Archives of Business Research – Vol. 10, No. 9
Publication Date: September 25, 2022
DOI:10.14738/abr.109.13038.
Ichdayati, L. I. (2022). The Role of Biopesticide in Increasing Rice Farmer's Profit. Archives of Business Research, 10(9). 43-52.

The Role of Biopesticide in Increasing Rice Farmer's Profit

Lilis Imamah Ichdayati
Agribusiness Department, Faculty of Science and Technology
State Islamic University Syarif Hidayatullah Jakarta, Indonesia

ABSTRACT

Rice farmers' excessive use of chemical pesticides has increased the brown planthopper infestation. The Integrated Pest Management - Farmer Field School (SLPHT) conducted efforts to replace pesticides with environmentally friendly materials. Cost savings arise because the farmers of the "IPM community" apply IPM principles such as using self-made bio-pesticides, hence, the quality of the grain produced is rated higher. Therefore, this study aims to determine the characteristics of farmers using production factors and to analyze the effect of biological pesticides on the profits of rice cultivars in the Indramayu Regency. The analysis tool consists of descriptive qualitative and multiple linear regression using pesticides as the independent variable. The highest cost of rice farming is the labor of 52% - 67%. Furthermore, approximately 61.8% of farmers own paddy fields measuring between 0.5 ha - 2 ha. The proportion of cultivars that uses biological and chemical pesticides are only 24.4% and 75.6%, respectively. The test shows that labor is a burden on farmers. This was observed from its negative effect, while the land area has a positive and significant impact on their profit levels. The results of this study are essential. This is shown by the negative relationship between profits and biological pesticides, indicating that the use of these pesticides did not provide better benefits than the chemical counterpart.

Keywords: Advantage, Biological pesticides, Brown planthopper, Integrated Pest Management

INTRODUCTION

The brown stem planthopper (WBC) *Nilaparvata lugens* (Stal) is a serious rice pest in Asia, causing production losses in China and Vietnam (Ghaffar et al., 2011; Bottrell & Schoenly, 2012), as well as spread to Ocean and Australia (Prasetyo et al., 2012). The brown planthopper (WBC) explosion in Indonesia recurred in the 2017/2018 planting season with increased infestation intensity and damage to rice plants. Climatic factors such as temperature, humidity, and rainfall create adequate conditions for insect pests, cause the appearance of WBCs in the land, and affect population development (Nurbaeti et al., 2010; Baehaki and Widiarta, 2010). Repeated attacks by planthoppers throughout the year will hamper efforts to achieve national and international rice self-sufficiency. However, climate change will have a greater overall impact.

WBC attacks occurred in several districts, especially in the northern part of West Java, each in Indramayu Regency 571 ha (0.49%), Cirebon 574 ha (1.08%), and Subang 384 ha (0.45%). WBC attacks occurred in several sub-districts within each district, ranging from mild to moderate. The damage caused by these pests in West Java for the 2017 MT period to June 2018 was 5,591 ha or 0.60% of the total area of rice fields in West Java (www.pertanian.go.id 11/9/2018).

After being attacked by the brown planthopper, the rice clumps were infected with the empty dwarf virus, called the klowor virus by the Indramayu farmers. This disrupts plant growth and fertilization, leaving many grains of rice empty. It is estimated that there are 70-80% of crop failures. Normally, 1 hectare of rice fields may yield 6 tons. However, due to brown planthopper infestations, only 4-5 kw of low quality are harvested. Farmers intensify their spraying in response to the attack, which exacerbates the infestation. Even farmers that pay 3 times the normal amount for pesticide replant 3-4 times as long as the water needs are abundant.

The situation in 2017-2021, with widespread outbreaks of brown plant hopper (WBC) in rice production centers, shows that over spraying insecticide can kill natural enemies, causing the pest population to increase uncontrollably (Heong et al., 2013). Similarly, excessive nitrogen fertilizers were applied to maximize plant productivity but became a necessary material for insect pests such as brown planthoppers (Zhu et al., 2020).

Adding fertilizers and pesticides on rice plants has become a requirement for farmers to maximize rice production. The training of cultivars to replace chemical fertilizers and pesticides with environmentally friendly materials was conducted through an adult (farmer) learning model, namely the Field School (FS) with an Integrated Pest Management (IPM) study. Finally, the FS-IPM programs have been implemented in Malawi and Indonesia (Berg et al., 2020), the Philippines (Gonzaga-palis, 2006), and Cambodia (Bell et al., 2016).

