Local resource utilization in integrated pest management in Lampung Province

Nila Wardani1, dan Yulia Pujiharti1

1 Lampung Assessment Institute for Agricultural Technology
Jl. ZA. Pagar Alam No. IA,Bandar Lampung

Email: wardaninila@yahoo.co.id

Abstract. The integration of rice and cow is one way to optimize the use of existing resources in farmers. This integration is mainly for farmers who have relatively narrow land (0.1 - 0.5 ha). In the bioindustry concept, the rice-cow farming system is primarily aimed at obtaining an ecological balance in one ecosystem because the agricultural system which does not take into account the principles of ecological balance is part of efforts to destroy natural resources and the environment. This paper will discuss the use of available resources in the location to integrated pest control (IPM) in the farming system of rice-cow in Lampung Province. These local resources can come from plants, microorganisms, animals etc. which together and integrated contribute to the application of IPM in rice cultivation. At paddy, Corine bacterium is often used to reduce infections from fungi and bacteria as in blas disease caused by Pyricularia sp. The use of local resources such as coryne bacterium frequency of 15 days can reduce blast disease approximately 45.82%, and crackle disease around 50.2%. The use of a combination of local resources such as corin, refugia and vegetable pesticides will be better able to suppress both pests and diseases on rice. The use of local resources will support the work of natural enemies on rice, and contributes to a sustainable agricultural system.

1. Introduction
The rice plant is a fairly complex ecosystem. To achieve the rice production target, the agricultural ecosystem (agroecosystem) holds a key factor. Rice ecosystems are theoretically unstable ecosystems. The stability of rice field ecosystems is not only determined by the diversity of community structures but also by the properties of the components as well as interactions between ecosystem components. The results of the study indicate that the rice field community was diverse [1]. The components in rice fields include rice, water, soil, pests, predators and parasitoid.

Agroecosystems produce a wide range of ecosystem services for agriculture, such as land regulation and water quality, carbon anchoring, support for biodiversity and cultivation services. Biodiversity (biodiversity) is all types of plants, animals and microorganisms that exist and interact in an ecosystem greatly determine the environmental quality of a community in a farming system. The end result of agriculture is the production of artificial ecosystems that require constant treatment by agricultural actors. Various research results show that the treatment in the form of agrochemical inputs (especially pesticides and fertilizers) has undesirable environmental and social impacts [2].

According to [3] explained that if interactions between components can be managed appropriately, the stability of agricultural ecosystems can be maintained. Thus it is possible that in agricultural ecosystems to create a stable state, the concept of IPM can be applied. Insecticides are the last
alternative and their use is very selective. In rice fields, natural enemies clearly function, resulting in a biological balance. This biological balance is sometimes achieved, but it can be the opposite. This is due to other factors that influence, namely agronomic treatment and the use of insecticides.

In order to maintain the balance or stability of the ecosystem, it is necessary to have a solution in cultivation, especially in controlling pests and diseases. To control pests and plant diseases it is recommended to follow the rules of integrated pest control (IPM). The IPM rule is to control by combining all methods from good cultivation to the use of natural ways to control pests and diseases.

In the concept of IPM, it is known as the so-called ecological IPM concept [4], in this case, pest control is based on knowledge and information about population dynamics of pests and natural enemies and the balance of ecosystems. In contrast to the concept of IPM technology that still accepts chemical pest control techniques based on economic thresholds, the concept of ecological IPM tends to reject pest control by chemical means. So that the agricultural system is more environmentally friendly.

Eco-friendly agriculture can be developed through a system of integrating plants and livestock. This is in line with a sustainable agricultural system that uses existing resources to maximize agricultural products. Livestock products are used as manure (solid manure), urine which can be used as liquid fertilizer or natural pesticides, besides that livestock is done as a side business with the aim of saving farmers, and labour (large livestock). If most farmers have limited land ownership, livestock can be used as an effort to intensify farming that requires more nutrient supply and crop protection [5].

The use of local resources has several things that need to be considered starting from how to maintain ecological balance, the types of local resources that can be utilized and their relation to increasing rice production.

2. Ecological Balance in Rice Plant

The rice planting ecosystem consists of several components that are fused to form a mutually influencing unit namely rice, soil, water, pests, diseases and natural enemies. Rice as the main component that will produce a product that can be utilized by humans. At a rice crop consisting of several communities will form ecosystems that affect each other. Disruption in one community will affect the other community, which in turn affects the balance of the existing ecosystem. Likewise in the rice plant ecosystem, disruption to the natural enemy community will affect the presence of pests, which in turn will also affect rice plants.

