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The integrated pest management farmer field school and its impact on arthropods diversity of rice fields

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Key words: IPM-FFS, Arthropods, Diversity, Rice fields.

Abstract

The purpose of theresearch on the impact of the Integrated Pest Management Farmer Field School (IPM-FFS) on arthropod diversity of rice fields in the South Kalimantan Province was to assess changes in arthropodbiodiversity due to differences in cultivation technique to grow ricemade by IPM-FFS and nonIPM-FFS alumni. The methods used in this research consisted of interviewthe IPM-FFS and the non IPM-FFS alumni using purposive sampling technique and collectingarthropodsfrom rice fields owned by FFS alumni and non-alumniin two locations: GuntungPayung and Sungai Rangas. Arthropods were collected using four different typesof trap (sweep net, yellow trap, pitfall trap and light trap)every week since one month of riceplanting until to harvest time or four months of rice planting. The interview results were analysed to determine differences in the rate of the IPM knowledge adoption between the IPM-FFS and nonIPM-FFS alumni. Data of quantity of collected arthropods were then calculated to determine the Shannon-Wiener diversity index (H'). Results of the research showed that the adoption rate of the IPM conceptswere higher for the FFS alumni with scores ranging between 81.00% and 86.51% compared to the non FFS alumni that had scores ranging between 53.56% and 55.10%. The results also revealed that the diversity index of arthropodsvariedbetween the locations, the diversity index was similar for the IPM and the non-IPM rice fields, namely 2.530 and 2.666 in the GuntungPayung; and 2,760 for IPM rice fieldand 2.527 for non-IPM rice field in the Sungai Rangas.

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Introduction

Integrated Pest Management (IPM) in Indonesia has been known since the 1980s as a national program introduced by The Ministry of National Development Planning. McClelland (2002) also stated that the IPM has been implemented in rice plants in Indonesia.The government organizes the Integrated Pest Management Farmer Field School (IPM-FFS) to farmer groups for rice commodities to socialize the program (Untung, 2006; Oka, 1995). In its development, the IPM-FFS is not only implemented forrice, butthe program is also applied for other commodities such as vegetables, soybeans and some other plantation crops. The IPM-FFS is an attempt to improve human resources of farmers or farmer groups with an empowerment approach on farming communities in crop protection activities (Directorate of Food Crop Protection, 2007). The goal of the IPM-FFS is to increase farmers' knowledge so that in the plant protection against plant pests attack, the environmental sustainability is maintained through healthy crop cultivation, periodic observations, the use of natural enemies and also to make farmers as the IPM experts that can make the decision about pesticide management. According to Price (2001), the IPM-FFS is an environmental education for farmers associated with better behavior in the pest management in accordance with the IPM concepts. Price and Gurung (2006) also stated that the IPM-FFS program contributes knowledge about insects in the pest management.

The IPM conceptsare one of the important programs in farm management because aside from the emphasis on production, they also prioritize on quality yield and environment, economic and social (Sembel, 2010). Untung (2006) reported that the purpose of the IPM are not only for pest management, but it also have comprehensive purposes such as maintaining high yield agricultural production, improving farmers' welfare, paying attention to the circumstances of the pest populations in balance, and considering the circumstances of biodiversity. In addition, it also improves competitiveness and value-added of agricultural products and where pesticides are forced to be used, the usage should be managed wisely.

The use of chemical pesticides unwisely will cause negative effects on the environment such as the killing of non-target organisms (Sembel, 2010). One of the non-target organisms from the pesticide applicationsis arthropods in the rice fields with the exception of arthropods that act as pest. As a result, pesticide application can result in decrease in the population of arthropods. Biodiversity, such as the diversity of arthropods in general and insects in particularaffect the biological balance. Swift and Anderson (1993) testified that the diversity is the environmental principles that can be used in crop protection systems.

The IPM-FFS alumniare expected to apply the IPM concepts in their farmland and provide examples to other farmers. The differences in rice cultivation by farmers who have not completed the IPM-FFS and farmers who have completed the IPM-FFS can describe the behavior of farmers against agroecosystem. The IPM practices conducted by the farmers show reductions in pesticide applications, and in terms of economic efficiency, IPM methods are more effective than conventional management methods (Bong Hoon Lee, 2002). The extent of influence of rice cultivation practicesthat had been done by farmers who have attended and who have not attendedthe IPM-FFS for rice plant management in the South Kalimantan Province, Indonesia is not known and have not been investigated.

