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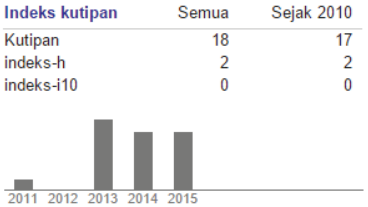

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The Effect of Hot Water Treatment and Dose *Trichoderma* sp. to Plant Tissue of Seedling Growth from Bud Chips of Sugarcane (*Saccharum officinarum*)

Pengaruh Perendaman Air Panas dan Dosis *Trichoderma* sp. terhadap Kualitas Jaringan pada Pertumbuhan Benih Asal Mata Tunas Tebu (*Saccharum officinarum*)

✉**Haryuni**

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Abstract

Sugarcane (*Saccharum officinarum*) is a high-value economical crops, only grows in tropical climates of Java and parts of Sumatra. Ratoon stunting disease (RSD) is a vascular disease in sugarcane which its visual symptoms is difficult to detect. The disease has spread across the sugarcane plantations in Indonesia with the percentage of attacks 10-100%. The use of buds chips treatment of seedling plant is an act of reducing pathogen development. The research effect of hot water treatment / HWT (0, 30, 60, and 90 min) and dose application of *Trichoderma* sp. (0, 25, and 50 g) using 864 varieties, is designed with a completely randomized factorial design. The results showed that *Trichoderma* sp. able to infect the roots and stems of seedling age 3 months, part of plant tissue increase of protein and proline content, decrease of glucose content so that increase resistance and health in the growth of sugarcane seedling before planting in the land.

Abstrak

Tanaman tebu (*Saccharum officinarum*) adalah tanaman yang bernilai ekonomi tinggi, hanya tumbuh di daerah beriklim tropis terutama di Jawa dan sebagian Sumatra. Penyakit ratoon stunting disease (RSD) merupakan penyakit pembuluh pada tebu yang sulit dideteksi gejala visualnya. Penyakit tersebut telah tersebar di seluruh pertanaman tebu di Indonesia dengan presentase serangan mencapai 10-100%. Penggunaan bahan tanam benih asal mata tunas (bud chip) dapat mengurangi perkembangan patogen. Penelitian pengaruh waktu perendaman air panas (0, 30, 60, dan 90 menit) dan aplikasi dosis jamur *Trichoderma* sp (0, 25, dan 50 g) terhadap pertumbuhan benih tebu klon 864, dirancang dengan menggunakan rancangan acak lengkap faktorial. Hasil penelitian menunjukkan bahwa jamur *Trichoderma* sp mampu menginfeksi bagian akar dan batang benih umur 3 bulan, pada bagian jaringan tanaman terjadi peningkatan kadar protein dan prolin serta penurunan kadar glukosa sehingga meningkatkan ketahanan dan kesehatan pada pertumbuhan awal benih tebu sebelum ditanam di lahan.

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INTRODUCTION

Sugarcane is a group of seasonal plantation plant used as a raw material to make sugar, grew in a tropical climate region, included to grass family and annual plant. On its development to be the raw material in sugar production, sugarcane passes four stages; they are bud, nursery, and ripeness.

The decline of sugarcane bud's health and endurance in a field is caused by *ratoon stunting disease* (RSD), bud chips spotted and *pokkah bung.* Those diseases are very harmful to the sugarcane ages 2-3 months so its seed growing is imperfect. A stem cannot be sterilized. The hot water treatment (HWT) to the bud chips is one of ways in slowing the RSD development (Semangun 2000; Anonymous 2011; Anonymous 2013).

Trichoderma sp. is a fungus from Deuteromycetes with straight conidiophores, many branches, cone shape, forming a chlamydosphores shape, the colony in its growth grows fast and its color is white until green. The perfect shape of this fungus is generally known as *Hyppocreales* or *Eurotiales, Clacipitales,* and *Spheriales.* The species included in the same group as *Trichoderma* sp. can show different species in *Hypocrea* as an *anamorf* because there are many sexual shape discrepancies from *Trichoderma* sp. (Chet 1987; Cook & Baker 1989; Alexopoulus *et al*. 1996; Semangun 2001). *Trichoderma* sp. is proven to be able to control decomposed disease on a vanilla stems (*Fusarium oxysporum* f. sp *vanilla*), the research was done by Hadisutrisno (2000), wilted on tomato caused by *Fusarium oxysporum* (Alfizar *et al*. 2011), and blight on potato leaves caused by *Phytophtora infestans* (Baihaqi *et al*. 2013). *Trichoderma* sp. effects the forming of cell wall constituents such as protein, glucose, and proline. Those ingredients have a role in endurance and plant scanning to pathogen.

RSD endemic is a disease which contracted by soil, is very harmful for seeds at the beginning growth and is considered a usual phenomenon even though it decreases the production until 30-40%. To improve a self-sufficient of sugar in 2014 in order to increase the sugarcane yield until 8,5%, efforts must be done to improve the health and endurance of the seeds. So, the RSD disease development must be prevented. Therefore this research is done to know the effect of HWT variation toward the tissue quality at the bud chips seeds growing. The testing is done with related institution hoping to give a contribution in spreading the information through the working units from the government institution in every regency.

RESEARCH METHODS

The multiplication of *Trichoderma* sp. was done at *Laboratorium Balai Proteksi Perkebunan* (Plantation Protection Hall of Laboratory) at Salatiga. The bud chips is taken from *Kebun Benih Lembaga* at Boyolali, the HWT treatment and seeds multiplication was done at green house Faculty of Agriculture Tunas Pembangunan University Surakarta. The research materials and equipments are including sugarcane seeds clone 864, *Trichoderma* sp. fungus, soil media, maize flour, grow controller substance, hipochlorit, combining fertilizer (NPK), water heater, polybag, sack, large plastic bucket, and soil strainer.

The experiment was arranged in a completely randomized factorial design, consisted of two factors. The first factor was *Trichoderma sp.* fungus inoculation including without *Trichoderma sp.* inoculation (T0), with *Trichoderma sp.* inoculation 25g (T1), and with *Trichoderma sp.* inoculation 50g (T2). The second factor was *Hot Water Treatment* consisting of treatment without hot water (P0), heating treatment for 30 minute (P1), heating treatment for 60 minute (P2), and heating treatment for 90 minute (P3). Each treatment was repeated three times and each replicate consisted of 10 plants.

The experiment was conducted to detect the resistance and the health of the plant consisting of protein level, glucose level, proline level, death of plants, the disseminating of *Trichoderma sp.* on its stems and root. Then, the data analysis were observed visually and analyzed with ANOVA, the Duncan Test was also used with the significance of 5 %.

RESULTS AND DISCUSSION

The detection of the resistance and the health of the plant is based on the parameter of the protein level, glucose level, and proline level. Figure 1 shows that the sugarcane seed without the *Trichoderma* sp. inoculation, its protein level is lower than that sugarcane seed with inoculation and it shows a significant difference in the hot water treatment variation (Table 1). *Trichoderma* sp., besides having a role as the pathogen controller, declining or failing the tomato yields, and helping to increase the phosphor (P element) availability which is difficult to get from the nature, it also is having a role as a soil decomposer. The availability of the P element is needed by the plants when they are growing and the increasing of the yields are effectd by this element also. Rosmarkam and Yuwono (2002)

state that the P element is involved in forming a number of certain proteins which are important in the photosynthesis and respiratory as a result, the P element is important in the entire plants growing. Besides, it also is essential to repair the plant root system.

The result of the test shows that giving *Trichoderma* sp. affects on the growth of sugarcane seed (the height of the plant, the length of the leaves, the amount of the leaves, the length of the root, and the volume of the root). Those are occurred because the fungal hypha of *Trichoderma* sp. in the root keeps the proteins in order to be used in physiology process. The proteins are formed from the nutrients such as C, H, O, N, S, P, and K which, in the synthesis process, will be transformed into nucleic acids, growth hormone and enzyme inside the plants body, and finally the proteins have a role in a daily cell activities such as the cleavage process or cell replacement, the change of the broken or old cell (Parman, 2007).

Living creature need proteins in their live used to catalyze a reaction, if as an enzyme, microtubule protein and microphilaments protein in the ribosome have a structural function, not as a catalyze. The other function are as an electron transporter during the photosynthesis and respiratory process, it is used also as an amino acids back up in the seed germination (Cech & Bass 1986). Proteins consist of one or more polypeptide chain and each consists of hundreds of amino acids, the type and the amount of amino acids subunit effect the composition and the size of each protein in most of plants protein the weight of the molecule is more than 40.000 daltons (ferredoxin protein in the photosynthesis process). As a result, the protein improves the tenacity of the plants and it agrees with the research result which (figure 1) that is the increase of *Trichoderma* sp. dose can improve the protein level.

The analysis result in the figure 2 above shows that the seed with *Trichoderma* sp. inoculation has lower glucose level than that of the seed without *Trichoderma* sp. inoculation and it shows a significant difference in the hot water treatment (table 1). The lysis mechanism on the pathogen of hypha is marked by the color

Table 1. The protein, glucose, and proline level on the sugarcane seed age 3 months

Treatment	Parameter		
	Protein Level (%)	Glucose Level (%)	Proline Level (µmol g $^{-1}$)
Tricoderma sp. (T)			
T0	3, 30 a	3,30 a	1,66 a
T1	1,36 a	1,36 a	5,17 b
T2	1,03 a	1,03 a	4,79 b
Hot Water Treatment (P)			
P0	3,36 a	3,36 a	3,26 b
P1	1,51 a	1,51 a	4,53 c
P2	1,40 a	1,40 a	1,85 a
P3	1,32 a	1,32 a	5,84 c
Interaction between *Tricoderma* sp. & *Hot Water Treatment* (TXP)			
T0 P0	1,65 a	6,86 b	2,2709 b
T0 P1	8,46 b	6,99 b	3,3206 b
T0 P2	2,97 a	5,70 b	0,7298 ab
T1 P0	3,38 a	5,84 b	5,3978 b
T1 P1	8,45 b	3,80 a	5,7328 b
T1 P2	15,56 cd	3,21 a	1,4222 ab
T1 P3	15,22 c	3,21 a	8,1226 b
T2 P0	21,64 e	3,80 a	2,1146 b
T2 P1	34,83 f	3,10 a	4,5491 b
T2 P2	18,60 de	3,08 a	3,3877 b
T2 P3	51,22 g	2,37 a	9,1053 b

Note: Score followed by the same letter in the row shows insignificant different based on the Duncan Test 5% rank.

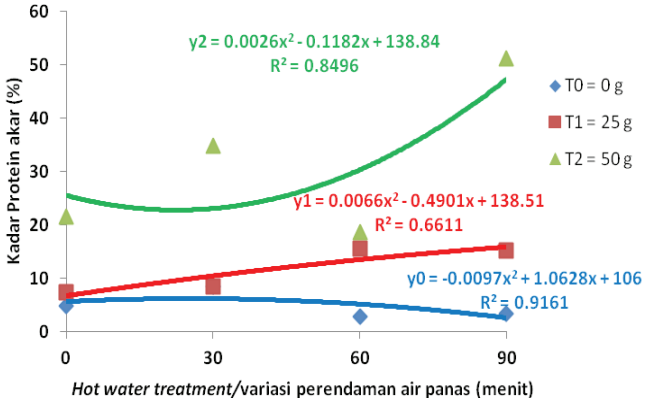

Figure 1. The influence of hot water treatment and *Trichoderma* sp. inoculation toward the protein level.

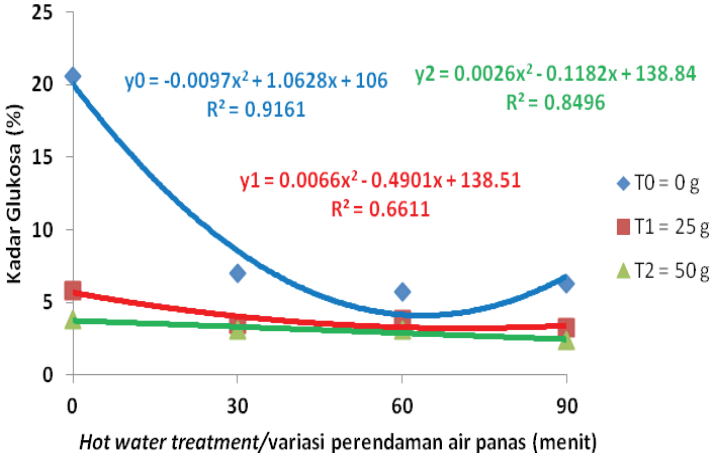

Figure 2. The influence of hot water treatment and *Trichoderma* sp. inoculation toward the glucose level.

changing on the pathogen of hypha becoming crystal clear and empty the cell content is used by the biological agents as a nutrient and the ability of the biological agents produces enzyme that can lyse the pathogen cell wall. It agrees with Djarir statement (1993) who states that *Trichoderma* can produce antibiotic that prevents the growth of the pathogen of hypha. For example, *Trichoderma viridae* produces *gliotoxin and viridian* antibiotic, while *Trichoderma* sp. can produce β-1 enzym, 3 *glucanase* and *chitinase* which can lyse the pathogen of hypha. The resulted enzyme can destroy the fungus pathogen cell wall and will cause cell death.

The antagonist fungus has been known since long time ago as a bio control agents which act through the production of gliophirin and gliotoxin (Howell on Suwandi 2008). The parasitic produces hydrolysis enzyme such as 1, 6-ß *glucanase* (Djonovic *et al*. on Suwandi 2008), competes to Fe nutrient by secreting *siderofor* (Wilhite *et al.* on Suwandi 2008) and also scans the tenacity (Viterbo *et al.* on Suwandi 2008). In this research, the domination on each mechanism of declining the disease cannot be reviewed in depth (Suwandi 2008).

The seed without inoculation has higher proline level than that of with the inoculation, because the proline level is one of the indicator on the occurrence of plants drought (Maestri *et al.* 1995; Farahani *et al*. 2008; Johari-Pireivatlou *et al*. 2010). Johari-Pireivatlou *et al*. (2010) says that proline can reduce the occurrence of protein damage which has an important role in the growth. BNR inoculation is not causing the proline excalation so that the abiotic disease intensity by the drought occurrence is low.

The adaptation mechanism done by the plants by adjusting the osmotic cell pressure forms an organic compound accumulation, so it reduces the potential of water inside the cell without limiting the enzyme function and keep the turgor cell. The low of the saturated soil becomes a barrier factor to the nutrient transport to the surface of the root in a drought condition (Lestari 2006). According to Christine *et al.*

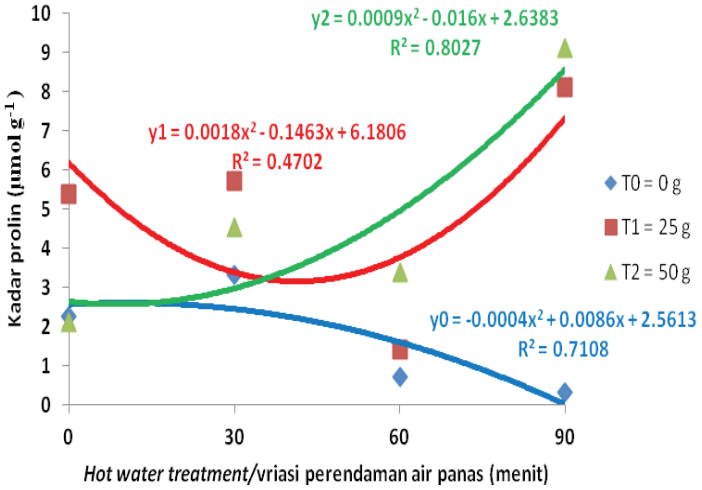

Figure 3. The influence of Hot water treatment and *Trichoderma* sp. inoculation toward the proline level.

(1996) and Sasli (1999) the seed of cotton plant and cocoa inoculated with mycorrhiza fungus has low proline level if the water level is decline and the decline reaches 70,33%.

Table 2. The effect of hot water treatment and *Trichoderma* sp. inoculation toward the plant death.

Treatments	Parameter
	Death of Plant (%)
Trichoderma sp. (T)	
T0	1,11 a
T1	0,14 a
T2	0 a
Hot water treatment (P)	
P0	0,74 a
P1	0,37 a
P2	0,37 a
P3	0,19 a
Interaction T x P	
T0 P0	5 ab
T0 P1	3,33 ab
T0 P2	3,33 ab
T0 P3	1,67 ab
T1 P0	1,67 ab
T1 P1	0 a
T1 P2	0 a
T1 P3	0 a
T2 P0	0 a
T2 P1	0 a
T2 P2	0 a
T2 P3	0 a

Note: Score followed by the same letter in the row shows insignificant different based on the Duncan Test 5% rank.

Figure 4 shows that the increase on the hot water treatment variation to the *Trichoderma* sp. inoculated seed and without inoculation shows insignificant different in the plant death. The increase of the time lapse treatment in the inoculated seed does not cause the plant death (0%), while the seed which is not being inoculated and having no treatment, the death reaches 5% (table 2). *Trichoderma* sp. fungus improves the endurance and the health of the plants so the inoculated plants does not have the cell damage and the death.

The result of Habazar and Yaherwandi research (2006) on the biological control using *Trichoderma* shows that paracite hypha of Trichoderma will grow abreast with the pathogen hypha and form side branches like a hook in the hypha surrounding and are able to penetrate the hypha pathogen. *Trichoderma* sp. hypha can grow and form a conidia inside of the pathogen hypha even it can penetrate to the rest structure of pathogen such as sclerotia (Sunarwati & Yoza 2010).

Enrich soil with soil microbe can suppress the development of plant disease caused by soil pathogen. The use of soil microbe in planting helps the supplying of nitrogen (N), phosphor (P), calium (K) so it can improve the quality of the plant (Setyowati *et al*. 2003). Microbe given with the organic compound also can improve the quality of soil aggregation (Rahimi 2000). The result of Setyowati *et al* research (2003) Trichoderma fungus is able to decrease the rotten root disease and the growth of weeds on the

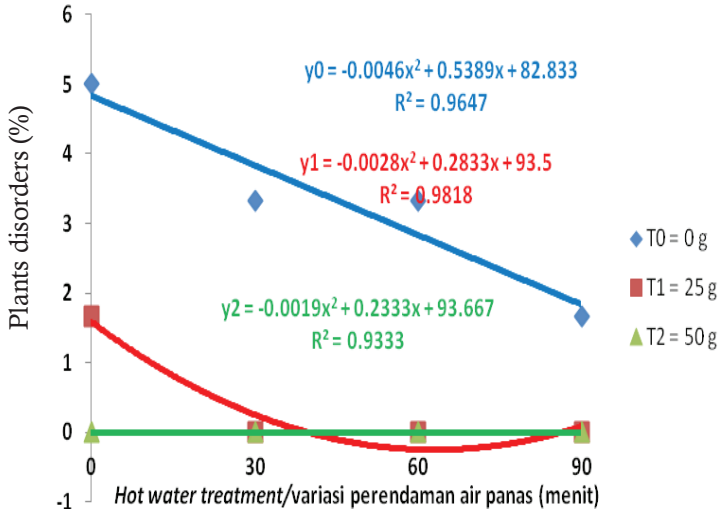

Figure 4. The influence of hot water treatment and *Trichoderma* sp. inoculation toward the plant nuisance

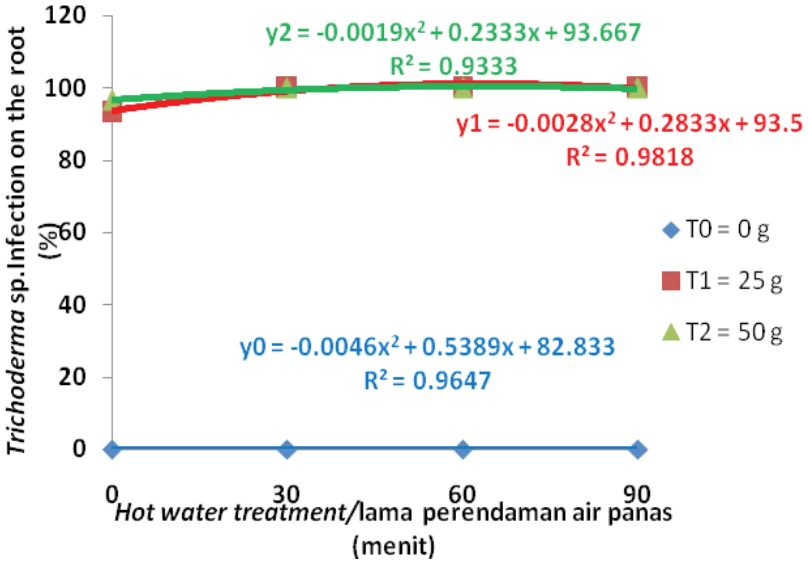

Figure 5. The influence of hot water treatment and *Trichoderma* sp. inoculation toward the *Trichoderma* sp. root infection.

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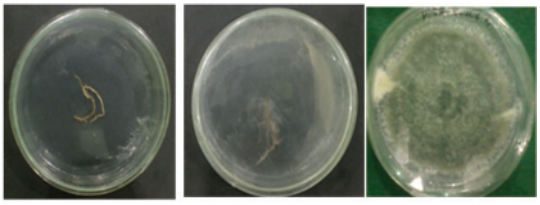


A B C

Figure 6 . Infection of *Trichoderma* sp. on the root macroscopically dan microscopically on the day 2 incubation (A: root without inoculation; B: root with inoculation)

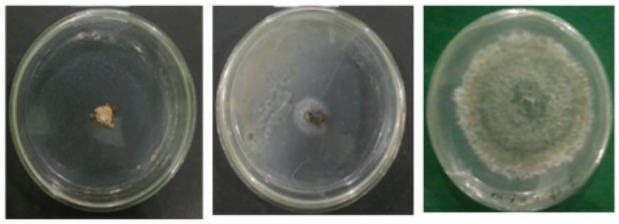
Table 3 shows that fungus interaction with *Trichoderma* sp. treatment and hot water treatment shows a significant different between inoculated Trichoderma sp. seed and non-inoculated Trichoderma sp. seed.

Figure 5 and 6 shows that the root without *Trichoderma* sp. inoculation has no infection, while the inoculated root with *Trichoderma* sp. has 100% infection in the root area in the 30, 60, and 90 minute of treatment.

The character of high speed of growing on the *Trichoderma* sp. and *Trichoderma virens* is one of the important factors which determine the potential of biological agents (Sunarwati & Yoza 2010). The important factor determining the antagonist microorganism activity which can control the pathogen is having the high speed of growing so that it can compete with the pathogen

Table 3. The influence of hot water treatment and Trichoderma sp. Inoculation toward the root and stalk infection

Perlakuan	Infeksi *Trichoderma* sp.	
	Akar (%)	Batang (%)
Trichoderma sp. (T)		
T0	0 a	0 a
T1	32,78 a	32,78 a
T2	33,06 a	33,06 a
Perendaman air panas (P)		
P0	21,11 a	21,48 a
P1	22,22 a	21,85 a
P2	22,22 a	22,22 a
P3	22,22 a	22,22 a
Interaksi T x P		
T0 P0	0 a	0 a
T0 P1	0 a	0 a
T0 P2	0 a	0 a
T0 P3	0 a	0 a
T1 P0	93,33 b	96,67 b
T1 P1	100 c	96,67 b
T1 P2	100 c	100 b
T1 P3	100 c	100 b
T2 P0	96,67 bc	96,67 b
T2 P1	100 c	100 b
T2 P2	100 c	100 b
T2 P3	100 c	100 b



A B C

Figure 7. The influence of hot water treatment and *Trichoderma* sp. inoculation toward the *Trichoderma* sp. stalk infection.

in case of food and space control and finally it can suppress the growth of fungus pathogen (Djafaruddin 2000; Sunarwati & Yoza 2010).

Figure 7 and 8 shows that without *Trichoderma* sp. inoculation, the stems area has no infection (0%), while the stems area which is being inoculated by *Trichoderma* sp. 1 day inoculation (B) and 7 days inoculation (C), the stems area is 100% free from infection in all hot water treatment variation. Djafaruddin (2000) explains that *Trichoderma* sp. has an important nature as the biological controller that is it can grow fast in a various substrate and have a competition ability either in getting food or in having grow space. Supported by Habazar and Yaherwandi (2006), the ability of *Trichoderma* in preventing the growth of fungus pathogen often is related with the ability in producing chitinase. This enzyme causes a damage in the pathogen fungus cell which can cause cell death.

CONCLUSION

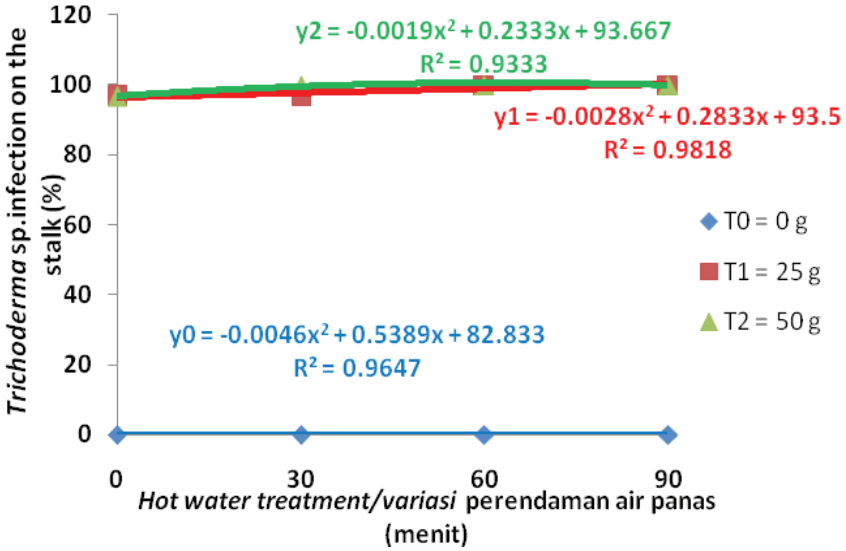


Figure 8. Infection of *Trichoderma* sp. on the stalk macroscopically dan microscopically on the day 2 incubation (A: stalk without inoculation; B: inoculated stalk age 1 day, C: inoculated stalk age 7 days)

The inoculation of *Trichoderma* sp. and variation of hot water treatment in the bud chips of sugarcane is able to improve the protein level, proline level, and to decrease the glucose level. It also improves the tenacity and the health of sugarcane seed preliminary growth. *Trichoderma* sp. is able to infect the root and the sugarcane stems.

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Description of Skin Anatomical Structures of the Rat Wistar after Exposed by X-Rays Radiation

Gambaran Struktur Anatomi Kulit Tikus Wistar setelah Terpapar Radiasi Sinar-X

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Abstract

The research was aimed to find out a profile of an anatomical structure of the *Rattus norvegicus* skin after exposed to X-ray radiation. Research was performed by treating the 20 Rattus norvegicus at the age of 1.5 months. The weight rats were weighed approximately 100 ± 13 g grouped into four treatments with different dose of X-ray radiation. The four treatments were 0 mgy (control), 50 mgy, 100 mgy, and 150 mgy X-ray radiation. The variable in this research was a dose of X-ray radiation and the anatomical structure of the rattus norvegicus skin. The data obtained were analyzed with qualitative description. The research results after exposure of X-ray radiation for 5-days showed that there was no damage on the skin macroanatomy. Whereas, the observation in the skin microanatomy showed that there was a damage, e.g. thinning of the epidermis, cell picnosys, cell injury, and hemoragic. The result indicated that the different dose of X-ray radiation affected the skin anatomy structure. The X-ray radiation exposure at 100 mGy on skin microanatomy were caused a thinning of the epidermis in stratum corneum layer, picnosys on the nucleus, cell injury and hemoragic.

Abstrak

Penelitian ini bertujuan untuk mengetahui gambaran struktur anatomi kulit tikus (*Rattus norvegicu*) strain Wistar setelah terpapar radiasi sinar-X. Sebanyak 20 ekor tikus umur 1,5 bulan dengan berat badan sekitar 100 ± 13 gram dikelompokkan ke dalam 4 perlakuan yaitu perlakuan dosis radiasi sinar-X sebesar 50 mGy, 100 mGy dan 150 mGy serta 1 kelompok kontrol. Paparan radiasi dilakukan selama 5 hari. Variabel penelitian ini adalah dosis paparan radiasi sinar-X dan struktur anatomi kulit. Data yang diperoleh dianalisis secara deskriptif kualitatif. Hasil penelitian menunjukkan bahwa secara makroanatomi kulit tikus tidak terlihat kerusakan, tetapi secara mikroanatomi terdapat kerusakan berupa penipisan epidermis, piknosis sel, jejas sel, dan hemoragik. Hal tersebut dikarenakan besarnya dosis radiasi mempengaruhi terhadap perubahan struktur anatomi kulit. Paparan radiasi sinar-X dosis 100 mGy, menimbulkan kerusakan kulit tikus secara mikroanatomi berupa penipisan epidermis dilapisan stratum korneum, piknosis inti, jejas sel dan hemoragik.

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INTRODUTION

An X-Rays radiation is a kind of radiation commonly known in a medical field in helping to diagnose a disease (Widyasari *et al.* 2005). One of the advantages of the X-Rays radiation is to detect the disease of abnormal organ through a radio diagnose. The use of X-Rays which is useful in the medical world should be aware because in spite of giving a useful information, it also can give dangerous effect to the living creatures' cells (Fauziyah & Dwijananti, 2013).

The radiation exposure will cause cell damage. The damage cell will influence the function of tissue or organ if the amount of death or broken cell in the tissue is quite a lot. The response from various tissue and organ to the radiation varies. Besides depending on the physical nature of radiation, it also depends on the biological characteristic of the composer of tissue or organ which is exposed (Kurniawan & Ida, 2008).

Body consists of several of organs such as skin, liver, kidney, lung, vertriculus, and many other. Skin is an elastic wrapper protecting the body from environment influence. It composes from different tissues such as blood vessel, connective tissue, fat, glands, senseing organ and nerve. When the outside organ is exposed by the X-Rays so the inside organ is exposed also. Skin for the living creatures has an important role as a protection from the outside nuisance like protecting the body from radiation, chemical substance, microorganism, and balancing the body temperature (Geneser, 1994).

When the X-Rays radiation contacts and penetrates the skin so the skin tissue composer will be broken. The ravage of the skin tissue because of over exposure will cause a skin malfunction, so the body protection toward the outside disturbance will be weak. From the point of view of how skin is important, so the research of the effect of X-Rays radiation exposure to the description of skin anatomical structures needs to be done.

RESEARCH METHODS

This research was done in the Physic and Biology Laboratory of Semarang State University, and also in the BBVET laboratory. This research used 20 female white rats (*Rattus norvegicus)* strain Wistar and the weight approximately 100 ± 13 gram and their age are 1,5 month. The research method uses a complete random design one factor with 4 treatments and 3 repetitions on each treatment. The radiation used as the treatment comes from radio diagnostic machine SF100BY with the power specification *supply voltage*: 180-240 V, *kilo voltage*: 50-100 kV, *time*: 0.08s~6.3s, energy: 120eV until 120KeV, target anode: tungsten (W) and the radiation dose is measured by radiography diagnostic. *Rattus norvegicus* is grouped into 4 treatments. Each treatment consists of 5 rats. The four groups of treatment are given the radiation doses that are: 50 mGy, 100 mGy, 150 mGy and 0 mGy as a controller. In giving the doses, the dose giver is based on the Fauziyah and Dwijananti (2013) research. The radiation is given for 5 days in a row. After the last day exposure, the rat is shaved and its skin is taken. The skin then is incorporated into formalin solution 10% in order to be made as a histology smear. The observation result is done by comparing the skin organ in a normal condition to a treatment condition. The observation of the skin anatomical structure is done by shaving the rat's hair including the absence of erythema, epilation, skin desquamation, and necrosis. Microanatomical observation is done by using a radiance microscope with 400 times optical zoom and HE coloring including the alternation of cell structure in the dermis and epidermis layer covering the absence of picnosis cell, karyorrhexis, karyolysis, and necrosis.