The sweeping net in 2013 in the Pantura paddy field showed that two rice pests, namely *Thaia oryzicola* and *Recilia dorsalis* were not found [6]. The loss of these two pests from the food chain (food chain) since 2002 will reduce the biodiversity of pest insects, resulting in the dominance of some pests will cause a sustained explosion. This is in line with [7] statement, which says that agricultural management practices can be a source of various service failures (disservices) that cause loss of wildlife habitat, loss of nutrients, river sedimentation, greenhouse gas emissions, and pesticide poisoning of humans and species not a target.

Integrated crop management needs to be done several components starting from tillage to production. Integrated crop management aims at the production of vegetable materials and meat with a zero-waste process to achieve sustainable farming systems [8].

Likewise in controlling pests and diseases in rice plants, it is better to consider the environmental aspects that are planted. Policies that need to be taken in the application of pesticides only in the area of attack (hot-spot) only when pest density reaches the economic threshold. The ecological engineering approach will create community mosaics that differ in composition and interaction between species aimed at inhibiting pest population explosions [9].
3. Potential local resources

3.1. Trap Crops

Trap crops are planting trap plants to protect the main cultivation plants from pests or certain pests. Trap crops can come from family groups that are the same or different from the main plants. Pest insects prefer trap plants to the main plants. Trap plants are a strategy to use plants as a trap that has economic value for farmers as animal feed so that this control technique is easily adopted by farmers. Trap crops used include sorghum and nappier grass. This trap crop serves to attract stem borers moths to put more eggs in trap crops than on the main plants; besides that, there is high mortality of these insect pests, so the population development is hampered [10,11]. There are two types of trap plants, namely perimeter traps and planting lines with intercropping. Perimeter planting traps (planting border traps) are planting completely trapped plants around cultivated plants (main crops). This prevents attacks from pests that originate from the outside of the planting area. Similar pests that are outside of agricultural land will be attracted at trap crops compared to the main crops. Intercropping in a Plant Line is planting trapping plants in rows in the main crop. The mixture is combining both perimeter traps (border traps and row intercropping). Similar pests that are located outside of agricultural land will be attracted at trap crops compared to the main crops.

Several studies have shown that trap crops are quite effective in suppressing populations of several pests as in the study of [12] which said that the use of trap plants (Jarak kepyar, sorghum, and green beans) has been shown to reduce pest populations in tobacco plantations. The pest population in tobacco can be reduced by up to 50% with traps of kepyar, sorghum, and green beans. In connection with the performance of the trap crops, the spraying of scheduled insecticides to control Besuki cigar tobacco pest is an ineffective and inefficient control measure. Horticultural commodities are reported that cabbage plants can avoid Plutella xylostella pests, because of the yellow rocket plant (Barbarea vulgaris (R. Br.) Var. Arcuata) which is used as a trap plant. The pest was very attracted to the yellow rocket for laying eggs, but the larvae did not live on the plant [13]. The treatment of corn cultivation uses a push-pull strategy to avoid pests Chilo partellus (Pyralidae) and Busseola fusca (Noctuidae) with grass traps or corn pest repellents. Elephant grass (Pennisetum purpureum) and Sudanese grass (Sorghum vulgare sudanense) have special features as trap plants, while molasses grass (Melinis minuflora) and silver leaf Desmodium (Desmodium uncinatum) refuse stem borer egg laying [14]. The intercropping of molasses grass with corn will reduce the attack of stem borer and increase parasitism by natural enemies, Cotesia sesamiae (11, 14], however, the four kinds of grass as well as traps and repellents are economically very important as food cattle in East Africa. Caisin plants are effectively used in dealing with clubroot disease and restore loss of cabbage yields significantly [15].

The advantages of using the trap crops method are 1. Environmentally friendly and the main thing is to reduce damage to the main plants from insect infestation to 75%. 2. Preserve the natural enemies of pest insects so that the balance of the ecosystem on the land will always be maintained 3. The quality of the crop is getting better because of the small amount of pesticide residue attached to crop 4. Reducing the use of pesticides 5. Reducing the cost of production [16].