The purpose of the study was to examine the differences in the rate of IPM concepts adoption between two farmer groups, IPM-FFS participants (IPM-FFS alumni) and non-participants (nonIPM-FFS alumni), as well as its impact on agroecosystem. By knowing the rates of the IPM concepts adoption through the IPM-FFS, then linked it to the arthropodspecies diversity of on farmlandsowned by the alumni and non-alumni farmers, then the impact of the IPM-FFS on the agro ecosystemwill be known. This will exemplify the extent to which the concepts of IPM have been implemented and its impact on the diversity of arthropods in the rice fields.

Materials and methods

Research location

The researchwas carried out in tworice fields: Guntung Payung and Sungai Rangas in the South Kalimantan Province, Indonesia.

Research materials

Localvariety rice crop ofPandak, chemical fertilizers: urea, SP36 and KCl, liquid organic Trichoderma fertilizers, chemical pesticides (carbofuran, glyphosate, paraquatdichloride, lamdasihalotrin) and biopesticide (nimba).

Research equipment

Light trap, insect nets, yellow trap, pitfall trap, collection bottles, Solosprayer, aspirator, 20 cm diameter plastic containers and killingbottles.

Research Implementations

Determination ofthe rates of farmer adoption

Interviews withthe IPM-FFSparticipants (alumni) and non-participants (non-alumni) of twodifferent locations (farmers for each location were selected using the purposive random sampling method) were carried out to determine the rates of farmers' IPM concept adoption.The interviewed respondentswere 15 farmers of the IPM-FFS alumni and 15 farmers of the non-IPM-FFS alumni; therefore,the total respondentswere 60farmers. The behavioural changes of farmers were assessed with an adoption rate variable of participants afterattending the IPM-FFSfor rice farming.

Determination of the arthropoddiversity

Observation plots were selected in two locations prior determination of the arthropodsspecies diversity. In each location, two observation plotswere chosen based on the different characteristics: rice fields cultivated by the IPM-FFS alumni (IPM) and rice fieldscultivated by the non-IPM-FFSalumni(non-IPM); therefore, therewere for observation plots for the three locations. Two light traps, yellow trap, and five pitfall traps, were then installed in each location. Collection of arthropodswas carried out every week since a month after rice planting until the rice plant reached the generative phase (grain filling stage). Collected arthropodsin both IPM and non-IPM rice fields were conducted in the form of wet and/or dry specimens, then identifiedat least up to the family group based on the morphospecies. Identification of the arthropods was referred to the Books of the Insect Introduction and the Natural Enemies of Pest for Rice Plant by Gauld (1984), Reissig *et al.* (1986), Goulet and Huber (1993), Bolton (1994), Barrion and Litsinger (1995), Christa and Deeleman Reinhold (2001) and Oosterbroek (1998), and then verified in the Entomology Laboratory of Indonesian Institute of Sciences (LIPI)in Cibinong. The number of individual then calculated todeterminethe arthropodspecies diversity using the species diversity index (H') of Shannon-Wiener (Zar, 1988).

Data analysis

Therate of adoption

The rate of adoption was calculated the formulaof Soedijo (2014). Differences in the rates of adoption between alumni and non-alumni farmers were determined by the X^2statistical test(SIagel, 1988).

Species diversity

Speciesdiversity was calculated by the diversity index (H') of Shannon - Wiener (Zar, 1988) using the formula:

$$H' = -\Sigma \{(ni/N)\mathrm{Ln}(ni/N)\}$$

WhereH '= species diversity index; ni = number of individual in each species; N = total number of all individuals; and Ln = natural logarithm.

Results and discussion

Farmers adoption rates

The farmer'sadoption rates of IPM conceptat three locations werehighfor the alumniFFSwith scores ranging between 81.00% and 86.51%, whereas therates of adoption for non-alumniFFS were low with scores ranging between 53.56% and 55.10% (Figure 1.)

Withhigherrates of adoption for the FFS alumni, theyare expected to apply the better concepts of the IPM than the non-FFS alumni. The FFS alumnihadhigher ratesof adoption than the non FFS-alumnibecause theyobtained information directly from the resource sources when they attended the IPM-FFS, whereas the low ratesadoption fornon FFS-alumniattributed to fact that they did not obtain information directly nor facilitieswhich the IPM-FFS alumni received. The non-FFS alumni only gotinformation from fellow farmers or from various media.