RESULTS AND DISCUSSION

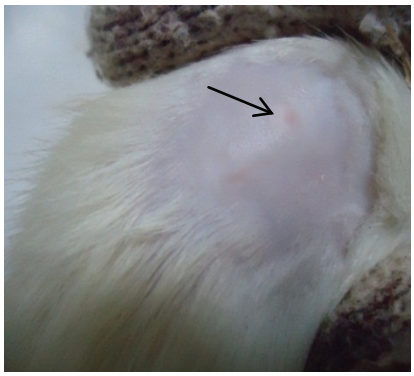
The Illustration of microanatomical skin structure of *Rattus norvegicus*

From the observation result, the treatment of the X-rays radiation exposure on 20 rats with doses of 50 mGy, 100 mGy, and 150 mGy for 5 days in a row tells that the result shows insignificant different for the control group. The condition of the skin surface on the treatment rat is in a normal condition. The observation result of the treatment rats' skin surface in each treatment can be seen in the Figure 1 as follows:

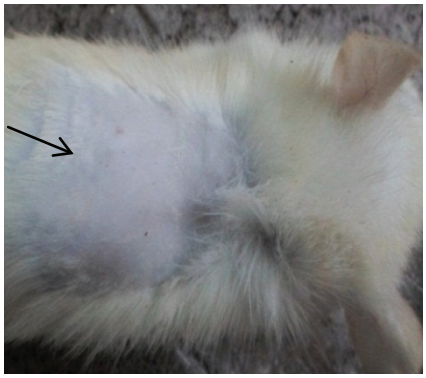
The observation result on the treatment of control group (Figure a) the rat's skin looks normal, white, and clean. Treatment on 2 and 3 (Figure b and c), the rat's skin still looks normal but there is a little red spot in the skin. The red spot, as seen at the Figure b and c, is still normal. The skin experiences a ravage if the erythema appears or if there is a bruise.

The illustration of the Microanatomical Structure of Rat's skin

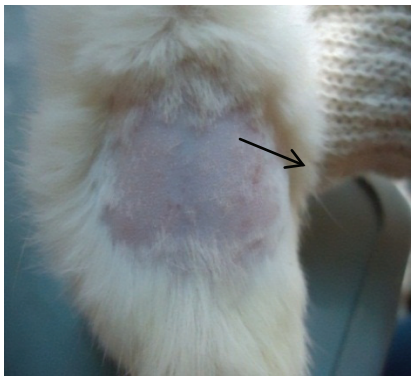
The observation result on the alteration of microanatomical skin from the Hematoxilin-



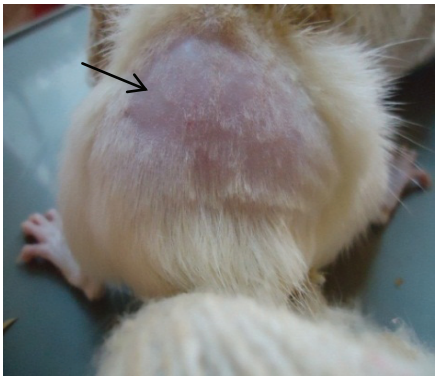
a. Control Group



b. Group 1 (50 mGy)



c. Group 2 (100mGy)



d. Group 3 (150mGy)

Figure 1. Microanatomical of the rat's skin structure after exposed by the X-rays radiation

Eosin coloring which is seen under the radiance microscope showing that the skin on the control group is in the normal condition, it is seen orderly with three layers; they are epidermis, dermis, and hypodermis (subkutan) (Figure 2).

The radiation exposure on the skin can cause a degradation of epidermis layer. It consistent with the research of Abuarra *et al* (2002) which states that the ravage of the skin tissue is increasing gradually and it is marked by the thinning of the epidermis also by losing of stratum corneum layer. This agrees with the illustration of the skin structure which is exposed by X-rays radiation as shown in the Figure (3, 4, and 5)

The skin obtaining the exposure of X-rays radiation treatment 100 mGy seems having an alteration in the microanatomical structure that is hemoragic in the dermis layer, the injury of the cell, and the finding of core picnosis.

The illustration of microanatomical structure on the treatment 3 (dose 150 mGy) shows that the epidermis layer looks thinner. The border of papila dermis is seen unclear. Many of the core of picnosis appears. On the dermis layer, the injury of the cell happens and the sudorifera gland is swelling.

Based on the reseach result on the wistar rat which is exposed by the X-rays radiation in 5 second for 5 days in a row shows that in the illustration of macroanatomical structure of the skin, there is no discrepancy between the control group and the treatment group. In the control group, the skin seems normal after exposed by the X-ray radiation, the skin surface is smooth, white, and clean. The skin condition after exposed by the X-ray radiation doses 50 mGy, 100 mGy, and 150 mGy remains the same as the control group. This is because the alteration of macroanatomical structure happened if the skin is exposed by the high dose (2Gy) of radiation or the big of the dose influences the change of the macroanatomical structure of the skin (Alatas 1998).

The lowest dose of the X-ray radiation which contacts the skin is 2 Gy. The dose under 2 Gy does not affect the macroanatomical structure of the skin (Stecker *et al.* 2009). The radiation exposure 2-5 Gy which contacts the skin will cause

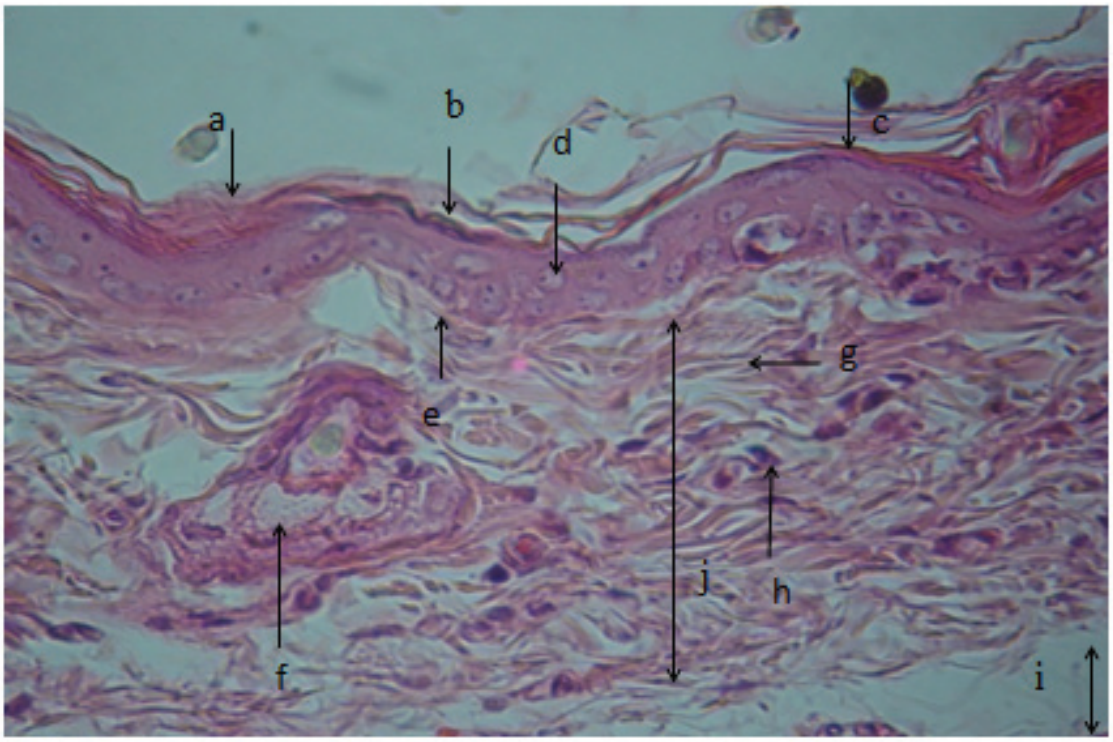


Figure 2. Microanatomical Structure of the Rat's Skin in the Control Group (400 times optical zoom with HE coloring)

Note

a. Stratum corneum	f. Sebaceous glands
b. Stratum lucidum	g. Fiber kolagen
c. Stratum granulosum	h. Fiber kolagen
d. Stratum spinosum	i. Dermis
e. Stratum germinativum	j. Subkutan

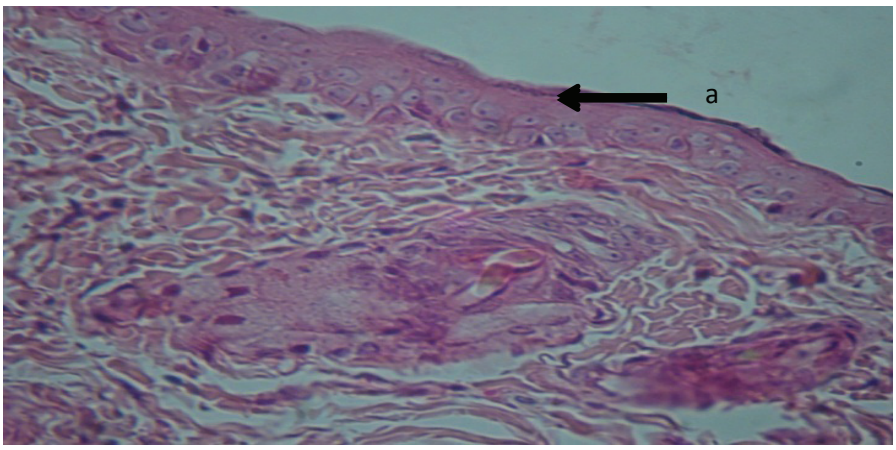


Figure 3. Microanatomical Structure on the Rat's Skin after Exposed by the x-Ray Radiation Dose 50 mGy (400 times optical zoom with HE coloring).

Note: a. the thinning of epidermis layer

a light erythema. Erythema is the skin damage because the blood vessel is swollen, so it turns the skins to red. This process can be caused by the high dose of radiation with shorter length of the wave. The symptoms are the red skin, warm, and bruise. Those effect are can be seen directly, the effect which can be examined directly after exposed by the high dose of radiation (Anitha, 2012).

The observation result in the

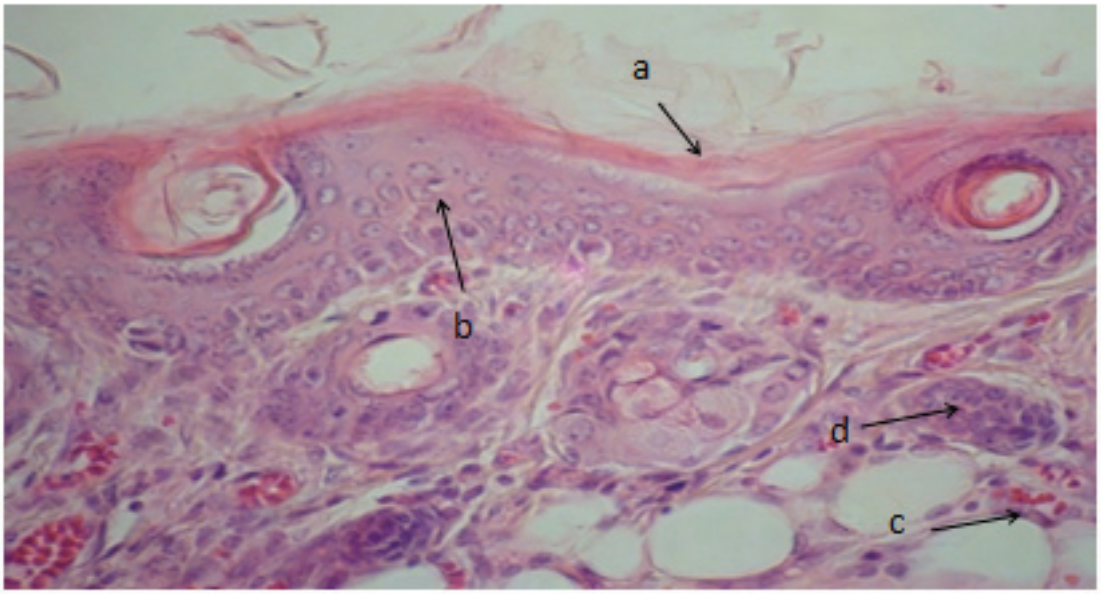


Figure 4. Microanatomical Structure on the rat's skin after exposed by the x-ray radiation dose 100 mGy (400 times optical zoom with HE coloring).
Note: a. The thinning of stratum corneum, b. the core of the picnosis, c. Hemoragic, d. The injury of the cell

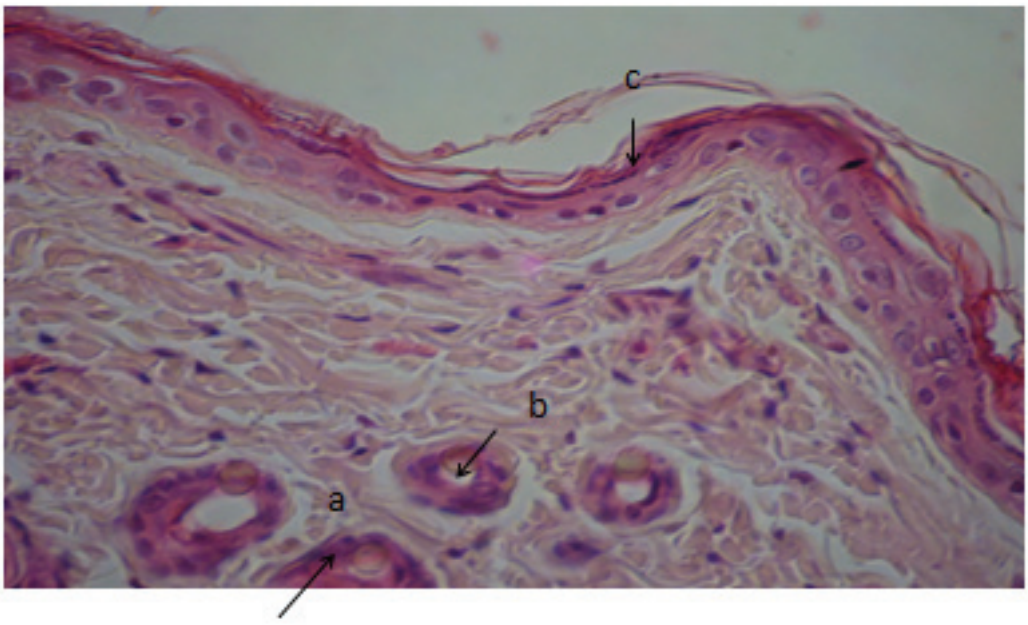


Figure 5. Microanatomical Structure on the rat's skin after exposed by the x-ray radiation dose 150 mGy (400 times optical zoom with HE coloring).
Note: a. the core of the picnosis, b. The injury of the, c. The thinning of epidermis layer

microanatomical skin is known that there is the difference between the control group and treatment group. In the experimental rat, the epidermis layer looks thinner than before, the injury of cell happens, the core of picnosis appears, and the hemoragic is happened. The change of the microanatomical skin is caused by the effect of photo thermal from the X-ray radiation. Cell is not be able to restrain the heat given, so the cell's form is changing. Abuarra *et al* (2012) explains that the effect of photo thermal can alter the skin tissue including the thinning of epidermis, swelling cell, and the change of colagen dermal.

The radiation exposure can cause the alteration to the skin. The heat that comes from X-ray will cause the epidermis damage then it can form the picnosis cell. The picnosis cell is an early stage to the cell death because of the radiation exposure (Shantiningsih *et al.* 2013).

The weakest cell which often damage because of the radiation exposure is the cell which experiences a mitosis so often such as the epitel cell in the digestive system, integumen cell, and the blood forming cell in the spinal cord (Corwin 2007). Proliferated cell will experience a damage if the radiation is given in the medium dose (1-2 Gy). If the cell having a broader DNA ravage or if it is not able to repair the damage, so the cell will do an apoptosis. The living cell can show the effect of ion radiation slowly that are mutation, aberation, chromosom, and genetic unstable. The damage cell genetically will be ferocious and become cancer (Mitchell *et al.* 2008).

Based on the research, the skin damage is not seen in the macroanatomical structure, but it is seen in the microanatomical structure. This is occurred because of the main target of the radiation is DNA which is inside the cell, so the damage or the alteration are seen in the cell level first (Alatas, 2004). This relates to the X-ray radiation exposure doses 50 mGy, 100 mGy, and 150 mGy, which is shown the alterations of microanatomical structure.

CONCLUSION

In short, the research finding explains that the X-ray exposure reaching 150 mGy dose on the female white rat strain Wistar does not affect the macroanatomical structure of the skin, but microanatomically, it shows the damage on the epidermis cell such as the thinning of *stratum corneum*, the core of the picnosis, the injury of the cell, and hemoragic. By 100 mGy, microanatomically, it shows the damage in the epidermis layer; in the stratum corneum, the core of the picnosis, the injury of the cell, and hemoragic.

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Development Life Skill Based Science Learning Devices Biotechnology Material in Junior High School

Pengembangan Perangkat Pembelajaran IPA Berbasis Kecakapan Hidup Materi Bioteknologi di SMP

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Abstract

The result of preliminary observations in Empu Tantular Semarang junior high school showed that the learning device was still focused on the achievement of cognitive competence. The present study aimed to develop a life skill-based science learning devices of biotechnology study material including syllabus, lesson plans, worksheets, and assessment instruments, as well as to test its feasibility and effectiveness. The research method used in this study was Research and Development, whereas the trial product design was a One Shot Case Study pattern. Trials of limited scale and large scale were done in the student of class IX at odd semester of year 2014/2015. The results of the three expert assessment of syllabi, lesson plans, worksheets, scale attitudes sheets, and vocational skills assessment sheet showed a very feasible criteria used. Inter-rater correlation analyzes were performed using the SPSS16 program which obtained a yield of 0.99. It indicated that the inter-rater reliability was exceptionally high. Classical completeness to the cognitive learning, affective and vocational skills of students of class IX A were 92.1%; 97.4%; 92.1%, respectively. Meanwhile, the results of class IX D were 74.4%; 94.9%; 100%, respectively. The percentage of student who reach the level of adherence to the learning ≥61% were 100% in class IX A and 87.2% in class IX D. Therefore, the developed learning device was fit to be used and also effectively applied in the Empu Tantular Semarang junior high school student.

Abstrak

Hasil Observasi awal di SMP Empu Tantular Semarang, menunjukkan perangkat pembelajaran yang diterapkan masih terfokus pada pencapaian kompetensi kognitif. Penelitian ini bertujuan untuk mengembangkan perangkat pembelajaran IPA berbasis kecakapan hidup materi bioteknologi yang meliputi silabus, RPP, LKS, dan instrumen penilaian serta menguji kelayakan dan efektivitasnya. Metode penelitian yang digunakan adalah *Research and Development* (R&D). Desain uji coba produk menggunakan pola *One Shot Case Study*. Uji coba skala terbatas dan skala luas dilakukan pada peserta didik kelas IX semester gasal tahun ajaran 2014/2015. Hasil penilaian dari ketiga pakar terhadap silabus, RPP, LKS, lembar skala sikap, dan lembar penilaian kecakapan vokasional mencapai kriteria Very Feasible digunakan. Analisis korelasi *inter rater* yang dilakukan menggunakan program SPSS16 memperoleh hasil sebesar 0,99. Hal ini menunjukkan bahwa reliabilitas *inter rater*/antar penilai tergolong sangat tinggi. Ketuntasan klasikal untuk hasil belajar kognitif, afektif dan kecakapan vokasional dari kelas IX A berturut turut 92,1%; 97,4%; 92,1% dan kelas IX D berturut turut 74,4%; 94,9%; 100%. Persentase jumlah anak yang mencapai tingkat keterlaksanaan pembelajaran ≥ 61% dari kelas IX A sebesar 100% dan kelas IX D sebesar 87,2%.Perangkat pembelajaran yang dikembangkan Very Feasible digunakan dan efektif diterapkan di SMP Empu Tantular Semarang.

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INTRODUCTION

Science learning process primarily concerns on giving direct learning experience to develop thinking skill, working, and scientific attitude. The implication, at school, Science learning would be better to be directed not only to know, to remember, or to understand knowledge, but also to encourage students to use the given knowledge in a daily life (DBE 2007). Learning device becomes an important aspect in determining the success of science learning process.

Compiling the learning device needs to be fitted to the right learning model in order to fulfill the need of the students in learning process. The life skill integrated model is one of the learning models that gives not only the academic knowledge but also certain skills that aims to reach the students' competencies, so it can be implemented in their real daily life. The characteristic of life skill integrated model can be seen from the learning device that put the life skill elements in the indicator and it is reflected through the learning activities so that the students' activities will be in accordance with their daily life context (Depdiknas 2007). Therefore, it is important to see the characteristic of a learning material in order to adjust it with life skill that can be developed. Biotechnology is one of the science subjects that is applicative, because the product resulted from it is familiar to our daily life and it can be related to the life skill aspect (Purwianingsih *et al.* 2009).

The preliminary research conducted in SMP Empu Tantular Semarang shows that the learning devices used by the science teacher are syllabus, lesson plan, and cognitive assessment. In fact, the teacher is emphasizing in giving the material and questions directly which administer to the cognitive competency achievement. It means that the learning process given by the teacher is still focus on developing the thinking skill. The thinking skill in the cognitive domain does not give a fully provision which can be used in the students' life in the future. All of the students grade IX show that they are able to achieve the science target of the study because the teacher always gives them a remedial to those who have not fulfill the target of the study. Unfortunately, that does not show that the students are already having a life skill provision. Although there are students' life skills appearing in the learning process, it is designed and developed accidentally by the teacher. Meanwhile, life skill is important to be had by the students because it gives them quality of life in the society (Ghombavani *et al.* 2012).

This research designs learning activities that directs the students to make a *soyghurt* that is one of the biotechnology food products coming from soy milk. Soy milk is easy to get because it is produced largely from the soybean industry in Semarang. *Soyghurt* is easy to be made and can be created based on our need.

The learning model in this research is *project based learning* which integrates the vocational skill in the indicator and designs the learning process with the method that aim at the contextual learning and cooperative. The given learning activities aim to give the vocational skill that is knowledge provision and skill which can be implemented in the students' daily life later. The learning evaluation is based on the life skill using a written test and a performance test because either the knowledge got by the students or the process in getting the knowledge is the important aspect in the life skills (Rassool & Sharifi 2008).

This research aims to develop thte science learning devices in biotechnology material including syllabus, lesson plan, student worksheet in making *soyghurt*, assessment instrument implemented to the students grade IX SMP Empu Tantular Semarang, testing the feasibility and analyzing the effectivity of the product which is developed. Product feasibility which is developed is measured based on the validity result/expert assessment and the product effectivity is measured based on the students learning outcomes in the biotechnology material including the cognitive domain, affective, and vocational skill, and also how far the biotechnology learning material based on the life skill is being implemented.

RESEARCH METHODS

This research was conducted using *Research and Development* (R&D) procedure modifying from Sugiyono (2012) and the research stages were identifying the potential and problem, collecting the data and designing the product, validating and revising the design, testing the product in a limited scale and revising the product, testing the product in a broader scale and revising the product, and making the final product. The research design in the limited and broader scale used *One Shot Case Study* pattern. Product testing in the limited and broader scale was done to the students grade IX SMP Empu Tantular Semarang year 2014/2015. The sample was taken simply based on the provision between

the teacher and the researcher. The sample used in the limited scale testing is 42 students of class IX B while the broader scale testing uses 77 students of class IX A and class IX D, the sample which was used in the limited scale testing is different from the broader scale testing.

The life skill learning device is appropriate to be used if each assessment from three experts is ≥ 67 % (reasonable criteria) and to be implemented effectively if the classical completeness is ≥ 70% for the cognitive learning outcomes score, vocational and affective learning outcomes as much as ≥ 70% of students reaching ≥ 61% on how far the learning process is being implemented. The data of feasibility assessment of the learning device were analyzed percentage descriptively by the experts, the learning outcomes data were analyzed descriptive quantitatively, and the data on how far the learning process is being implemented were analyzed percentage descriptively.

RESULTS AND DISCUSSION

The learning device of biotechnology material used by the science teacher at SMP Empu Tantular Semarang is including yearly program, semester program, syllabus, lesson plan, and cognitive domain assessment. The learning model used by the teacher is *Direct Instructional, Cooperative Learning* using discussion information method. All of the environments such as family, school society, and the society itself have a responsibility in giving the students the life skill provisions, but only some of the science learning which is integrated its material with a life skill. The science teacher still is focus on the cognitive competence achievement. It can be seen from the teacher's learning device which consists of cognitive competence indicator and cognitive assessment. The skill which is developed in the learning process still is thinking skill. Meanwhile, the students actually need a competency that will be useful in their future life.

The potential existed in SMP Empu Tantular is the science laboratory along with the facilities that can be used by the teacher in teaching science. Fortunately, in Semarang, there are many soybean industries that produce food product like soybean milk. So, this soybean milk can be created as a biotechnology food product, such as *soyghurt*. Therefore, the learning process can be designed to provide the students with the vocational skill that is the skill in making *soyghurt* that can be used in their daily life.

The improvement of quality of learning process can be done by enriching the variation of learning method and model which has to be fitted to the material and the students' condition. An innovative learning is strongly determined by the teacher creativity in presenting the material based on the learning source that she has (Haryono 2009). Biotechnology is the material that relates to our daily life and it can be related to the life skill. Science learning which is integrating with the life skill can be implemented in the biotechnology material. The life skill needs to be developed in the learning process based on the need of the students, school potential, and society. Vocational skill is suitable with the characteristic of biotechnology material and the students' need in accompanying the thinking skill given by the teacher. Society potential which is related to biotechnology field is soybean industry that is easily found in Semarang. This industry produces not only *tempe* (fermented soybean) but also soy milk that can be turned into simple biotechnology food product like *soyghurt*. The soy milk can be used as a learning source in biotechnology material. So, the science leaning in biotechnology material has a chance to be presented as a vocational skill learning based through making the *soyghurt* by the students.

The assessment used by the teacher is the result of the written test and students' homework. The assessment aspect is one of the keys to show the accomplishment of the learning goal. The assessment needs to be done authentically as a process, done by the teacher, of collecting information about the development and the learning accomplishment which is done by the students through the various techniques that can be revealing, proving, or showing accurately that the learning goal is mastered and accomplished (Ngadip 2009).

The learning device used by the teacher and its implementation in the learning process is still lack and need to be developed. The students need knowledge and skill that can be used in their life. Therefore, the development of science learning device life skill based need to be integrated on the syllabus, lesson plan, students worksheet as a guide in making *soyghurt* and as the authentic assessment.

In the data collecting stage, the data which is obtained are the life skill that relevant with the biotechnology material and life skill that needed by the students, the data about the characteristic of the life skill integrated model, the principal of the learning device based life skill, and the characteristic of biotechnology material. The life skill which is mostly needed

by the students is the vocational skill; this skill is relevant with the biotechnology material and is suitable with the demand of Standard Competence and Basic Competence. The integrated life skill model is not a subject that can stand independently and it does not need additional hours in its implementation but it is done integrated in the subject. The characteristic of this model is and giving certain knowledge and skill that is applicable in the students' real life. The learning device which is developed are syllabus, lesson plan, students' worksheet, attitude scale in the affective assessment, and vocational skill assessment instrument.

The vocational skill which is suitable with the need of the students' need, school potential, and society becomes the main aspect concerned in this research. It aims to give a useful knowledge and skill that can be used by the students in their daily life activity so that it can give a positive contribution in their future life as a member of a family or a society. Therefore, in this research, the data of students' need, school potential, and society is strongly needed to develop the life skill based learning device.

The development of life skill based learning device aims to complete and to make the teacher leaning device more perfect. The perfectness is done by adding the life skill competence and affective competence, arranging the indicator that relates each other functionally in order to achieve the competency, making the students' worksheet in a vocational skill activity, and making an authentic assessment covering the cognitive domain, affective, and vocational skill.

The developed syllabus contains standart competence, basic competence, affective competence, and skill competence. Indicator of vocational skill is supported by the cognitive and affective indicator that is demanding the students to master the competency completely which are knowledge, attitude, and skill. The learning material is being responsible scientifically and put the daily event commonly happened in the society, and the given portion is appropriate with the students' development. The scope of the indicator and learning material is adequate to support the life skill development. It shows that the syllabus has already fulfilled the principal in developing the syllabus according to BSNP and life skill integrated model.

The given learning material is designed to encourage the students to obtain knowledge and skill that can be used in their daily life activity. The learning activity is contained in the syllabus and completed in the lesson plan through an explanation and teacher and students activity. The learning activity is given through presenting pictures via power point so that it can be easily accepted by the students. food product and simple biotechnology food product is presented in the class as a source of study. The students write the definition of biotechnology according to the scheme in the power point media, make a table, collect information in pair, identify the picture, have a discussion, lab work, and presentation. Those activities show that the learning activity is using contextual approach and focus on the students' activeness.

The lesson plan is developed according to the principals of development based on the life skill based integrated model. Indicator and competence achievement are made in the syllabus and lesson plan including the cognitive indicator and vocational skill indicator, and affective indicator. The vocational skill indicator in the learning device produces an interesting and a good quality of *soyghurt*. It means that the students are demanded to have not only the skill in making *soyghurt* but also making a good quality of *soyghurt*. Vocational skill indicator is supported by the cognitive indicator which is made to lead the students finding the concept of making *soyghurt.* The life skill learning device is shown by the existence of life skill based integrated in the syllabus and lesson plan. Based on the competence achievement indicator made on the syllabus and developed lesson plan, it shows that learning device already fulfills the criteria of life skill based integrated learning.

The students' worksheet is a worksheet that has to be done by the students. The worksheet has to be prepared by the teacher thoroughly and presents the proper knowledge and the skill. The worksheet must fulfill at least the criteria relating to whether the basic competence is accomplished and mastered by the students or not (Chodijah *et al* 2012). The developed worksheet contains instruction in making *soyghurt,* questions about principal in making *soyghurt*, and instruction for the assignment report. Worksheet also is used as a learning media and source of the assessment form from one of cognitive indicators. The cognitive indicator which is meant is indicator which is made in purpose to support the vocational skill indicator which is explaining the principals in making *soyghurt*.

The assessment instrument which is developed covering th cognitive assessment, affective, and vocational skill. The assessment is done authentically to find out all of the competence domains accomplished by the

students'. the assessment forms used are multiple choice, the students' activity and report, group discussion based on the question provided on the worksheet, and attitude scale. The assessment used is already covering the completeness of whole indicators. It means that the assessment can give information about the whole competence which is mastered by the students.

The junior high school science learning process is not only as pure knowledge and developing of thinking skill, but it should be applicative, oriented on the learning skill, curiosity, building a care and responsibility attitude toward the surrounding environment (Widhy 2013). This research is developing the learning device which is applicative through the integrated life skill which is the vocational skill. The contextual learning has a big potential to develop the skill of life (DBE 2009). The thinking ability, study skill, and curiosity are developed using the contextual learning approach and the life skill based integrated. The responsible and care attitude toward the surrounding nature and social environment are developed through the facts and events that happen in the social life such as the effect of biotechnology implementation and the effort in solving it as a part of the learning material and source of the study.