Furthermore, Berg et al. (2020) reported that the Field School Program for farmers started in Indonesia with a focus on IPM, which was successfully implemented in the 1990s. Until now, the program's application in Indonesia remains relevant, because of the excessive use of insecticides and nitrogen fertilizers in rice production. The IPM alumni group is reported to continue their experiments in the field, but the extent to which this happens remains unknown. Preparation and use of organic fertilizers, biological agents such as IPM, and plant refugia, are actively promoted in the Field School. FS alumni farmer groups have become a major force, forming the spirit of 'Community IPM,' namely institutionalizing the program at the community level.

Farmers in the "IPM community" in Indramayu Regency face attacks from rice pests, including brown planthoppers, in traditional ways using natural ingredients (Ichdayati, 2019). In Kalensari Village, there is a tradition of "ngopyori pari," which is the practice of repelling ancient pests using lemongrass leaves, bangle', brown sugar and grated coconut, or burning rice husks with a certain mixture ("ngerawun"). The botanical pesticides used are made from berenuk, picung, srikaya, brotowali and other plant materials that insects dislike. Currently, the vegetable pesticide used by Indramayu farmers is the forest betel fruit, which controls planthopper attacks by up to 70% (Handayani, 2021). This can also be accomplished physically by using light traps and ultrasonic waves when the attack begins (Afrizal et al, 2021).

The profits made by farmers in the "IPM community" come from two things, namely savings in input costs (homemade fertilizers and pesticides) and higher selling prices for crops in Indramayu Regency (Ichdayati, 2019). Similarly, in Malaysia, the use of biological pesticides can sustain the quality of the grain produced, increasing its value (Kamarulzaman et al., 2016). This, in turn, results in the production of high-quality rice.

Research on integrated pest management using biological pesticides has been widely published in various journals in South Bangka (Akiyana & Pranoto, 2020), England (Sharma et al., 2009), Kenya (Constantine et al., 2020), Malaysia (Kamarulzaman et al., 2016), and China (Wang et al., 2018a).

Several analytical approaches have investigated the role of pesticides in rice farming. Sharma et al. (2009) measured IPM adoption using parametric and non-parametric methods. However, multiple regression analyses can also be conducted (Akiyana & Pranoto, 2020). Constantine et al. (2020) and Kamarulzaman et al. (2016) used non-parametric statistical methods to measure farmers' WTP against biopesticides and rice productivity using the biological pesticide neem. Wang et al. (2018a) employ a binary profit model in estimating the factors that led to the excessive use of chemical pesticides. Meanwhile, since the relationship between biological pesticides and rice farmers' profits remains unknown, it needs to be studied further.

The novelty of this research is the restoration of integrated pest control practices, especially the use of biological pesticides on rice farms in the Indramayu Regency. Therefore, the aims of this research are (1) to determine the characteristics of farmers using rice production factors in the Indramayu Regency and (2) to analyze the effect of biological pesticides on the profits of the cultivars in Indramayu.

RESEARCH METHODS

The research location is a rice production center in Indramayu Regency, West Java, and data were collected between August – September 2018. This was selected as the study site because there are FS alumni community institutions as "IPM communities," such as IPPHTI (Indonesian Plant Pest Control Farmers Association), AB2TI (Association of Indonesian Seed Banks and Farmers Technology), Amarta Padi (Association of Rice Farmers Society) KPCH (Indonesian Farmers Association), and Daily Weather Watch Group. The population is farmers included in the "IPM community" and those that own rice fields in Indramayu Regency. About 32 farmers from seven different areas were chosen randomly to represent the "IPM community." Using the Slovin method, 98 individuals were selected at random from the population of rice farmers having rice fields. Therefore, the total number of respondents amounted to 130 in numbers.

The characteristics of respondent farmers employing the production factors were determined using qualitative descriptive analysis based on land area, land status, labor and pesticides (biological or chemical). The factors affecting rice farming profits were discovered through multiple linear regression analysis using the pesticide dummy variable as the independent variable (Constantine et al., 2020; Sharma et al., 2009). Furthermore, the following shows the formulation of the profit model of rice farming in Indramayu Regency.

$$ln\ \pi = \ln \alpha_0 + \alpha_1\ ln\ X_1 + \alpha_2\ ln\ X_2 + \delta_1 D + e$$

Where : π = rice farming profit (rupiahs), X_1 = land area (ha), X_2 = labor wage (Rp/working's People's day), D = pesticide dummy (1 = biological pesticide, 0 = other). Expected parameter sign: $\alpha_1 > 0$, $\alpha_2 < 0$ and $\delta_1 > 0$.