The adoption rates of farmers in Guntung Payung and Sungai Rangas on the four principles of IPM: healthy crops cultivation, preservation of natural enemies, periodic observations,and IPM expert farmers wereranging between low andhigh. For the cultivation of thehealthycrop, therange varied between lowand medium, the preservation of natural enemies ranged between low and high, the periodic observations ranged from low to high and the IPM expertfarmers ranged from medium to high. The adoption rates of farmers on the four principles of IPM were described Table 1.

Table 1. The adoption rates of four principles of IPM for alumni and non-alumni FFS in theGuntung Payung and Sungai Rangas.

Location / Village	The adoption rates on the four principles of IPM(score percentage)							
	Healthy crop cultivation		Preservation of natural enemies		Periodic observations		IPM expert farmers	
	IPM-FFS alumni	IPM-FFS non-alumni	IPM-FFS alumni	IPM-FFS non-alumni	IPM-FFS alumni	IPM-FFS non-alumni	IPM-FFS alumni	IPM-FFS non-alumni
GuntungPayung	Medium (71.11)	Medium (65.56)	Medium (74.07)	Medium (59.26)	High (77.78)	Medium (68.89)	High (89.63)	Medium (66.11)
Sungai Rangas	Medium (77.41)	Medium (72.96)	High (88.89)	Medium (74.07)	High (100)	Medium (71.11)	High (80.74)	Medium (70.37)

Note: The result of the statistical test using X^2 test to differentiate the adoption rates of the four principles of IPMbetween alumni and non-alumni FFS are significantly different.

Low adoption ratesof non-alumni farmersbecause these farmers did not have knowledge on the IPM through the FFS, but they acquiredthe knowledge through the diffusion process (disseminated among the public in order to be recognized and understood although not necessarily carried out).Although the non FFS alumni had lower the adoption rates of IPM conceptsthan alumniFFS, IPM not been fully enforced by the IPM-FFS alumni.

Important questions concerning the application of the concept of IPM that became the basis to declare these conditions are:

1. The cultivation of plants healthy: about the source of seeds used on any of the growing season, and fertilizing.
3. The preservation of natural enemies: about the introduction of natural enemies, and maintain the existence of natural enemies.
4. Periodicalobservations: about observations concerning implementation.
5. Farmers as expert IPM: about the ability of distinguishing between pest with disease of paddy, the ability of distinguishing between parasitoid and predators, another option besides material pesticide chemical (bio pesticide).

Crop cultivation

The FFS alumni in the Guntung Payung used different types of seeds for rice cultivation: 7% used certified seed, 40% usedpartially certified seed and most (53%) used the seed frompreviousharvest, while 100% farmer in Sungai Rangas used partially certified seed (Figure 2). These farmers realized that the riceproductions from thistypeof seed are not as high as previous results. The cause of certified seed have not been use by all farmers is the unavailability of certified seeds, especially local rice varieties. Farmers also reasoned that it ismore practical using seeds from crops than certified seeds.