According to [12], at horticultural commodities reported that cabbage plants can avoid Plutella xylostella pests, because of the yellow rocket plant (Barbarea vulgaris (R. Br.) Var. Arcuata) which is used as a trap plant. The pest was very attracted to the yellow rocket for laying eggs, but the larvae did not live on the plant [13]. Trap crops in corn cultivation use a push-pull strategy to avoid the Chilo partellus (Pyralidae) and Busseola fusca (Noctuidae) pests with grass traps or corn pest repellents. Elephant grass (Pennisetum purpureum) and Sudanese grass (Sorghum vulgare sudanense) have special features as trap crops, while molasses grass (Melinis minuflora) and silver leaf Desmodium (Desmodium uncinatum) refuse stem borer egg laying [14]. Intercropping of molasses grass with corn will reduce stem borer attacks and increase parasitism by natural enemies, Cotesia sesamiae [14], however, the four kinds of grass as well as traps and repellents are economically very important as fodder in East Africa.
The selected type of edge crop must have a dual function, that is, aside from being a barrier to the entry of pests into the main crop, also as a refugia plant which functions for temporary shelter and provider of pollen for alternative predatory food, if the main prey is low or not in the main crop. Cropping system such as planting marginal plants can encourage the conservation of natural enemies such as predators [17]. According to resolution experts, refugia is a crop of several types of plants that can provide shelter, food sources or other resources for natural enemies such as predators and parasitoid [18]. Refugia works as a microhabitat that is expected to be able to contribute to natural conservation efforts. Some studies mention the types of ornamental plants proposed as a refuge among other sunflowers (Helianthus annuus), zinnia paper flowers (Zinnia peruviana), (Zinnia acerosa), (Bicolor Zinnia), (Zinnia grandiflora), (Zinnia elegans), kenikir (Cosmos caudates) etc. [18]. If planting a number of ornamental plants in paddy fields can increase the population of natural enemies in rice plantations. The diversity of fauna due to the existence of refugia will cause the formation of a more stable ecosystem, which in turn will maintain the balance of ecosystem components. The presence of flowering plants is thus very important to preserve natural enemy populations in an ecosystem such as agroecosystems [19]. Based on the research of [20], the use of refugia plants in the form of long bean plants and corn on tidal rice plant plots showed an abundance of herbivorous insects obtained on subplots with lower refugia plants compared to rice plants without refugia, both on vegetative and generative phases.

3.2. The using of microorganisms

The infection of diseases caused by fungi and bacteria often troubles farmers. The diseases in the field include crackles, bacterial leaf blight (BLB), and balst. Losses caused by disease attacks on rice plants can cause considerable losses and can even reach 75%. Therefore, the handling of disease control is necessary. One of them is by using micro-organism antagonists that can suppress the development of rice disease. There are several microorganisms that can be used to help support integrated pest control programs. Among the microorganisms that can be utilized are *Trichoderma* sp, *Corinebacterium*. *Corynebacterium* can suppress the development of diseases caused by bacteria and fungi. In rice use *Corynebacterium* effectively suppresses diseases caused by Bacterial Leaves. In the 1999 Purwakarta case study, the disease can be suppressed by 27%, and secondary infections (inter-family transmission) can be reduced by 84% [21]. The use of *Corynebacterium* in rice is also able to reduce the percentage of disease attacks caused by fungi. According to [22] said that the use of corin with a frequency of 15 days can reduce blast disease (*Pyricularia* sp) by approximately 45.82%, and kresek disease (*Xanthomonas oryzae*) around 50.2% compared to without the use of corin. For the use of corin with a frequency of 30 days it only suppresses the disease <20%. The use of corin has no effect on the performance of natural enemies in rice plantations. Fungi that cause leaf rust (*Puccinia horiana* P. Henn) on chrysanthemums, which are treated with biofungicides with active ingredients *Corynebacterium* sp, which is formulated with 0.3% PGPR, and is applied through root immersion, followed by spraying at 7-day intervals giving emphasis to leaf rust disease of 3.55 [23]. *Corynebacterium* is an antagonistic bacterium in other microorganisms, as an antagonist of these microorganisms able to intervene in the pathogenic activity of plants causing diseases. These antagonistic bacteria can produce antibiotics and ciderophore can also play a role as a competitor of nutrients for plant pathogens.