The assessment on the learning device feasibility is done by the three experts, they are two lecturer from biology major UNNES and a science teacher class IX from SMP Empu Tantular Semarang. Those three experts assess the same aspect using the same feasibility assessment sheet also. The feasibility of the learning device including syllabus, lesson plan, students' worksheet, the making of *soyghurt*, and assessment instrument (attitude and vocational skill) are measured based on the result of feasibility assessment done by the three experts. 1st and 2nd are the experts from UNNES, they are biology lecturers. They assess the product twice, because in the first assessment it shows that the product need to be revised. Therefore, the product is being repaired based on the first assessment result by the 1st and 2nd experts, and then it is reexamined. The 3rd experts assesses the product along with the 1st and 2nd experts when the second assessment is done by the 1st and 2nd experts so that the product which is being assessed by the 3rd experts is the product which has been repaired previously. The detail assessment result toward the learning device is presented on the table 1 as follows:

Table 1 shows that in the first assessment by the 1st and 2nd expert toward the syllabus design, lesson plan, worksheet, and assessment instrument are still lacked so that it need to be improved. The next product has been fixed and then it is being reexamined by the experts. The reparation on the learning device is done based on the suggestion from the experts in the lacked aspect. The 3rd assessment done by the 1st, 2nd, and the 3rd experts shows the learning device design achieves very feasible criteria, so the product can be tested in the limited scale.

The second assessment of the 1st and 2nd experts and also assessment from the 3rd expert toward the learning device (syllabus, lesson plan, worksheet, affective assessment instrument, and vocational skill assessment instrument) then it is analyzed its reabillity using *Intraclass Corelation Coeficient* with the SPSS16 program reaching 0,99 which is included into very high reabillity. The correlation measurement between the assessor/ *inter rater* aims to find out the consistency between the *rater*, the more the consistency of the product assessment, the more it is reliable. The high reability from the rater can be achieved because of the consistency from the three experts has the high similarity in giving score in the aspects which is graded. This tells that the three experts as a subject has the same vision on the object being assessed which is the life skill based learning device.

The limited scale test was done to 42 students of SMP Empu Tantular Semarang year 2014/2015. The result was used to follow-up the product before it enters to the broader scale test on the result of how far the learning implementation is achieved by the students. In this research, It is already determined that the product can be tested in a broader scale if as much as ≥ 70% of the students reaching the level of learning adherence ≥ 61%. The level of the learning adherence using the developed product ix presented on the Table 2

Table 2 shows that the level of learning adherence fulfills the achievement target that is The number of the students who achieve the level of learning adherence ≥ 61% are71,4% therefore, the product can be used in the broader scale test.

The product test on a limited scale is done based on the lesson plan design. Based on the result, it shows that the success of learning process is determined not only with its excellent planning but also its execution or implementation. It is proved that with the learning device product which gets the feasibility test from the three experts and the result shows that it is very feasible to be used, in fact, when it is implemented, the lack of the learning device is still exist. A good learning plan through the learning device need

Table 1. The experts assessment result on the learning device feasibilty

Product	Percentage (%)				
	1st expert assessment		2nd expert assessment		3rd expert assessment
	1st	2nd	1st	2nd	
Syllabus	66,7 Feasible	93,9 Very Feasible	75,7 Feasible	96,9 Very Feasible	93,9 Feasible
Lesson Plan	78,3 Feasible	91,7 Very Feasible	65 Fairly Feasible	96,7 Very Feasible	95 Very Feasible
Worksheet	80,7 Feasible	98,2 Very Feasible	82,4 Feasible	98,2 Very Feasible	98,2 Very Feasible
Affective assessment instrument	60 Fairly Feasible	100 Very Feasible	86,7 Very Feasible	96,7 Very Feasible	100 Very Feasible
Vocational skill assessment instrument	73,3 Feasible	100 Very Feasible	80 Feasible	93,3 Very Feasible	93,3 Very Feasible

Table 2. The level of learning adherence based on the life skill in the limited scale test

No	Criteria	Amount (people)	Percentage (%)	Note
1.	Very High	10	23,8	The number of the students who achieve the level of learning adherence ≥ 61% are71,4% therefore, the product can be used in the broader scale test with a little revision.
2.	High	20	47,6	
3.	Fair	12	28,6	
4.	Lack	0	0	
5.	Low	0	0	
∑ the students who achieve the learning adherence ≥ 61%		30	71,4	
∑ the students who achieve the learning adherence ≤ 61%		12	28,6	

to be balanced with a good implementation also, so the learning based life skill which is designed can be succeed along with its learning goal that is giving provisions that can be used by the students in their future life. Along with that things, Jalmo (2008) states that life skill needs to be practiced purposively and planned, and the teacher has to be a perfect fasilitator in the learning process. Therefore, besides the learning plan which is stored in the learning device, the learning implementation which is based on the life skill becomes a concerned aspect to achieve the learning success based life skill.

This research analyzes the product feasibility which is developed in order to test its effectivity. The learning device effectivity is measured based on the completeness of the target of study (cognitive, affective, and vocational skill) of the students classically and the level of learning adherence in the broader scale test. The learning device is said effectively if the classical accomplishment ≥ 70% for the cognitive learning outcomes, affective, and vocational skill as much as ≥ 70% of the students who achieve the level of learning adherence ≥ 61%. The students learning outcomes in the broader scale test covering the cognitive domain, affective, and vocational skill is presented in the Table 3:

Table 3 Students learning outcomes in the broader scale test

Learning Outcomes	Classically completeness (%)		Effective Criteria
	ClassIX A	Class IX D	
Cognitive	92,1	74,4	Classically completeness ≥70% for the cognitive, affective, and vocational skill learning outcomes.
Affective	97,4	94,9	
Vocational skill	92,1	100	

Table 3 shows that class IX A achieves the classical completeness for the cognitive, affective, and vocational skill learning outcomes bigger than the determined effective criteria. Class IX D shows the same result as the class IX A. the effectiveness of learning device is determined by the level of learning adherence in the broader scale test presented in the Table 4:

Table 4 The result of the level of learning adherence in the broader scale test

The level of learning adherence	Class IX A (%)	Class IX D(%)	Effective Criteria
∑ Students who achieve the level of learning adherence ≥ 61%	100	87,2	≥70% Students who achieve the level of learning adherence ≥ 61%

Table 4 shows that the percentage of the number of the students who achieve the level of learning adherence ≥ 61% either in class IX A or in class IX D also is bigger than the research target achievement. Based on the students' cognitive, affective, and vocational skill learning outcomes and also based on the level of learning adherence in the broader scale test, the students are able to reach the effective criteria which are determined in the research; it means that the learning device is implemented effectively in the SMP Empu Tantular Semarang.

Next, the learning device product still enters to the final revision before it becomes a final product. The revision is done based on the lack that appear in the broader scale test and the suggestion that comes from the science teacher through the teacher questionnaire toward the learning based life skill. The input from the science teacher comes from the given material. Biotechnology sub material traditionally and modernly is still not balance so the teacher gives suggestions so that the learning process focuses not only on the traditional biotechnology but also modern biotechnology. Therefore, the material presented through the powerpoint media is multiplied with the examples and pictures of the implementation of modern biotechnology such as transgenic food plants.

The final product of this research is the learning device including syllabus, lesson plan, worksheet, and assessment instrument of affective and vocational skill. The product passes the feasibility test and effectivity so that it is declared very feasible used and effective to be implemented at SMP Empu Tantular Semarang. The biotechnology learning device based on the life skill which is implemented at SMP Empu Tantular Semarang is proven in giving a positive contribution toward the students' learning outcomes. The learning device designs the contextual learning approach, which helps the students finding the meaning of their learning by connecting the academic knowledge to their daily life context (Johnson, 2007). The students make an important connections resulting the meaning by doing the soyghurt project that they design, they also have to working together as a team, think creatively, and take part on the assignments authentic assessment.

Contextual approach is one of the learning concept that helps the teacher connecting the material to the real world situation and encourage the students to make a connection between the knowledge that they have and its implementation in their life as a family and society member. The learning outcomes obtained by the students is consider more meaningful for them, because what they have learned is useful for their future life (Irwandi, 2009). The learning outcomes obtained by the students through the developed learning device are able to give cognitive competence, affective, and vocational skill which support each other and meaningful so that it can be used for their daily life matter.

Teacher gives a positive response to the biotechnology learning based life skill which id implemented. The developed learning device is easy to understand and to used by the teacher. The biotechnology material taught to the students is the material which is needed by them

to be integrated with the vocational skill. The learning activity aimed to provide the students with the vocational skill, knowledge, and positive attitude can be accepted well by the students. they look very enthusiastic in following the learning process.

This research gives a positive thing but still far from perfectness. The product validation which is developed is still simple that is *face validity* using the assessment sheet of feasibility by the experts. The problem is limited on one school that is SMP Empu Tantular Semarang, so the product which is developed cannot be implemented to the other school which have different problem characteristic. The source of study used in this research is not adequate to maximize the potential of local society in Semarang. The raw material of the soyghurt in this research is supposed to use the soy milk raw material produced by the people from the soybean industry directly. Besides soy milk, this industry also produces liquid waste of the soybean processing becoming one of the source of river water pollution. Meanwhile, the making of soyghurt uses not only soy milk raw material, it also can use the liquid waste of soybean processing (Kristanti *et al.* 2012). It shows that this research can be developed further by maximize the people potential through the reuse of the liquid waste of soybean processing which is available to be turned into the food product in order to solve the negative effect for the environment in implementing the biotechnology.

CONCLUSION

Based on this research, it can be concluded that developing the learning device based life skill needs to be done because the learning device used by the science teacher has not integrated the fully life skill aspects yet. The assessment comes from three experts toward the product which is developed reaches the very feasible criteria with the high reability among the experts. The classical completeness for the learning outcomes covering the cognitive domain, affective, and vocational skill, also the level of learning adherence are able to reach the effectiveness of the target determined in this research, so that the learning device that is developed is declared effective to be implemented at SMP Empu Tantular Semarang.

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Development of *In Vitro* Conservation Medium of *Carica Pubescens* Lenne & K. Koch Through Nutrients Concentration Reduction And Osmoregulator Addition

Pengembangan Medium Penyimpanan *Carica pubescens* Lenne & K. Koch Secara In Vitro dengan Reduksi Konsentrasi Nutrisi dan Penambahan Osmoregulator

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Abstract

Carica pubescens Lenne & K. Koch is a rare species that need to be conserved. The research aim was to develop a slow growth method of *in vitro* conservation medium through determining some effects of nutrition decreasing availability in the conservation medium on growth and survival of explants. Establishing epicotyls reached from *in vitro* seed germination was grown on diluted basic medium of 75% MS (Murashige and Skoog), 50% MS, 25% MS, while osmoregulator compound of mannitol and sorbitol was added to the full MS medium in several concentrations. The treatments were arranged in a completely randomized design with three replications. The epicotyls were grown at storage medium for 12 and 16 weeks, then their survival were evaluated at regeneration medium and rooting medium. The diluted basic medium and osmoregulator addition were evaluated for its influence in retarding the culture growth in terms of improved survival over the period of 16 weeks. Data analyzed by one way analysis of variance and Duncan's multiple range test. The results showed that the decreasing of nutrition concentration suppressed the growth of the epicotyls until 16 weeks after conservation. Epicotyls taken from 16 weeks after conservation could grow on the regeneration medium. The best survival was shown by the 75% MS, 50% MS and supplementing of 20 g/l mannitol treatments.

Abstrak

Carica pubescens Lenne & K. Koch (karika dieng) merupakan tanaman yang langka sehingga perlu dilestarikan. Penelitian ini bertujuan untuk memperoleh medium penyimpanan *in vitro* dengan teknik pertumbuhan minimal dengan mengamati pengaruh penurunan ketersediaan nutrisi dalam medium terhadap penurunan pertumbuhan dan daya tumbuh eksplan.Eksplan berupa epikotil kecambah *in vitro*. Perlakuan penurunan ketersediaan nutrisi dilakukan melalui reduksi konsentrasi nutrisi dari medium Murashige & Skoog (MS) dan penambahan osmoregulator (manitol dan sorbitol) dengan berbagai konsentrasi. Penelitian dilakukan dengan rancangan acak lengkap satu faktor dengan tiga ulangan. Epikotil dipelihara dalam medium penyimpanan selama 12 dan 16 minggu, kemudian dievaluasi daya tumbuhnya dengan memelihara dalam medium regenerasi dan medium pengakaran. Data dianalisis dengan analisis varians satu arah dan uji Duncan. Hasil penelitian menunjukkan bahwa penurunan kecepatan penyerapan nutrisi berpengaruh terhadap pertumbuhan eksplan. Epikotil yang telah disimpan selama 12 minggu dan 16 minggu dan ditumbuhkan kembali pada medium regenerasi masih dapat tumbuh dengan intensitas tertinggi pada perlakuan pengenceran 50% MS dan 75% MS, serta penambahan manitol 20 g/l. Komposisi medium ini dapat dimanfaatkan untuk penyimpanan karika dieng selama 16 minggu tanpa sub-kultur.

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INTRODUCTION

Carica pubescens Lenne & K.Koch is a species belonging to the Caricaceae . Unlike *Carica papaja L.* (papaya) that grows and spreads in various regions, C. *pubescens* only grow in certain plateau. In Java, this species only grows optimally in Dieng Mountains, Central Java, therefore known as *dieng papaya* . At this time, *C. pubescens* is processed into various types of food and drinks, sweets, syrup, *dodol,* and it is potential to be developed into a leading commodity. However, the cultivation of *C. pubescens* is relatively limited compared to potato cultivation that is done very intensively in the area of Dieng. *C. pubescens* only grow on the roadside, land borders, or less productive land (direct observation 2008-2013). So, if the cultivation of *C. pubescens* is not developed optimally, it is concerned that this germplasm will be increasingly rare and extinct. Therefore it is necessary to do some conservation efforts because it is not cultivated specifically.

As endemic plant that produce recalcitrant seeds, the plant is suitable to be conserved in *in vitro* storage, especially with minimal growth technique. The technique is done by maintaining the plant material in a culture medium that inhibits the rate of plant growth and development. The success of *in vitro* storage method, according Uyoh et al. (2003) and Paunesca (2009) depends on the ability to 1) suppress plants' growth and development to extend the time interval between sub-cultures, 2) maintain the viability and stability of plant genetic material that is kept as much as possible, and 3) significantly save energy resource, time and cost in the conservation activities.

Culture conditions that allow minimal growth can be achieved through the use of not optimal culture medium and environmental conditions culture, by reduction of medium concentration, osmoregulator addition, plant growth inhibitor addition, and manipulation of environmental condition culture (i.e. decreasing of temperature and light duration). These factors can be combined. Planting medium recipes generally used in *in vitro* storage is Murashige and Skoog 1962 or MS (Uyoh et al. 2003). Medium nutrient reduction can be done by lowering the concentration to be ¾, ½, ¼, or even up to 1/10 of an optimal concentration. The optimal concentration for *in vitro* storage differs between one species to others (Gopal et al., 2002, Bermawie & Kristina 2003, Seswita et al., 2003, Tyagi et al., 2009, Yun-peng et al., 2012).

The giving of osmoregulator substance aims to reduce water potential in the culture medium. Osmoregulator substance often used in *in vitro* storage is sugar alcohol, such as mannitol and sorbitol. Those substances are high-weight molecular that dissolves in the water and will increase the concentration of the solution or decreasing the availability of water in the growing medium (Rajashekaran 2008, Paunesca 2009). As a result, the rate of diffusion of nutrients from the culture medium to plant material decreases, the need to grow is not sufficient and the growth declines. Osmoregulator using for *in vitro* conservation has also been widely reported, for example, the conservation of sugarcane (Sarwar & Siddique 2004), garlic (Hassan 2007), and *Coleus* (Dube et al., 2011). However, the storage medium for *C. pubescens* has never been developed.

This study aims to develop *C. pubescens in vitro* conservation medium with minimal growth techniques by nutrient concentration reduction and osmoregulator addition. Protocol of storage medium is useful as a basis for *C. pubescens* conservation as an alternative to *in situ* conservation done in the area of Dieng.

RESEARCH METHODS

The study was conducted in the Laboratory of Plant Tissue Culture, Department of Biology, Semarang State University, for 24 weeks. The plant materials were seedlings derived from *in vitro* germination of seeds. Epycotyl of 10 mm length was cut from seedling and used as explants.

The research was carried out experimentally by using completely randomized design of the nutrient concentration reduction and osmoregulator addition. Nutrient concentration reduction consisted of four level, i.e. concentration of 25%, 50% and 75% MS medium (Murashige and Skoog 1962), while osmoregulator addition consisted of five-level, they were mannitol 20%, mannitol 40%, sorbitol 20%, sorbitol 40%, and a mixture of sorbitol and mannitol consisting 20% of each substance. Osmoregulator addition was applied to the 100% MS medium. As the control 100% nutrient concentrations without the osmoregulator addition was used. Each treatment was repeated three times. Experimental units were five culture bottles each planted by one explant.

Conservation medium with various treatments made by standard techniques were poured into culture bottle size of 100 cc consisting 30 cc of each bottle. One epicotyl was planted into each culture bottle, then it was put randomly based on experimental design, in a

closed incubation room in temperature of 15 2 ° C with 40 watt light for 24 hours continuously. Partial cultures were maintained for 12 weeks, and some others were maintained up to 16 weeks with no sub-culture.

After storage for 12 and 16 weeks, the survival testing was done. In this case suvival is the explant ability to develop into complete plantlets. To test the survival, all epicotyls that have been maintained in the storage medium in the previous stage were transferred to the regeneration medium (MS + BA 2 mg / l) and root induction medium (MS + NAA 10 mg / l).

The survival was evaluated by observing the number of epicotyls that were capable to develop into normal plantlet with more than 10 mm height, consisting at least two open leaves and normal root. The parameters observed were the height of explants, the percentage of explants that formed the roots, the number of root and its length. An explant was declared formed roots when it formed at least three roots with length of ≥ 3 mm. The number of roots was determined by counting the number of roots with length ≥ 3 mm. In addition, morphological of plantlets include etiolation, browning and necrosis was also observed.

Quantitative data were analyzed by one-way Analysis of Variance and Duncan Analysis by using statistical analysis program of SAS System for Windows 9.0. Optimal conservation medium was determined by selecting the composition of the conservation medium resulting the growth of explants with minimum rate but was still be able to retain its survival to be normal plantlets.

RESULTS AND DISCUSSION

The nutrient concentration reduction and osmoregulator addition significantly affected the survival (visually it looks green and rigid) and height of epicotyls. After 12 weeks of storage, the percentage of survivable epicotyls in the MS nutrient concentration of 75% and 50% and the addition of sorbitol 20 % did not differ significantly from the control one (MS 100%), but in the other treatments of osmoregulator addition the percentage of survivable epicotyls were significantly lower than that the control. There was a tendency of the higher concentration of osmoregulator, the survivable epicotyl percentage decreases. The height of epicotyls of all nutrient concentration reduction and osmoregulator addition treatments were significantly lower compared to the control one (Table 1).

The nutrient reduction treatment also significantly influenced the survival and the height of explants after 16 weeks of storage. The survival of explants in the 75% medium concentration did not differ significantly from the control one, while in the 50% medium concentration and all treatments of osmoregulator addition was significantly lower than that the control. As in the 12-week storage period, the height of epicotyls on all treatments of nutrient concentration reduction and osmoregulator addition significantly lower than that the controls (Table 1).

All of epicotyls maintained in the 75% and 100% medium were able to grow, while in the 25% MS they were not able to grow (Table 1). Explants performance in the conservation medium of 75% MS (Figure 1B) was similar to the control (Figure 1A). Otherwise, in the medium of 50%, the chlorosis happened and some leaves fell (Figure 1C). This fact occurs as a result of non-optimal nutrient availability interferes with metabolic processes of plant, that turns to inhibit their growth. Growth is an expression of the integration of the various biochemical reactions, biophysical phenomenons and physiological processes in plant cells with external factors. Optimal plant growth can be achieved when environmental factors (for example nutrients) are in adequate number. If a factor is not balanced with other factors, this factor can reduce or even sometimes stops the growth of plants (Taiz & Zeiger 2010).

The observation results showed that the *C. pubescens* explants had relatively slow growth and proliferation properties, so it could be stored in concentration of 50% or 75% without sub-culture. This result is consistent with the research result on vanilla that can be stored in ¾ MS medium without sub-culture (Seswita et al. 2003); and the cardamom that can be conserved in the medium of ½ MS (Tyagi et al., 2009).

The addition of mannitol and sorbitol in many concentrations also affected the percentage of the growth of healthy explants (characterized by morphological that is fresh and green) and the height of epicotyls. The data showed that the higher of the osmoregulator concentration, the lower the value of both parameters. The shortest epicotyls resulted from the mannitol treatment of 20 g/1 + sorbitol 20 g/1 were not significantly different from mannitol treatment 40 g/1 (Table 1). The osmoregulator addition is able to lower osmotic potential in the medium (Serraj & Sinclair, 2002) that slows the absorption of nutrients and lower the growth rate (Taiz & Zeiger, 2005). On two wheat genotypes, decrease of osmotic potential due to the osmoregulator

Table 1. The survival and the height of epicotyls in 12 and 16 weeks of conservation period from various conservation medium treatments

No	Conservation medium	Conservation periods			
		12 weeks		16 weeks	
		Survival percentage (%)	Height(mm)	Survival percentage(%)	Height(mm)
	Nutrients concentration (%)				
1	100	100 a	33,4 a	100 a	36,4 a
2	75	100 a	22,2 b	100 a	24,6 b
3	50	87 ab	15,7 c	67 b	16,2 c
4	25	0d	0 e	0 d	0 f
	Osmoregulator addition(g/l) on MS 100%				
5	mannitol 20	80 b	14,8c	53 c	16,0 cd
6	mannitol 40	67 c	12,5 cd	53 c	13,1 de
7	sorbitol 20	87 ab	15,6 c	53 c	16,2 cd
8	sorbitol 40	67 c	13,2 cd	53 c	14,3d
9	manitol 20 + sorbitol 20	67 c	11,5d	33 d	13,0 de

* Numbers followed by the different letter in a column indicate significantly different based on Duncan test with significance level of 5%

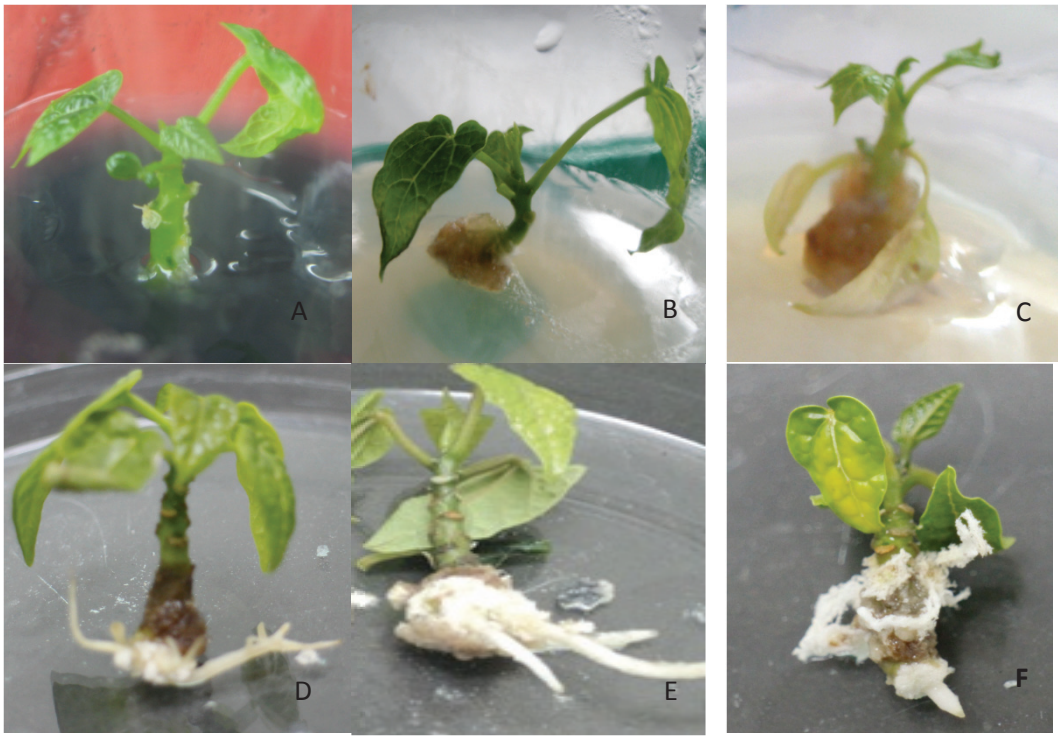

Figure 1. Performance of explants in the conservation medium and after root induction. Explant in conservation medium of 100% MS (A), 75% MS (B) and 50% MS (C). Roots formed from explants were stored in the conservation medium of 100% MS (D), 75% MS (E) and 50% MS (F).

addition negatively affected on the growth of callus (Javed & Ikram, 2008).

Several previous studies have also concluded that the addition of osmoticum material in the medium can inhibit the growth of explants. Medium added by 0.1M sorbitol inhibits the growth of shoots, root length, and the number of garlic roots (*Allium sativum* L.) cv *peds-40* which was stored for 18 months. During the storage time there are no seedling growing, then

after 18 months the percentage of survived tubers reach up to 100% (Hassan, 2007). Research result of Dube et al. (2011) showed that the optimal concentration of mannitol for *Coleus forskohlii* Briq. storage is 4 M.

To determine the effectiveness of the conservation medium, epicotyls that had been grown in the conservation medium during a certain time was tested its growing potency by planted it in regeneration medium, i.e. MS + BA 2 mg / l for 4 weeks. Growing potency was shown by the growth of stems and leaves, both in quantity and morphology. Result showed that the decreasing of the nutrients availability in the conservation medium affected the growing potency after being transferred to the regeneration medium. Treatment of nutrient concentration decreasing of 75% and 50% did not result in decreasing growing potency in the regeneration medium, either after the storage of 12 weeks or 16 weeks. This was indicated by the parameters of increasing of height and leaves after being maintained in the regeneration medium; both those parameters did not differ significantly between the treatment of nutrient concentration of 100%, 75% and 50%. The addition of 20% mannitol and 20% sorbitol resulting in increasing of height and leaves was not different from the control one; whereas another treatment significantly lowered both parameters (Table 2). The results showed that the concentration of nutrients conservation medium of 75% and 50%, and the addition of 20% mannitol and 20% sorbitol did not reduce the growth potency or regeneration ability after the plantlet was taken from conservation medium.

Epicotyls successfully grew, were induced to form roots by maintaining them in the medium of MS + 10 mg / l NAA for 4 days, then they were transferred to MS medium without PGR for 1 week. Result showed that the lowering of nutrient absorption in the conservation medium affected the root growth after being transferred to root induction medium. The treatment of nutrient concentration of 75% and 50% did not decrease the ability of explants to form roots, both of after the storage of 12 and 16 weeks. This statement was indicated by the parameters of explants percentage that can form roots and the average number of formed roots. There was no significant difference in those parameters of the treatment of nutrient concentrations of 100%, 75% and 50% (Table 3, Figure 1D, 1E, 1F).

Osmoregulator addition inhibited root formation; epicotyls percentage that was able to form roots and number of root of all treatment of osmoregulator addition was significantly lower than the control, except for the addition of 20% mannitol and 20% sorbitol for 12 weeks. Epicotyls stored for 16 weeks in the various treatment of osmoregulator addition was able to form roots and number of root was significantly lower than that the control, except for the addition of 20% mannitol (Table 3).

Reduction of nutrient concentration of 75% and 50% significantly decreased the height of epicotyls during conservation period (Table 1), but when it was returned to the regeneration

Table 2. Epicotyls growth response after being conserved for 12 and 16 weeks in regeneration medium.

No	Conservation medium	Conservation period			
		12 weeks		16 weeks	
		Height (mm)	Leaves number	Height (mm)	Leaves number
	Nutrients concentration (%)				
1	100	9,2 a	2,3 a	11,4 a	2,0 a
2	75	10,0 a	2,7 a	10,6 a	2,3 a
3	50	10,2 a	2,0 a	11,2 a	2,3 a
4	25	-	-	-	-
	Osmoregulator addition (g/l) on MS 100%				
5	mannitol 20	9,8 a	2,3 a	6,0 b	2,3 a
6	mannitol 40	3,5 c	0,7 c	2,1d	0,0 c
7	sorbitol 20	7,6 ab	1,7 b	6,2 b	2,7 a
8	sorbitol 40	2,2 d	0,0 d	3,3cd	1,0 c
9	mannitol 20 + sorbitol 20	1,5 d	0,3 d	3,0 d	0,0 c

* Numbers followed by the different letter in a column indicate significantly different based on Duncan test with significance level of 5%

Table 3. The growth of root after being conserved for 12 and 16 weeks in root induction medium

No	Conservation medium	Conservation period			
		12 weeks		12 weeks	
		Percentage of rooted epicotyls	Number of root	Percentage of rooted epicotyls	Number of root
	Nutrients concentration (%)				
1	100	100 a	6,6 a	100 a	5,3 a
2	75	100 a	6,1 a	100 a	5,8 a
3	50	100 a	5,5 a	100 a	4,9 ab
4	25	-	-	-	-
	Osmoregulator addition (g/l) on MS 100%				
5	mannitol 20	100 a	6,3 a	85 b	5,4 a
6	mannitol 40	40 c	4,0 b	30 c	3,3 c
7	sorbitol 20	87 b	5,5 a	50 c	3,4 c
8	sorbitol 40	40 c	3,7 b	40 c	3,2 c
9	mannitol 20 + sorbitol 20	30 c	3,1 bc	40 c	2,4 cd

* Numbers followed by the different letter in a column indicate significantly different based on Duncan test with significance level of 5%

medium epicotyls grew, formed normal leaves (Table 2) and roots (Table 3). This condition did not significantly different with the control. Based on the data it can be stated that the nutrient concentration of 75% or 50% MS was effectively used for *in vitro* conservation of *C. pubescens* for 16 weeks with no sub-culture, so it can save energy and cost, while negative influence of genetic such as somaclonal due to frequent sub-culture can be avoided.

Osmoregulator addition with concentration total of 60%, 40% and 20% resulted in the withered of explant of 100%, 33%, and 13-20%, respectively, in 16 weeks conservation period; and 100%, 67% and 47%, respectively, in 12 weeks conservation period (Table 1). The survival after the conservation period had the same tendency. The survival of explants grown in medium added by 20% mannitol was not significantly different from the control (Table 2, Table 3). This result is in line with the finding on pepper (*Capsicum chinense* Jacq.), where the addition of 2% mannitol results minimum growth of plantlets and it does not negatively affect its physiology and quality; whereas the addition of sorbitol decreases the quality of plantlets (Montalvo-Peniche et al. 2007).

Because osmoregulator compounds can inhibit the growth of explants and in certain concentration it can maintain the explants growing potency, it can be stated that the addition of osmoregulator can be used as a compound of efficient *in vitro* conservation. Osmoregulator additon also has many advantages, such as stored culture is alive and growing very slow, so it can save people work for sub-culturing and save the cost of medium production. Besides, the decreasing of growth keep viability and genetic stability , because somaclonal variation can be avoided. Somaclonal variation can occur when cultures are sub-cultured repeatedly (Pontaroli & Camadro 2005). Therefore the recommended addition of osmoregulator for *in vitro* conservation of *C. pubescens* is 20% mannitol concentration.