URL: http://dx.doi.org/10.14738/abr.109.13038

RESULTS AND DISCUSSION

Characteristics of Respondents

Respondents' land area ranged from 0.14 to 7.14 hectares, averaging 1.15. Approximately 91 farmers, or 69.47%, own the land on which their paddy fields are situated. 43 (32.82%) and 38 respondents (29.01%) had paddy fields between 0.5 and 1 hectares and 1-2 hectares, respectively. Therefore, the cultivars were mostly middle-class farmers. In addition to paddy fields, rice farming requires production factors such as superior rice seeds, fertilizers, pesticides, labor and management.

Table 1 presents a detailed description of lowland rice farming by respondents in the Indramayu Regency.

Table 1. Descriptive Statistics of Rice Farming in Indramayu Regency 2017

	Profit	Land area	Working People's Day
Valid	130	130	130
Missing	0	0	0
N	19128303.92	1.151	70411.71
Median	13023333.50	.7100	70000.00
Mode	4500000[a]	.71	70000
Std. Dev	23038673.75	1.113	20118.43
Variance	4.940	1.239	404751031.9
Range	192939667	7.00	133945
Minimum	977000	.14	28636
Maximum	193916667	7.14	162581

Farmers will generally buy all of their farming needs at agricultural shops/kiosks, which are spread evenly in each village. However, for the "IPM community," farmers that have acquired skills from FS-IPM can reduce the reliance on synthetic fertilizers and pesticides by utilizing the natural wealth around their fields and homes (Harahap, 2012). Local farmers conducted this same thing in Thailand (Doi & Pitiwut, 2014), the Philippines (Gonzaga-palis, 2006) and Malawi (Berg et al., 2020). Plants and residual waste, such as animal and household waste, are organic materials that can function as fertilizers and pesticides (Sharma et al., 2018). Therefore, they tend to replace chemical fertilizers and pesticides with organic materials (Constantine et al., 2020), which is the reason they are classified as "organic rice farmers."

The number of farmers using biological pesticides is approximately 32 (24.4%). They have relied on this treatment to maintain the growth of their rice seeds from pests and diseases. These farmers are trained through FS-IPM "not to use pesticides when they are not needed" but always to monitor the presence of pests in their fields. Furthermore, they "maintain natural enemies" (Bell et al., 2016) to "grow healthy plants" and "become an IPM expert farmer on his land" (Gonzaga-Palis, 2006). The remaining 98 farmers (75.6%) used various chemical pesticides. There are many types of chemical and biological pesticides used by farmers, hence, a pesticide dummy variable was used by the model to determine its effect on the profits of rice farmers.

The labor cost component is a burden that 52% - 67% of farmers bear. This condition is experienced by them, especially when a lot of energy is needed to conduct activities such as

planting and harvesting quickly. Labor costs have become expensive, making it increasingly difficult to find laborers in their villages. This condition gave rise to groups outside the community providing planting and harvesting services. The cultivars then pay the laborers' salaries for each operation and the rental fees for agricultural equipment.

Analysis of Rice Farmers' Profit Factors

The classical assumption test has shown that the analyzed data is free from multicollinearity, heteroscedasticity, and normally distributed data, hence, meeting the BLUE requirements and proceeding to the next stage. Furthermore, simultaneous statistical tests, partial, and determinant coefficients were conducted to determine the magnitude and direction of each independent variable's influence on the rice farming profit model, namely land area, HOK (Working People's Day), and dummy pesticides.

The statistical study of the rice farming profit model in the Indramayu Regency is presented in Table 2.