More intensive use of Corrine is able to reduce the development of pathogenic fungi. Antagonist fungi can grow faster than pathogenic fungi [24]. The ability of this antagonistic fungus is in accordance with plant disease control systems that are environmentally friendly and that support sustainable agriculture. This control is often called biological control which aims to reduce the use of synthetic pesticides that have an impact on the environment and food. The use of microbes or microbial products to control plant diseases and to increase crop production is an integrated part of sustainable agriculture [25]. Antagonist fungi are usually isolated from soils that have not been touched either by cultivation practices or chemicals. This land is called suppressive soil. Fungi isolated
from suppressive soils have great potential to be used as biological agents [26, 27]. One of them is Corryne bacterium.

The advantage of using this bacteria is because it is relatively easy to make, with ingredients that come from resources that are in the location around the farmers' rice plants. These materials include one tube Coryne starter, 15 kg potato, 150 grams white sugar, clean water 5 l.

Another microorganism that is often used in cultivating farmers is PGPR (Plant Growth Promoting Rhizobacteria) Plant Growth Promoting Rhizobacteria is a type of bacteria that lives around the roots of plants. This bacterium provides benefits in the process of plant physiology and its growth. root growth and physiology and can reduce disease or damage by insects. PGPR can also produce plant hormones, add bacteria and fungi that benefit and control plant pests and diseases [28]. According to [29], the types of materials contained in local microorganisms include bamboo shoots, pineapple, bamboo roots, banana weeds, coconut fibre, corn roots, elephant grassroots, shy princess roots and so forth. These bacteria colonize plant roots after inoculation through seeds, and these bacteria can increase plant growth. As a result of the colonization process: microbes multiply in the spermosphere because of the seed exudates, microbes attached to the root surface, and colonizing the growing root system. The existence of microorganisms for plants will be very beneficial. These bacteria provide benefits in the process of plant physiology and growth. There are several benefits of using PGPR in rice plants, according to [30]. PGPR actively colonizes plant roots by having three main roles for plants, namely as biofertilizer, biostimulant and bioprotectant namely: able to stimulate growth and root physiology, capable of reducing disease, increase the availability of other nutrients such as phosphate, sulfur, iron and copper, produce plant hormones, add bacteria and fungi to benefit and control plant pests and diseases. PGPR is commonly used when vegetative growth of plants. Usage doses that are commonly used are as follows: 1 glass versus 1 litre of water for soaking the seeds for 6 hours and for watering the planting media or seedling media, and 1 cup compared to 14 litres of water for application to plants with watering or spraying. This bacterium is capable of killing pathogenic organisms or plant diseases after the bacteria multiply properly. These microbes suppress disease growth through the mechanism of systemic resistance induction from plants, namely the production of siderophore which chelates iron so that iron is not available for pathogens, synthesis of antifungal metabolites such as antibiotics, enzymes that degrade fungal cell walls, or hydrogen cyanide which suppresses the growth of pathogenic fungi. These microorganisms are also able to compete with pathogens for nutrition at the root. Making PGPR is simple, the technique often used at the farmer level is to soak bamboo roots in cold boiled water 2-4 days, then ingredients (4 ounces of sugar, traces of 2 ounces, 1 kg of fine bran, 10 lt of water, flavouring: to taste) boiled for 20 minutes until boiling, after cold enter the bamboo roots, store d anaerobically for 2-3 weeks, strain, ready to use, mix 1 ltr / tank, spray on to unplanted land, repeat every 20 days. The use of PGPR is able to increase the number of tillers and vegetative growth of rice plants in accordance with the study of [31], which states that PGPR is able to increase N0 uptake - from the soil and N2 fixation, with its ability to absorb nutrients so it can supply N needed in plants.

An entomopathogenic fungus is one type of bioinsecticide that can be used to control plant pests. Several types of entomopathogenic fungi that have been known to effectively control important pests in agricultural crops are Beauveria bassiana, Metarhizium anisopliae, Nomuraea rileyi, Paecilomyces fumosoroseus, Aspergillus parasiticus, and Lecanicillum lecanii. The use of various types of fungi often faces obstacles, including the lack of knowledge of farmers about the types of insects and pathogens, as well as the benefits and efforts to maintain the viability and effectiveness of fungi in pest control, including how to multiply, prepare and apply [32]. One of the potential entomopathogenic fungi to control several species of pest insects is Beauveria bassiana (Balsamo) Vuillemin. This fungus is reported as a biological agent that is very effective in controlling a number of species of insect pests including termites, white fleas, and several species of beetles [33]. B. bassiana is one of the entomopathogenic fungi that can be used widely as biological control. More than 200 species of insects can be infected with these fungi such as whiteflies, aphids, grasshoppers, termites, Colorado potato beetle, Mexican bean beetle, Japanese beetle, boil weevil, cereal leaf beetle, bark beetle, lygus
bugs, fire ants, European corn borer, codling moth, and Douglas fir tussock moth and cicada family Gryllidae and aphid. To control pests in rice plants, especially brown planthopper, many microorganisms are used in the form of entomopathogenic fungi, including *Beauveria sp*, and *Metarhizium anisopliae*.