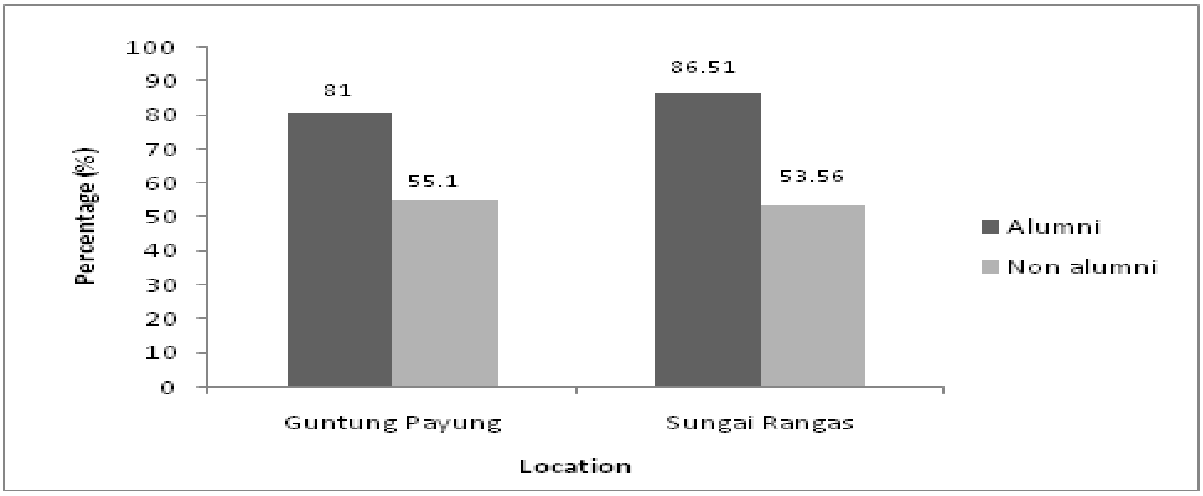

Fig. 1. The adoption rate of IPM concept for alumniand non-alumni FFSin the Guntung Payung, and Sungai Rangas.

Farmers in these locations applied fertilizers not based on the scientific information, but merely dependon the experience of the farmers. For chemical fertilizers, the majority of farmers (60%) applied fertilizers with the amount not recommended by the government. The amount of chemical fertilizers applied by the farmers isalso dependent on the economic conditions of the farmers.Farmers frequentlyappliedfertilizers in excess amount even though the funds to buy the fertilizers were borrowed from others and will be paid at the harvest time. This is due to the farmers do not acquired appropriate information on the fertilization fromthe extension officers and media. Another factor contributed to this situation is low income of the farmers.

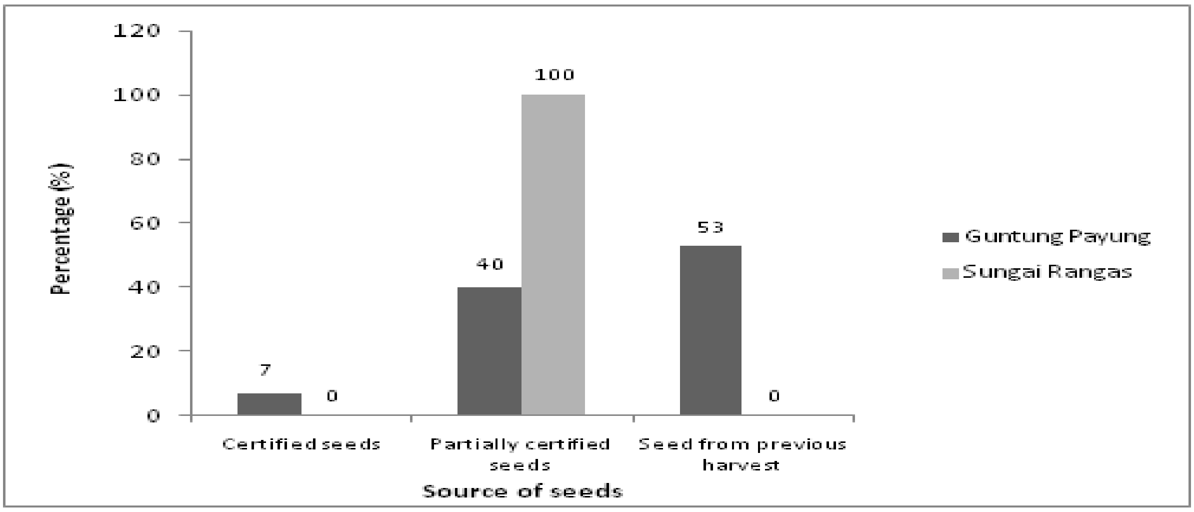

Fig. 2. The source of seeds used by IPM-FFS alumni in theGuntungPayung and Sungai Rangas.

Preservation of natural enemies

In the GuntungPayung, 26.7% of farmers allowedthe natural enemies to be alive, 47% did not care and the remaining did not know about the natural enemies. Results of the interview also showed that the majority of farmers (73%) agreed that natural enemiesare beneficial, and 26.3% of farmers did not know about them.In the Sungai Rangas, 93% of the farmers allowedthe natural enemies to be alive, and 7% of farmers did not acknowledged the existence of the natural enemies (Figure 3).