Table 2. Multiple Linear Regression Analysis

		Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	14.204	2.305		6.163	.000	.868	1.152
	LnLuas	1.003	.092	.751	10.873	.000	.874	1.145
	LnHOK	-.383	.220	-.120	-1.740	.085	.973	1.028
	Dpes	-.233	.129	-.118	-1.804	.074		
2	Adjusted R Square	.541						
3	F Test (simultan) sig.	.000						

The Summary model shows a 0.541 coefficient of determination level (Adjust R square). This implies that about 54.1% of the variation in rice farming profits can be explained by the value of all the independent variables, namely land area, HOK (Working People's Day) and dummy pesticides. Variables outside the model explain the remaining 45.9%. The simultaneous test shows that the significance of the F test is 0.0, which implies the independent variables, including land area, HOK and dummy pesticides, affect the dependent variable, namely the profit of rice farming significantly at the alpha level of 1%.

According to Table 2, the parameter test above shows that all independent variables significantly affect 1% and 10% alpha levels. Therefore, the following can be used to formulate the profit model of rice farming.

$$ln\ \pi = ln\ 14.204 + 1.003\ ln\ X_1 - 0.383\ ln\ X2 - 0.233\ ln\ Dpes$$

URL: http://dx.doi.org/10.14738/abr.109.13038

The constant coefficient of 14,204 indicates that when the variables are not used, the farmer can still earn a profit of 14,204 rupiahs. This condition shows the existence of side jobs that provide benefits outside rice farming.

The regression coefficient for the variable land area is 1.003, where an increase of 1 m^2 could raise farmers' profits by IDR1.003, provided that other variables are constant. The variable land area has a considerable impact on farmers' profits at the 1% alpha level, hence, it was determined to reject H0 and accept H1, which indicates the model's initial hypothesis can be accepted. Furthermore, the positive sign of the land area shows that the relationship between these two variables is in the same direction, thereby the size of land cultivated by the farmer is directly proportional to the profit obtained.

According to several other research results, the total land for vegetable crops in Swaziland affects farmers' gross profitability margins. The larger land area indicates the opportunity for economies of scale (Xaba & Masuku, 2013), as well as in Thailand, where the average rice farm ownership is 3.2 ha/farmer (Suebpongsang et al., 2019). However, when the rice fields are rented, it can burden production costs, reducing farmers' income (Listiani et al., 2019). Siregar et al. (2021) show that the area of paddy fields tends to decrease yearly due to conversion to non-agricultural land. This condition threatens the sustainability of rice production as the staple food of the Indonesian people.

The HOK (Working People's Day) variable regression coefficient of -0.383 indicates that the increase in working hours and the number of people employed reduces the profits. Furthermore, this was observed from the negative signs of the variable. The coefficient value's magnitude shows an increase in labor wages of IDR1000, reduces farmers' profits by IDR383, provided other variables are constant. The HOK (Working People's Day) variable affects farmers' profits significantly at the alpha level of 10%, hence, it was concluded that the second hypothesis of the profit model is acceptable.

According to Beckmann et al. (2009), when farmers employ wage labor, the adoption rate of IPM is significantly lower. Listiani et al. (2019) added that the relationship between labor and farmers' income is in the opposite direction (negative). Meanwhile, Darmawan et al. (2015) stated that land area positively affects employment, but farmers have experienced difficulties obtaining labor during transplanting and harvesting.

Table 2 shows that the regression coefficient for the pesticide dummy variable is negative, which indicates an inverse relationship between the use of biological pesticides and the profits of rice farming. The interpretation of the dummy variable, which is qualitative, only shows that the use of biological pesticides provides lower benefits compared to the chemical counterpart. However, the biological pesticide dummy variable affects farmers' profits significantly at the alpha level of 10%. It was concluded that the third hypothesis of the profit model is acceptable but in the opposite direction. This was explained using the results of Akiyana & Pranoto (2020), which state that the adoption of IPM among farmers is low. It indicates that farmers do not completely adopt integrated crop management. According to Waterfield & Zilberman (2012), IPM is biotechnology that plays a role in controlling pests, but when knowledge is widely disseminated, there will be obstacles in the adoption process.

This is different from Suroso et al. (2016), which stated that integrated pest control positively impacts increasing production, decreases production costs and increases income. It is believed that biological pesticides can distinguish between insect-eating and rice pests. Meanwhile, Saragih & Saleh (2016) show that the cost of pesticides does not affect farmers' income because they generally use chemical pesticides. Farmers do not use organic pesticides because they are more expensive and difficult to obtain.

Controlling IPM by farmers is generally considered less practical as it requires more labor, such as ngoyos (Indramayu farmers' term, namely cleaning grass pests by sinking the grass into the mud). In Thailand, rice farmers sink straw into the soil to enrich the land properties (Doi & Pitiwut, 2014). The rice field ecosystem and the pests' condition should be observed (Gonzaga-palis, 2006), while their production results are considered sub-optimal.