CONCLUSION

Based on the research it can be concluded that nutrient concentration reduction of 75% and 50% of the MS basic formulation and mannitol addition of 20g/l decreased the growth of *C. pubescens* in *in vitro* conservation for 16 weeks, and maintained its survival after being returned to the regeneration medium. Based on the results, the nutritional composition of 50% and 75% of MS as well as the addition of mannitol 20 g/l on MS medium can be used for *in vitro* conservation of *C. pubescens* without sub-culture for 16 weeks

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Effectivity of Pedada Fruit (*Sonneratia caseolaris*) Extract to The Level of SGOT and SGPT in Rat Treated by Paracetamol Induction

Efektivitas Ekstrak Buah Pedada (*Sonneratia caseolaris*) terhadap Kadar SGOT dan SGPT Tikus Putih yang Diinduksi Parasetamol

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Abstract

The study was aimed to determine the effectiveness of pedada fruit extract as a hepatoprotector in the experimental rat that fed by toxic dose of paracetamol. The total of 30 white rats (Wistar strain, two months age, and 150-200 g weight) were randomly divided into 5 groups. Group I (normal control) only given distilled water for 7 days). Group II (negative control) that given distilled water for 7 days and then treated by 270 mg/head single dose of paracetamol. Group III, IV, and V (treatment group) were given a pedada fruit extract at a dose of 28 mg/head/day, 56 mg/head/day, and 84 mg/head/day for 7 days and then treated by 270 mg/head single dose of paracetamol. On the 9th day of treatment, the blood samples were taken and were further measured for its SGOT and SGPT level using photometry enzymatic method. The result of LSD test on SGOT and SGPT data showed that III, IV, and V groups were not significantly different to the group I ($p>0.05$). However, it significantly different with the group II ($p <0.05$). Data of SGOT showed that group IV were significantly different ($p <0.05$) with the group V. Whereas, the data of SGPT among groups III, IV, and V were not significantly different ($p>0.05$). The result of linier regression test indicated that dose 28 mg/head was the most effective dose. It was concluded that pedada fruit extract was able to provide a hepatoprotective effects in rats that fed by toxic dose of paracetamol and most effective dose as a hepatoprotector was 28mg/head/day.

Abstrak

Penelitian ini bertujuan untuk mengetahui efektivitas ekstrak buah pedada sebagai hepatorotektor tikus putih yang diberi parasetamol dosis toksik.Sebanyak 30 ekor tikus putih (strain Wistar jantan berumur dua bulan dengan berat badan 150-200 g) dibagi secara acak dalam lima kelompok.Kelompok I (kontrol normal) diberi aquadest selama tujuh hari.Kelompok II (kontrol negatif),diberi aquadest selama tujuh hari dilanjutkan pemberian parasetamol 270 mg/ekor dosis tunggal.Kelompok III, IV, dan V (kelompok perlakuan) diberi ekstrak buah pedada pada dosis 28 mg/ekor/hari, 56 mg/ekor/hari, dan 84 mg/ekor/hari selama tujuh hari dilanjutkan pemberian parasetamol 270 mg/ekor dosis tunggal. Hari ke-9 darah diambil dan diukur kadar SGOT dan SGPT dengan metode fotometri enzimatik. Hasil uji LSD data SGOT dan SGPT menunjukkan bahwa kelompok III, IV, dan V tidak berbeda nyata terhadap kelompok I ($p>0,05$), namun berbeda nyata terhadap kelompok II ($p<0,05$). Data SGOT kelompok IV berbeda nyata ($p<0,05$) dengan kelompok V. Data SGPT tidak ada perbedaan nyata ($p>0,05$) antara kelompok III, IV, dan V. Hasil uji regresi linier, dosis 28 mg/ekor adalah dosis paling efektif.Disimpulkan bahwa ekstrak buah pedada mampu memberikan efek hepatoprotektor pada tikus yang diberi parasetamol dosis toksik dan dosis yang paling efektif sebagai hepatoprotektor adalah dosis 28 mg/ekor/hari.

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INTRODUCTION

Liver is the largest organ in the body and the most complex one. it composed of liver cells (hepatocytes) that play role in the metabolism of nutrients, drug and toxicant. The liver performs more than 500 functions, including (1) production of bile (2) production and secretion of glucose, proteins, vitamins, fats and other compounds (3) breakdown of hemoglobin (4) conversion of ammonia to urea (Haws, 2008). Liver is the main place of amino acid metabolism in the body and also the main place urea synthesis. It is the only organ that has all lines to form and break down the amino acid through transamination reaction. The enzyme that catalyzes this reaction is known as transaminase or aminotransferase (Marks et al., 2000). Therefore, liver is one of organs that contain a lot of aminotransferase enzymes.

Disease caused by impaired liver function is a major problem in the world of health. Until now, liver disease affects hundreds of millions people around the world, causing acute and chronic illness and approaching 1.4 million people die every year (WHO 2013). Liver damage is caused by microorganisms such as viruses and bacteria, while the use of drugs, alcohol, chemicals and environmental toxins can also lead to lever damage (Eswaraiah et al. 2013). Chemical and drug that can lead to liver damage (hepatotoxicity), are alcohol, carbon tetrachloride (CCl_4), galactosamine, paracetamol, isoniazid and rifampicin, antibiotic, peroxidised oil, and aflatoxin (Sowjanya et al. 2013).

One indicators of liver damage is increasing the level of liver enzymes in the serum, including the level of SGPT and SGOT (Wahyuni 2005). Serum Glutamate Pyruvate Transaminase (SGPT) and Serum Glutamate Oxaloacetate Transferase (SGOT) is an aminotransferase enzyme that catalyzes the reversible transfer of amino acid group of amino acid to alpha-keto acid (Sacher & McPherson 2004). SGPT and SGOT enzymes are sensitive indicators of liver cell damage (Barlett, 2004). Liver damage can lead to permeability membrane damage so the intracellular enzyme freely exit and enter the extracellular space and blood vessels (Krysanti & Widjanarko 2014).

Diseases caused by liver damage can occur to all level of people in any level of age, gender or economic level. Therefore, the use of natural materials as traditional medicine has started to be developed. This increases community awareness of the side effects caused by synthetic drugs that is greater than the natural drug or medicine (Armansyah et al. 2010). In addition, the price is much cheaper than synthetic drugs, natural medicine is faster and easier to obtain. Therefore, it is necessary to find an alternative treatment to prevent liver damage by using traditional medicine such as *Pedada* fruit (*Sonneratia caseolaris*).

Pedada fruit (*Sonneratia caseolaris*) has 24 components including eight steroids, nine triterpenoids, three flavonoids and four derivatives of benzenecarboxylate (Varghese et al., 2010). The component has function as an anti-inflammatory, analgesic, antioxidant, anti-allergic, anti-fungal and anti-microbial. Triterpenoids also serves as the prevention and treatment of hepatitis (Peteros & Uy 2010). Flavonoids in *Pedada* fruit (*Sonneratia caseolaris*) also have antioxidant activity (Shadu et al. 2006).

There are three bioactive components of methanol extracts *Pedada* fruit (*Sonneratia caseolaris*), which are oleanolic acid, β-sistosterol-β-D-glukopyranoside and luteolin. Oleanolic acid in *Pedada* fruit was able to inhibit α-glucosidase enzyme and act as active component of antihyperglicemic (Tiwari et al. 2010). Oleanolic acid has hepatoprotective activity, anti-inflammatory, antimicrobial, hypoglycemic, antimutagen, antioxidants and antifertility (Furtado et al., 2008). Oleanolic acid is derived from triterpenoids which protects from various hepatotoxins in animals (Reisman et al., 2009). In a low dose, oleanolic acid generates adaptive response, whereas at high doses it can cause hepatotoxicity (Liu 2005).

According to Charoenteeraboon et al (2007) research, parts of *Sonneratia caseolaris* like calyx, seeds, fruit skins, pulp, seeds, petals, pneumatophore, and stamen have hepatoprotective activity. Hepatoprotective (liver protector) is a drug compound that has the therapeutic effect, to restore, maintain, and treat the damage of liver function. Based on its content, therefore the effectiveness of *Pedada* fruit against liver damage in rats was conducted.

As previously mentioned, one of the drugs that can lead liver damage is paracetamol which is in fact widely used by the society, the misuse of paracetamol can cause poisoning. Paracetamol or acetaminophen is an analgesic and antipyretic drug that is used for the treatment of various conditions of arthritis, rheumatism, joint pain and other diseases such as headache, pain during menstruation (dysmenorrhea), muscle pain (myalgia), and nervous system pain (neuralgia). Paracetamol overdose is often associated with acute liver and kidney damage in humans and experimental animals (Pierro & Rossoni 2013).

The recommended dose is 1-2 g/day. It does not irritate the stomach, kidney cell and liver cell, but high doses (> 2 g / day) of paracetamol may affect complications in the intestines, stomach, kidney function and liver damage (Malar & Mettilda 2012). In single dose (15 g or more), paracetamol can cause liver damage through toxic metabolites of NAPQI (N-Acetyl-P-benzoquinone imine) (Clark et al. 2012). At therapeutic doses, NAPQI reacts with sulfhydryl groups of glutathione into non-toxic metabolites and it is excreted through the urine. Whereas in excessive doses of NAPQI, it increases beyond the ability of glutathione to detoxify, so the metabolite reacts with liver cells that lead necrosis centrilobular (Darsono 2002).

The formation metabolites NAPQI in large numbers and decreasing the number of hepatic glutathione causes oxidative stress cell and necrosis or liver damage (Gopalakrishnan & Kalaiarasi 2013). Oxidative stress can disrupt the hepatocyte membrane integrity resulting in the release of various enzymes from hepatocytes, for example SGOT and SGPT (Armansyah et al. 2010). Liver damage can increase blood lipid peroxide because lipid peroxide of the body cannot longer be detoxified in the liver (Heirmayani 2007). Giving *Pedada* fruit could inhibit the occurrence of lipid peroxide and it is able to increase glutathione that is responsible for maintaining the antioxidant (Furtado et al., 2008).

Based on the description, liver damage can be detected by measuring levels of SGOT and SGPT in the blood. On the other hand, *Pedada* fruit content has a role as hepatoprotector. Therefore, this study will assess the effectiveness of *Pedada* fruit extract (*Sonneratia caseolaris*) as hepatoprotector of white rat (*Rattus novergicus*) induced by toxic dose of paracetamol.

RESEARCH METHODS

This research was a lab experiment. The design used was Post Test Randomized Control Design with Completely Random Design. Experimental animals used in this research are 30 male Wistar strain rats aged two months, weight of 150-200 g that were obtained and maintained in LPPT Unit 4 Gajah Mada University.

Hepatoprotector test material used was 85% methanol extract of *Pedada* fruit (*Sonneratia caseolaris*) from Randusanga, Brebes area. Ripe fruit was cleaned, cut into small pieces, and dried for 15 days under the sunlight. Then it is blended up into coarse powder, and extracted by using soxhlet method. The extraction was stored in refrigerator at a temperature of 7-10 ° C (Hasan et al. 2013). Hepatotoxic inducer material used is paracetamol doses of 270 mg/rat /single dose.

Thirty rats were randomly divided into five groups. Group I (control normal) were given only distilled water for seven days. Group II (control negative), were given distilled water for seven days and then continued by giving single dose of paracetamol of 270 mg/rat. Group III, IV, and V (treatment group) were fed by *Pedada* fruit extract at dose of 28 mg/rat/day, 56 mg/rat /day, and 84 mg/rat/day for seven days and then continued by giving single dose of paracetamol of 2,7ml/each single dose. On the 9th day, blood samples were taken to measure the level of SGOT and SGPT.

Blood samples were drawn through *plexus retroorbitalis* by using microhematocrit and collected in 1.5 mL eppendorf tubes to the brim, and then waited for 60 minutes in order to separate serum from blood. Furthermore, it was centrifuged at 4000 rpm for 10 min or 12,000 rpm for 2 minutes to get serum. Then the activity of SGOT and SGPT was read by using enzymatic photometric method.

The data were normally distributed and homogeneous, then One Way ANOVA test with 95% significance level was performed. The result showed that it has significant effect, then LSD test with 95% significance level was performed to determine the most effective dose by using the Linear Regression test. Data analyses were performed by using Statistical Product and Service Solutions (SPSS) 16.0 for Windows (Santosa 2005).

RESULTS AND DISCUSSION

The results showed that each group of rats showed variations of the level of SGOT and SGPT. Shapiro-Wilk test results indicated that the data of SGOT and SGPT were normally distributed ($p > 0.05$) and variant of data was homogeneous ($p > 0.05$). One Way ANOVA test result showed the level of SGOT and SGPT had significance value of 0.000 or less than 0.05 significance level ($p < 0.05$), it means that the *Pedada* fruit extract can give significant effect on the level of SGOT and SGPT of rats that are given the toxic dose of paracetamol. To find out the difference of five treatment groups, further LSD test at 5% level was conducted. Result of statistical test of SGOT and SGPT can be seen in Table 1.

The average level of SGOT and SGPT in group II (control negative) was higher (119.18

Table 1. Statistics Test Result of SGOT and SGPT Level (U/L).

Group	SGOT (Rerata ± SD)	SGPT (Rerata ± SD)
I (Control normal)	89,05 ± 9,08[a]	49,72 ± 10,56[a]
II (Control negatif)	119,18 ± 8,21[b]	69,80 ± 1,59[b]
III (Pedada fruit extract dose of 28 mg)	88,08 ± 11,29[a]	48,62 ± 3,09[a]
IV (Pedada fruit extract dose of 56 mg)	78,42 ± 5,97[ac]	52,08 ± 10,99[a]
V (Pedada fruit extract dose of 84 mg)	96,08 ± 12,86[ad]	55,10 ± 6,83[a]

Note : Numbers followed different letters in the same column showed significant difference ($p < 0,05$) of LSD test at 5% level.

U / L and 69.80 U / L) than group I (normal control) (Table 1). Based on the result of further LSD test showed that group II (control negative) had significant difference ($p < 0.05$) of group I (control normal). It means that the paracetamol of dose of 270 mg/rat can bring damage effects on the rats' liver. According to Clark et al. (2012), a single dose of paracetamol (15 g or more) can cause liver damage by toxic metabolites of NAPQI (N-acetyl-para-benzoquinoneimine)

Paracetamol toxic dose lead to increase of N-acetyl-para-benzoquinoneimine (NAPQI) formation and lipid peroxide concentration. Lipid peroxides are formed due to liver cells are not able to prevent oxidation caused by free radicals of N-acetyl-para-benzoquinoneimine. Antioxidant process is only done naturally by enzymes contained in the body that have smaller number than free radicals, thus hepatic glutathione is getting decreasing. This is consistent with Rustandi (2006) that the group of rats that were given paracetamol increased lipid peroxide concentrations during treatment with concentration of 60.42% that was higher than the normal group.

The formation of high amounts of reactive metabolites NAPQI and decreasing the number of hepatic glutathione will enhance the Radical Oxygen Species (ROS). The increasing of ROS that is not accompanied by the increasing of antioxidant will lead oxidative stress. Free radicals damage cell membranes, mitochondria and endoplasmic reticulum resulting the increasing of cytosolic Ca^{2+}. The increasing of cytosolic Ca^{2+} will activate the phospholipase, protease, endonucleases, and ATPase enzymes which phospholipids decreasing, membrane proteins and cytoskeleton disruption, DNA fragmentation, and ATP decreasing. These conditions will initiate the death of liver cells (necrosis) or liver damage (Sulistyowati et al. 2013). Liver damage will cause the release of intracellular enzymes, including SGOT and SGPT. The intracellular enzyme will increase its level in the serum so it can be indicator of liver damage (Wahyuni 2005).

Hepatoprotector effect in *Pedada* fruit extracts was shown from the average difference level of SGOT and SGPT among group II and group III, IV, and V. Rats given *Pedada* fruit extract and paracetamol toxic dose had lower average level of SGOT and SGPT compared to rats who were not given *Pedada* fruit extracts but given toxic dose of paracetamol. Statistical analysis by LSD test, showed that group II had significant difference to the groups III, IV, and V. This means that *Pedada* fruit extracts at dose of 28 mg/rat/day, 56 mg/rat/day, and 84 mg/rat/day were able to provide hepatoprotector effect due to the consumption of toxic doses of paracetamol. Hepatoprotector effect showed by *Pedada* fruit extracts was probably caused by the presence of secondary metabolites that have antioxidant and hepatoprotector activity.

According to Wu et al. (2009), there are nine compounds contained in methanol extracts of *Pedada* fruit (*Sonneratia caseolaris*) including (-)-(R) -nyasol; (-)-(R) -4'-O-methyllnyasol; 3,8-dihydroxy-6H-benzo [b, d] Pyrans-6-one; 3-hydroxy-6H-benzo [b, d] Pyrans-6-one; oleanolic acid; maslinic acid; luteolin; luteolin 7-O-β-glucoside; and benzyl-O-β-glucopyranoside. Luteolin and luteolin 7-O-β-glucoside are flavonoid compounds that have antioxidant activity (Shadu et al. 2006). Flavonoids are supposed to influence in inhibiting liver damage by binding free radicals produced by paracetamol so the impact to the liver is reduced.

Oleanolic acid is a pentacyclic triterpenoid compounds that can be found in plants in the form of the free acid and has important role in inhibiting lipid peroxide and increasing glutathione (Furtado et al.2008). Oleanolic acid compound is seen to be able to protect liver cells from toxic materials. Oleanolic acid is an Nrf2-ARE pathway activator, where this pathway has an important role in the regulation of genes that control the expression of proteins in detoxifying and eliminating electrophilic (Nguyen et al.,

2009).

Nrf2 (nuclear factor erythroid 2-related factor 2) is a transcription factor that induces antioxidant and cytoprotective genes or known as Human Antioxidant Response Element (ARE) (Reisman et al. 2009). ARE is enhancer sequence action or element arrangement found in the promoter region of many genes in detoxification and antioxidant enzymes. Oleanolic acid is ARE inducer that stimulates Nrf2-ARE pathway so this line will work optimally. Oleanolic acid will increase the activity of Nrf2, then this Nrf2 activates transcription by identifying the parts of the connective tissue of ARE so antioxidant genes such as glutathione will be expressed. The increasing of antioxidants in the body such as glutathione will also increase the Total Antioxidant Status (TAS). Increasing will inhibit the occurrence of free radical and electrophilic caused by toxic dose of paracetamol.

Based on the result of LSD test of SGOT, it showed that the group III, IV, and V did not have significant differences (p> 0.05) to group I (control normal). Group III (28 mg dose) did not have significant differences (p> 0.05) to group IV (56 mg dose) and group V (dose 84 mg). Meanwhile, there was significant differences (p <0.05) between group IV and V group, although both of those groups can still prevent the increasing of SGOT level.

The average levels of SGPT of groups III, IV, and V are 48.62 (U / L), 52.08 (U / L), and 55.10 (U / L). Based on the results of LSD test with 95% significance level, it was found out that among those three dose groups, they did not have significant differences (p> 0.05) to the control normal group (49.72 U / L). So, based on the result of LSD test of SGOT and SGPT showed that *Pedada* fruit extract at doses of 28 mg/rat / day, 56 mg/rat/day, and 84 mg/rat /day already provided hepatoprotective effect due to the giving of toxic doses of paracetamol and the dose of less than 28 mg/rat also had possibilities of having hepatoprotective effect, while the dose of 84 mg/ rat gave hepatotoxic effects.

In this research, to determine the most effective dose of *Pedada* fruit extract as hepatoprotective in rats, the statistical test of linear regression was performed. Regression analysis of SGOT data indicated there was relationship between dose of *Pedada* fruit extract and SGOT level with the linear regression equation model of Y = 69.867 + 0,315X (Figure 1). It means that when the dose of *Pedada* fruit extract is 0 (zero) then SGOT level will be at 69.867 point and every increasing of 1 (one) dose of extract, SGOT level will increase 0.315. Positive coefficient (+0.315) means that there was a positive relationship between the increasing of *Pedada* fruit extract dose, and the increasing of SGOT level, so it was less effective as hepatoprotector. Dose of 28 mg/ rat/day had lower Y value (78.687) compared to dose of 56 mg/rat/day and 84 mg/rat/day (87.507 and 96.327). So, *Pedada* fruit extract at dose of 28 mg / head / day dose was the most effective in lowering SGOT level because it has the lowest predictive value of SGOT (Y) level.

Regression analysis of the SGPT data indicated that there was relationship between *Pedada* fruit extract dose and SGPT level with linear regression equation model of Y = 45.453 + 0,116X (Figure 2). It means that when the dose of *Pedada* fruit extract is 0 (zero) then SGPT level will be at 45.453 SGPT levels and and every increasing of 1 (one) dose of extract, SGPT level will increase 0.116. Positive coefficient (+0.116 means that there was a positive relationship between the increasing of *Pedada* fruit extract dose, and the increasing of SGPT level, so it was less effective as hepatoprotectior. Dose of 28 mg/ rat/day had lower Y value (48.701) compared compared to dose of 56 mg/rat/day and 84 mg/ rat/day (51.949 and 55.197). So, *Pedada* fruit extract at dose of 28 mg / head / day dose was the most effective in lowering SGPT level because it has the lowest predictive value of SGPT (Y) level.

The difference of the result between the level of SGOT and SGPT was because SGOT is the enzyme that is not only produced by the liver but the heart, skeletal muscles, kidney and brain, too while SGPT is the enzyme that can be found most in the liver in large numbers (Sadikin 2005). Therefore, more specific parameter to indicate the damage of liver cells is by observing the SGPT enzyme activity, because most of this enzyme is mostly produced in the liver (Kendran et al. 2013). The increasing of SGOT level also happens when liver tissue is damaged, both of the enzyme activities are measured to measure the liver damage (Sadikin 2002). In addition, both of SGOT and SGPT enzymes can routinely be checked in daily examination to determine the condition of the liver (Sibuea et al.2005). In this research, *Pedada* fruit extract is most effective used as hepatoprotector in rat by emphasizing of looking at the results of SGPT level measurement.

Based on the result of linear regression test it showed that the higher dose of *Pedada* fruit extract, the lower the effectiveness of rats hepatoprotector induced by toxic dose of paracetamol. This is due to compound that is

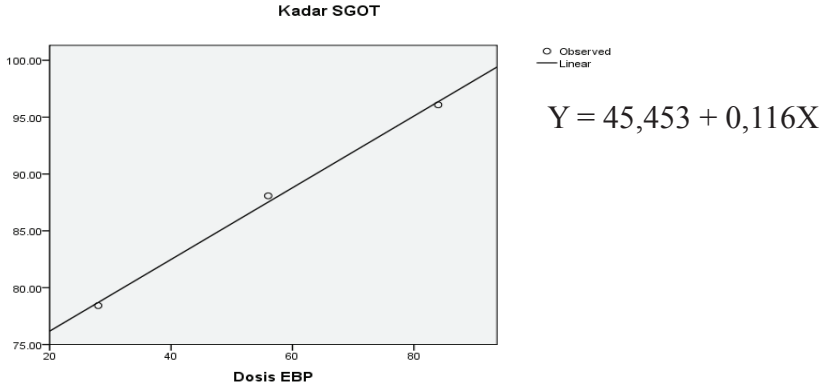

Figure 1. Linear Regression Line between Dose of *Pedada* Fruit Extract and SGOT

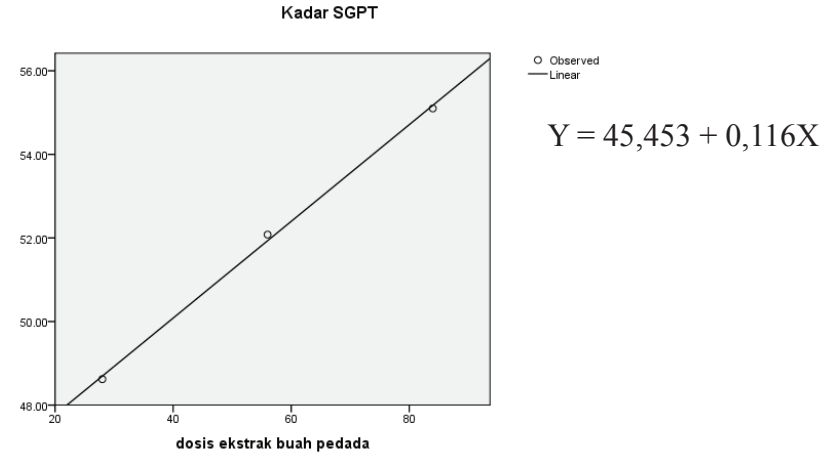

Figure 2. Linear Regression Line between Dose of *Pedada* Fruit Extract and SGPT

antagonists towards hepatoprotector. According to Liu (2005), oleanolic acid contained in *Pedada* fruit has hepatoprotector activity in low doses and hepatotoxic in high doses. The possibility of the compound (-) - (R) -nyasol, (-) - (R) -4'-O-methyllnyasol, and maslinic acid also affects the increasing of SGOT and SGPT level. All those compounds have cytotoxic properties in the body (Wu et al., 2009). The higher dose of *Pedada* fruit extract, the higher the oleanolic acid content, (-) - (R) -nyasol, (-) - (R) -4'-O-methyllnyasol, and maslinic acid so its activity is no longer as hepatoprotector.

Pedada fruit extract dose used in this study refers to Hasan et al (2013) research, about methanol extract activity of *Pedada* fruit as hypoglycemic. The study explained that the highest dose of *Pedada* fruit extract of 400 mg/kg body weight was able to lower blood sugar level in mice effectively compared to doses of 50 mg/kg, 100 mg/kg and 200 mg/kg. In this study, dose of 200 mg/kg in mice or equal to 28 mg/rat was the most effective dose to prevent liver damage due to toxic dose of paracetamol, but apparently it has not been used as a treatment for liver damage. Therefore, it is necessary to conduct further research on the use of *Pedada* fruit extract as treatment for of liver damage disease.

The results showed that the methanol extract of *Pedada* fruit was able to provide hepatoprotector effect by preventing the increasing of SGOT and SGPT level in rats that were given toxic dose of paracetamol and the most effective dose used as hepatoprotector is 28 mg/rat/day.

CONCLUSION

Based on the result of this research it can be concluded that methanol extract of *Pedada* fruit (*Sonneratia caseolaris*) was able to provide

hepatoprotector effects in rats induced by toxic dose of paracetamol and the most effective dose used as hepatoprotector is 28 mg/rat/day.

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Kajian Kualitatif Kemelimpahan Spesies Burung di Hutan Pegunungan Telaga Bodas, Garut, Jawa Barat

Qualitative Assessments of Bird Species Abundance in The Telaga Bodas Mountains Forest, Garut, West Java

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History Article

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Abstrak

Tujuan penelitian adalah untuk melengkapi *list* spesies burung-burung penetap di hutan pegunungan Jawa Barat dan mengkaji secara kualitatif kemelimpahan dari keragamannya di salah satu hulu DAS Citandui, yaitu di hutan Telaga Bodas, Garut, Jawa Barat. Metode penelitian menggunakan TSCs (*Time Score Counts*), yang dilakukan pada 25-29 April 2014. Sebanyak 51 spesies burung ditemukan di hutan Telaga Bodas. Diantaranya, sepuluh spesies memiliki rata-rata skor kemelimpahan tinggi, yaitu: *Collocalia linchi* (5.82), *Halcyon cyanoventris* (4), *Pycnonotus aurigaster* (3.73), *Cacomantis merulinus* (3.27), *Zosterops palpebrosus* (2.91), *Orthotomus sutorius* (2.82), *Tesia superciliaris* (2.63), *Pycnonotus goiavier* (2.55*), Lanius schach* (2.45) dan *Lonchura leucogastroides* (2.27). Hasil komparasi indeks kesamaan spesies burung di beberapa DAS Citandui menunjukkan nilai tertinggi terjadi antara komunitas burung di Telaga Bodas vs G. Sawal, yaitu IS=62.3%. Sementara itu, indeks kesamaan spesies burung di G. Telaga Bodas vs G. Geder terendah, yaitu IS=39.25%. Hasil penelitian menunjukkan bahwa tutupan lahan hutan di wilayah hulu DAS Citandui sangat kaya dengan spesies burung, 35 dari 108 spesies burung hanya tersebar terbatas, endemik dan migran di hutan pegunungan Jawa Barat. Oleh karena itu, pengelolaan kawasan hutan pegunungan di Jawa Barat diperlukan langkah bijak apabila tidak ingin kehilangan fungsinya.

Abstract

The purpose of this research was to compile the list of the resident bird species in the West Java mountain forests and to examine the abundance of their diversities qualitatively in the one of Citandui Riverine Basin, i.e. the Mts.Telaga Bodas forest, Garut, West Java Province. TSCs (Time Score Counts) method was used to record the bird's abundance during 25 to 29 April, 2014. At least, 51 species of birds were recorded in the Telaga Bodas forests. There were 10 species of birds found more abundant qualitatively, namely: *Collocalia linchi* (5.82), *Halcyon cyanoventris* (4), *Pycnonotus aurigaster* (3.73), *Cacomantis merulinus* (3.27), *Zosterops palpebrosus* (2.91), *Orthotomus sutorius* (2.82), *Tesia superciliaris* (2.63), *Pycnonotus goiavier* (2.55*), Lanius schach* (2.45) and*Lonchura leucogastroides* (2.27). According to the result of similarities index comparation, of birds species (SI), itknown that birds comunities in the Mt.Telaga Bodas vs Mt.Sawal were highest, i.e.. SI=62.3%, and then between Mt.Telaga Bodas vs G.Geder were lowest, i.e.SI=39.25%. The results also showed that the coverage forests in the above of Citandui Riverine Basin were still rich species of birds, and 35 of 108 list species of birds were restricted, endemic and migratory species in the West Java mountain forests. Therefore, a proper management of the West Java mountain forests is needed. If not, we can lose their important functions.

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PENDAHULUAN

Wilayah sungai (S) Citandui memiliki luas 463.488 ha, terbagi menjadi dua daerah aliran sungai, yaitu Citandui dan Segara Anakan (Yekti *et al*. 2013). Daerah Aliran Sungai (DAS) secara harfiah diartikan sebagai permukaan miring yang mengalirkan air. Dalam konteks suatu unit pengelolaan, DAS didefinisikan sebagai bentang lahan yang dibatasi oleh topografi pemisah aliran, yaitu punggung bukit atau gunung yang menangkap curah hujan, menyimpan dan kemudian mengalirkannya melalui saluran-saluran pengaliran ke satu titik, yang umumnya berada di muara sungai atau danau (Manan 1976 dalam Prasetyo 2014). Menurut Undang-undang Republik Indonesia No. 7 tahun 2004 tentang Sumberdaya Air bahwa yang dimaksud dengan Daerah Aliran Sungai (DAS) adalah suatu wilayah daratan yang merupakan satu kesatuan dengan sungai dan anak-anak sungainya, yang berfungsi menampung, menyimpan dan mengalirkan air yang berasal dari curah hujan ke danau atau ke laut secara alami, yang batas di darat merupakan pemisah topografis dan batas di laut sampai dengan daerah perairan yang masih terpengaruh aktivitas daratan (Anonimus 2014[a])

DAS Citandui, sebagai salah satu DAS dari wilayah S.Citandui merupakan salah satu DAS prioritas di Jawa (khususnya Jawa Barat). Hal ini disebabkan beberapa hal di antaranya: [1] S. Cintandui yang membentang dari Jawa Barat dan Jawa Tengah, merupakan sumber mata air untuk aktivitas pertanian dan perikanan sebagian besar masyarakat, [2] Di bagian hilir S. Citandui terdapat ekosistem mangrove yang kaya akan keragaman flora dan fauna, serta Segara Anakan yang terancam keberadaannya karena proses pendangkalan oleh sedimen S. Citandui (Prasetyo 2014)

Pada kenyataannya tutupan lahan di sepanjang DAS Citandui telah mengalami berbagai perubahan. Perubahan itu untuk berbagai kepentingan manusia sebagai langkah meningkatkan hutan tanaman produksi (pinus, rasamala, karet, jati, sengoninasi), perkebunan teh, untuk menanam komoditas sayur-sayuran, dan pembukaan area untuk persawahan dalam upaya memacu produksi padi. Perubahan tutupan lahan di kawasan DAS Citandui untuk berbagai kepentingan memerlukan pengurangan vegetasi natural di hutan alam seiring semakin meningkatnya kebutuhan manusia di berbagai sektor, terutama dalam hal pangan, sandang, papan dan kepentingan ekonomi. Perubahan itu menyebabkan luas tutupan lahan hutan di wilayah S.Citandui dari tahun 1991 yaitu 196.887.982 ha telah turun menjadi 162.963.554 ha di tahun 2003. Penurunan berlanjut hingga di tahun 2010 tinggal 72.323.958 ha (Yekti *et al*. 2013). Tutupan lahan hutan di bagian hulu DAS Citandui diketahui merupakan habitat penting bagi berbagai spesies burung, khususnya burung-burung penetap hutan dan migran yang kini semakin terbatas ruang geraknya, sebagai tempat mencari pakan maupun perkembanbiakannya. Dengan demikian, luasan tutupan lahan yang tersisa akan sangat bermakna bagi kehidupan beraneka ragam spesies burung.

