The use of botanical insecticide based on local resources to increase swamp rice yield in South Kalimantan, Indonesia

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Abstract. The use of botanical insecticide is one of the ways to reduce the negative impact on the agricultural environment due to chemical insecticide applications. Some plants have been identified as botanical insecticide such as Azadirachta indica (Neem), Swietenia mahagoni (Mahagony), Aegle marmelos (Maja fruit), etc. This study was conducted as a part of the demonstration farm located in the swamp rice field in South Kalimantan. The objective of the study was to increase the swamp rice yield by controlling plant pests and disease based on local resources environment friendly. The plot experiment was arranged in a randomized block design with three treatments and six replications and the plot size was 1,000 m². The treatments consisted of fully RAISA technology (T1 treatment), RAISA + IAERI botanical insecticide (T2 treatment), and RAISA + Galam botanical insecticide (T3 treatment). The result showed that the highest yield rice was produced in T2 treatment (6.5 t ha⁻¹ unhusked dry rice), then T3 and T1 treatments were 5.5 and 5.1 t ha⁻¹ unhusked dry rice, respectively. The highest amount of insect was found at T1 treatment, followed T2 and T3 treatments, respectively.

1. Introduction

High attack of pests and diseases is one of the important problems in crop cultivation. Some insects of food crop are rice stem borer (Scirpophaga innotata Walker), cartepillar (Phyllophaga Hellen), Rice Whorl Maggot (Atherigona oryzae and Atherigona exigua), and stinker (Leptocorisa oratorius Fabricius). While blast disease is a dangerous rice disease and promote harvest failure [1].

Agriculture product security is one of the global market demands which prioritize free contaminant and pesticide residue. Several researchers reported that pesticide residue still is detected in soil, water, and other agricultural products on center of food crop and horticulture production, even banned pesticides have been found in the soil, water, and crop production.

Pests and diseases controlling in agriculture should be considered for environmental safety. An integrated pest and disease control is a better practice to reduce the negative impact of chemical pesticide use. Crop protection could be conducted using some of the natural local resources as botanical pesticide. Some of the natural resources are turmeric, neem leaves (Azadirachta indica), sugar apple seed, kenikir leaves, neem leaves/seed, mindi leaves/seed, mahogany seed, and brotowali. The botanical pesticide based on local resources has advantages such as easy to obtain, made, cheap, and environment friendly. Continuously application of botanical pesticide is safe for the environment without leaving pesticide residue in the soil, water, and crop production. It due to the botanical pesticide is relatively easily degradable.
Indonesian Agriculture Environment Research Institute (IAERI) has initiated to improve botanical pesticide base on local resources of mahogany leaves, neem leaves, liquid smoke, cattle urine, and Bacillus aryabhattai. This natural pesticides has been observed in food crop and vegetable cultivation. Neem or Azadirachta indica is one of an effective and a safe botanical pesticide to environment. The plant contains azadirachtin, salanin, nimbin, nimbidin, and meliantriol which can disturb growth of insect biology activity by reducing insect appetite, sterility and also as insect repellent [1]. Other material such as Galam (Melaleuca cendra) is expected as natural insecticide because contains flavonoid, tannin, triterpenoid and steroid [2]. Liquid smokes which is obtained from the condensation of smoke resulted by the combustion of organic compounds during the pyrolysis process [3]. Liquid smoke is the result of burning hemicellulose, cellulose, and lignin which produce anti-microbial, anti-bacterial, and anti-oxidant as phenols, alcohols, aldehydes, carbonyls, chetones, and pyridines [4]. Cattle urine is residual excretion from metabolism of cattle which can be used as botanical pesticide material [5] and as liquid fertilizer [6]. Bacillus aryabhattai bacteria are nitrogen fixing bacterial non symbiotic and IAA hormone (indol-3 acetate acid) which affect to plant physiology process and cell division at paddy crop [7].

The main function of botanical pesticide is to prevent crop plant from pest and disease. Several researchers reported that pesticide residue still is detected in the soil, water, and agricultural product. A study by Setiawan [8] explained that botanical pesticides are non-toxic material for the human, animal, and other plants, easily to be degraded, has no side effect on the environment, abundant raw material and simple to be produced.

The objective of this research was to increase the productivity of rice in tidal swamp land through integrated pest and disease control based on local resources environment friendly.

2. Materials and methods

2.1. Location and time.
This research was conducted on the tidal swamp field located in Barito Kuala District, South Kalimantan from January to December of 2019.

2.2. Materials and equipments.
The field materials consisted of rice variety of Inpari 42, IAERI botanical pesticide (neem leaves, mahogany leaves, turmeric, liquid smoke, cow urine, Bacillus aryabhattai isolates and water), galam botanical pesticide (galam leaves, cow urine, liquid smoke, and Bacillus aryabhattai isolates) and chemical pesticide. The equipment for conducting the research was tractor, water pump, meter roll, weighting machine, net, meter scale, bucket, plastic, sample bottle and measuring cups.