According to Wang et al.(2018b), farmers in China have used chemical pesticides excessively because they are unwilling to make losses, avoiding the risk of losing income due to pests and plant diseases. Furthermore, Constantine et al. (2020) and Santaweesuk et al. (2020) stated that the reason small-scale farmers in Kenya and Thailand do not use biological pesticides is because of the perception that biopesticides are not very effective (the speed of action of biopesticides is slow). Another obstacle is the affordability and accessibility of biopesticides in the village due to the low supply by dealers and the availability of means to purchase relatively expensive pesticides.

The study results indicate that using biological pesticides to control pests and diseases in lowland rice remains a burden for farmers in the "IPM community" of Indramayu Regency because it reduces their profit. Meanwhile, they believe that substituting chemical pesticides with organic materials will minimize toxic residues in food caused by the use of chemical fertilizers and pesticides (Doi & Pitiwut, 2014) and the use of chemical pesticides that are hazardous to farmers' health (Craig et al., 2015; Santaweesuk et al., 2020).

Farmers' "IPM community" can produce organic materials for the right formula of biological pesticides. However, to be economically marketed, assistance from other parties is required, such as certification of biological pesticide products, mass production permits, and assistance in selling these goods at affordable costs. In Thailand, the government provides subsidies and incentives for the use of organic fertilizers, while the private sector is encouraged to produce organic and biological treatment, in part to reduce dependence on imported fertilizers (Suebpongsang et al., 2019). In contrast to agriculture in developed countries such as the Netherlands (Zhengfei et al., 2005), conventional farming relies on pesticides and machinery to reduce crop damage, while organic counterpart relies on machinery and cultivation processes using pest-resistant varieties and organic materials.

CONCLUSION

Rice farmers in the Indramayu Regency that are part of the "IPM community" are working to apply the principles of integrated pest management adopted from the field school. The weakness of IPM practice is that it relies on manual routines and farmer discipline, which requires a lot of time and effort. However, when difficulties such as brown plant hopper attacks make it easy for farmers to obtain chemical pesticides, drug company employees become their

URL: http://dx.doi.org/10.14738/abr.109.13038

immediate companions. Extension staff has a limited ability to neutralize these pesticide business agents.

This is supported by the results of testing the use of biological pesticides, which show a lower profit level for rice farmers "IPM communities" than using the chemical counterpart. It implies that rice farmers' "IPM community" benefits, but not as much as those using chemical pesticides. The condition can be an obstacle to the spread of IPM innovations among farmers. Therefore, an appropriate technological breakthrough is needed to help them save energy and time in pest and disease control practices. The availability of cheap and easily accessible biological pesticides requires the participation of the private sector, government and institutions concerned with the welfare of farmers.

SUGGESTION

Farmers understand that using biopesticides provide benefits and produce healthier and better quality grain. This condition is an opportunity for other parties to supply organic pesticides in bulk to achieve an affordable price. Further analysis, such as a feasibility study, is needed to calculate the area of land in a break event point condition as a reference for the limit of organic rice business.

References

Afrizal dkk. 2021.Planthopper Pest Control Strategy in Pagedangan Udik Village. Dibrata Journal Vol 3 Number 1, December 2021; 154-158. ISSN: 2776-3943

Baehaki dan Widiarta, IN. 2010. Planthopper Pests and How to Control them on Rice Plants. Rice Research Center.

Beckmann, V., Irawan, E., & Wesseler, J. (2009). Discussion Paper: The Effect Of Farm Labor Organization On Ipm Adoption Empirical Evidence from Thailand. In V. Beckmann & K. Hagedorn (Eds.), *ICAR Discussion Paper 21/2009* (pp. 1–30). http://www.agrar.hu-berlin.de/wisola/fg/ress

Bell, A. R., Bell, A., Zhang, W., & Nou, K. (2016). Pesticide Use And Cooperative Management Of Natural Enemy Habitat In A Framed Field Experiment Pesticide Use And Cooperative Management Of Natural Enemy Habitat In A Framed Field Experiment. *AGSY*, *143*(April 2021), 1–13. https://doi.org/10.1016/j.agsy.2015.11.012