Kawasan hutan Telaga Bodas yang ditetapkan sebagai Cagar Alam berdasarkan dokumen gambar tanggal 12-3-1935 Nomor : 17 Stbl 104 dengan luas 285 Ha. Selanjutnya pada tanggal 15-2-1978 berdasarkan Surat Keputusan Menteri Pertanian Nomor : 98/Kpts/Um/2/1978 sebagian Cagar Alam Telaga Bodas seluas 23,85 Ha diubah statusnya menjadi Taman Wisata Alam, sehingga luas cagar alamnya hanya menjadi 261,15 Ha. Kawasan ini termasuk wilayah Kecamatan Wanaraja, Kabupaten Garut dan sebagian di antaranya termasuk Kabupaten Tasikmalaya (Anonimus 2014[b]). Kawasan Taman Wisata Alam (TWA) dan Cagar Alam (CA) Telaga Bodas terletak di daerah berbukit yang memiliki topografi bergelombang dengan sudut kemiringan antara 30-70%. Menurut klasifikasi Schmidt dan Ferguson, iklimnya termasuk tipe iklim C dengan curah hujan rata-rata 2.473 mm per tahun.

Penelitian ini merupakan serangkaian hasil pengamatan burung di wilayah hulu DAS Citandui yang dilakukan pada tanggal 25-29 April 2014 di kawasan hutan Cagar Alam Talaga Bodas (Garut) dan hasilnya dikomparasi dengan pengamatan sebelumnya, yaitu pengamatan di G.Geder Garut selatan (Widodo 2006), G.Sawal Ciamis (Widodo 2013) dan G.Galunggung Tasikmalaya (Widodo 2014). Penelitian dilakukan secara eksploratif terhadap spesies burung-burung hutan untuk menegaskan daerah lokasi penyebaran maupun tempat bagi pelestarian berbagai spesies burung. Harapannya adalah bahwa tutupan lahan hutan di bagian hulu DAS Citandui masih berpotensi sebagai tempat pelestarian beranekaragam spesies burung. Oleh karena itu, berbagai pihak diharapkan mengupayakan tutupan lahan di lingkungan DAS Citandui, khususnya di wilayah Telaga Bodas Kab. Garut agar tetap merupakan daerah penting untuk pelestarian burung. Kondisi vegetasi pendukungnya juga sangat penting sehingga pengelolaan kawasan DAS

perlu langkah kebijakan saksama agar degradasi lahan dan pemanfaatan tutupan lahan hutan di sepanjang DAS tidak berdampak buruk terhadap kepentingan konservasi flora maupun fauna, khususnya fauna burung.

METODE PENELITIAN

Penelitian dilakukan dalam dua kategori habitat, yaitu habitat hutan (HHT) pada altitud±1600-1800 m dan non hutan (NHT) pada altitud±1300-1600)m dpl. Habitat hutan adalah kondisi hutan alam di lokasi CA Telaga Bodas, dengan tumbuhan tumbuh lebat, tinggi pohon lebih dari 35 m dan rapat. Vegetasi di CA Telaga Bodas masih didominasi oleh beberapa spesies tumbuhan seperti puspa *(Schima walichii)*, saninten *(Castanea argentea)*, pasang *(Quercus platycorpa)*, suagi *(Vaccinium varingifolium)*, manglid (*Magnolia sp.*) (Anonimus 2014[b]). Di pinggiran hutan terdapat belukar yang tumbuh rapat seperti kaliandra merah dan kaliandra putih (*Callyandra* spp.), kaso-kasoan/glagah (*Sacharum spontaneum*), sente (*Lantana camara*), kirinyuh (*Eupatorium inulifolium*). Sedangkan, habitat non hutan adalah habitat burung di lahan Perhutani yang sebagian besar kondisi hutan telah terbuka, karena masyarakat menyewanya untuk kepentingan budidaya komoditas tanaman sayur-sayuran, seperti kentang, kol, cabe, tomat, daun bawang dan sejenisnya. Sementara itu, pihak Perhutani wilayah Garut mengharuskan masyarakat petani tetap menanam tanaman kayu-kayuan keras, seperti pinus (*Pinusmerkusii*), kayu putih/ampupu (*Eucalyptus alba*), puspa (*Schima walicii*), jati (*Tectona grandis*), suren (*Toona sureni*). Bibit tanaman kayu-kayuan keras disediakan pihak Perhutani secara gratis. Di sisi lain, petani juga menanam tanaman padi dan kopi-kopian di bawah tegakan puspa/pinus. Jarak antara habitat hutan dan non hutan (lahan pertanian) sekitar 100-500 m.

Secara eksploratif pengamatan burung dilakukan pada tanggal tanggal 25-29 April 2014 dengan lokasi di dalam dan di seputar kawasan Cagar Alam dan Taman Wisata Alam Telaga Bodas, Garut, Jawa Barat. Penelitian dilakukan dengan metode *Timed Species-counts* (TSCs) mengacu Bibby *et al*. (2000) dan Sutherland (1997). Metode ini dilakukan dengan cara berjalan perlahan sambil mengamati dan mencatat setiap spesies burung yang dilihat dan atau didengar di area studi secara langsung dalam satu set periode pengamatan. Satu set periode pengamatan adalah selama 1 jam yang dibagi menjadi 6 x interval 10 menit waktu observasi. Spesies burung yang ditemukan pertama kali dalam interval 10 menit pertama dicatat dan diberi skor 6, pada 10 menit interval kedua skor 5, 10 menit interval ketiga skor 4, 10 menit interval keempat skor 3, 10 menit interval kelima skor 2 dan 10 menit interval keenam diberi skor 1. Area studi pada satu set observasi dilakukan dalam kisaran seluas 100 x 100 m^2. Dengan metode ini dapat dihitung secara kualitatif nilai indeks kemelimpahan burung di lokasi penelitian. Pengamatan burung menggunakan teropong *binocular* Nikon 8x30. Identifikasi nama spesies burung mengacu MacKinnon (1990) dan MacKinnon *et al*. (1998). Koordinat lokasi penelitian di area pengamatan burung dicatat menggunakan GPS (Tabel 1). Data penelitian yang dianalisis adalah nilai indeks

Tabel 1. Koordinat dan altitude pusat pengamatan burung di kawasan Telaga Bodas, Garut 25-29 April 2014

No	Lokasi habitat pengamatan	Kisaran bentang geografis		Altd (m)
		LS	BT	
I	Batu Rahong (NHT)	07^{0}10’59.8”-07^{0}11’36.4”	108^{0}02’49.7”-108^{0}03’19.5”	1314-1544
II	Talaga Bodas (HHT)	07^{0}11’44.1”-07^{0}12’11.2”	108^{0}03’24.0”-108^{0}03’55.0”	1589-1655
III	Area pertaniankomoditi Sayuran dan tanaman penghijauan Perhutani (NHT)	07^{0}11’26.9”-07^{0}11’32.8”	108^{0}03’21.4”-108^{0}03’25.6”	1549-1599
IV	Area hutan sekitar Pemandian air panas Pancuran 7 (HHT)	07^{0}11’11.2”-07^{0}12’36.4”	108^{0}04’04.4”-108^{0}04’25.4”	1644-1711
V	Hutan di tepian Kawah Talaga Bodas (HHT)	07^{0}12’11.4”-07^{0}12’44.2”	108^{0}03’49.6”-108^{0}03’52.8”	1713-1766

Keterangan: HHT=habitat hutan, NHT=habitat non hutan.

kesamaan spesies burung, yang digunakan untuk mengetahui besarnya kesamaan atau kemiripan komposisi spesies burung di bagian hulu DAS Citandui, yaitu G. Telaga Bodas (2014). Hasil dikomparasi dengan nilai indeks kesamaan spesies burung pada penelitian sebelumnya, yaitu di G.Galunggung (Maret 2013),G. Sawal (Maret 2012) dan G. Tilu Geder (September 2006). Formula indeks kesamaan spesies burung merujuk Fachrul (2007)

HASIL DAN PEMBAHASAN

Keragaman Spesies Burung

Spesies burung yang ditemukan di lokasi penelitian disajikan pada Tabel 2. Berdasarkan pengamatan sedikitnya terdapat 51 spesies burung dari 26 suku. Bila dibandingkan dengan penelitian di bagian hulu DAS Citandui sebelumnya, yaitu di kawasan hutan G.Sawal Ciamis, dicatat sedikitnya 55 spesies burung (Widodo 2013) dan di kawasan kawah Galunggung Tasikmalaya ditemukan 39 spesies burung (Widodo 2014). Hasil tersebut menunjukkan bahwa keragaman spesies burung di wilayah Telaga Bodas Garut 30.76% lebih banyak dibandingkan dengan kondisi di wilayah Galunggung, Tasikmalaya. Namun demikian hasil ini tidak jauh berbeda dengan keragaman spesies burung-burung di kawasan hutan G.Sawal, Ciamis. Di wilayah kawasan Garut lainnya, yaitu di G. Papandayan tercatat lebih banyak spesies burung-burungnya, yaitu 73 spesies burung dari 26 suku (Sulistyawati *et al*. 2006). Hasil penelitian di wilayah hutan Garut selatan, yaitu di kawasan G.Tilu Geder (Widodo 2006) dapat diidentifikasi secara langsung 53 spesies burung. Hal itu tidak termasuk 3 spesies tambahan yang menempati area perkebunan teh di sekitar hutan Tilu Geder, karena pada area perkebunan teh tersebut ditemukan burung-burung tekukur (*Streptopelia chinensis*), kutilang (*Pycnonotus aurigaster*) dan bubut alang-alang (*Centropus bengalensis*)

Hasil penelitian menunjukkan bahwa perbedaan nilai keragaman spesies burung sangat dipengaruhi kondisi lingkungan hutan dan okupasi manusia di sekitar lokasi penelitian. Dengan dibukanya kawasan Cagar Alam menjadi Taman Wisata Alam, khususnya pada hari-hari libur, cenderung menjadikan lingkungan kawasan lebih ramai dan jumlah lalu lalang pengunjung pun kian meningkat. Tampaknya hal itu belum begitu berpengaruh terhadap keragaman spesies burung-burung di hutan pegunungan Telaga Bodas. Status hutan cagar alam Telaga Bodas yang sebagian menjadi taman wisata alam masih mampu digunakan sebagai kawasan konservasi penting bagi burung-burung hutan. Meskipun beberapa spesies burung endemik dan terancam punah seperti *Cochoa azurea* dan *Collocalia vulcanorum* tidak dijumpai di Telaga Bodas, namun sekitar 30 spesies (58.8%) burung penetap hutan masih dapat ditemukan di kawasan tersebut. Di antara spesies burung-burung hutan yang ditemukan saat observasi dan dikategorikan penetap di Telaga Bodasserta endemik Jawa adalah : *Arborophila javanica, Loriculus pusillus, Halcyon cyanoventris, Megalaima armillaris, Stachyris thoracica, Stachyris melanothorax, Rhipidura phoenicura, Aethopyga mystacalis, Aethopyga eximia,* dan *Lophozosterops javanicus*. Kawasan G.Telaga Bodas selama ini tidak dimasukkan ke dalam daftar "27 Daerah Penting Bagi Burung (DPB)" untuk wilayah Jawa Barat, sebagaimana yang disampaikan oleh Rombang dan Rudyanto (1999). Suatu persyaratan kawasan dikategorikan sebagai DPB apabila memenuhi 3 hal, yakni: [1] Di dalam kawasan terdapat burung yang terancam punah secara global, [2] Di dalam kawasan secara tetap terdapat burung-burung sebaran terbatas dan [3] Di dalam kawasan terdapat burung yang hidup berkelompok besar. Saat ini di wilayah Jawa Barat, khususnya di kabupaten Garuttelah ditetapkan 3 DPB, yaitu DPB G.Papandayan, G.Cikurai dan Leuweung Sancang.

Di Jawa tercatat 494 spesies burung, 368 spesies diantaranya termasuk burung-burung penetap dan 126 spesies yang lain adalah burung-burung migran (Setiadi *et al*. 2000). Dengan demikian, ±15% spesies burung-burung hutan penetap di Jawa dapat diwakili di Telaga Bodas. Keragaman spesies burung kemungkinan bertambah bila penelitian juga dilakukan pada hutan ketinggian di atas 1800 m dpl. Area di bawah 1600 m dpl, kondisi habitat telah dialihkan fungsinya sebagai kawasan pertanian dengan jumlah spesies burung yang cenderung lebih sedikit atau kosmopolitan, seperti tekukur, kutilang, pentet, dan pipit. Namun demikian, burung-burung yang kosmopolitan bukan sebagai spesies burung-burung yang tidak berarti karena kondisi burung-burung yang kosmopolitan pun mendapat tekanan adanya pemanfaatan pestisida petani yang cenderung intensif dan berlebihan. Oleh karena itu, tutupan vegetasi atau lahan hutan yang masih ada dan tumbuh lebat di kawasan Telaga Bodas (termasuk bagian hulu DAS Citandui), tidak boleh mengalami penyusutan lagi jika lokasi kawasan Telaga Bodas tidak ingin kehilangan fungsinya. Saat ini hulu

Tabel 2. Kemelimpahan kualitatif spesies burung di kawasan hutanTelaga Bodas, Garut (April 2014)

No	Nama suku	Nama Ilmiah	Skor kemelimpahan tiap satu jam periode pengamatan											M	R
			1	2	3	4	5	6	7	8	9	10	11		
1	Accipitridae	*Ictinaetus malayensis*		6										5.82	1
2	Phasianidae	*Arborophila javanica*						6						2.27	10
3	Turnicidae	*Turnix suscitator*											3	3.27	4
4	Columbidae	Ptilinopus melanospila							6					0.91	25
5	Columbidae	*Streptopelia chinensis*	4		5					5		6		0.82	27
6	Psittacidae	*Loriculus pusillus*	1	2										2.45	9
7	Cuculidae	*Cuculus saturatus*	5	3				6	4					3.73	3
8	Cuculidae	*Cacomantis merulinus*	6	1	5			6	1	5		6	6	2.55	8
9	Cuculidae	*Centropus bengalensis*	2	5	6		2			6				4.0	2
10	Apodidae	*Collocalia fuciphagus*	3		2	1								1.82	13
11	Apodidae	*Collocalia linchi*	6	6	6	6	6	6	5	6	6	6	5	0.64	29
12	Alcedinidae	*Alcedo meninting*									1			1.82	13
13	Alcedinidae	*Halcyon cyanoventris*	5		6	6	4	5	2	6		6	4	0.36	44
14	Alcedinidae	*Halcyon chloris*											6	0.55	31
15	Capitonidae	*Megalaima armillaris*	1	4	1			6	1	6				1.64	16
16	Picidae	*Dendroco-pus macei*	3				3	5				1	6	0.27	45
17	Hirundini-dae	*Hirundo rustica*								6				1.91	12
18	Campepha-gidae	*Pericroco-tus lammeus*							6					0.27	45
19	Campepha-gidae	*Hemipus hirundina-ceus*									5			0.55	31
20	Pycnonoti-dae	*Pycnonotus aurigaster*	6		6		6	6		6		6	5	2.91	5
21	Pycnonoti-dae	*Pycnonotus bimaculatus*	6									4		1.64	15

22	Pycnonoti-dae	*Pycnonotus goiavier*	6	5		4		6	1		4	2		2.82	6
23	Pycnonoti-dae	*Criniger bres*	5								2			0.27	45
24	Laniidae	*Lanius schach*	6		6	1	5					5	4	0.55	31
25	Turdidae	*Brachyp-teryx leucophrys*		6										1.36	20
26	Turdidae	*Copsychus saularis*						4		3				2.0	11
27	Timaliidae	*Stachyrus thoracica*		6					4					0.55	31
28	Timaliidae	*Stachyris melano-thorax*		3	5			3	4					0.91	25
29	Sylviidae	*Tesia supercili-aris*			4	6		3	6	5	5			0.45	42
30	Sylviidae	*Cettia vulcania*				3								1.0	24
31	Sylviidae	*Orthotomus cucullatus*		6					5	5	6			1.55	18
32	Sylviidae	*Orthotomus sutorius*	1		4	6	2	6		3	6	3		1.73	17
33	Rhipiduri-dae	*Rhipidura phoenicura*		6	6				1	2				1.36	20
34	Sittidae	*Sitta azurea*									1			1.55	18
35	Dicaeidae	*Prionochilus percussus*			2	5	2							1.09	22
36	Dicaeidae	*Dicaeum chrysor-rheum*									6			2.64	7
37	Dicaeidae	*Dicaeum concolor*	6									3		0.82	27
38	Dicaeidae	*Dicaeum sanguino-lentum*			6			3	3					0.27	45
39	Nectarinii-dae	*Cinnyris jugularis*	5	5								4	6	0.18	49
40	Nectarinii-dae	*Aethopyga eximia*			6	2		1	2	6				0.55	31
41	Nectarinii-dae	*Aethopyga mystacalis*		4		2			2	3	6			0.64	29
42	Nectarinii-dae	*Arachno-thera longirostra*	4											0.55	31
43	Zosteropi-dae	*Zosterops palpebrosus*	1	3	6	5		2		4	6		5	0.55	31
44	Zosteropi-dae	*Lophozos-terops javanicus*							3	4	5			1.09	22

45	Estrildidae	*Lonchura leucogas-troides*	6		6	5			3	5	0.55	31
46	Estrildidae	*Lonchura punctulata*	1							5	0.55	31
47	Sturnidae	*Aplonis panayensis*		5							0.45	42
48	Sturnidae	*Acridothe-res java-nicus*								6	0.09	50
49	Dicruridae	*Dicrurus macrocer-cus*				2					0.09	50
50	Dicruridae	*Dicrurus leuco-Phaeus*	5	6							0.55	31
51	Artamidae	*Artamus leucorhyn-chus*	2				1				0.55	31

Keterangan : Klasifikasi ilmiah merujuk Sukmantoro *et al* (2007)
M=Skor rata-rata, R=Ranking spesies.

DAS Citandui semakin kritis dengan semakin sedikitnya lahan berhutan dan intensifnya eksploitasi lahan. Kawasan DAS Citandui mencakup enam kabupaten, yakni Garut, Tasikmalaya, Ciamis, Majalengka, Kuningan dan Cilacap, sudah semestinya dikelola secara adil, setiap wilayah memiliki hak dan kewajiban serta integratif untuk mengakomodasi kemungkinan konflik kepentingan antar wilayah (Winarno & Setyawan 2003). Selain itu, luasan penggunaan lahan DAS Citandui hulu tinggal berhutan sekitar 20.73% dari total luas DAS Citandui yang secara keseluruhan mencapai 72.409,5 ha (Junaedi & Maryani 2013).

Spesies burung migran yang ditemukan saat penelitian termasuk kategori sedikit di antaranya adalah *Hirundo rustica*. Hal ini disebabkan belum waktunya musim migrasi burung atau burung-burung migran lebih dominan menempati bagian hilir S. Citandui, yaitu kawasan hilir Segara Anakan yang merupakan *feeding ground* burung-burung migran.Tersedianya ekosistem mangrove di Laguna Segara Anakan, Cilacap, merupakan habitat yang tepat bagi berbagai satwa liar. Selain sebagai tempat berlindung, mencari pakan, beristirahat, dan berkembang biak bagi beberapa spesies burung, mangrove juga menjadi tempat persinggahan burung migran (Kartijono *et al*. 2010). Kawasan Laguna Segara Anakan disebutkan mampu menyediakan bagi sedikitnya 85 spesies burung (Winarno & Setyawan 2003).

Nilai Kemelimpahan Spesies Burung

Berdasarkan Tabel 2 terlihat sebanyak 10 spesies burung dengan rata-rata skor kemelimpahan tinggi, yaitu: *Collocalia linchi* (5.82), *Halcyon cyanoventris* (4), *Pycnonotus aurigaster* (3.73), *Cacomantis merulinus* (3.27), *Zosterops palpebrosus* (2.91), *Orthotomus sutorius* (2.82), *Tesia superciliaris* (2.63), *Pycnonotus goiavier* (2.55*), Lanius schach* (2.45) dan *Lonchura leucogastroides* (2.27).*Halcyon cyanoventris* dan *Orthotomus sutorius* adalah spesies burung penetap hutan yang mampu menyesuaikan diri dengan lanskap baru di habitat non hutan yang terbangun dari berbagai jenis tanaman sayur-sayuran dengan sedikit pohon pelindung yang terdapat di gili-gili lahan pertanian. Beberapa spesies lainnya, seperti *Zosterops palpebrosus, Orthotomus sutorius, Collocalia linchi, Pycnonotus aurigaster* merupakan spesies burung yang memiliki tingkat kehadiran 100% pada seluruh titik yang diamati merupakan spesies yang mempunyai daya adaptasi baik terhadap kehadiran manusia (Nugroho *et al*. 2013). Sementara itu, sebagian besar burung-burung penetap hutan yang tidak mampu menyesuaikan lanskap baru, ini menunjukkan bahwa kehidupannya sangat tergantung dengan keutuhan habitat hutan dan relatif kurang toleran terhadap kehadiran manusia maupun dentuman alat-alat berat serta suara-suara sarana transportasi di kawasan penelitian. Burung-burung penetap hutan hanya menyebar sampai pembatas area tepi hutan dengan lahan perkebunan/pertanian sayur-sayuran. Kondisi ini juga berkaitan dengan sumber pakan yang tersedia, yaitu buah-buahan hutan maupun serangga, yang lebih melimpah di pinggiran hutan sampai bagian interior hutan. Walaupun serangga juga melimpah di area lahan perkebunan/

pertanian, namun intensitas pengendalian hama serangga dengan racun pembasmi serangga di lahan pertanian/perkebunan cenderung tinggi. Hal ini menyebabkan burung-burung insektivora dari hutan kurang dapat menyesuaikan dan mencari pakan di lokasi perkebunan/pertanian. Terbukti dari hasil penelitian hanya beberapa spesies burung hutan yang mengunjungi lahan tutupan non hutan. Di antaranya adalah tengtelok (*Pycnonotus bimaculatus*), ciblek (*Orthotomus sutorius*) dan burung kacamata (*Zosterops palpebrosus*). Berdasarkan hasil penelitian, ternyata menunjukkan begitu pentingnya sruktur dan keragaman spesies vegetasi yang menyusun habitat hutan bagi keragaman spesies burung di kawasan hutan CA dan TWA Telaga Bodas. Semakin berubahnya area hutan menjadi lanskap pertanian/perkebunan, maka beragam spesies burung kian bergeser ke arah semakin tinggi di mana spesies tumbuh-tumbuhan semakin sedikit keragaman spesiesnya. Fungsi vegetasi di bagian hulu DAS Citandui tidak hanya untuk kepentingan konservasi satwa burung-burungnya, tetapi juga untuk kepentingan menyimpan cadangan air, termasuk sumber air bagi kehidupan masyarakat. Semakin berkurangnya vegetasi di bagian hulu hutan pegunungan kawasan DAS Citandui, akan menyebabkan derasnya tingkat erosi dan meningkatnya sedimentasi di bagian hilir S.Citandui. Oleh karenanya itu, sumber pakan bagi burung-burung hutan di bagian hilir akan menjadi terbatas sehingga keragaman spesies burung dan kemelimpahannya pun kemungkinan di bagian hilir menjadi menurun.

Komparasi Kesamaan Spesies Burung

Komparasi nilai Indeks kesamaan spesies (IS) burung di kawasan hutan G.Telaga Bodas dengan di beberapa lokasi kawasan hutan dalam wilayah DAS Citandui lainnya disajikan pada Tabel 3. Hasil komparasi ternyata menunjukkan bahwa IS tertinggi terjadi pada komunitas burung antara G.Talaga Bodas vs G.Sawal, yaitu 62.3%, IS di antara lokasi G. Galunggung vs G.Sawal menempati urutan kedua yaitu sebesar 55.32%, sedangkan IS di antara hutan G.Telaga Bodas vs G.Geder terendah, yaitu 39.25%. Hasil tersebut menunjukkan bahwa kemiripan spesies burung yang menyusun hutan di sekitar kawah putih yang mengandung air panas bersulphur Telaga Bodas sedikit berbeda dibandingkan dengan di hutan G. Galunggung, yaitu tingkat kemiripan sekitar 50% walaupun kawasan hutan Telaga Bodas dan Galunggung berdekatan.

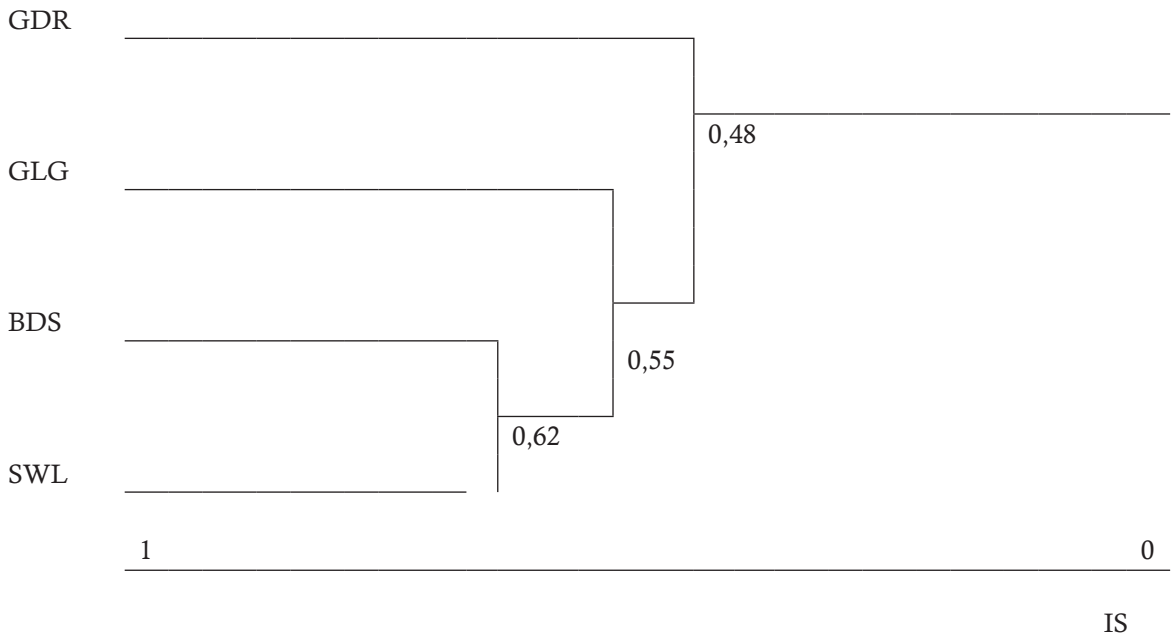
Sejak Gunung Galunggung meletus tahun 1982 tahun yang lalu, komposisi spesies burung-burung di hutan sekitar kawah Galunggung masih dalam tahap suksesi diakibatkan dahsatnya letusan pada saat itu. Berdasarkan pengamatan Maret 2013, spesies burung-burung hutan yang tampak sering teramati di Galunggung hanya sedikit, di antaranya adalah *Stachyris melanothorax, Brachypteryx leucophrys, Orthotomus cucullatus, Myophonus caeruleus* dan *Halcyon cyanoventris*. Hanya satu spesies dari lima spesies burung hutan yang umum ditemukan di Galunggung tersebut tidak dijumpai pada saat penelitian di Talaga Bodas, yaitu *Myophonus caeruleus*. Apabila waktu observasi maupun lokasi yang dieksplorasi lebih luas lagi mungkin spesies tersebut dapat ditemukan di Telaga Bodas. Sementara lebih dari 85% burung-burung yang ditemukan di G.Telaga Bodas juga ditemukan di G.Sawal. Perbedaan spesies burung-burung di G.Talaga Bodas dan G.Sawal relatif sedikit. Hal ini mungkin disebabkan keduanya adalah kawasan konservasi, sehingga burung-burung masih relatif lebih aman dan mampu bertahan mencari pakan dan *breeding* di dalam hutan. Bahkan, di kawasan hutan G.Sawal masih ditemukan burung paruh-kodok jawa (*Batrachostomus javensis*) yang dikategorikan sebagai spesies burung-burung terancam punah di Indonesia (Shannaz *et al*. 1995)

Komparasi nilai IS burung di beberapa lokasi DAS Citandui yang diteliti dapat ditunjukkan dalam dendogram seperti pada Gambar 1. Pada dendogram tersebut terlihat jelas bahwa terdapat dua pengelompokan kesamaan komunitas spesies burung di tutupan lahan hutan DAS Citandui yang disurvei. Pengelompokan

Tabel 3. Nilai indeks kesamaan spesies burung berdasarkan formula Sorensen (IS, %)

Indeks kesamaan Spesies burung	BDS	GLG	SWL	GDR
BDS	100	48.89	62.30	39.25
GLG		100	55.32	42.10
SWL			100	41.44
GDR				100

Keterangan: BDS=Talaga Bodas; GLG=G.Galunggung SWL=G.Sawal dan GDR=G.Geder/Tilu Geder.



Gambar 1. Dendogram indeks similaritas spesies burung di empat wilayah tutupan lahan hutan kawasan hulu DAS Citandui, Jawa Barat

tersebut adalah berdasarkan tipe habitat hutan. Meski tidak tampak mencolok, kecenderungan kemiripan spesies burung-burung mengelompok terjadi di tiga lokasi penelitian yaitu Telaga Bodas-Sawal – Galunggung. Kondisi ini mungkin disebabkan faktor ketinggian tempat pada ke tiga hutan pegunungan tersebut adalah relatif sama. Hal ini berbeda dengan kondisi di lokasi G.Geder, sehingga komunitas burung di lokasi tersebut membentuk kelompok tersendiri.

Menurut Irwan (2007) tipe habitat hutan di empat daerah survei dapat diklasifikasikan sebagai berikut: [1] Hutan hujan pegunungan bawah (600-1400 m dpl) yang diwakili oleh komunitas burung-burung di lokasi hutan G.Geder dan [2] Hutan hujan pegunungan atas (1400-3000 m dpl.), yang diwakili oleh komunitas burung-burung di lokasi G.Telaga Bodas, Galunggung dan G. Sawal. Sesuai peta distribusi gunung-gunung di Jawa Barat, terlihat jelas bahwa kawasan hutan Telaga Bodas, Galunggung dan G.Sawal berkisar antara 1764-2201 mdpl. Sedangkan, kawasan hutan yang disurvei di G. Geder berada sekitar 1400 m, dengan puncaknya di G. Mandalagiri setinggi 1555 mdpl.