One of the other important fungi in controlling biological pests is *Metarhizium anisopliae* Metch. Sorokin. *M. anisopliae* var anisopliae fungi can infect insects from the order Orthoptera, Coleoptera, Hemiptera, Lepidoptera and Hymenoptera [34]. In the field this fungus infects many green leafhoppers along brown planthopper [35]. In Brazil, *M. anisopliae* mushrooms have been used to control ladybug insect populations [36], and stem hopper and leafhopper in alfalfa plants [37]. Insects infected by *M. anisopliae* fungi and die colored to green-green; this is caused by the color of the conidia fungus. Insect death can be caused by toxins released by the fungus [38]. Mushroom mycelium is reported to be able to produce toxic metabolites to insects [39]. On the other hand, [36] suggests that in the process of its infection the conidia of pathogenic fungi infect the cuticle part of the insect, but until now the mechanism of infection is unclear. Conidia or fungal hyphae of *M. Anisopliae* (measuring approximately 1.6 x 7.8 urn) can infect various parts of the body of insects of brown plant hopper. Mushroom hyphae that grow on the body parts of dead insects can spread to other insects when contact occurs and are supported by environmental conditions (temperature and humidity) that are suitable for the growth of pathogenic fungi [40].

*M. anisopliae* fungus can kill soil bedside pest (*Stibaropus molginus*) (Hemiptera: Cydnidae) on 5 days after application, it can be said that *M. anisopliae* can quickly infect *S. molginus* [41].

### 3.3. Use of livestock waste

Urine is known to contain nutrients, especially nitrogen, phosphorus, potassium. Many studies suggest that livestock urine contains growth stimulants that can be used as growth regulators, and the typical smell of livestock urine can also prevent the arrival of various plant pests including whitefly [42]. Livestock urine is liquid waste from animals which contain many elements needed by plants such as nitrogen, phosphorus, etc. At present, the use of livestock urine is still not popular at the farm level, due to lack of knowledge about the benefits of livestock urine and other technical problems. This liquid waste with a touch of technology to be bio-urine can be utilized for plant fertilizers and pesticides. According to [43] cow urine contains complete nutrients so that it can be used to strengthen plant vigour.

Liquid manure is liquid fertilizer derived from livestock urine. All livestock urine can be used as liquid fertilizer. One of the livestock urine that is widely used is cow urine. The content of nitrogen and potassium in cow urine is generally greater than the content in solid dung [44]. Cow urine is liquid manure for plants, cow urine is also a plant grower, this is because cows consume a lot of leaves with many substances that are beneficial for plant growth. The chemical content in cow urine is N: 1.4 to 2.2%, P: 0.6 to 0.7%, K: 1.6 to 2.1%, usage. Urine cattle also have a positive influence on plants, because the smell is typical of cow urine can also function as pest control in plants. Added by [45], cow urine fermentation has a regulatory substance called auxin. In addition, cow urine is also resistant to pests. Organic fertilizers in the form of cow urine contain nitrogen, potassium, auxin hormones, gibberellin and kinetin acids. According to [45], explained that IAA (Indol Acetic Acid) is auxin which affects plant growth, cell enlargement or elongation, shoot dominance, flowering and root initiation, fruit formation and others. Whereas gibberellic acid influences cell division and enlargement, genetic traits, flowering, irradiation, parthenocarpy, and carbohydrate mobilization. Then kinetin is a growth regulator that stimulates cell division in plant cells.