2.3. Methods.
This research was arranged completely randomized block design with three (3) treatments and six (6) replications. The size of plots was 1.000 m² and Inpari 42 as indicator crop. The treatments were as follows (figure 1):

1. The control as RAISA technology package with chemical pesticide (T1 treatment)
2. RAISA without chemical pesticide + IAERI botanical pesticide (T2 treatment)
3. RAISA without chemical pesticide + galam botanical pesticide (T3 treatment)

RAISA (Rawa Intensif Super dan Aktual) technology package is a new technology package specific to swamp land agroecosystem as a result of Indonesia Agency for Agricultural Research and Development (IAARD)’s innovation. The component technology of RAISA was: use of the improved variety, planting system with Jajar Legowo 2:1, micro water management, land amelioration (dolomite), biofertilizer application, balanced fertilization as PUTR recommendation, integrated control of plant pests (chemical pesticide), and ecological engineering, and agricultural mechanization.
Figure 1. The plot design in field

The botanical pesticide was applied every two weeks depending on the condition of the pest attack. If the pest attack was very high, more botanical pesticides would be applied (every week). Application of Botanical pesticide started at 14 day after planting (DAP) until 84 DAP and the dose of 10 ml liter\(^{-1}\) water. Recommendation RAISA package for chemical pesticide based on pest observation that population was still below the economic threshold and control threshold. Pest observation was conducted every two weeks with the quadrant method (1 m x 1 m), then the pest was counted based on the kind of founded pest on the field.

The data result was processed used analysis of variance to know the difference in the effectiveness of botanical pesticide at rice production to pest attack. If at the analysis of variance the treatment showed a difference significant at 5% level, then further testing was carried out by using Duncan’s Multiple Range Test (DMRT) to know the difference between the treatment combinations. The Analysis was conducted by used Statistical Analysis System (SAS) version 9.1 software [13].

3. Results and discussion

3.1. Plant height.
Growth of plant height was affected by genetic traits and plant ability in adapted to environmental conditions. Observation of plant height was conducted to find out plant performing, normal or some specific deficiency symptoms. Plant height could be influenced by some factors such as the uptake of water and nutrients, addition of ameliorant, application of animal manure. Plant height increased along with the increasing age of the plant. Plant height at various treatments showed not significant difference (figure 2.)
3.2. Number of tiller.

The number of rice tillers continuously increases until maximum tiller at 56 DAP. The number of tiller changed from the vegetative phase to the productive phase that started to produce panicle, therefore the number of tillers did not increase anymore. One of the materials IAERI botanical pesticide (T2 treatment)-Bacillus aryabhattai-played the role of a phosphate solvent and non-symbiotic N fixer bacteria. T2 treatment showed some tillers compare to other treatments (figure 3). A published study showed that the number of a tiller at the maximum vegetative phase is not productive tiller at all [9]. The number of productive tillers occurred in 70 to 84 DAP [10].
3.3. Number of productive panicles.
The number of productive panicles at harvesting necessary to be accounted for to estimate yield. The un-husked dry weight correlated with the number of tiller and number of panicles. Increasing panicle per clump promoted and increase in the un-husked dry weight. T2 treatment provided the highest number of productive panicles on average of 25 panicles, followed by T1 and T3 as 23 and 22 panicles, respectively (figure 4).

![Figure 4. Number of productive panicles](image)

3.4. Rice yield.
The rice yield was very affected by some factors, among other healthy plant conditions (not attacked by the pest and disease), sufficient nutrient, and sufficient water availability. T2 treatment produced the highest yield and significantly difference with T1 treatment at 0.05 levels DMRT. The weight of dry un-husked rice of each treatment was T2, T3, and T1 as 6.5, 5.5, and 5.1 ton ha\(^{-1}\), respectively. The increasing yield was expected that botanical pesticide had multi-functional properties, as resulted from the composition of cow urine and bacteria isolates (\textit{Bacillus aryabhattai}) which useful for the crop.

\textit{Bacillus aryabhattai} bacteria is positive gram bacteria, has a long survival, and relatively easy to be inoculated. \textit{Bacillus aryabhattai} has a brown color, able to survive at 4 to 37\(^\circ\) temperature, tolerant to high ultra violet, polluted soil, saline, and nutrient poor, but able to increase crop productivity [11].

The yield of rice and biomass showed in table 1.

| No. | The treatment | Dry rice (t ha\(^{-1}\)) | Biomass (t ha\(^{-1}\)) |
|-----|---------------|--------------------------|------------------------|
| 1.  | T1            | 4.9 a                    | 18.5 ab                |
| 2.  | T2            | 6.3 b                    | 19.9 a                 |
| 3.  | T3            | 5.2 ab                   | 18.6 ab                |

Note: in the same column followed by the same letter is not significantly different at 5% level DMRT.

Plant inoculated by \textit{Bacillus aryabhattai} bacteria more resistant to drought and able to increase productivity, because the bacteria produce growth hormones, therefore it is potential as bio fertilizer [12]. Observation of the number of pest attacks also was conducted regularly, every 2 weeks at 14 DAP to 56 DAP. At beginning observation (14 DAP), T2 treatment showed a higher pest number than T3 and T1 treatments. But after 28 DAP T2 treatment pest number decreased dramatically from 42 insects to 6 insects. It might be promoted by the application of botanical pesticide which more frequently after first controlling. At 56 DAP T1 treatment (chemical control) showed the highest pest
attack as 113 insects found, followed by T3 and T1 treatments as 93 and 62 insects, respectively (figure 5).

4. Conclusions
Application of IAERI Botanical pesticide (T2 treatment) in swamp land South Kalimantan provided higher rice yield than application T3 and T1 (chemical pesticide) treatments as 6.3 t ha\(^{-1}\), 5.2 ton ha\(^{-1}\), and 4.9 t \(^{-1}\) un-husked dry rice, respectively. Application of T2 and T3 treatments were able to reduce the number of pests as 54.9% and 8.2%, respectively. It is necessary to do further research related to the potential of the material of other botanical pesticide local which is abundant.

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