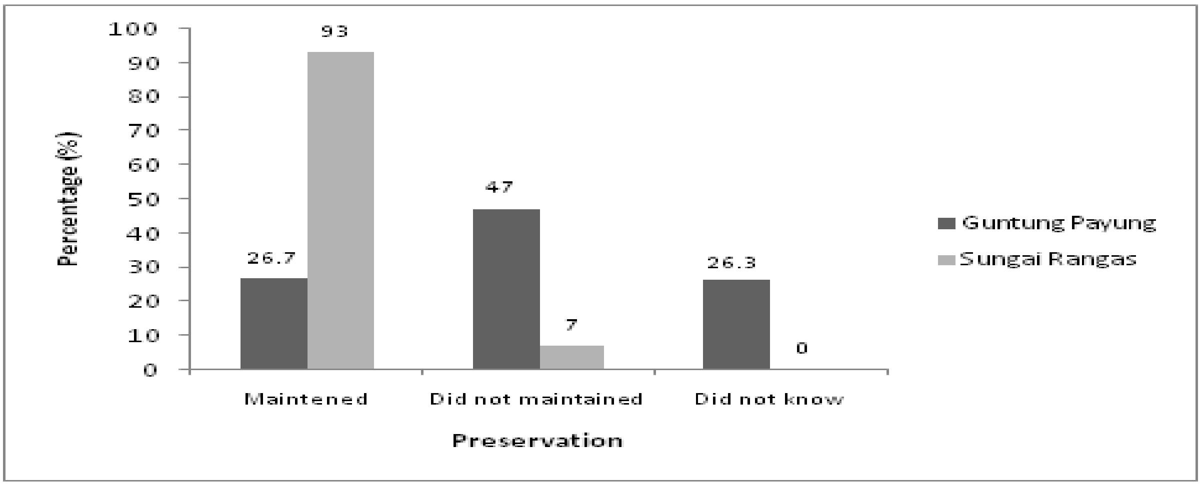

Fig. 3. Preservation of the natural enemies by alumni in the Guntung Payung andSungai Rangas.

One way to maintainthe existence of the natural enemies is to allowavariety of plant species growing surrounding the cultivation areas, especially flowering types because the stadia imagoof parasitoid group requiresnectarsfor living before transferred to the host.

The biological knowledge of every natural enemyis required to be able to maintain or conserve the natural enemies, and the information obtained during the IPM-FFSis insufficient.

Periodical Observations

Not all farmers did observation on aregular basis.All farmers in the Sungai Rangasdid the maximum observations (100%). Only33% of farmersin the GuntungPayungdid observations and 67% of farmers did frequent observation (Figure 4).

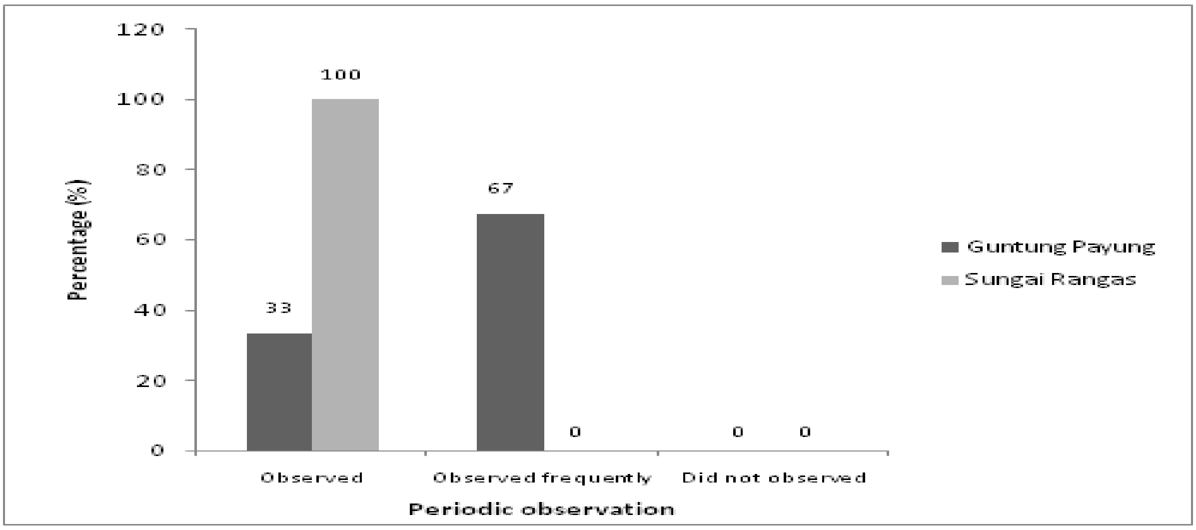

Fig. 4. Periodical observations by alumni in the GuntungPayung, and Sungai Rangas.