### 3.4. Botanical pesticides

It has been widely studied that certain plant extracts contain molecules, which work singly or interact with other molecules that can act as pesticides. Mode of action of these molecules can be as biotoxin (poisonous), antifeedant, feeding deterrent, repellent and / or natural intruder, both obtained from plants and microorganisms called biorational pesticides (biorational pesticides). [46], his results of
the study of [47] showed that vegetable pesticides in the form of a mixture of biotoxins from *Azadirachta indica* plants, *Andropogon nardus*, *Alpinia galanga*, a mixture of *Tithonia diversifolia*, *A. nardus*, *A. galanga* have the potential to control various pests in potato plants, chilli and shallots. Some of these plant material at the study site can also be used as vegetable pesticides to control the vector of the yellow virus in hot chilli.

The criteria for “good” botanical pesticides (PESTITANI) are: Toxicity to the body is not a zero or low target; Botoxins have more than one way of working, the power of persistence is not too short; Extracted from source plants that are easily propagated, resistant to suboptimal conditions, prioritized perennials, will not be weeds or alternative hosts; Source plants as much as possible not or less compete with the cultivated plants; The source plant can function multipurpose; Biotoxin has been effective below the concentration of 10 ppm, practically about 3-5% dry weight of ingredients; As far as possible the solvent/solvent is water; Pestitani raw materials can be used both in fresh, dry conditions and other simple conditioning; Pestitani technology is not contradictory, even rooted in traditional technology, easy to understand and simple; Pestitani technology does not cause new problems, is affordable, raw materials are easy to obtain, continuous supply [48].

Some local resources such as neem leaves contain antibacterial active ingredients [49], soursop leaves [50], mahogany leaves and betel leaves [51] can be used for botanical pesticides.

4. Conclusion
Rice is a plant cultivated by farmers, as a staple food for most of the Indonesian people. Plant ecosystems need a balance between organisms living in that place. If there is no balance, various problems arise from the emergence of pests and diseases. The result is affecting farmers to control by using pesticides. The use of chemical pesticides causes the killed of insects non targets. This causes beneficial insects such as natural enemies to die. As known through its role as a natural enemy of insects, it is very helpful for humans in efforts to control pests. Besides that insects also help in maintaining the stability of food webs in an agricultural ecosystem [52]. Recognizing the increasing use of chemical pesticides, the greater the danger of using pesticides, the government introduces the concept of control based on an ecological (environmental), economic and social approach, namely Integrated Pest Management (IPM).

The principle of Integrated Pest Management provides an opportunity for farmers to be able to utilize local resources around them as ingredients that can be used to control pests and diseases that exist in rice plants. The use of non-chemical local resources is very useful in supporting the achievement of sustainable agriculture.

References
[1] Untung, K. 2006. *Pengantar pengelolaan hama terpadu*. Edisi ke dua. Yogyakarta: Gadjah Mada University Press.
[2] Altieri MA. 1999. Applying agroecology to enhance productivity of peasant farming systems in Latin America. *Environ Dev Sustain* 1:197–217.
[3] Baehaki S.E., A. Riffki, dan A. Salim Yahya. 1991. *Penentuan biotipe wereng coklat di daerah sentra produksi padi*. Media Penelitian Sukamandi No.9. p.26-30.
[4] Waage, J. 1996. Integrated pest management and biochemistry: An analysis of their potential. p. 36-47. In G.J. Persley (Ed.). *Biotechnology and Integrated Pest Management*. CAB International, Cambridge.
[5] Salikin, K.A. 2003. *Sistem Pertanian Berkelanjutan*. Kanisius, Yogyakarta.
[6] Baehaki SE. dan I. J. Mejaya. 2014. Wereng coklat sebagai hama global bernilai ekonomi tinggi dan strategi pengendaliannya. *IPTEK Tanaman Pangan* 9 (1): 1-12.
[7] Power, A.G. 2010. Ecosystem services and agriculture: tradeoffs and synergies. Phil. Trans. R. Soc. B (2010) 365: 2959-2971. doi:10.1098/rstb.2010.0143.
[8] Baehaki S.E, Irianto N.B.E, dan Widodo S.W. 2013. Rekayasa Ekologi dalam Perspektif Pengelolaan Tanaman Padi Terpadu. *Iptek Tanaman Pangan* Vol. 11 No. 1.
[9] Coll, M. 2004. Precision agriculture approaches in support of ecological engineering for pest management. 133- 142, In Gurr et al 2004. Ecological Engineering for Pest Management. Advances in Habitat Manipulation for Arthropods. CSIRO Publishing. p.225.