Berg, H. van den, Ketelaar, J. W., Dicke, M., & Fredix, M. (2020). Is The Farmer Field School Still Relevant? Case Studies From Malawi and Indonesia (pp. 1–15). NJAS-Wageningen Journal of Life Science. www.elsevier.com/locate/njas

Bottrell, D. G., & Schoenly, K. G. (2012). Resurrecting The Ghost Of Green Revolutions Past : The Brown Planthopper As A Recurring Threat To High-Yielding Rice Production In Tropical Asia. *Journal of Asia-Pacific Entomology*, *15*, 122–140. https://doi.org/10.1016/j.aspen.2011.09.004

Constantine, K. L., Kansiime, M. K., Mugambi, I., Makale, F., Mulema, J., & Lamontagne-godwin, J. (2020). Why Don' T Smallholder Farmers In Kenya Use More Biopesticides ? *Pest Management Science*, *August*. https://doi.org/10.1002/ps.5896

Craig, I. P., Bundschuh, J., & Thorpe, D. (2015). Pesticide Sustainable Management Practice (Smp) Including Porous Biochar / Geopolymer Structures For Contaminated Water Remediation. *International Journal of GEOMATE*, *9*(2), 1523–1527.

Darmawan, Ig. H., Arnawa, I. K., & Tamba, I. M. (2015). Labor Absorption and Farmer Income Integrated Agricultural System Program (Simantri) in Kec. Mengwi Kab. Badung, Denpasar. Agrimeta: Journal of Ecosystem Balance-Based Agriculture, 6–16.

Doi, R., & Pitiwut, S. (2014). From Maximization to Optimization : A Paradigm Shift in Rice Production in Thailand to Improve Overall Quality of Life of Stakeholders. In *The saintific World Journal* (Vol. 2014, pp. 1–11). https://doi.org/http://dx.doi.org/10.1155/2014/604291

Ghaffar, M. B., Pritchard, J., & Ford-Lloyd, B. (2011). Brown Planthopper (N.lugens Stal) Feeding Behaviour on Rice Germplasm as an Indicator of Resistance (pp. 1–6). Plos ONE 6(7): e22137. https://doi.org/http://doi.org/10.1371/journal.pone.0022137

Gonzaga-palis, F. G. (2006). The Role Of Culture In Farmer Learning And Technology Adoption : A Case Study Of Farmer Field Schools Among Rice Farmer In Central Luzon, Philippines. *Agriculture and Human Values*, 1–11. https://doi.org/10.1007/s10460-006-9012-6

Harahap, K. B. (2012). Impact Before and After Implementation of Integrated Pest Management Field School (SLPHT) on Production Costs, Production and Income of Rice Farmers in Serdang Bedagai Regency. [Thesis]. Masters Program in Agribusiness Faculty of Agriculture, USU, Medan.

Heong, K. L., Wong, L., & Reyes, J. H. D. L. (2013). Addressing Planthopper Threats to Asian Rice Farming and Food Security : Fixing Insecticide Misuse. In *ADB Sustainable Development Working Paper Series* (Publicatio, Issue 27, pp. 1–20). © 2013 by Asian Development Bank. www.adb.org

Ichdayati, L. I. (2019). Local wisdom : Local Rice Excellence From Creativity of Farmer Breeders (Case Study of Indramayu Regency , West Java). *Archives of Business Research*, *7*(9), 243–254. https://doi.org/10.14738/abr.79.7131

Kamarulzaman, P. S. D., Dailin, D. J., & Yusup, S. (2016). Trait Associations of Rice (Oryza sativa) Productivity upon Neem-Based Biopesticide Treatment by SPSS. *American Journal of Biochemistry*, *6*(6), 137–144. https://doi.org/10.5923/j.ajb.20160606.01

Listiani, R., Setiadi, A., & Santoso, S. I. (2019). Farming Income Analysis of Rice Farmers in Mlonggo District, Jepara Regency. Agrisocionomics, Journal of Agricultural Socioeconomics, 3(1), 50. https://doi.org/10.14710/agrisocionomics.v3i1.4018

Prasetyo, S. Y. J., Winarko, E., & Daryono, B. S. (2012). Endemic Outbreaks of Brown Planthopper (Nilaparvata lugens Stal.) in Indonesia using Exploratory Spatial Data Analysis. International Journal of Computer Science, 9(5), 162–171.