Farmers as the IPM experts

Allfarmers of twolocations were capable of distinguishing between pests and disease (Figure 5).

The farmers who was able to differentiate predator and parasitoid groups in the GuntungPayungthe reached to 33% of farmers, 60% of farmes was less able and 7% of farmers was not able to distinguish predator and parasitoid groups. On the other hand, no farmers in the Sungai Rangas was less able to differentiate between parasite and predator groups(Figure6). Similar to the case of the introduction of natural enemies, thesecaused by the farmers do not possesswritten and pictorial materials and the farmers still need to be accompanied by officers in the fields.

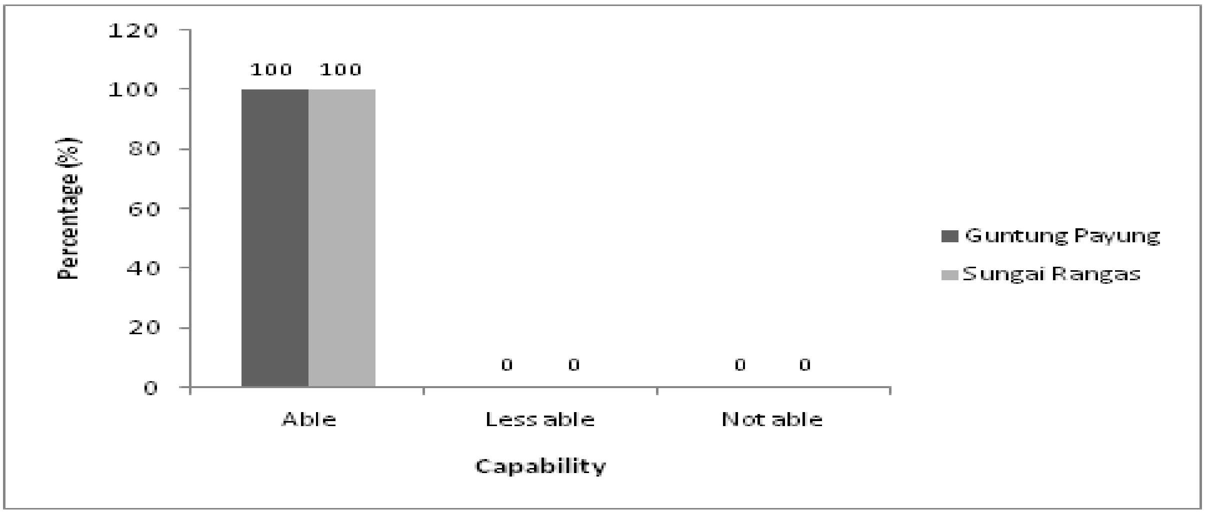

Fig. 5. The capability alumni in the Guntung Payung, and Sungai Rangas to differentiate between pests and disease.

Not all farmers agreed that biopesticides used to substitute chemical pesticides. However, more than 80% of the farmers agreed that biopesticides are farmers' choice.Pilot plotsor comparison plots between botanical and non-biopesticides arerequired to improve awareness of for biopesticide utilization. Potential plants for raw materials of biopesticides should be introduced and cultivated surrounding the rice fields.

The changes in the alumni IPM-FFS obtained from this study is in agreement with the research of Karlina (2008) who stated that there were increasesin knowledge, attitudes, and skills of farmers attending the IPM-FFS. Similar results also reported in other studies (Lund *et al.*, 2010; Supriatna and Sadikin, 1998; Palis, 2006). Pest control preemptive measureswere well adopted, the scheduled use of pesticides was abandonedand spraying chemical pesticides was conducted on the basis of the results of observation in the rice fields. Decreasesin pesticides sprayinghave also been reported by Bong-Hoon Lee (2002) who stated there was 34-54% decreases in the pesticide application during the period of 1996-1998 although the results obtained from farming are not significant. However, the IPM method is more efficient than the conventional method in terms of economic efficiency.Lubis (2008) also said that the use of pesticides in Deli Serdang.