Keberadaan vegetasi sebagai habitat bersarang dan sumber pakan merupakan dua hal yang sangat penting bagi kelestarian beragam spesies burung hutan (Himmah *et al.* 2010). Namun, kepentingan ekonomi dari hasil hutan kadang mengesampingkan nilai ekologis dari hasil non kayu, seperti burung dan satwa lainnya. Apalagi saat ini adalah era otonomi daerah. Pemerintah daerah menjadi raja-raja kecil yang berhak memanfaatkan hasil hutan di wilayahnya secara besar-besaran sehingga kurang memikirkan nasib generasi mendatang maupun kelestarian lingkungannya (Suliantoro 2011). Oleh karena itu, Djajadiningrat & Hardjolukito (2013) mengingatkan perlunya indikator-indikator baru untuk mengarahkan pembangunan. Pertumbuhan berkelanjutan harus inklusif, berkeadilan sosial dan memproteksi ekosistem dan iklim di muka bumi ini. Mantra "pertumbuhan sekarang, membersihkan kemudian" tidak dapat diberlakukan lagi saat ini dan masa mendatang di mana pun tempatnya. Napitupulu (2013) menyatakan ada 6 faktor kunci keberlanjutan pengelolaan lingkungan, yaitu: (1) Pemanfaatan fungsi lingkungan yang bersifat kontinu. Keberlanjutan fungsi lingkungan hanya akan terjadi jika lingkungan dirawat oleh manusia sebagai penghuni, bukan hanya diambil nilai fungsinya belaka, (2) Pemanfaatan lingkungan yang dilakukan tanpa henti dan tanpa rasa tanggung jawab akan menyebabkan kerusakan yang permanen bahkan kemusnahan, (3) Pemeliharaan lingkungan dilakukan dengan menjaga agar fungsi lingkungan tetap berjalan pada kondisi normalnya, (4) Pengawasan pada lingkungan dilakukan dengan Undang-undang dan Peraturan Pemerintah, (5) Pengendalian lingkungan dengan penyadartahuan dan kepedulian diri masyarakat dan (6) Pemulihan

lingkungan dengan menanam kembali (reboisasi) segera setelah dimanfaatkan. Bila keenam faktor kunci keberlanjutan pengelolaan lingkungan di atas dapat ditrapkan oleh para pengelola kawasan hutan tutupan lahan sepanjang wilayah hulu DAS Citandui, maka hal itu akan memberikan nilai penting bukan saja untuk peranan ekowisata di wilayah propinsi Jawa Barat, tetapi juga untuk menjadikan kawasan DAS Citandui sebagai daerah penting bagi konservasi burung-burung penetap hutan maupun burung-burung migran.

SIMPULAN

Hasil pengamatan di hutan Talaga Bodas Garut tercatat sebanyak 51 spesies burung, dan daftar 10 spesies burung dengan rata-rata skor kemelimpahan tinggi, adalah : *Collocalia linchi* (5.82), *Halcyon cyanoventris* (4), *Pycnonotus aurigaster* (3.73), *Cacomantis merulinus* (3.27), *Zosterops palpebrosus* (2.91), *Orthotomus sutorius* (2.82), *Tesia superciliaris* (2.63), *Pycnonotus goiavier* (2.55*), Lanius schach* (2.45) dan *Lonchura leucogastroides* (2.27). Hasil komparasi dengan penelitian sebelumnya diperoleh tingkat kemiripan komposisi spesies burung tertinggi terjadi di antara G. Telaga Bodas vs G. Sawal, yaitu 62.3%, sedangkan kemiripan komposisi spesies burung di G. Telaga Bodas vs G. Gedertercatat paling rendah, yaitu 39.25%. Hasil penelitian menunjukkan bahwa fauna burung pada tutupan lahan hutan wilayah hulu DAS Citandui sangat spesifik, yaitu 35 dari 108 spesies burung di antaranya endemik,hanya tersebar terbatas dan migran di hutan pegunungan Jawa Barat. Oleh karena itu pengelolaan kawasan hutan pegunungan di Jawa Barat diperlukan langkah bijak kalau tidak ingin kehilangan fungsinya.

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Keanekaragaman dan Kelimpahan Gastropoda di Pantai Selatan Kabupaten Pamekasan, Madura

Diversity and Abundance of Gastropods in Southern Shores of Pamekasan Regency, Madura

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Abstrak

Pesisir selatan Kabupaten Pamekasan memiliki beberapa pantai dengan profil yang berbeda-beda. Perbedaan profil pantai tersebut tampak pada substrat dasar perairan masing-masing, sehingga komunitas biota dasar perairan, misalnya Gastropoda yang terdapat di pantai-pantai tersebut juga berbeda. Penelitian ini bertujuan untuk mengidentifikasi jenis-jenis, keanekaragaman, dan kelimpahan Gastropoda di pantai selatan Kabupaten Pamekasan Madura. Pengambilan sampel menggunakan metode transek dilakukan di pantai selatan Pamekasan pada tiga stasiun penelitian, yaitu Pantai Bengkal, Pantai Talang Siring, dan Pantai Jumiang. Pada setiap pantai ditentukan tiga garis transek ke arah laut dan pada masing-masing garis transek dibagi menjadi tiga bagian, yaitu intertidal atas, intertidal tengah, dan intertidal bawah. Keanekaragaman Gastropoda dianalisis berdasarkan perhitungan indeks keanekaragaman dan kelimpahan relatif. Hasil penelitian menunjukkan bahwa di pantai selatan Kabupaten Pamekasan Madura ditemukan 29 jenis Gastropoda yang terbagi ke dalam 14 famili. Indeks keanekaragaman jenis Gastropoda sebesar 3,0075, termasuk kategori keanekaragaman yang tinggi. Gastropoda yang paling melimpah adalah *Nassarius distortus* diikuti *Littoraria scabra* dan *Nassarius leptospirus* dengan kelimpahan relatif berturut-turut 11,21%; 9,09%; dan 8,03%.

Abstract

Southern shores of Pamekasan consists of beaches with different profiles. The difference can be found in the type of substrate which causes variation of invertebrate community living in this shores, i.e.gastropods. The study aimed to identify the species of gastropods as well as to describe the diversity and abundance of gastropods in the southern shores of Pamekasan Madura. Sampling was carried out on three research stations located at the southern shores of Pamekasan (Bengkal Beach, Talang Siring Beach, and Jumiang Beach). Three transect lines were placed at each research station and each transect line was divided into three sampling sites, namely upper intertidal, middle intertidal, and lower intertidal. The diversity of gastropods was analyzed using the diversity index and relative abundance. The results showed that 29 species of gastropods which belong to 14 families were found in the southern shores of Pamekasan. The diversity of gastropods in southern shores of Pamekasan was high (the diversity index was 3.0075). The most abundant species was *Nassarius distortus*, followed by *Littoraria scabra* and *Nassarius leptospirus* with relative abundance 11.21%; 9.09%; and 8.03%, respectively.

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PENDAHULUAN

Kabupaten Pamekasan merupakan salah satu kabupaten di Pulau Madura yang memiliki wilayah pesisir dengan garis pantai yang panjang. Kabupaten Pamekasan memiliki wilayah seluas 792,30 km^2 dengan posisi geografis pada koordinat antara 6°51'-7°31' LS serta 112°19'-113°58' BT. Kabupaten Pamekasan memiliki beberapa komoditas perikanan andalan, misalnya ikan layang, teri nasi, ikan lemuru, kerang lorjuk, tongkol, cakalang, dan peperek (Bappeda Pamekasan 2013).

Pesisir selatan Kabupaten Pamekasan memiliki beberapa pantai indah yang dijadikan sebagai objek wisata, di antaranya adalah Pantai Jumiang dan Pantai Talang Siring (Bappeda Pamekasan 2013). Pantai-pantai tersebut mempunyai profil pantai yang berbeda-beda. Pantai Jumiang dan Pantai Talang Siring mempunyai profil pantai yang landai dan sedikit vegetasi, sedangkan Pantai Bengkal mempunyai profil pantai yang landai dan terdapat komunitas mangrove. Perbedaan profil pantai tersebut juga tampak pada substrat dasar perairan masing-masing sehingga komunitas biota dasar perairan, misalnya Gastropoda yang terdapat di ketiga pantai tersebut juga berbeda. Di lain pihak, wilayah ini juga berpotensi mengalami penurunan kualitas perairan yang disebabkan oleh berbagai aktivitas manusia. Selain itu, Suprakto (2005) menyatakan bahwa di kawasan pesisir pantai selatan Kabupaten Pamekasan terjadi perubahan baik alami maupun buatan. Perubahan tersebut disebabkan karena aktivitas manusia seperti penambangan pasir dan pembuangan sampah yang tidak dapat terurai. Selain itu, dinamika sedimentasi, arus serta abrasi di pantai selatan lebih tinggi dibanding pantai utara Madura. Hal itu dikarenakan pantai selatan Kabupaten Pamekasan adalah jalur lintas Madura dari Bangkalan menuju Sumenep sehingga mengakibatkan tingginya dinamika aktivitas penduduk dibandingkan dengan pantai utara Madura. Dinamika tersebut berakibat negatif terhadap ekosistem pantai di pesisir selatan Kabupaten Pamekasan yang pada akhirnya berdampak pada komunitas makhluk hidup laut yang ada di dalamnya.

Berdasarkan hasil survei pendahuluan diketahui bahwa salah satu komunitas penghuni ekosistem pantai selatan Kabupaten Pamekasan adalah Gastropoda. Gastropoda merupakan salah satu moluska penyusun komunitas bentik pada suatu perairan. Gastropoda adalah moluska anggota kelompok Kelas Gastropoda, bergerak menggunakan otot perut, mengalami torsi, dan apabila bercangkang, bentuk cangkangnya adalah kerucut terpilin. Poutiers (1998) menyatakan bahwa Gastropoda banyak ditemukan di perairan laut dan beberapa di antaranya dikonsumsi oleh masyarakat. Nybakken & Bertness (2005) menyatakan bahwa Gastropoda merupakan moluska paling sukses dan memiliki penyebaran sangat luas, yaitu mulai dari darat hingga laut dalam. Hendrickx *et al.* (2007) menyatakan bahwa Gastropoda dan Bivalvia merupakan penyusun komunitas makrozoobentos di kawasan pesisir pantai.

Keberadaan Gastropoda sebagai salah satu komunitas penghuni pantai selatan Kabupaten Pamekasan secara tidak langsung terkait dengan kualitas perairan di wilayah tersebut. Perubahan struktur komunitas Gastropoda dapat meliputi keanekaragaman, kelimpahan, dan sebagainya. Kelimpahan dan keanekaragaman Gastropoda di alam dipengaruhi oleh faktor abiotik dan biotik seperti kondisi lingkungan, ketersediaan makanan, pemangsaan oleh predator, dan kompetisi (Susiana 2011). Gastropoda mempunyai peranan penting dalam ekosistem, terlibat dalam siklus rantai makanan, yaitu sebagai sumber makanan bagi hewan-hewan lainnya. Selain itu, Gastropoda juga ada yang dapat dimanfaatkan manusia sebagai sumber protein hewani (Cappenberg 2006). Hasil penelitian Yuniarti (2012) menunjukkan bahwa kondisi lingkungan perairan memengaruhi keanekaragaman dan kelimpahan Gastropoda. Jumlah Moluska (Gastropoda dan bivalvia) yang ditemukan dipengaruhi oleh perbedaan karakteristik substrat dan habitat serta aktivitas manusia.

Mengingat pentingnya peranan Gastropoda dalam rantai makanan terhadap organisme-organisme yang hidup di ekosistem pesisir, serta minimnya informasi tentang keberadaan Gastropoda di daerah pantai selatan Kabupaten Pamekasan, perlu dilakukan penelitian tentang keanekaragaman dan kelimpahan Gastropoda di pantai selatan Kabupaten Pamekasan.

METODE PENELITIAN

Pengambilan sampel dilakukan di pantai selatan Kabupaten Pamekasan dengan tiga lokasi, yaitu Pantai Bengkal, Pantai Talang Siring, dan Pantai Jumiang (Gambar 1). Pengambilan sampel menggunakan metode transek, dengan menempatkan tiga garis transek ke arah laut (Yusron 2013) dan pada masing-masing garis transek dibagi menjadi tiga bagian,

yaitu intertidal atas, tengah, dan bawah. Setiap garis transek diletakkan masing-masing tiga plot kuadrat berukuran 1 m^2 di masing-masing intertidal. Gastropoda yang diambil adalah Gastropoda yang terdapat pada setiap plot kuadrat dan di dalam substrat sampai kedalaman 5 cm. Semua Gastropoda dalam plot kuadrat disortir dan dihitung jumlah setiap jenisnya. Dalam setiap jenis diambil 2-3 individu untuk diawetkan dalam botol koleksi yang telah diberi label dan berisi larutan alkohol 70%. Pengambilan sampel Gastropoda dilakukan selama tiga hari, yaitu pada tanggal 27-29 Juni 2014 pada pukul 15.00-17.45 pada WIB pada saat surut terjauh. Parameter fisika-kimia habitat yang diukur meliputi suhu, pH, salinitas dan tipe substrat. Tipe substrat dianalis dan diuji dengan metode saringan di Laboratorium Mekanika Tanah Institut Teknologi Sepuluh Nopember Surabaya (ITS).

Indeks keanekaragaman (H') dihitung menggunakan indeks Shanon-Wiener (Odum 1993), berikut:

$$H' = -(\sum pi \ln pi)$$

Keterangan:
H'= Indeks keanekaragaman jenis
Pi = ni/N
ni = Jumlah individu dari masing-masing spesies
N = Jumlah seluruh individu
dengan kriteria sebagai berikut:

H > 3,0 : Keanekaragaman tinggi
1 < H < 3: Keanekaragaman sedang
H < 1 :Keanekaragaman rendah

Kelimpahan relatif dianalisis menggunakan rumus sebagai berikut (Odum 1993):

$$KRi = \left(\frac{ni}{N}\right) \times 100\%$$

Keterangan:
KRi = Kelimpahan relatif
ni = Jumlah individu jenis ke-i
N = Total individu seluruh spesies

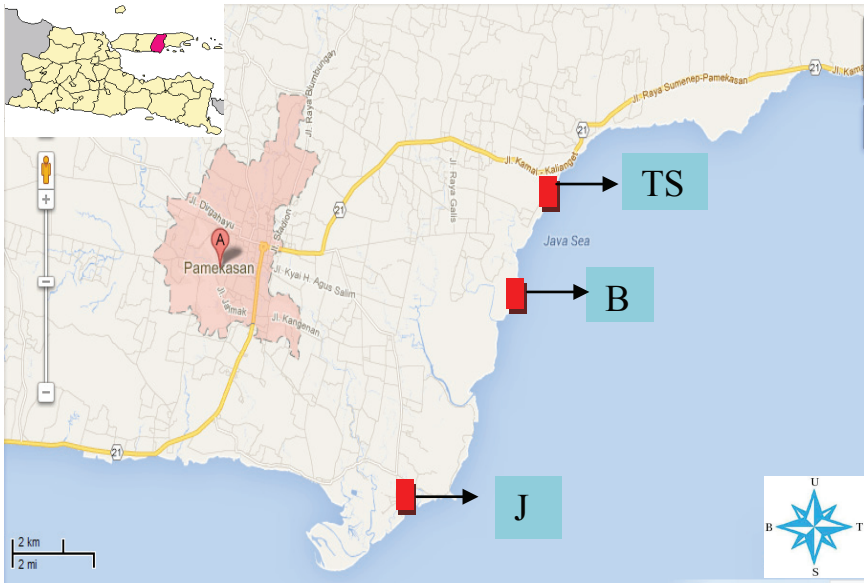
Data parameter fisika-kimia habitat, meliputi suhu air, pH substrat, salinitas, dan tipe substrat ditabulasi dan dianalisis secara deskriptif.

HASIL DAN PEMBAHASAN

Pada umumnya di pesisir selatan Madura berprofil landai dengan surut terendah berkisar 80-100 m dan substrat berlumpur. Profil tersebut merupakan habitat yang mendukung kehidupan Gastropoda. Hasil identifikasi Gastropoda di pantai pesisir selatan Kabupaten Pamekasan ditemukan 14 famili yang terdiri dari 29 jenis Gastropoda.

Jumlah jenis yang ditemukan pada masing-masing lokasi penelitian berbeda-beda. Di Pantai Jumiang ditemukan 8 jenis Gastropoda di Pantai Talang Siring ditemukan 12 jenis Gastropoda, dan di Pantai Bengkal ditemukan 16 jenis Gastropoda. Perbedaan tersebut dikarenakan ketiga lokasi penelitian memiliki perbedaan karakteristik/profil pantai.

Pantai Jumiang memiliki tipe substrat berjenis pasir. Hal ini menyebabkan jenis Gastropoda yang ditemukan lebih sedikit (8 jenis) bila dibandingkan dengan kedua pantai



Gambar 1. Peta lokasi penelitian; B = Pantai Bengkal, J = Pantai Jumiang, TS = Pantai Talang Siring

lainnya. Menurut Nybakken & Bertness (2005), rendahnya jumlah organisme besar yang mampu menetap di pantai dengan substrat dasar berjenis pasir dikarenakan kondisi substrat tidak stabil dan terus-menerus bergerak. Penelitian yang dilakukan Hawari *et al.* (2014) menunjukkan bahwa Gastropoda yang ditemukan di perairan Pantai Pandan Sumatera Utara dengan substrat berjenis pasir lebih sedikit jenis dan jumlahnya bila dibandingkan pada substrat dasar berjenis lumpur. Kurangnya vegetasi yang terdapat pada Pantai Jumiang juga mempengaruhi jumlah jenis Gastropoda pada pantai tersebut. Hal ini dikarenakan, Gastropoda sebagai pemakan detritus membutuhkan vegetasi dengan jumlah yang mencukupi pada habitatnya.

Di Pantai Talang Siring ditemukan 12 jenis Gastropoda. Jenis ini lebih banyak bila dibandingkan dengan Pantai Jumiang. Hal ini disebabkan jenis substrat dasar pada pantai tersebut adalah lempung berpasir cocok sebagai tempat hidup dan perkembangan Gastropoda. Penelitian Budi *et al*. (2013) menunjukkan bahwa Gastropoda yang ditemukan pada umumnya membenamkan diri dalam substrat dasar berlumpur.

Pantai Bengkal yang memiliki substrat dasar berjenis lanau berlempung ditemukan Gastropoda sebanyak 16 jenis. Jenis yang ditemukan pada pantai ini terbanyak bila dibandingkan di kedua lokasi lainnya. Hal ini dikarenakan Pantai Bengkal memiliki hutan mangrove. Pantai yang memiliki hutan mangrove sangat cocok bagi kehidupan Gastropoda. Nybakken &Bertness (2005) menyatakan bahwa pada hutan mangrove, gerakan air relatif minimal sehingga sedimen yang partikelnya berukuran lebih kecil cenderung terendap dan terkumpul di dasar perairan. Oleh karena itu, substrat pada hutan mangrove biasanya lumpur. Selain itu, sistem akar yang padat pada mangrove menunjang pengendapan partikel-partikel halus di sekitar akar mangrove, membentuk kumpulan lapisan sedimen. Di lain pihak, kandungan bahan organik pada sedimennya tinggi. Daun-daun serta ranting pohon mangrove yang berguguran didekomposisi oleh pengurai sehingga kandungan bahan organik di sedimennya menjadi tinggi. Onrizal *et al*. (2009) melaporkan bahwa kelas Gastropoda yang banyak ditemukan pada hutan mangrove kemungkinan disebabkan oleh tingginya bahan organik sebagai sumber makanan bagi Gastropoda.

Keanekaragaman Gastropoda dipengaruhi oleh substrat dasar perairan. Nybakken & Bertness (2005) menyatakan bahwa ukuran partikel suatu substrat berkaitan dengan penyebaran organisme dan kelimpahannya terletak pada retensi air dan kesesuaiannya untuk digali. Hal tersebut juga sesuai dengan penelitian Cappenberg (2006) yang melaporkan bahwa substrat sebagai tempat hidup dari moluska khususnya Gastropoda sangat memengaruhi jumlah jenisnya.

Indeks keanekaragaman Gastropoda pada masing-masing pantai lokasi penelitian menunjukkan nilai yang berbeda-beda. Pantai Bengkal memiliki nilai indeks keanekaragaman tertinggi, yaitu sebesar 2,4398 diikuti Pantai Talang Siring dengan indeks keanekaragaman sebesar 2,0988. Nilai indeks keanekaragaman terendah adalah Pantai Jumiang, yaitu 1,6200 (Gambar 2).

Keanekaragaman dan jumlah jenis Gastropoda dipengaruhi oleh substrat dasar perairan. Gastropoda lebih banyak ditemukan pada pantai dengan substrat dasar berlempung bila dibandingkan dengan substrat dasar berpasir.

Indeks keanekaragaman Gastropoda di pantai selatan Kabupaten Pamekasan Madura secara total sebesar 3,0075. Hal tersebut menunjukkan bahwa Gastropoda di pantai selatan Kabupaten Pamekasan Madura memiliki keanekaragaman yang tinggi. Gastropoda yang paling melimpah adalah *Nassarius distortus* diikuti

Gambar 2. Indeks keanekaragaman di setiap lokasi penelitian

oleh *Littoraria scabra dan Nassarius leptospirus* dengan kelimpahan relatif berturut-turut 11,21%; 9,09%; dan 8,03% (Tabel 1).

Indeks keanekaragaman Gastropoda di pantai selatan Kabupaten Pamekasan sebesar 3,0075. Hal tersebut berarti bahwa pantai selatan Kabupaten Pamekasan memiliki keanekaragaman Gastropoda yang tinggi. Tingginya indeks keanekaragaman menunjukkan bahwa penyebaran individu tiap jenis tinggi dan kestabilan komunitasnya juga tinggi. Odum (1993) menyebutkan bahwa suatu komunitas dikatakan memiliki keanekaragaman tinggi jika komunitas tersebut terdiri dari banyak jenis dengan kelimpahan besar, sama rata atau hampir sama rata.

Pantai Jumiang, Pantai Talang Siring, dan Pantai Bengkal memiliki keanekaragaman Gastropoda yang berbeda-beda. Pantai Jumiang memiliki indeks keanekaragaman sebesar 1,6200. Nilai indeks keanekaragaman ini merupakan yang terendah bila dibandingkan dengan dua lokasi lainnya. Akan tetapi nilai ini masih menunjukkan bahwa Pantai Jumiang memiliki keanekaragaman jenis yang tergolong dalam kategori sedang. Kondisi ini menunjukkan bahwa produktivitasnya cukup tinggi, kondisi ekosistem seimbang, dan tekanan ekologi sedang. Di pantai ini ditemukan 8 jenis Gastropoda dengan jumlah individu sebanyak 105. Jumlah ini lebih sedikit bila dibandingkan dengan kedua lokasi lainnya. Hal ini disebabkan lokasi pantai ini

Tabel 1. Jenis-jenis Gastropoda yang ditemukan di pantai pesisir selatan Kabupaten Pamekasan, Madura

Famili	Jenis	Kelimpahan Relatif (%)	Lokasi
Muricidae	*Chicoreus brunneus*	5,2	Jumiang,
	Thais kieneri	1,69	Jumiang
Ranellidae	*Gyrineum natator*	3,81	Jumiang
Buccinidae	*Chantarus undosus*	2,54	Jumiang
	Polinices mamilla	0,85	Jumiang, Talang Siring, Bengkal
Naticidae	*Natica gualteriana*	1,69	Bengkal
	Natica tigrina	1,06	Talang Siring, Bengkal
	Natica vitellus	2,96	Talang Siring, Bengkal
Turbinidae	*Turbo brunneus*	0,42	Jumiang
Nassariidae	*Nassarius distortus*	11,21	Jumiang, Bengkal
	Nassarius pullus	1,69	Bengkal
	Nassarius jacksonianus	5,29	Talang Siring
	Nassarius leptospirus	8,03	Talang Siring, Bengkal
	Nassarius castus	4,86	Talang Siring
	Nassarius stolatus	3,81	Talang Siring
Olividae	*Oliva irisans*	0,21	Jumiang
Neritiidae	*Nerita nigrita*	0,85	Bengkal
Littorinidae	*Littoraria scabra*	9,09	Bengkal
	Littoraria melanostoma	7,61	Bengkal
	Littoraria intermedia	3,81	Bengkal
	Littoraria articulata	4,44	Bengkal
	Littoraria pallescens	2,11	Bengkal
	Littoraria sp.	0,21	Bengkal
Cerithiidae	*Cerithium corallium*	7,82	Bengkal
Costellariidae	*Vexillum funereum*	4,65	Talang Siring, Bengkal
Architectonicidae	*Architectonica gualtierii*	0,42	Talang Siring
	Architectonica perspectiva	0,21	Talang Siring
Turridae	*Turricula javana*	2,54	Talang Siring
Turritellidae	*Turritella terebra*	0,85	Talang Siring

berdekatan dengan pemukiman penduduk dan pantai ini merupakan pantai wisata sehingga diduga dipengaruhi aktivitas manusia, misalnya buangan limbah domestik. Soegianto (2004), menyebutkan bahwa keanekaragaman jenis juga dipengaruhi oleh keadaan lingkungan. Suatu ekosistem yang masih alami dan belum terganggu oleh aktivitas manusia, biasanya memiliki keanekaragaman jenis organisme yang tinggi. Jenis yang mendominasi adalah *Nassarius distortus* dengan jumlah individu sebanyak 38 dan jenis terendah adalah *Polinices mamilla* dan *Oliva irisans* dengan jumlah individu satu. Tingginya jumlah individu *Nassarius distortus* dikarenakan anggota dari famili Nassariidae ini merupakan hewan yang aktif dan dapat bergeser cepat di pasir atau lumpur, sebagaimana dikemukakan oleh Poutiers (1998).

Keanekaragaman Gastropoda di Pantai Talang Siring tergolong kategori sedang, dengan nilai keanekaragaman sebesar 2,0988. Pada pantai ini ditemukan 12 jenis Gastropoda dengan jumlah individu sebanyak 123. Spesies yang mendominasi adalah *Nassarius jacksonianus* dengan jumlah individu sebanyak 25, diikuti oleh *Nassarius castus* dengan jumlah individu sebanyak 23. Keduanya termasuk famili Nassariidae. Banyaknya jumlah anggota famili Nassariidae di pantai ini juga disebabkan karena faktor fisika-kimia pantai tersebut memenuhi syarat hidupnya. Suhu pada pantai ini sebesar 28°C, sedangkan pH substrat 6, dan salinitas perairan 33°/$_{oo.}$ Jenis yang paling sedikit ditemukan, yaitu *Polinices mamilla, Natica tigrina,* dan *Architectonica perspectiva* yang masing-masing hanya ditemukan satu individu.

Pantai Bengkal memiliki indeks keanekaragaman 2,4398. Hal tersebut menunjukkan bahwa keanekaragaman jenis Gastropoda di Pantai Bengkal termasuk kategori sedang. Pada pantai tersebut ditemukan 16 jenis Gastropoda dengan jumlah individu 245. Banyaknya jenis Gastropoda yang ditemukan di pantai ini berkaitan erat dengan keberadaan ekosistem hutan mangrove pada pantai tersebut. Hutan mangrove mampu memenuhi kebutuhan hidup berbagai jenis Gastropoda, terutama sebagai tempat mencari makan, tempat perkembangbiakan dan tempat untuk membesarkan anakan. Jenis yang mendominasi pada Pantai Bengkal adalah *Littoraria scabra* (43 individu) dan *Cerithium corallium* (37 individu). Sementara,, jenis terendah adalah*Littoraria* sp. (satu individu) dan *Polinices mamilla* (dua individu).

Kelimpahan Relatif (KR) Gastropoda di pantai selatan Kabupaten Pamekasan yang tertinggi dimiliki oleh *Nassarius distortus,* yaitu sebesar 11,21% diikuti oleh *Littoraria scabra* dan *Nassarius leptopirus* yang berturut-turut memiliki KR sebesar 9,09% dan 8,03%. Kelimpahan relatif (KR) terendah adalah *Oliva irisans, Littoraria* sp. dan *Architectonica perspectiva*, yaitu sebesar 0,21%. Tinggi rendahnya kelimpahan suatu organisme dipengaruhi oleh berbagai faktor di antaranya adalah fisika-kimia perairan,meliputi suhu, salinitas, pH, arus, dan substrat dasar. Hasil pengukuran parameter fisika dan kimia habitat serta analisis substrat dasar masing-masing lokasi penelitian masih sesuai untuk menunjang kehidupan biota laut. Suhu perairan berkisar antara 28-29°C. pH substrat berkisar antara 5,8-6 dan salinitas perairan sebesar 33°/$_{oo.}$ Hasil analisis struktur sedimen pada setiap zona intertidal di lokasi penelitian menunjukkan bahwa masing-masing lokasi penelitian memiliki tipe substrat yang berbeda. Pantai Jumiang memiliki tipe substrat berjenis pasir di semua zona intertidalnya. Pantai Talang Siring memiliki tipe substrat berjenis lempung berpasir di setiap zona intertidalnya. Pantai Bengkal memiliki tipe substrat berjenis lanau berlempung di setiap zona intertidalnya (Tabel 2).

Suhu merupakan faktor pembatas bagi pertumbuhan dan distribusi makhluk hidup karena suhu berpengaruh terhadap proses metabolisme suatu organisme (Odum 1993). Gastropoda dapat melakukan proses metabolisme secara optimal pada kisaran suhu antara 25-35°C (Suwondo *et al.* 2006). Riniatsih & Edi (2009) melaporkan bahwa Gastropoda dapat hidup pada kadar salinitas antara 29-32^{0}/$_{00.}$ Derajat keasaman (pH) penting untuk mendukung kelangsungan

Tabel 2. Hasil pengukuran parameter fisik-kimia dan analisis jenis struktur sedimen di pantai pesisir selatan Kabupaten Pamekasan, Madura

No.	Parameter	Lokasi penelitian		
		Jumiang	Talang Siring	Bengkal
1.	Suhu air (°C)	29	28	28
2.	Salinitas (^{0}/$_{00}$)	33	33	33
3.	pH substrat	5,9-6,0	6,0	5,8
4.	Jenis substrat dasar	Pasir	Lempung berpasir	Lanau berlempung

hidup organisme akutik. Hal ini dikarenakan pH dapat memengaruhi jenis dan tersedianya unsur hara serta toksisitas unsur renik. Rendahnya pH substrat pada masing-masing lokasi penelitian (Pantai Bengkal, Pantai Talang Siring, dan Pantai Jumiang) yang cenderung asam diduga diakibatkan oleh aktivitas penduduk pada masing-masing lokasi penelitian sehingga menyebabkan rendahnya pH substrat. Sastrawijaya (2000) menyebutkan bahwa setiap organisme akuatik memiliki toleransi yang berbeda-beda terhadap nilai pH. Pada umumnya Gastropoda dapat hidup pada kisaran pH 5-8.