Handayani, Lilis Sri. 2021. Indramayu Farmers Fight Planthoppers Using Forest Betel Fruit

https://www.republika.co.id/NEWS/qz609q327/petani-indramayu-lawan-wereng-gunakan-buah-sirih-hutan

Santaweesuk, S., Boonyakawe, P., & Siriwong, W. (2020). Knowledge, Attitude And Practice Of Pesticide Use And Serum Cholinesterase Levels Among Rice Farmers in Nakhon Nayok. *Journal of Health Research*, *34*(5), 379–387. https://doi.org/10.1108/JHR-09-2019-0204

Saragih, F. H., & Saleh, K. (2016). Factors Affecting Rice Farmer's Household Income. *Agrica*, *9*(2), 101–106. https://doi.org/e-ISSN : 2541-593X

Sharma, A., Bailey, A., & Fraser, I. (2009). Technology Adoption And Pest Control Strategies Among UK Cereal Farmers : Evidence from Parametric and Nonparametric Count Data Models ∗. *The International Association of Agricultural Economists Conference, Beijing, China, August 16-22, 2009*, 1–19.

Sharma, K. R., Raju, S., & Thakur, S. (2018). Biopesticides : An Effective Tool For Insect Pest Management And Current Scenario In India. *Indian Journal of Agriculture and Allied Sciences*, *4*(2), 60–62. https://www.researchgate.net/publication/326479231%0ABIOPESTICIDES:

Siregar, A. P., Oktaviana, N., & Tarsilohadi, E. R. (2021). The Development of Rice Field Area in Special Region of Yogyakarta. *SOCA: Jurnal Sosial Ekonomi Pertanian*, *14*(3), 557–571. https://doi.org/https://doi.org/10.24843/SOCA.2020.v14.i03.p16

Suebpongsang, P., Ekasingh, B., & Cramb, R. (2019). Commercialisation of Rice Farming in Northeast Thailand. In *White Gold: The Commercialisation of Rice Farming in the Lower Mekong Basin* (pp. 39–68). https://doi.org/10.1007/978-981-15-0998-8

Suroso, S., Watemin, W., & Utami, P. (2016). Economic Efficiency of Semi-Organic Rice Farming in Sawangan Village, Kebasen District, Kab. Banyumas. *Agritech*, *1*(Juni 2016), 60–72. https://doi.org/ISSN : 1411-1063

Wang, J., Chu, M., & Ma, Y. (2018a). Measuring Rice Farmer' s Pesticide Overuse Practice and the Determinants : A Statistical Analysis Based on Data Collected in Jiangsu and Anhui Provinces of China. *Sustainability*, *10*(677), 1–17. https://doi.org/10.3390/su10030677

Wang, Y., Zhu, Y., Zhang, S., & Wang, Y. (2018b). What Could Promote Farmers To Replace Chemical Fertilizers With Organic Fertilizers ? *Journal of Cleaner Production*, *199*, 882–890. https://doi.org/10.1016/j.jclepro.2018.07.222

Waterfield, G., & Zilberman, D. (2012). Pest Management in Food Systems : An Economic Perspective. *The Annual Review of Environment and Resources*, *37*, 223–247. https://doi.org/10.1146/annurev-environ-040911-105628

Xaba, B. G., & Masuku, M. B. (2013). Factors Affecting the Productivity and Profitability of Vegetables Production in Swaziland. *Journal of Agricultural Studies*, *1*(2), 37. https://doi.org/10.5296/jas.v1i2.3748

Zhengfei, G., Lansink, A. O., & Wossink, A. (2005). Damage Control Inputs : A Comparison Of Conventional And Organic Farming Systems. *European Review of Agricultural Economics*, *32*(2), 167–189. https://doi.org/10.1093/eurrag/jbi015

Zhu**,** Pingyang, Xusong Zheng, Hongxing Xu, Anne C. Johnson, Kong Luen Heong, Geoff M. Gurr & Zhongxian Lu**.** **(**2020). Nitrogen Fertilization Of Rice Plants Improves Ecological Fitness Of An Entomophagous Predator But Dampens Its Impact On Prey, The Rice Brown Planthopper, *Nilaparvata lugens. Journal of Pest Science* volume 93, pages747–755 (2020)

www.pertanian.go.id (11/9-2018). This is the Steps of West Java Farmers to Block WBC; https://www.pertanian.go.id/home/?show=news&act=view&id=2204