District is greatly reduced up to 26.47%, although in this case the use of chemical pesticidesisstill the main choice. Irham (2002) argued that the IPM farmers obtained "incentive" in the form of low yield loss rate, low pest, and better productivity. However, In terms of performanceaccording to Feder *et al.* (2003) in the period of 1991-1999, therewas no significant impact of the IPM-FFSfor both alumni and non-alumni farmers.

Arthropods diversity

Data of collected arthropods that have been identified in the two research sites, it has been known that the total number of species and arthropods abundance in the IPM rice fields at the two locations wererelatively high compared to those in the non-IPM rice fields. The species in the IPM rice fields ranged between 86species (Guntung Payung) and 118 species (Sungai Rangas) and their abundanceranged between 8,577 individuals(Guntung Payung) and 8,879individuals (Sungai Rangas), while the non-IPM rice fields the species ranged between 73 species (Guntung Payung) and 108 species (Sungai Rangas) and their abundance ranged between 7,417individuals (Guntung Payung) and 7,990 individuals (Sungai Rangas).

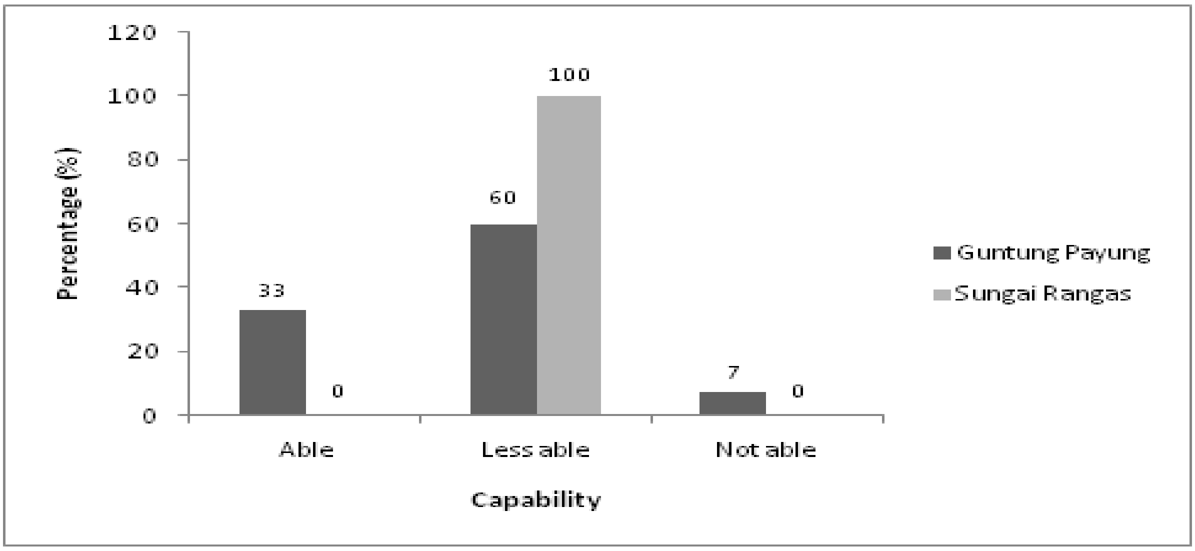

Fig. 6. The capability of alumni in the Guntung Payung and Sungai Rangas to differentiate between parasite and predator groups.

Results of analysis also showed that the diversity index (H') values obtained from the two locations,the arthropodsspecies diversity tended to be higher in the IPM rice fields compared to that in the non-IPM rice field. The highest H'value was obtained in the Guntung Payungand the lowest was observed in the Sungai Rangas (Figure 8). The H' for the IPM field in the Guntung Payung was 2.652 and was inthe Sungai Rangas was 2.577. The H' for the non IPM field in the Guntung Payung and the Sungai Rangas were 2.666and 2.527, respectively. The high value of H' is in line with the higher number of species at these sites compared to the other sites, because the farmers do not use chemical pesticides. This is in accordance with the opinion of Arifin *et al.* (1997) who said that the species diversity indexin the rice ecosystem without pesticides are relatively higher with highernumber of species and this condition resulted in the stable population. The diversity of organisms in a habitat formed a food web that is beneficial for all the components and ultimately created the stable agro ecosystem (Tarmizi, 2008). According to Oka (1995) the use of chemical pesticides resulted in the increasein the concentration of chemicals in organisms (biological magnification), which can be deadly for animals or organisms in the food chain and finally reduced the complexity of the food web. The H'values at three locations were ranged between 2.527 and 2.666, which means between medium.These criteria, as used by Rahayu, Setiawan, Husaeni and Suyanto (2006) whostatedthat H'values will range between 1 and 3, with H'<1 means that the diversity is low, the value of 1 <H'<3means medium diversity and H'> 3 means a high diversity.