Jenis yang paling banyak ditemukan di pantai selatan Kabupaten Pamekasan Madura adalah *Nassarius distortus*, yaitu sebanyak 53 individu. Tingginya jumlah individu jenis tersebut dikarenakan kondisi pantai selatan Kabupaten Pamekasan Madura sesuai dengan habitat jenis tersebut. *Nassarius distortus* termasuk famili Nassariidae. Anggota famili Nassariidae sering dijumpai pada daerah intertidal dan sublittoral serta merupakan hewan yang aktif. Anggota famili tersebut memiliki sifon untuk memudahkan mencari makanan atau membenamkan diri pada substrat dan dapat bergerak cepat masuk ke dalam pasir ataupun lumpur (Poutiers 1998). Selain itu, Gastropoda jenis ini biasanya merupakan pemakan detritus (*detritus feeder*) dan pengurai serasah.

SIMPULAN

Hasil identifikasi Gastropoda yang ditemukan di pantai selatan Kabupaten Pamekasan Madura terdiri atas 29 jenis dan termasuk dalam 14 famili, dengan indeks keanekaragaman sebesar 3,0075 (kategori tinggi). Gastropoda yang paling melimpah adalah *Nassarius distortus* diikuti oleh *Littoraria scabra* dan *Nassarius leptospirus* dengan kelimpahan relatif berturut-turut 11,2100%, 9,0900%, dan 8,0300%.

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Respon Kecambah Padi (*Oryza sativa L.*) Asal Bengkalis, Riau Terhadap Cekaman Garam

Response of Rice Seedlings (*Oryza sativa L.*) from Bengkalis, Riau to Salt Stress

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Abstrak

Varietas padi yang tahan terhadap cekaman garam sangat diperlukan untuk mengatasi masalah cekaman garam di wilayah pesisir pantai. Penelitian ini bertujuan menganalisis respon pertumbuhan akar dan tajuk serta pertambahan biomassa akar dan tajuk dari enam varietas padi pada fase kecambah. Varietas padi lokal yang digunakan berasal dari Kecamatan Bantan, Kabupaten Bengkalis, yaitu Amat Candu, Sadani, Solok, dan Yamin. Dua varietas pembanding yang digunakan adalah IR64 dan Indragiri. Penelitian dilakukan menggunakan Rancangan Acak Kelompok dengan dua faktor dan tiga kali ulangan. Faktor pertama adalah konsentrasi NaCl, yaitu 0 mM (kontrol), 15 mM, 30 mM, dan 45 mM. Faktor kedua adalah enam varietas padi. Hasil penelitian menunjukkan bahwa pada kontrol maupun perlakuan garam, pertumbuhan akar kecambah pada varietas padi Amat Candu lebih cepat dibandingkan dengan lima varietas padi lainnya. Secara keseluruhan, respon pertumbuhan akar dan tajuk pada kecambah dari varietas padi Indragiri (sebagai varietas padi pembanding yang tahan cekaman garam) paling baik dibandingkan lima varietas padi lainnya yang diuji. Varietas padi lokal Riau yang memberikan respon pertumbuhan dan biomassa akar paling besar adalah Amat Candu dan Amat Candu tergolong varietas padi moderat cekaman garam. Empat varietas padi lainnya, yakni Solok, Sadani, dan Yamin serta IR64, tergolong tidak tahan cekaman garam. Selain itu, bahwa respon kecambah padi terhadap perlakuan cekaman garam sebaiknya diteliti dengan mengamati parameter pertumbuhan akar pada perlakuan garam sebesar 30 mM.

Abstract

The salt-stress tolerant rice varieties are very important to overcome the salt stress in coastal area. This study was aimed to analyze the responses of shoot and root of seedlings of six rice varieties to the salt stress. The rice varieties used in this study were obtained from Kecamatan Bantan, Kabupaten Bengkalis. The varieties were Amat Candu, Sadani, Solok, and Yamin. The two rice varieties, namely IR64 and Indragiri, were used as the comparation group. This study was conducted using Randomized Block Design with two factors and three replications. The first factor was salt (NaCl) concentration, i.e 0 mM (control), 15 mM, 30 mM, and 45 mM. The second factor was six rice varieties. The results showed that the seedling roots growth in Amat Candu was faster when compared to the others. According to the seedling roots growth, Indragiri was the salt tolerant rice variety, Amat Candu was the salt moderate rice variety, and IR64, Sadani, Yamin, and Solok were the salt sensitive rice varieties. Beside that, the seedling roots growth was the best parameter to study the salt tolerance in rice.

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PENDAHULUAN

Kadar garam tinggi merupakan masalah utama yang dihadapi oleh pertanian di daerah pesisir yang dipengaruhi oleh pasang surutnya air laut. Walaupun garam merupakan hara esensial yang diperlukan untuk pertumbuhan tanaman padi, namun akan berdampak buruk bagi pertumbuhan dan produksi tanaman padi jika konsentrasinya melebihi batas normal yang dapat ditolerir oleh tanaman padi. Pada kondisi demikian dikatakan tanaman mengalami cekaman garam.

Cekaman garam menyebabkan defisit air pada tanaman, penurunan laju pertumbuhan tanaman, kerusakan daun, dan peningkatan rasio akar:tajuk. Jika garam NaCl terlarut di dalam tanah, maka ion Na^+ akan menyebabkan ion lain yang dibutuhkan oleh tanaman, seperti ion Mg^+, K^+, dan Ca^{++}) menjadi tidak tersedia. Selain itu akumulasi ion Cl- di dalam jaringan daun tanaman akan mengganggu produksi klorofil dan fotosintesis (Romero-Aranda & Syvertsen 1996; Munns 2002). Tanaman yang toleran cekaman salinitas harus mampu mempertahankan rasio K^+:Na^+ agar tetap tinggi atau mempertahankan konsentrasi Na^+ tetap rendah di dalam sel (Blumwald *et al*. 2000).

Salah satu daerah pesisir pantai di Provinsi Riau yang banyak ditanami oleh tanaman padi adalah Desa Bantan Air, di pesisir Pulau Bengkalis. Pulau Bengkalis terdiri dari dua kecamatan, yaitu kecamatan Bengkalis dan Bantan. Kemiringan tanah di Pulau Bengkalis termasuk kecamatan Bantan relatif datar, yaitu 0-3%. Tipe tanah yang ada di kecamatan Bantan adalah tropaquepts, troposaprists, dan hydraquents, dengan yang paling mendominasi adalah tipe tropaquepts (Fitmawati *et al*. 2012). Tanah tropaquepts merupakan group great dari ordo inseptisol dan sub ordo aquept. Tanah tropaquepts memiliki rasio natrium dapat tukar (ESP) sebesar 15% atau lebih, dan rasio adsorpsi natrium (SAR) sebesar 13% atau lebih. Umumnya tanah inseptisols memiliki kadar pasir 60%, mengandung sulfat masam, terdapat karatan, banyak terdapat di lembah-lembah atau daerah aliran sungai dan dataran pantai, merupakan tanah mineral dengan kadar P rendah, Al dan Fe tinggi, serta pH 5-7 (Juma 1999).

Di antara varietas padi, ada yang sensitif dan ada pula yang toleran atau tahan cekaman garam. Varietas padi IR651 (Zhen-hua *et al*. 2012), Matsumae (Wang *et al.* 2012), Pokkali, Nona Bokra, Pucuk, Pelita I-1, dan Bayar Putih (Silitonga 2004) termasuk toleran cekaman garam, sedangkan IR64 tergolong sensitif cekaman garam (Zhen-hua *et al*. 2012). Cekaman garam dapat menghambat pertumbuhan dan produksi tanaman padi, karena konsenterasi garam yang lebih tinggi di tanah menyebabkan proses penyerapan nutrisi oleh akar tanaman melambat. Untuk mengatasi masalah cekaman garam, selain cara bercocok tanam yang sesuai, Slavich *et al*. (2006) merekomendasikan juga penggunaan varietas padi yang tahan cekaman garam tinggi. Selain itu, petani juga lebih menyukai menanam varietas-varietas padi yang toleran terhadap cekaman abiotik dan biotik tertentu karena lebih praktis, murah, dan ramah lingkungan (Mandal *et al*. 2004).

Oleh karena itu penelitian bertujuan menganalisis respon pertumbuhan akar dan tajuk serta pertambahan biomassa akar dan tajuk dari empat varietas padi lokal dari Desa Bantan Air, Kecamatan Bantan, Kabupaten Bengkalis pada fase kecambah terhadap cekaman garam.

METODE PENELITIAN

Bahan tanaman

Bahan tanaman yang digunakan pada penelitian ini adalah varietas padi lokal asal Desa Bantan Air, Kecamatan Bantan, Kabupaten Bengkalis, yaitu Amat candu, Sadani, Solok, dan Sonopu. Varietas padi pembanding yang digunakan adalah IR64 sebagai varietas padi yang tidak tahan cekaman garam dan Indragiri sebagai varietas padi yang tahan terhadap cekaman garam. Kedua varietas padi diperoleh dari Balai Besar Penelitian Tanaman Padi Kebun Percobaan Tanaman Padi Muara, Bogor, Jawa Barat.

Kultur Hara

Biji padi disterilisasi permukaan mengikuti prosedur seperti yang dilakukan oleh Roslim *et al*. (2010). Biji padi yang sudah disterilisasi selanjutnya dikecambahkan sebanyak 10 biji per varietas padi per ulangan, dengan total ulangan sebanyak tiga kali. Analisis ketahanan terhadap cekaman garam dilakukan menggunakan teknik kultur hara pada larutan hara minimal (Miftahudin *et al*. 2002). Kecambah padi ditumbuhkan pada larutan hara minimal selama tiga hari (Nam 2012), kemudian dilakukan pengukuran pada panjang akar dan tajuk. Setelah itu, kecambah dipindahkan ke larutan hara minimal dengan perlakuan garam pada konsentrasi 15, 30, dan 45 mM NaCl (Ibraheem *et al*. 2011; Wang *et al*. 2012) dan ditumbuhkan selama tiga hari. Kecambah padi juga ditumbuhkan secara terpisah pada

larutan hara tanpa penambahan NaCl sebagai kontrol.

Setelah tiga hari dilakukan pengamatan terhadap parameter panjang akar, panjang tajuk, bobot basah dan bobot kering akar dan tajuk secara terpisah. Panjang akar diukur menggunakan penggaris mulai dari pangkal akar sampai ujung akar dengan satuan centimeter. Pengukuran dilakukan sebanyak dua kali, yaitu pada saat sebelum cekaman garam dan setelah cekaman garam sehingga diperoleh rata-rata selisih panjang akarnya. Panjang tajuk diukur menggunakan penggaris dimulai dari pangkal batang paling bawah hingga ujung daun tertinggi dalam satuan centimeter. Panjang tajuk diamati sebanyak dua kali, yaitu pada saat sebelum cekaman garam dan setelah cekaman garam sehingga diperoleh rata-rata selisih panjang tajuknya. Bobot basah akar dan tajuk ditentukan dengan terlebih dahulu mengeringkan akar dan tajuk dengan kertas tisu, lalu menimbangnya dalam keadaan segar. Bobot kering akar dan tajuk ditentukan dengan cara mengeringkan akar dan tajuk di dalam oven pada suhu 37^0C selama 3x24 jam, lalu menimbangnya. Bobot basah dan bobot kering ditentukan pada akhir pengamatan.

Analisis Data.

Data kuantitatif dianalisis menggunakan Analisis Ragam berdasarkan Rancangan Acak Kelompok dengan tiga ulangan menggunakan program SPSS versi 15.0. Apabila perlakuan berpengaruh nyata dilanjutkan dengan uji *Duncan Multiple Range Test* (DMRT).

HASIL DAN PEMBAHASAN

Pertumbuhan Akar

Pertumbuhan akar padi saat tercekam garam dapat dilihat pada Tabel 1. Hasil penelitian menunjukkan bahwa pada perlakuan kontrol, 15 mM, dan 30 mM terdapat perbedaan nyata antara varietas-varietas padi yang diuji. Pertumbuhan akar kecambah padi Amat Candu lebih cepat dibandingkan dengan lima kecambah padi lainnya, baik pada kontrol maupun pada perlakuan garam (Tabel 1).

Pada konsentrasi garam 30 mM, varietas padi Amat Candu menunjukkan respon pertumbuhan akar yang tidak berbeda nyata dengan varietas padi pembanding yang tahan cekaman garam (Indragiri). Varietas padi Solok, Sadani, dan Yamin menunjukkan respon pertumbuhan akar yang tidak berbeda nyata dengan varietas padi IR64 yang merupakan varietas pembanding yang tidak tahan cekaman garam. Hal ini menunjukkan bahwa perlakuan garam dengan konsentrasi sebesar 30 mM dapat membedakan secara tegas antara varietas padi yang tahan dan tidak tahan cekaman garam.

Hasil penelitian ini juga menunjukkan bahwa konsentrasi garam yang dapat digunakan untuk menyeleksi tanaman padi yang tahan dan tidak tahan cekaman garam berdasarkan parameter pertumbuhan akar kecambah padi adalah konsentrasi garam sebesar 30 mM, karena pada konsentrasi garam sebesar 30 mM dengan jelas dapat membedakan pertumbuhan akar antara varietas padi yng tahan dan tidak tahan cekaman garam.

Sebaliknya, konsentrasi garam sebesar 45 mM tidak dapat digunakan untuk menyeleksi kecambah padi yang tahan dan tidak tahan garam, karena tidak ada perbedaan nyata antara varietas padi yang diuji dan semua varietas padi yang diuji menurun pertumbuhan akarnya pada perlakuan garam sebesar 45 mM. Hasil ini juga menunjukkan bahwa kemungkinan ambang batas toleransi kecambah padi tehadap cekaman garam adalah pada konsentrasi garam lebih dari 30 mM.

Omokawa *et al*. (2002) telah melakukan penelitian pengaruh cekaman garam sebesar 60 mM terhadap pertumbuhan akar dari kecambah padi. Hasil penelitiannya menunjukkan

Tabel 1. Rata–rata pertumbuhan akar (cm) kecambah padi pada perlakuan berbagai konsentrasi garam.

Varietas Padi	Perlakuan NaCl (mM)			
	0	15	30	45
IR64	1,64[a]	1,83[a]	1,77[a]	1,09[a]
Indragiri	1,95[a]	2,40[ab]	3,23[b]	1,56[a]
Solok	1,71[a]	2,06[a]	1,31[a]	0,61[a]
Sadani	1,63[a]	2,12[a]	1,99[a]	1,39[a]
Yamin	1,74[a]	1,90[a]	1,57[a]	1,55[a]
Amat Candu	2,88[b]	3,06[b]	3,51[b]	1,88[a]

Keterangan: Angka pada kolom yang sama diikuti oleh huruf yang sama tidak berbeda nyata pada uji DMRT α=0,05.

bahwa cekaman garam sebesar 60 mM telah menghambat pertumbuhan akar kecambah padi sebesar 54%. Akan tetapi dengan penambahan ameliorant, terjadi penurunan penghambatan pertumbuhan akar atau pertumbuhan akarnya naik menjadi 71%. Hasil penelitian Omokawa *et al*. (2002) ini mendukung hasil penelitian yang telah dilakukan bahwa semakin tinggi konsentrasi garam maka semakin menurun pertumbuhan akar kecambah padi, dan bahwa tanaman padi secara alami tanpa pemberian amelioran dapat mentolerir kadar garam tinggi sampai pada level konsentrasi garam NaCl sebesar 30 mM.

Biomassa Akar

Biomassa akar diperoleh dari selisih antara bobot basah akar dengan bobot kering akar. Rata-rata biomassa akar kecambah padi dari keenam varietas padi saat tercekam garam dapat dilihat pada Tabel 2.

Rata-rata biomassa akar kecambah pada keenam varietas padi yang diuji pada perlakuan konsentrasi garam 0 mM dan 30 mM tidak menunjukkan perbedaan nyata. Hasil tersebut menunjukkan tidak ada respon biomassa akar kecambah padi terhadap perlakuan konsentrasi garam 30 mM.

Sebaliknya, pada perlakuan garam 45 mM, varietas padi Indragiri memiliki nilai rata-rata biomassa akar kecambah yang tertinggi dan berbeda nyata dengan kelima varietas padi lainnya, diikuti Amat Candu yang berbeda nyata dari IR64. Hasil ini menunjukkan bahwa pada perlakuan garam sebesar 45 mM, varietas padi Indragiri menghasilkan respon biomassa akar yang paling tinggi diikuti Amat Candu. Respon biomassa akar paling rendah terjadi pada varietas padi IR64, Solok, Sadani, dan Yamin. Berdasarkan biomassa akar tersebut, Indragiri digolongkan sebagai varietas padi yang tahan cekaman garam, Amat Candu tergolong moderat, dan empat varietas padi lainnya tergolong tidak tahan cekaman garam.

Bobot kering akar pada penelitian ini mengalami penurunan yang sangat drastis dari bobot basah akar. Hal ini sejalan dengan yang telah dilaporkan oleh Siringam *et al*. (2011) bahwa cekaman garam menghambat karakter pertumbuhan akar, yang meliputi jumlah, panjang, bobot basah, dan bobot kering akar. Penurunan persentase perkecambahan, laju perkecambahan, panjang akar dan tajuk, serta bobot kering akar dan tajuk akan semakin besar seiring dengan peningkatan konsentrasi cekaman garam (Anbumalarmath & Mehta 2013).

Menurut Munns *et al*. (2006) cekaman garam dapat menginduksi cekaman osmotik dan keracunan ion. Cekaman osmotik menurunkan kemampuan tanaman untuk menyerap air dan keracunan ion menyebabkan kerusakan sel-sel daun, dan selanjutnya menurunkan fotosintesis dan pertumbuhan tanaman.

Hasil penelitian biomassa akar menunjukkan bahwa konsentrasi garam sebesar 0 mM dan 30 mM tidak dapat digunakan untuk menyeleksi tanaman padi yang tahan atau tidak tahan garam berdasarkan parameter biomassa akar, karena tidak ada perbedaan nyata antara varietas-varietas padi yang diuji. Konsentrasi garam yang dapat digunakan untuk menyeleksi kecambah padi yang tahan dan tidak tahan cekaman garam berdasarkan parameter biomassa akar adalah pada konsentrasi garam 45 mM, karena pada konsentrasi tersebut dengan jelas dapat membedakan biomassa akar antara varietas padi Indragiri dengan IR64, Solok, Sadani, Amat candu, dan Yamin, dan antara Amat Candu dengan IR64, Solok, dan Sadani.

Data biomassa akar sejalan dengan pertumbuhan akar, yaitu varietas padi Indragiri dan Amat Candu menunjukkan pertumbuhan akar dan biomassa akar yang paling tinggi dan berbeda nyata dengan varietas padi lainnya. Hal ini sejalan dengan hasil penelitian Omokawa *et al*. (2002) bahwa penurunan pertumbuhan akar diikuti dengan penurunan biomassa akar.

Tabel 2. Rata-rata biomassa akar (g) kecambah padi pada perlakuan berbagai konsentrasi garam.

Varietas	Perlakuan NaCl			
	0 mM	15 mM	30 mM	45 mM
IR64	0,02^{a}	0,02^{ab}	0,02^{a}	0,02^{a}
Indragiri	0,03^{a}	0,03^{c}	0,03^{a}	0,03^{c}
Solok	0,02^{a}	0,02^{a}	0,02^{a}	0,02^{a}
Sadani	0,02^{a}	0,02^{a}	0,02^{a}	0,02^{a}
Yamin	0,02^{a}	0,03^{ab}	0,02^{a}	0,02^{ab}
Amat Candu	0,03^{a}	0,03^{bc}	0,02^{a}	0,02^{b}

Keterangan: Angka pada kolom yang sama yang diikuti oleh huruf yang sama tidak berbeda nyata pada uji DMRT $\alpha = 0,05$

Pertumbuhan Tajuk

Pertumbuhan tajuk varietas padi lokal Bengkalis saat tercekam garam dapat dilihat pada Tabel 3. Rata-rata pertumbuhan tajuk pada berbagai perlakuan garam (0 mM, 15 mM, 30 mM dan 45 mM) menunjukkan terdapat perbedaan nyata antar varietas-varietas padi yang diuji. Pada konsentrasi 0 mM (kontrol), varietas padi Solok pertumbuhan tajuknya lebih cepat dibandingkan kelima varietas padi lainnya. Pada konsentrasi garam 45 mM dapat membedakan secara jelas pertumbuhan tajuk antara varietas padi Yamin dengan IR64, Indragiri, Solok, Sadani, dan Amat Candu. Namun, parameter pertumbuhan tajuk pada kecambah padi tidak dapat mencerminkan derajat toleransi terhadap cekaman garam pada varietas padi yang diuji. Hal ini kemungkinan karena cekaman garam belum dapat direspon oleh tajuk dalam waktu singkat, yaitu dalam penelitian ini tiga hari perlakuan cekaman garam. Kemungkinan tajuk merespon cekaman garam membutuhkan waktu lebih dari tiga hari. Hal ini terkait dengan translokasi garam dari akar ke tajuk dan juga kemampuan mengasingkan garam ke vakuola di daun. Hasil penelitian ini sejalan dengan yang telah dilakukan oleh Omokawa *et al*. (2002) bahwa cekaman garam NaCl dalam waktu beberapa hari tidak terlalu berpengaruh terhadap pertumbuhan tajuk dari kecambah padi.

Tingkat ketahanan tanaman terhadap cekaman garam antar spesies atau genotipe tanaman pertanian adalah kumpulan dari ekspresi sejumlah proses, yakni selektifitas influks, pertukaran K/Na dan ekstruksi Na, kompartementasi Na di korteks akar, regulasi Na dan Cl di endodermis, mendapatkan kembali Na dari aliran xylem, efisiensi transpirasi, mencegah akumulasi apoplastik, retranslokasi Na dan Cl di floem, retranslokasi K, akumulasi zat terlarut organik, kompartementasi Na dan Cl di daun dan lain-lain. Oleh karena itu mekanisme fisiologi yang berkaitan dengan ketahanan terhadap cekaman garam merupakan kumpulan dari proses fisiologi secara bersama-sama. Proses-proses tersebut berinteraksi pada level organisme untuk menentukan level utama toleransi (Subbarao 2002).

Biomassa Tajuk

Biomassa tajuk diperoleh dari selisih antara bobot basah tajuk dengan bobot kering tajuk. Rata-rata biomassa tajuk dari keenam varietas padi yang diuji saat tercekam garam dapat dilihat pada Tabel 4.

Hasil penelitian biomassa tajuk menujukkan bahwa biomassa tajuk varietas padi

Tabel 3. Rata-rata pertumbuhan tajuk (cm) kecambah padi pada perlakuan berbagai konsentrasi garam.

Varietas	Perlakuan NaCl			
	0 mM	15 mM	30 mM	45 mM
IR64	5,63^{c}	4,91^{bc}	5,51^{cd}	5,82^{c}
Indragiri	4,22^{b}	4,20^{ab}	3,74^{b}	3,65^{b}
Solok	7,03^{d}	5,68^{bc}	5,87^{d}	6,10^{c}
Sadani	5,22^{c}	5,15^{bc}	4,62^{bc}	4,09^{b}
Yamin	3,25^{a}	3,34^{a}	2,23^{a}	2,78^{a}
Amat Candu	5,67^{c}	5,88^{c}	5,04^{cd}	4,23^{b}

Keterangan: Angka pada kolom yang sama diikuti oleh huruf yang sama tidak berbeda nyata pada uji DMRT $\alpha = 0,05$

Tabel 4. Rata-rata biomassa tajuk (g) kecambah padi pada perlakuan berbagai konsentrasi garam.

Varietas	Perlakuan NaCl			
	0 mM	15 mM	30 mM	45 mM
IR64	0,05^{ab}	0,04^{ab}	0,05^{b}	0,04^{ab}
Indragiri	0,06^{b}	0,05^{b}	0,05^{b}	0,05^{c}
Solok	0,05^{ab}	0,05^{ab}	0,05^{b}	0,04^{bc}
Sadani	0,05^{ab}	0,05^{ab}	0,04^{ab}	0,04^{ab}
Yamin	0,04^{a}	0,04^{a}	0,04^{a}	0,03^{a}
Amat Candu	0,05^{ab}	0,05^{ab}	0,04^{ab}	0,04^{abc}

Keterangan: Angka pada kolom yang sama diikuti oleh huruf yang sama tidak berbeda nyata pada uji DMRT $\alpha = 0,05$

Indragiri pada kontrol dan perlakuan garam sebesar 45 mM lebih besar dibandingkan lima varietas padi lainnya, tetapi tidak berbeda nyata. Seperti halnya pertumbuhan tajuk, biomassa tajuk juga tidak dapat mencerminkan derajat toleransi kecambah padi yang diuji terhadap cekaman garam.

Hasil penelitian ini secara keseluruhan menunjukkan bahwa varietas padi lokal Riau yang kemungkinan tergolong moderat terhadap cekaman garam adalah Amat Candu, dan tiga varietas lainnya, yakni Solok, Sadani, dan Yamin, tergolong tidak tahan cekaman garam. Selain itu, bahwa respon kecambah padi terhadap perlakuan cekaman garam sebaiknya diteliti dengan mengamati parameter pertumbuhan akar pada perlakuan garam sebesar 30 mM.

Beberapa penelitian menunjukkan bahwa cekaman garam memberikan pengaruh serius kepada pertumbuhan dan produksi tanaman padi. Pencarian dan pengembangan padi yang toleran cekaman garam memerlukan metode skrining yang dapat diulang dan mensimulasikan kondisi di lapang. Cekaman garam dalam bentuk NaCl dapat menghambat pertumbuhan daun dan akar pada fase kecambah (Omokawa *et al*. 2002; Batlang *et al*. 2013) dan pembungaan (Batlang *et al*. 2013). Hal tersebut dapat terjadi karena garam NaCl menurunkan fotosintesis dan terjadi pemrograman ulang ekspresi gen akibat cekaman garam tersebut (Batlang *et al*. 2013).

Toleransi kecambah padi tidak hanya terkait dengan regulasi penyerapan dan translokasi ion Na^+ tetapi juga tergantung kemampuan kecambah tersebut mempertahankan level polyamin (biosintesis dan metabolisme) di daun selama cekaman garam (Yamamoto *et al*. 2011). Toleransi juga terkait erat dengan varietas padi karena setiap varietas mengembangkan derajat toleransi cekaman garam yang berbeda-beda pada level kecambah (Abbas *et al*. 2013).

Kemampuan tanaman untuk tumbuh pada kondisi cekaman garam akan menentukan distribusi dan produktifitasnya (Pattanagul & Thitisaksakul 2008). Peningkatan kadar garam pada tanah pertanian diramalkan berdampak pada hilangnya 30% tanah pertanian 25 tahun yang akan datang, dan 50% di tahun 2050 (Wang *et al*. 2003). Oleh karena itu pengembangan tanaman padi toleran cekaman garam melalui berbagai teknik pemuliaan tanaman harus dilakukan agar dapat menjamin keberlanjutan pangan manusia.

SIMPULAN

Pada kondisi tanpa cekaman garam (kontrol) dan dengan perlakuan cekaman garam, respon pertumbuhan akar kecambah padi Amat Candu lebih cepat dibandingkan dengan lima genotipe padi lainnya. Secara keseluruhan, respon pertumbuhan akar dan tajuk pada kecambah dari varietas padi Indragiri (sebagai varietas padi pembanding yang tahan cekaman garam) paling baik dibandingkan lima varietas padi lainnya yang diuji. Varietas padi lokal Riau yang memberikan respon pertumbuhan dan biomassa akar paling besar adalah Amat Candu dan Amat Candu tergolong varietas padi moderat cekaman garam. Empat varietas padi lainnya, yakni Solok, Sadani, dan Yamin, serta IR64 tergolong tidak tahan cekaman garam. Selain itu, bahwa respon kecambah padi terhadap perlakuan cekaman garam sebaiknya diteliti dengan mengamati parameter pertumbuhan akar pada perlakuan garam sebesar 30 mM.

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Kualitas Hasil Fermentasi Pada Pembuatan Pakan Ternak Ruminansia Berbahan Baku Eceng Gondok (*Eichornia crassipes*)

The Quality of Fermented Ruminant Feed Made from Common Water Hyacinth (*Eichornia crassipes*)

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Abstrak

Eceng gondok (*Eichornia crassipes*) merupakan gulma perairan yang mengganggu ekosistem. Eceng gondok mengandung protein dan serat kasar yang tinggi. Kandungan serat kasar sulit dicerna, oleh karena itu, eceng gondok perlu diolah menjadi pakan ternak rendah serat kasar dengan cara fermentasi. Tujuan penelitian ini untuk mendeskripsikan kualitas hasil fermentasi eceng gondok pada berbagai lama waktu fermentasi dan konsentrasi bioaktivator. Jenis penelitian yang digunakan adalah eksperimental dengan 2 perlakuan yaitu konsentrasi bioaktivator dan lama fermentasi. Variasi konsentrasi ragi tempe sebagai bioaktivator meliputi 0 g/kg (V0), 14 g/kg (V1), 17,5 g/kg (V23), 21 g/kg (V3) dan 24,5 g/kg (V4). Variasi lama fermentasi yaitu 5 hari (L5) dan 10 hari (L10). Selanjutnya, proses fermentasi untuk setiap perlakuan adalah 10 kg Eceng gondok dengan 5 kali ulangan keseluruhan sampela berjumlah 50. Parameter yang diukur meliputi kadar protein, serat kasar dan kandungan energi, serta struktur fisik. Hasil analisis menggunakan anava dua arah menunjukkan bahwa perlakuan V1L5 (14 g/kg dengan waktu fermentasi 5 hari) dengan kandungan protein kasar 11,09%, kadar serat kasar 21,16% serta kandungan energi 1064,27 Kcal/kg menunjukkan kualitas terbaik. Hasil fermentasi eceng gondok secara fisik berstruktur remahan, berwarna coklat kehitaman, dan berbau khas tempe.

Abstract

Water hyacinth (*Eichornia crassipes*) is an aquatic weed that disrupts the ecosystems. Water hyacinth contains high protein and fiber. However, the content of crude fiber is difficult to be digested; therefore, water hyacinth needs to be transformed into low crude fiber animal feed by fermentation processes. The purpose of this study was to describe the quality of fermented hyacinth on various duration of fermentation and various concentration of bioactivator. The study was an experimental study with two treatments, i.e. variation of bioactivator concentration and fermentation duration. The concentration of bioactivator (yeast of tempe) were 0 g/kg (V0), 14 g/kg (V1), 17.5 g/kg (V23), 21 g/kg (V3) and 24.5 g/kg (V4), whereas the duration of fermentation were 5 days (L5) and 10 days (L10). The fermentation process for each treatment was 10 kg Hyacinth with 5 replications; hence the total number of samples was 50. Parameters measured in this study included the levels of protein, crude fiber, energy content and physical structure. The results of the analysis using two-way ANOVA showed that the best quality was resulted from the V1L5 treatment (14 g/kg and the duration of fermentation was 5 days), namely 11.09% crude protein, 21.16% crude fiber content and energy content of 1064.27 Kcal/kg. The physical structure of fermented hyacinth were crumbs, blackish brown, and it had the distinctive smell of tempe.

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PENDAHULUAN

Eceng gondok merupakan gulma liar yang banyak terdapat di badan-badan perairan yang keberadaannya dapat menimbulkan efek negatif yang serius pada ekosistem perairan. Banyak usaha yang telah dilakukan untuk memanfaatkan gulma perairan ini, antara lain adalah usaha menggunakan eceng gondok sebagai pakan ternak unggas, seperti itik (Wahyono *et al*. 2005) serta sebagai pakan ikan nila merah (Muchtaromah *et al.* 2009).