[10] Khan, Z.R., C.A.O Midega, N.J. Hutter, R.M. Wilkins, and L.J. Wadhams. 2006. Assessment of the potential of Napier grass (Pennisetum purpureum) varieties as a trap plants for management of Chilo partelus. Entomologia Experimentalis et Applicata 119:15–22.

[11] Khan, Z.R., C.A.O Midega, L.J Wadhams, J.A. Pickett, and A. Mumuni. 2007. Evaluation of Napier grass (Pennisetum purpureum) varieties for use as trap plants for the management of African stem borer (Busseola fusca) in a ‘push–pull’ strategy. Entomologia Experimentalis et Applicata 124:201–211.

[12] Nurindah, D.A. Sunarto, dan Sujak. 2009. Tanaman Perangkap untuk Pengendalian Serangga Hama Tembakau. Buletin Tanaman Tembakau, Serat & Minyak Industri 1 (2), Oktober 2009 ISSN: 2085-6717.

[13] Perez, F.R.B., A.M. Shelton, and B.A. Nault. 2004. Evaluating trap crops for diamondback moth, Plutella xylostella (Lepidoptera: Plutellidae) Journal of Economic Entomology. 97(4):1365-72. DOI:10.1603/0022-0493- 97.4.1365.

[14] Khan, Z.R., and J.A. Pickett. 2004. The “push–pull” strategy for stemborer management: a case study in exploiting biodiversity and chemical ecology in Ecological Egineering for Pest Management, page 155-164.

[15] Hadiwiyono, Sholahuddin, Sulastri, E., 2011. Efektivitas caisin sebagai Tanaman Perangkap Patogen Untuk Pengendalian Penyakit Akar Gada Pada Kubis. Jurnal HPT Tropika. Vol 11 (1): 22-27.

[16] Baideng EL. 2016. Jenis dan padat populasi hama pada tanaman perangkap Collard di sayuran kubis. Jurnal LPPM Bidang Sains dan Teknologi Volume 3 Nomor 2 Oktober 2016

[17] Mahmud, Taufiq. 2006. Identifikasi Serangga di sekitar Tumbuhan Kangkungan (Ipomoeas crassicaulis RooB).Skripsi.Universitas Islam Negeri Malang.

[18] Allifah A A, Bagyo Y, Zulfaidah P G , Amin S L. 2013. Refugia sebagai microhabitat untuk meningkatkan peran musuh alami di lahan pertanian. Prosiding FMIPA Universitas Pattimura 2013.ISBN : 978-602-97522-0-5. Jurusan Biologi. Fakultas MIPA. Universitas Brawijaya Malang.

[19] Kurniawati N. dan Edhi M. 2015.“Peran Tumbuhan Berbunga sebagai Media Konservasi Artropoda Musuh Alami”.Jurnal Perlindungan Tanaman Indonesia, Vol. 19, No. 2, 2015: 53–59.

[20] Pujiajutti Y, H.W.S.Weni, Abu U. 2015. “Peran Tanaman Refugia terhadap Kelimpahan Serangga Herbivora pada Tanaman Padi Pasang Surut”.Prosiding Seminar Nasional Lahan Suboptimal (8-9 Oktober 2015).

[21] Ismail N, Taulu LA, Bahtiar. 2011. Potensi Corynebacterium Sebagai Pengendalian Penyakit Karat Putih pada Krisan. Jurnal Teknologi Lingkungan Vol. 19, No 1. Hal 459-465.

[22] Wardani N dan Y Pujiharti. The use of bacteria Coryne bacterium antagonists as preventive actions to reduce main diseases in rice. Proceeding of ISAE Interenasional Seminar, Bandar Lampung, 2017. Hal 445-449.

[23] Nuryani W, Silvia E, Hanudin, dan Budiarto K. 2018. Aplikasi Biofungisida Berbahan Aktif Ramah Lingkungan dalam Pengendalian Penyakit Karat Putih pada Krisan. Jurnal Teknologi Lingkungan Vol. 19, No 1. Hal 23-32.

[24] Whipps, J.M. 2001. Microbial interactions and biocontrol in the rhizosphere. Journal of Experimental Botany, Volume 52. Pages 487–511.

[25] Haggag WM, and HA Muhamed. 2007. Biotechnological Aspects of Microorganisms Used in Plant Biological Control. American-Eurasian Journal of Sustainable Agriculture, 1 (1): 7-12.