The H' value > 3 wasonly obtained in the IPM rice fields in the Pasar Kamis, while for other sites,either in the IPM rice fields and the non-IPMs,theH' values of arthropods diversity werewithinmedium category, ranged between 2 and 3. According to Yaherwandi and Syam (2007), speciesdiversity is one of the main parameters in ecological research, such as to study the effects of environmental changes onthe species diversity and how the diversity affects natural communities' stability. According to Arifin *et al.* (1997), the ecosystem stability is closely related to the diversity index. Arthropodbiodiversity, especially biological agents, before the implementation of IPM are simpler than after the implementation of IPM, and is able to reduce the population ofmajor pest in rice commodities (Laba, 2001).

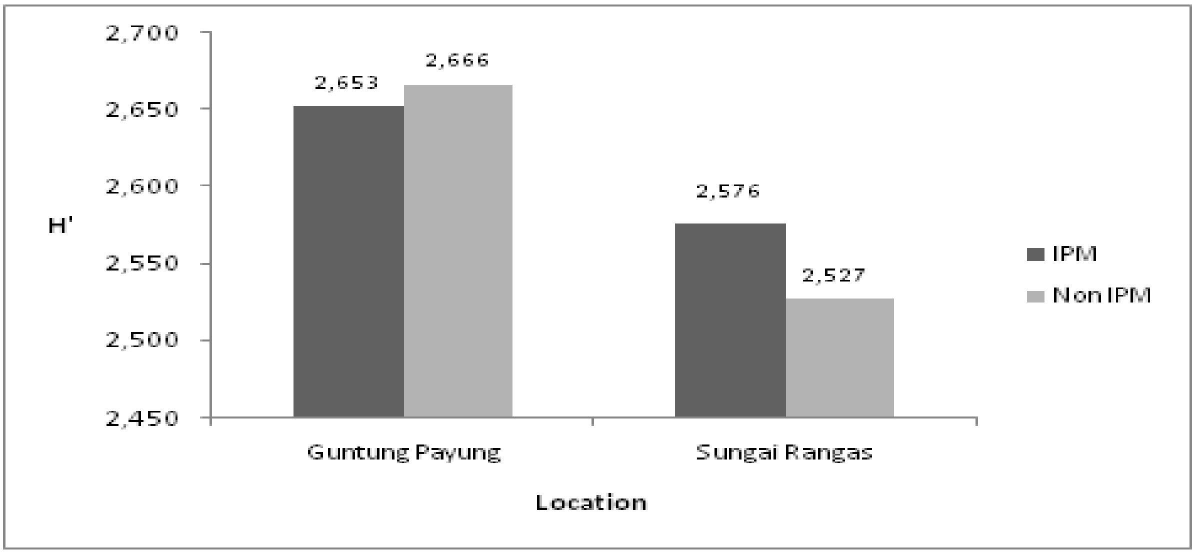

Fig. 7. The H'valuesof the IPM and the non-IPM rice fields in the Guntung Payungand Sungai Rangas.

This is consistent with the opinion of Untung (1992) who stated the biodiversity of ecosystems can be enhanced without pesticides and led to maximizingthe role of natural enemies in controlling pest population and it will increase the arthropodsspecies and populations compared to the ecosystem without pesticide application. Supporting the idea, Mahrub (1999) stated that functions and positionsof insects in the agro ecosystemof rice fieldsweredynamics and helped maintain the balance and stability of the ecosystem.

Conclusion

Therate of the IPM concepts adoption of the IPM-FFS alumni are higher than that of the non IPM-FFS alumni, but the implementation isnot yet fully fit with the concepts of the IPM.The abundance of species and species diversity indexof arthropodsin rice fields managed by the IPM-FFS alumni tends to be higher than those undertaken by the non IPM-FFS alumni.The implementations of IPMrelatively can improve stability rice fields'agroecosystem.

Suggestions

Althoughthe IPM-FFS alumni in managing their lands are able to improve the rice fields agroecosystem, but in order to optimize these improvements, it is still required the assistances to implement the actual IPM concepts.

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