it is concluded that the different incell wall component (cellulose, hemicellulose and lignin) of local rice did not affect to the BHP population.

1. Introduction

Brown planthopper (BPH) is a destructive insect pest in rice plants and/or cultivation. This insect attack to the rice field in in China, Vietnam, Thailand, India, Pakistan, Malaysia, and Philippines [1], Japan and Korea [2]. In Indonesia, brown planthopper damage is occurred every year. Serious attack was happened in 2010 and 2011 resulting loss of 137,768 ha and 218,060 ha of rice cultivation and caused yield loss of 1-2 tons / ha [3]. Besides attacking rice fields, brown planthopper also attacks upland rice [4]. The use of resistant varieties is a method that many farmers choose to control BPH [5], although the use of resistant varieties was not solved this problem [6].

Before 1970, farmers in various parts of Indonesia planted local rice varieties with a relatively narrow spread according to their environmental characteristics. Naturally, local rice varieties have been tested against various environmental stresses including resistance pests [7, 8], some local rice has aromatic rice [9] which has a higher selling price than non-aromatic rice. As the result, farmers began to switch to local rice cultivation. Local rice planting will increase the risk of pest attacks including
BPH. Therefore, it is necessary to identify the source of resistance to BHP including the cell wall of rice plants.

Plant structural such cell wall is the first physical barrier to feeding by the herbivores [10]. In getting food, there are two stages that herbivores must take, namely pre-ingestion and post-ingestion. At the pre-ingestion stage, the cell wall is a form of plant protection. The cell wall component is an important factor for detecting plant resistance to herbivore attack [11]. The presence of lignin will strengthen the cell wall and protect it from herbivorous attacks [12]. According to the previous report [13], cell wall component of hemicellulose affects the attack of fall armyworm (Spodoptera frugiperda), whereas cellulose has a negative correlation with plant resistance and lignin does not affect plant resistance. However, the cell wall as one component of local rice resistance to brown planthoppers is unknown. The study aimed to identify the components of plant cell walls as a source of resistance to BHP.

2. Material and methods
The study was performed using nine local rice varieties consist of aromatic varieties namely Rojolele, Pandanwangi, Mentikwangi, Mentiksusu; non-aromatic varieties namely Rojopusur, Saudah, Slegeng, Blackrice, and Srikiti and comparative variety of Inpari 13. The method of cultivation was carried out according to the National Ministry of Agriculture protocols. During the study pesticide spraying was not carried out and weed control was done manually.

2.1. Cell wall analysis
Cell wall analysis of hemicellulose, cellulose, and lignin was performed according to Chesson method [14], with three replications for each variety. The plant part for analysis was stem.

2.2. Population of brown planthopper
The research was conducted during the rainy season (1st planting season). Observations were carried out every 7 days from 14 day after transplanting (DAT) to 98 DAT by calculating the number of nymphs and adult of BPH. Data of hemicellulose, cellulose, and lignin contents were compared to varieties. Regression analysis was then performed to know the relationship between population.

3. Result and discussion
The cell wall is the first protection organ of plants to against to pathogens and herbivorous insect attacks [10, 15]. Plant resistance to pest attacks is influenced by fiber content in the cell wall. Plant fibers are the main components of the cell wall constituent [16].

3.1. Cellulose
Cellulose is the main component of plants and is a linear biopolymer of anhydroglucopranose molecules in β-1,4 glucosidic bonds that are abundant in nature [17]. Cellulose content in high-level plant cell walls is about 35-50% of plant dry weight [18]. In rice straw, the cellulose content of 22.07% [19]. This research showed local rice cellulose content ranged 24-27%. Cellulose levels of graminea plants are around 25% [20]. There were differences in cellulose content between rice varieties (Figure 1). The highest cellulose content showed in Inpari 13 variety and the lowest was Rojopusur. This difference showed the variation between varieties. The composition of the cell wall varies between parts of plants, varieties, and types of plants [21].
The regression analysis showed a very low relationship between BPH population and plant cellulose content ($R^2 = 0.00156$). However, the regression equation showed that the tendency of increasing cellulose content will reduce the brown planthopper population even though it was not significant (Figure 2).

Cellulose is a fiber component which is a major component of cell walls. Fiber can interfere with eating activity for herbivores. Tissue plants with high fiber content will be tougher and more resistant to attack by chewing or haustellate insects [22]. Cellulose levels are negatively correlated with leaf-eating pests [13].

### 3.2. Hemicellulose

Hemicellulose has a shorter chain than cellulose which functions to bind cellulose fibers to form microfibrils which increase the stability of the cell wall. Hemicellulose is also crosslinked with lignin to form complex tissues and provide a strong structure [23]. Dicotyledonous plants have hemicellulose levels of 30% [20], while rice straw hemicellulose content is 27.5% [24]. The results showed that hemicellulose content in rice stems ranged from 22-30% and varied between varieties. The highest hemicellulose levels were shown in Slereng varieties (30.91%) which were significantly different from other varieties. The lowest hemicellulose level was shown by Pandanwangi variety (Figure 3).
Figure 3. Histogram of hemicellulose content of local rice. Abbreviation: RL (Rojolele), PW (Pandanwangi), MW (Mentikwangi) MS (Mentiksusu), RP (Rojapusur), PH (Blackrice), Sau (Saudah), Sle (Slereng), Sri (Srikiti), Inp (Inpari13)

The results of regression analysis showed that hemicellulose levels were less influential on the BHP population. This was indicated by the low value of $R^2$ (0.0529). However, there was a tendency for an increase in hemicellulose levels to increase the BHP population even though it was not significant. Hemicellulose levels do not always have a positive effect on plant resistance. Hemicellulose levels in corn plants have a positive effect on the fall armyworm attack, but have no effect on Southwestern Corn Borer [13].

![Figure 4. Regression of brown planthopper population with cellulose content of local rice](image)

3.3. Lignin
Lignin is a component that functions as a binder between fibers, which is not easily soluble. Lignin is bound to hemicellulose and cellulose which forms a layered structure. Rice straw contains 18% lignin [25]. The results of the observation showed that lignin levels ranged from 10-14% (Figure 3). There were differences in the levels of lignin between varieties and the highest levels of Slereng and lowest Rojolele. This difference indicates the variation in lignin levels between varieties. The content of plant lignin is influenced by various factors such as plant stage, plant parts, genotypes, and environmental
factors [26]. In this study, rice was planted with the same environmental conditions thus that differences in lignin levels were more due to genetic factors.

Figure 5. Histogram of lignin contents on local rice varieties. Abbreviation: RL (Rojolele), PW (Pandanwangi), MW (Mentikwangi), MS (Mentiksusu), RP (Rojopusur), PH (Blackrice), Sau (Saudah), Sle (Slereng), Sri (Srikiti), Inp (Inpari13)

The results of regression analysis showed a negative correlation between lignin levels and BPH population with $R^2$ 0.1321 (Figure 6). This shows that the higher the lignin level, the lower the BHP population. In this study it can be seen the influence of lignin levels on BHP. According to previous report [27], the lignin content in corn plants correlated with its resistance to European Corn Borrer. Lignin is a source of plant resistance to herbivorous attacks. The higher of lignin content, the toughness tissue is attacked by herbivores [28].

Figure 6. Regression of brown planthopper population with lignin content of local rice

4. Conclusion
In local rice stems, the cellulose, hemicellulose and lignin content were ranged from 24-27%, 22-30%, and 10-14%, respectively. Cell wall components did not affect to BHP population. Moreover, there was a tendency for higher lignin and cellulose content result in lower BPH population.
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