[26] Westphal, A., and J. O. Becker. 2001. Components of soil suppressiveness against Heterodera schachtii. Soil Biology and Biochemistry 33:9–16.
[27] Tribe, H. T. 1977. Pathology of cyst nematodes. *Biological Reviews* 52:477–507.

[28] Wiwana. 2012. PGPR (Plant Growth Promoting Rhizobacteria). http://www.PGPR (Plant Growth Promoting Rhizobacteria) « keloposongo.html. Diakses tanggal 19 Oktober 2012.

[29] Setiawan. 2000. *Memamfaatkan Kotoran Ternak*. Jakarta : Penebar Swadaya.

[30] Gholami, A., Shahsavani S. dan Nezrat S. 2009. The Effect of Plant Growth Promoting Rhizobacteria (PGPR) on Germination, Seedling Growth and Yield of Maize. Proceedings of World Academy of Science, *Engineering and Technology*. 3(7):19-24

[31] Cummings P.S. 2009. The application of plant growth promoting rhizobacteria (PGPR) in low input and organic cultivation of grainaceous crops; potential and problems. *Environmental Biotechnology*. 2:43-50.

[32] Koswanudin D, dan Wahyono TE. 2014. Keefektifan Bioinsektisida Beauveria bassiana Terhadap Hama Wereng Batang Coklat *(Nilaparvata lugens)*, Walang sangit *(Leptocorisa oratorius)*, Penghisap polong *(Nezara viridula)* dan *(Riptortus linearis)*. Prosiding Seminar Nasional Pertanian Organik. Bogor, 18 – 19 Juni 2014.

[33] Soetopo Deciyanto dan IGAA Indrayani. 2007. Status Teknologi dan Prospek Beauveria bassiana Untuk Pengendalian Serangga Hama Tanaman Perkebunan Yang Ramah Lingkungan. *Perspektif* Volume 6 Nomor 1, Juni 2007: 29-46

[34] Hall RA and CC Payne. 1986. Potential of insect pathogens in the tropics, 187–196. In: MY Husein and AG Ibrahim (Eds). Biological Control in the Tropics.

[35] Suryadi Y dan Kadir, TS. 2007. Pengamatan infeksi jamur patogen serangga *Metarhizium anisopliae* (Metsch. Sorokin) pada wereng coklat *(Stibaropus molginus)* (Hemiptera:Cydnidae) dari beberapa formulasi. *Berita Biologi 8*(6) - Desember 2007.

[36] Phimantoro H. 1996. *Memupuk Tanaman Buah*. Cetakan I. Penebar Swadaya. Jakarta.

[37] Hadisoejoganda, W.W. dan Udiarto. B.K. 1998. Pengaruh Ekstrak Kasar Tanaman Pupuk Organik untuk Mengendalikan OPT Utama pada Tanaman Kentang, Cabai dan Bawang Merah. Laporan Penel. Proyek APBN 1997/1998. 32 hal. (mimeograf).
[48] Balitsa. 2004. Pestisida Botani untuk Mengendalikan Hama dan Penyakit pada Tanaman Sayuran. *Balai Penelitian Tanaman Sayuran*, Pusat Penelitian dan Pengembangan Hortikuluta, Badan Penelitian dan Pengembangan Pertanian, Lembang-Bandung. 34 hal.

[49] Apristiani, D dan P. Astuti. 2005. Isolasi Komponen Aktif Antibakteri Ekstrak Kloroform Daun Mimba (*Azadirachta indica* A. Juss.) dengan Bioautografi. *Biofarmasi* 3 (2): 43-46.

[50] Kuruseng, M.A., Vandalisna, dan Aburaera. 2009. Evaluasi Penyuluhan Terhadap Aplikasi Pestisida Nabati Daun Sirsak Sebagai Pengendalian Ulat Tritip Pada Tanaman Sawi. *Jurnal Agrisistem*. 5 (1): 1 – 10.

[51] Rachmawati, D dan E.Karlina. 2009. Pemanfaatan Pestisida Nabati Untuk Pengendalian Organisme Pengganggu Tanaman. Balai Pengkajian Teknologi Pertanian Jawa Timur, Departemen Pertanian.

[52] Pradana RA, G. Mujino, S Karindah. 2014. Keanekaragaman serangga dan laba-laba pada pertanaman padi organik dan konvensional. *Jurnal HPT* Vol 2, No 2.