Eceng gondok memang sangat potensial untuk pakan hewan, karena kandungan proteinnya yang tinggi (11,2%) namun satu kelemahan eceng gondok ialah merupakan bahan pakan yang ketercernaannya rendah karena banyak mengandung serat kasar (16,79%)

Untuk mengubah eceng gondok menjadi bahan pakan yang bernilai gizi baik dan mudah dicerna, maka salah satu cara yang dapat ditempuh adalah menggunakan teknologi fermentasi. Penelitian yang telah dilakukan oleh Fitrihidajati & Ratnasari (2005) bahwa pemanfaatan mikrobia yang terdapat dalam *Effective Microorganism* (EM4) dapat mempercepat dekomposisi limbah Blotong yang berupa serat menjadi pupuk organik. Demikian pula hasil penelitian yang lain oleh Isnawati (2008), telah berhasil mengembangkan probiotik yang dapat digunakan untuk mendegragasi materi-materi yang berasal dari tumbuhan. Isnawati (2010) dan Pamungkas & Khasani 2010 juga telah berhasil mencoba memfermentasi pakan ternak dari limbah pertanian dan diimplementasikan pada ruminansia.

Tujuan penelitian ini adalah untuk mengetahui kualitas hasil fermentasi eceng gondok pada berbagai konsentrasi bioaktivator dan lama fermentasi.

METODE PENELITIAN

Jenis penelitian adalah eksperimental dengan dua faktor perlakuan berbagai konsentrasi bioaktivator berupa ragi tempe dan lama fermentasi. Konsentrasi ragi tempe yang digunakan meliputi: 0 g/kg (V0), 14 g/kg (V1), 17,5 g/kg (V23), 21 g/kg (V3) dan 24,5 g/kg (V4) selama 5 hari (L5) dan 10 hari (L10). Setiap perlakuan dibuat dengan menggunakan bahan baku eceng gondok sejumlah 10 kg dengan 5 ulangan sehingga jumlah sampel 50. Pakan hasil fermentasi dari berbagai perlakuan lalu dianalisis kadar protein, serat kasar, kandungan energi serta struktur fisik.

Bahan – bahan yang digunakan ialah eceng gondok yang diambil bagian batang dan daunnya dengan berat 800 kg, tetes tebu (molase) konsentrasi 100% sebanyak 4 liter, serbuk tongkol jagung 200 kg, ragi tempe 15,4 kg, air untuk mengukus, dan daun pisang.

Proses fermentasi eceng gondok menggunakan 5 konsentrasi ragi tempe, yakni 0 g/kg, 14 g/kg, 17,5 g/kg, 21 g/kg dan 24,5 g/kg. Kelima konsentrasi tersebut diberi kode secara berturut-turut V0L5, V1L5, V2L5, V3L5, dan V4L5 dengan lama fermentasi 5 hari serta V0L10, V1L10, V2L10, V3L10, dan V4L10. Masing-masing perlakuan diulang sebanyak 5 kali. Sebelum dilakukan proses fermentasi, eceng gondok dicacah terlebih dahulu. Setelah dicacah, eceng gondok dikering-anginkan selama 7 hari, kemudian dicampur dengan bahan tambahan (10 kg eceng gondok + 2,5 kg, serbuk tongkol jagung + 50 cc molase), kemudian dikukus selama 20 menit. Setelah dikukus, bahan campuran didinginkan sampai suhu ruangan (± 27°C), kemudian ditambahkan ragi tempe sesuai dengan perlakuan. Eceng gondok siap fermentasi dimasukkan kedalam keranjang kotak yang telah dilapisi daun pisang pada bagian samping dan bawahnya, serta menutup bagian atasnya. Fermentasi dilakukan selama 5 hari dan 10 hari dengan dilakukan pengecekan setiap hari terhadap suhu untuk memaksimalkan pertumbuhan ragi tempe. Setelah fermentasi bahan kembali dikering-anginkan sampai menjadi remah.

Analisis data dilakukan dengan menggunakan analisis statistik Anava dua arah (*Two Way Annova*) dengan membandingkan hasil fermentasi pada setiap perlakuan terhadap kandungan gizi eceng gondok. Analisis dilanjutkan dengan uji beda *Duncan*.

HASIL DAN PEMBAHASAN

Hasil fermentasi eceng gondok berstruktur remah, berwarna coklat kehitaman, dengan aroma cenderung berbau khas tempe seperti pada Gambar 1.

Berdasarkan hasil analisis proksimat di atas memperlihatkan bahwa pada dasarnya semua perlakuan menghasilkan pakan yang layak untuk diberikan pada hewan uji coba. Tetapi apabila dibandingkan perlakuan yang menghasilkan pakan terbaik berdasarkan kriteria kandungan protein kasar tertinggi, serat kasar terendah dan energi tertinggi ialah perlakuan pada V1L5.

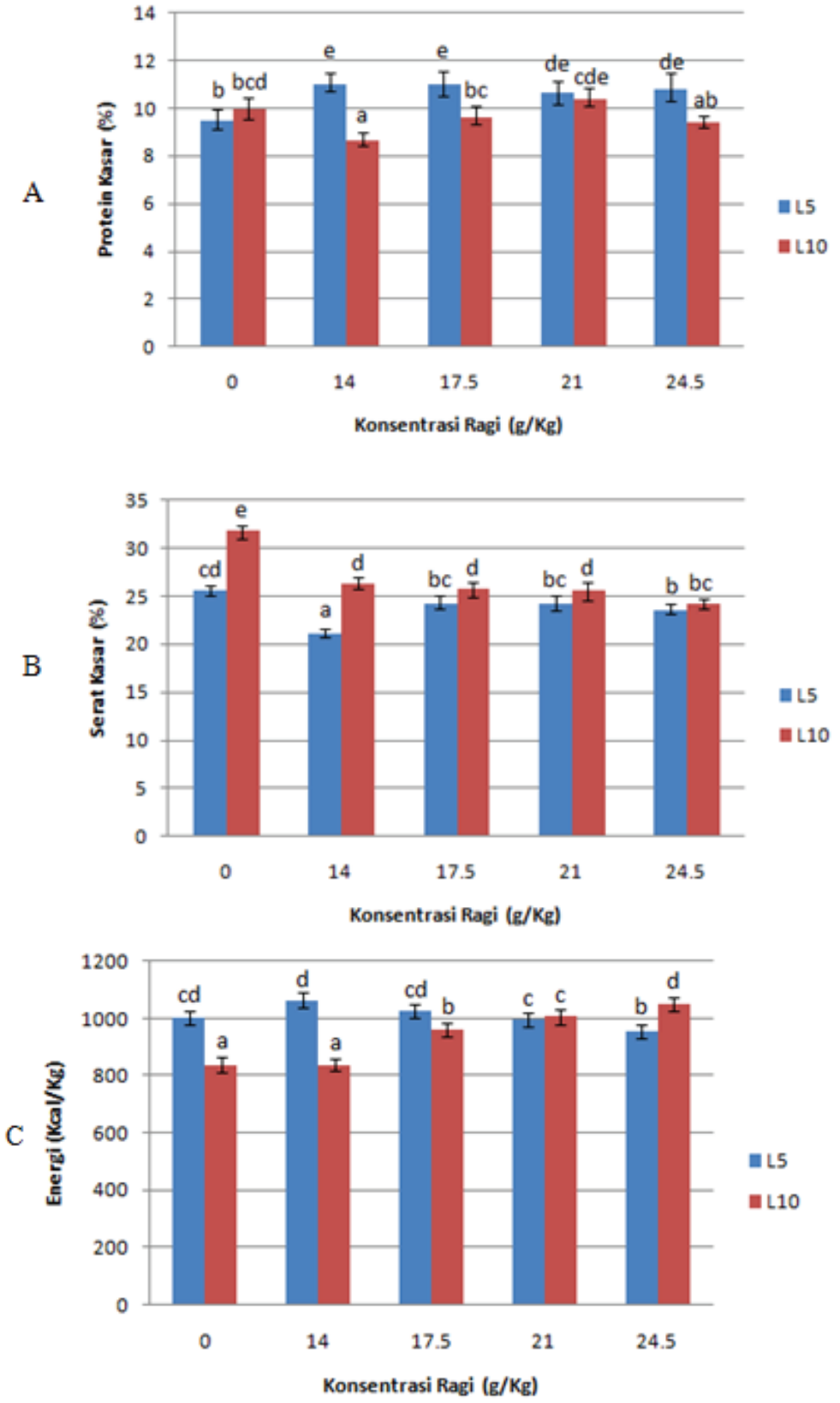
Gambar 1. Hasil Fermentasi Eceng Gondok Berbentuk Remahan

Pakan eceng gondok yang difermentasi dengan penambahan ragi tempe pada berbagai konsentrasi mempunyai nilai gizi yang relatif lebih baik jika dibandingkan dengan pakan eceng gondok yang pada proses fermentasinya tidak menggunakan ragi tempe (kontrol/V1L5). Hal ini disebabkan pada ragi tempe terkandung sejumlah mikroorganisme dari kelompok selulolitik, amilolitik, proteolitik dan lipolitik. Kelompok selulolitik akan mendegradasi selulosa menjadi komponen penyusunnya yaitu glukosa (Isnawati 2010), kelompok amilolitik akan menguraikan komponen amilum yang terdapat pada bahan baku pakan menjadi glukosa, komponen protein akan diuraikan menjadi peptide yang lebih sederhana oleh organisme proteolitik. Sedangkan komponen lemak akan disederhanakan oleh kelompok lipolitik (Antonius 2009; Rai *et al.* 2010). Proses penguraian akan lebih cepat dengan penambahan ragi tempe dibandingkan fermentasi tanpa penambahan ragi tempe karena mikroorganisme yang terkandung dalam ragi tempe menjadi agen pendegradasi komponen-komponen tersebut (Tirajoh 2003). Hal serupa juga dilaporkan oleh Zaman (2013) bahwa ragi tempe dapat digunakan untuk mempercepat proses fermentasi dan meningkatkan kandungan gizi kiambang (*Salvinia molesta*). Proses degradasi tetap terjadi pada bahan baku yang tidak ditambah ragi tempe, karena pada bahan tersebut sudah terdapat mikroflora yang menjadi penghuni alamiah. Adapun jenis-jenis mikroflora yang terdapat pada ragi tempe adalah *Rhizopus oligosporus*, *Rhizopus oryzae*, *Rhizopus stolonifer,* dan *Rhizopus arrhizus* (Fardiaz 1992). Ragi tempe yang ditambahkan itu sendiri juga menjadi tambahan gizi pada pakan yang dibuat, utamanya sumber protein.

Perbedaan yang menonjol antara pakan fermentasi eceng gondok yang ditambah ragi tempe dan tanpa penambahan ragi tempe adalah bahwa pada pakan eceng gondok tanpa penambahan ragi tempe kadar serat kasarnya tinggi. Hal ini menunjukkan bahwa jenis karbohidrat yang tidak tercerna oleh mikroorganisme ini banyak yang tetap utuh belum terdegradasi. Dada (2002) melaporkan bahwa pakan dengan tambahan eceng gondok yang dikeringkan tanpa melalui proses fermentasi memiliki kadar serat kasar yang tinggi yakni antara 22-31%. Serat kasar yang tinggi ini menunjukkan kandungan selulosa yang tinggi. Pendegradasian selulosa memang relatif sulit karena biasanya mikroorganisme tidak dapat mencerna titik-titik percabangan pada molekul besar (Lehninger 1982).

Berdasarkan hasil penelitian, perlakuan V1L5 menghasilkan pakan fermentasi eceng gondok yang kandungan gizinya relatif lebih tinggi dibandingkan dengan perlakuan lainnya. Hal ini dapat terjadi karena tercipta kondisi berimbang antara jumlah mikroorganisme yang mendegradasi dengan bahan yang didegradasi. Apabila jumlah mikroorganisme yang mendegradasi senyawa kimia kompleks sedikit, maka jumlah gizi atau bahan yang terdegradasi juga hanya sedikit. Senyawa kimia kompleks masih terlalu banyak yang tersisa tidak terdegradasi, sehingga nilai gizinya juga turun. Pada penambahan ragi tempe yang terlalu banyak juga akan menghasilkan proses perubahan bahan kompleks menjadi bahan sederhana yang siap pakai juga cepat. Jumlah mikroorganisme yang terdapat di dalamnya juga banyak, maka sebagian bahan hasil degradasi bahan itu akan digunakan kembali oleh mikroorganisme itu untuk mempertahankan hidupnya dan tumbuh. Hal ini disebabkan karena pertumbuhan mikroorganisme itu cepat dan menunjukkan kurva yang eksponensial (Pelczar & Chan 1986). Berdasarkan hal inilah mengapa penambahan ragi tempe yang lebih banyak (V2, V3 dan V4) menghasilkan pakan yang nilai gizinya relatif lebih sedikit.

Apabila dicermati maka ternyata lama



Gambar 2. Histogram perbandingan kadar protein kasar (A), serat kasar (B), dan kandungan energi pada pakan hasil fermentasi eceng gondok (C).

fermentasi mempengaruhi nilai gizi pakan yang dihasilkan. Sebagai gambaran dapat dikemukakan hasil perhitungan protein kasar pada lama fermentasi 5 hari lebih tinggi dibandingkan dengan lama fermentasi 10 hari, dan kandungan energi pakan hasil fermentasi eceng gondok dengan lama fermentasi 5 hari lebih tinggi dibandingkan dengan lama fermentasi 10 hari. Hal ini disebabkan semakin lama waktu fermentasi yang kita berikan semakin panjang kesempatan bagi mikroorganisme untuk mendegradasi bahan yang terdapat di dalamnya. Sebagaimana kita ketahui bahwa proses pendegradasian itu merupakan proses enzimatik yang memerlukan waktu relatif lama (Isnawati 2010; Lestari *et al*. 2005). Dalam hal ini seharusnya dengan waktu fermentasi yang lebih lama kualitas hasilnya lebih baik tetapi kenyataanya tidak demikian. Hal tersebut disebabkan karena jumlah ragi yang diberikan konsentrasinya sama antara fermentasi 5 hari dengan 10 hari, sehingga degradasi telah tercapai saat 5 hari. Demikian pula volume bahan baku sama sementara waktu 10 hari lebih lama. Zakaria *et al*. (2013) juga menemukan bahwa lama penyimpanan jerami pada yang ditambahkan inokulan kapang tidak memberikan efek yang nyata terhadap kadar proteinnya.

Hal yang penting dalam penelitian fermentasi eceng gondok untuk pakan ruminansia ini adalah bahwa pada dasarnya semua perlakuan menghasilkan pakan yang aman untuk dikonsumsi hewan uji, karena tidak mengadung zat-zat yang membahayakan. Sebelumnya, Marlina & Askar (2001) menyebutkan bahwa eceng gondok dapat digunakan sebagai pakan tambahan yang baik untuk ternak non ruminansia. Kandungan protein kasar yang terdapat pada pakan hasil fermentasi eceng gondok pada semua perlakuan telah memenuhi kebutuhan dasar domba untuk hidup. Sebagai pedoman kasar, jumlah protein kasar minimum yang diperlukan domba untuk hidup pokok sebesar 8% dari bahan kering. Domba yang sedang tumbuh atau laktasi memerlukan protein kasar sejumlah 11% dari bahan kering (Guntoro 2002).

Pakan yang nilai gizinya tinggi pasti dapat memicu pertambahan berat badan lebih cepat. McDonald *et al* (2002) menyatakan bahwa pertumbuhan ternak dikontrol oleh konsumsi nutrisi khususnya konsumsi energi.

Berdasarkan pembahasan dapat diketahui bahwa eceng gondok dapat dimanfaatkan sebagai pakan tambahan. Proses fermentasi seperti yang telah digunakan pada pakan-pakan alternatif lainnya yakni menggunakan ragi tempe sebagai agen fermentasi (Amit *et al*. 2010). Dengan demikian mempunyai potensi sebagai pakan tambahan untuk ruminansia lainnya.

SIMPULAN

Hasil fermentasi eceng gondok secara fisik berstruktur remahan, berwarna coklat kehitaman, dan berbau khas tempe. Hasil analisis proksimat, diketahui bahwa perlakuan V1 (14g/kg) mengandung kandungan gizi terbaik yaitu memiliki kandungan protein kasar yang paling tinggi yakni 11,09% dan kadar serat kasar yang relatif rendah (21,16%) dan kandungan energi 1064,27 kcal/kg.

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Eksplorasi dan Pengamatan Intensitas Serangan Hama Penting Tanaman Tebu di PTPN VII, Cinta Manis Sumatera Selatan

Exploration and Intensity Observation of Important Pests Attack At Sugar Cane Plant in PTPN VII, Cinta Manis South Sumatra

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Abstrak

Penelitian bertujunan mengamati serangga-serangga hama penting yang menyerang tanaman tebu di PTPN VII, Cinta Manis Sumatera Selatan, dilakukan dari bulan Februari sampai September 2012.Metode survei langsung ke pertanaman dengan mengikuti jadual early warning system (*EWS*) PTPN VII.Hasil penelitian ditemukan serangga hama penting tanaman tebu ialah penggerek batang bergaris (*Chilo saccharipaghus*), penggerek batang berkilat (*Chilo auricilius*), dan penggerek pucuk (*Scirpophaga nivella*). Gejala serangan penggerek batang dan pucuk tebu ditemukanpada umur 2 bulan, serangan tinggi pada umur 3-5 bulan, hal ini berkaitan dengan cuaca.Pada saat penelitian dilakukan serangan tertinggi terjadi pada bulan Mei sampai Juli, dengan suhu, curah hujan, jumlah hari hujan, dan kelembaban nisbi berturut-turut adalah 26,6^{O}C, 245,5 mm, 17 hari dan 98%. Serangan pada tanaman muda, menyebabkan kematian. Pada tanaman yang sudah membentuk ruas, gejala penggerek batang jelas terlihat dari luar jika daun tebu "diklentek". Gejala serangan penggerek pucuk terlihat pada helai daun yang berlubang.Intensitas serangan penggerek batang tertinggi pada umur tebu 3 bulan (6,69%), sedangkan intensitas serangan (2,97%) dan populasi penggerek pucuk (44,60 larva) tertinggi pada umur 3,5 bulan.

Abstract

The research aims to observe the important pest insects attacking sugarcane in PTPN VII, Cinta Manis,South Sumatra. Direct Survey methodto the crop by following the schedule ofearly warning system (EWS) of PTPN VII, conducted from February to September 2012. The resultsfoundthatimportant insect pests attacking sugarcane werestriped stem borer (*Chilo saccharipaghus*), shiny stem borer (Chilo auricilius), and shoot borers (Scirpophaga nivella). Symptomsattackof shotand stemborer of sugarcane were found at 2 months of sugarcane age, high attack at the age of 3-5 months, it is highly related to weather.The highest attack occurred in May and July, with the temperature, precipitation, number of rainy days, and the relative humidity in were 26.6 oC, 245.5 mm, 17 days and 98% respectively.Attack on young plants, causing death. In plants that were already established segments, stem borer symptoms clearly visible from the outside ifsugarcane leaves were "diklentek".Shoot borers attack symptoms seen in the perforated leaves. The highest intensity attackof stem borer was at 3 months of sugarcane age (6.69%), while the attack intensity (2.97%) and the highestpopulation of shoot borer(44.60 larvae) were at3.5 months of sugarcane age.

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PENDAHULUAN

Tanaman tebu (*Saccharum officinarum* L.) merupakan tanaman penghasil utama gula. Tanaman tebu yang dibudidayakan dengan baik dapat menghasilkan bobot kering rata-rata 1000-1200 kuintal per hektar (Pratama *et al*., 2010).Hasil panen tersebut sering tidak tercapai karena serangan hama tanaman, hal itu juga terjadi di perkebunan tebu Cinta Manis. Penurunan produksi gula karena serangan hama dapat mencapai 20% per tahun (Sutejo, 2008).Di Reunion Island pada tingkat serangan berat kedua hama ini dapat menyebabkan kehilangan tebu berkisar antara 30-40 ton (Conlong & Goebel, 2003). Hama utama tebu di sentra perkebunan tebu Cinta Manis antara lain penggerek batang bergaris (*Chilo sacchariphagus*), penggerek batang berkilat (*Chilo auricilius*), dan penggerek pucuk (*Scirpophaga nivella*) (Juklak PHT Cinta Manis, 2010).

Serangan serangga hama penggerek batang dan pucuk tebu sangat berpengaruh terhadap pertumbuhan tanaman tebu.Kerusakan yang disebabkan oleh hama penggerek batang dan pucuk tebu tersebut akan mengurangi volume nira tebu, akibatnya produksi gulamenjadi berkurang. Kehilangan hasil gula akibat serangan penggerek pucuk dapat mencapai 8,9% (Sudarsono *et al*., 2011).Serangan penggerek batang tebu pada perkebunan tebu PT GMP, Lampung Tengah, dilaporkan mencapai 6,43%, sementara pada varietas rentan kerusakan dapat mencapai 19 % (Sunaryo, 2003).

Hasil pengamatan penulis terhadap serangan penggerek batang dan pucuk pada tanaman tebu yang masih muda dapat menyebabkan tanaman mati.Serangan penggerek batang dan pucuk pada tanaman yang berumur lebih dari 5 bulan terbentuk terowongan yang dapat mengakibatkankualitas dan kuantitas gula rendah.Penelitian yang dilakukan oleh Sudarsono *et al*., (2011) menunjukkan bahwa di perkebunan tebu Gunung Madu serangan hama penggerek pucuk tebu dapat mencapai 20,73% dengan rata-rata 17,03%.

Pengendalian terhadap hama penggerek batang dan pucuk ini masih sangat mengandalkan pestisida.Pemakaian pestisida memiliki dampak negatif terhadap produk pertanian (Sukmawaty *et al*., 2008; Hamijaya *et al*., 2004; Hamid *et al*., 2003).Penggunaan pestisida yang berspektrum luas juga dapat mematikan serangga-serangga lain yang bermanfaat (Amirhusin, 2004; Kartohardjono, 2011).Hama penggerek batang dan pucuk berada di dalam batang, sehingga tidak efektif dikendalikan dengan pestisida.

Data di pabrik gula Cinta Manis Sumatera Selatan, menunjukkan penurunan produksi gula dalam 5 tahun terakhir.Pada musim tanam 2006/2007 di Cinta Manis tercatat intensitas serangan penggerek pada tebu siap panen sebesar 11,25% (Juklak PHT Cinta Manis, 2010). Tujuan penelitian memberikan informasi mengenai hama-hama penting yang menyerang tanaman tebu di PTPN VII, Cinta Manis Sumatera Selatan.

METODE PENELITIAN

Penelitian ini dilakukan di PTPN VII Cinta Manis Sumatera Selatan, sejak bulan Februari sampai September 2012.Suhu dan kelembaban pada saat penelitian berkisar antara 24,4–37,2°C, dan 88-98%.Pengamatan dilakukan sejak tanaman tebuberumur 1,5 sampai 6,5 bulan setiap 2 minggu sekali.Metode survei digunakan untuk mengamatilangsung ke tanaman tebu, mengikuti jadual *Early Warning System* (EWS), seperti yang dilakukan diperkebunan Cinta Manis (Juklak PHT Cinta Manis, 2010).

Eksplorasi hama-hama penting tanaman tebu di Cinta Manis

Kegiatan mengumpulkan telur, larva, pupa dan imago dari tanaman tebu dilakukan pada pagi hari sebelum pukul 7.00 WIB. Larva penggerek batang diambil dengan cara membelah batang tebu yang menunjukkan gejala serangan penggerek batang.Larva penggerekpucuk dikumpulkan dengan cara mengambil bagian pucuk tanaman tebu yang menunjukkan gejala serangan penggerek pucuk. Spesimen yang didapat dimasukkan ke dalam botol vial berisi alkohol 70%, dan dibawa ke laboratorium untuk identifikasi.Identifikasi hama-hama penting pada tanaman tebu dilakukan berdasarkan cirri morfologi telur, larva, pupa dan imago.

Imago penggerek batang dan pucuk ditangkap menggunakan jaring serangga.Imago yang tertangkap kemudian dimatikan lalu ditempatkan di kertas segitiga dan dibawa ke laboratorium untuk dijadikan koleksi.

Telur, larva, pupa dan imago yang didapat dari lapangan sebagian dibiarkan hidup dan dipelihara di laboratorium.Tujuan dari pemeliharaan tersebut ialah untuk mendapatkan informasi mengenai prilaku yang dikaitkan dengan kejadian-kejadian di pertanaman tebu.

Pengamatan Intensitas Serangan dan Populasi Penggerek Batang dan Pucuk Tebu

Pengamatan intensitas serangan

penggerek batang dan pucuk tebu dilakukan pada lahan pertanaman tebu seluas 1 ha.Lahan seluas 1 ha ini dibagi menjadi 5 titik pengamatan secara diagonal, masing-masing seluas 200 m^2 dengan populasi tanaman tebu pada masing-masing titik pengamatan lebih kurang 1500 batang.

Kerusakan batang tebu akibat penggerek batang dan pucuk diamati secara langsung pada batang tebu tanaman contoh.Batang tebu yang menunjukkan gejala serangan diberi tanda dan diamati.Pengamatan terhadap populasi serangga penggerek pucuk tebu dilakukan dengan cara membelah pucuk tebu yang menunjukkan gejala serangan.Untuk menghindari kematian tanaman tebu contoh, maka pengamatan populasi hama batang tebu tidak dilakukan.Pengamatan ini dilakukan setiap 2 minggu sejak tanaman berumur 1,5 bulan sampai 6,5 bulan.Penentuan tingkat kerusakan batang tebu yang disebabkan oleh penggerek batang dan pucuk dilakukan dengan metode Knutson (2007).

Analisis Data

Data hasil eksplorasi serangga hama penting tanaman tebu, dianalisis secara deskriptif dan disajikan dalam bentuk gambar.Tingkat populasi larva dan kerusakan batang tebu oleh larva *C. sacchariphagus* dan *C. auricilius*, dan tingkat kerusakan oleh larva *S. nivella* dianalisis dengan Analysis of Variance (ANOVA) yang dilanjutkan dengan uji BNJ pada taraf 5%.

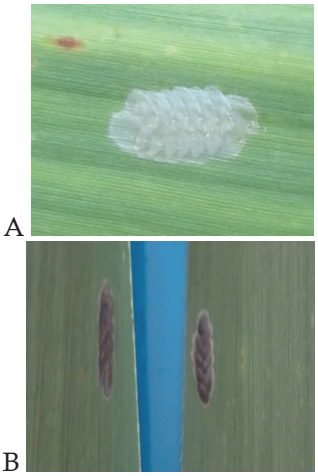
HASIL DAN PEMBAHASAN

Eksplorasi hama-hama penting tanaman tebu di Cinta Manis

Hasil penelitian menunjukkan serangga hama penting yang menyerang tanaman tebu di perkebunan tebu Cinta Manis Sumatera Selatan ada 3 spesies.Ketiga spesies itu ialah penggerek batang *Chilo auricillius*, *Chilo sacchariphagus*, dan penggerek pucuk *Scirpophaga nivella.*

Gejala serangan ketiga jenis hama penggerek tersebut dapat ditemukan sejak tanaman tebu berumur 2 bulan.Kerusakan tertinggi dari serangan ketiga jenis serangga hama tersebut terjadi pada tanaman tebu berumur antara 3-5 bulan.

Telur serangga penggerek batang *C. sachariphagus* dan *C. auriciliu* relatif sama, berbentuk elips dan pipih.Telurdiletakkan tersusun menyerupai susunan gentingdalam 2 atau 3 baris.Susunan telur tersebut terletak di permukaan atas atau permukaan bawah daun. Susunan telur juga dapat ditemukan di pelepah daun yang masih muda.Telur yang baru diletakkan terlihat jernih (Gambar 1a), sedangkan telur yang hampir menetas berwarnakehitaman (Gambar 1b).Telur terlihat jelas, karena tidak ditutupi oleh rambut-rambut.Hasil pengamatan didapat ukuran telur-telur itu berkisar 1 mm atau lebih.Menurut Pramono (2005), ukuran telur hama penggerek batang berkisar 1,30x1,60 mm sampai 0,70x1,20 mm.Hasil penelitian Kumar *et al* (2010) didapat ukur telur penggerek berkisar antara 0,75-1,25 mm dengan rata-rata 0,95 mm.Stadia telur berlangsung 7-9 hari (Achadian, 2007).

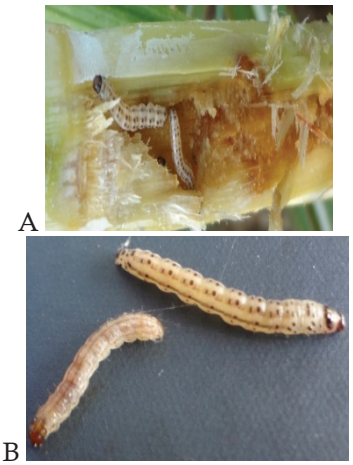


Gambar 1. Telur serangga penggerek batang yang baru diletakkan (a) dan menjelang menetas (b).

Hasil penelitian terhadap kelompok telur menunjukkan bahwa telur banyak ditemukan di tanaman tebu berumur 3-5 bulan.Pada tanaman yang berumur 7-9 bulan telur-telur penggerek batangsulit ditemukan di pertanaman tebu. Peletakan telur oleh imago sangat dipengaruhi oleh umur tebu dan kondisi iklim.Saat tebu berumur 7-9 bulan, penelitian berlangsung pada bulan Juli sampai September.Pada waktu itu suhu, curah hujan, jumlah hari hujan, serta kelembaban nisbi berturut-turut adalah 28,3^{O}C, 15 mm, 6 hari dan 87%.Jumlah telur yang dihasilkan oleh imago betina sekitar 50-100 butir per hari dan diletakkan pada malam hari selama 3-5 hari.Jumlah ini juga sama dengan hasil penelitian yang dilakukan oleh Pramono (2005).

Larva penggerek batang tebu dapat ditemukan apabila batang tanaman tebu yang menunjukkan gejala serangan itu dibelah.Di dalam batang tebu tersebut dapat ditemukan lebih dari 1 ekor larva instar 1 dan 2 (Gambar 2a). Larva yang ditemukan hanya satu ekor apabila telah mencapai instar 3 atau pupa (Gambar 3).Perbedaan jumlah larva yang ditemukan itu disebabkan oleh prilaku larva penggerek batang

yang bersifat kanibal.



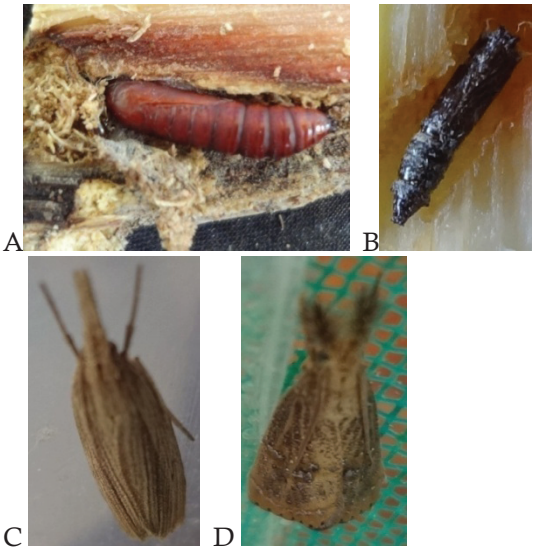
Gambar 2. Larva *C. sachariphagus* dan *C. auriciliu*instar 1 dan 2 (a) dan instar 3 (b).

Gambar 3. Larva penggerek batang instar 3 dan pupa di dalam batang tebu

Larva penggerek batang yang baru menetas bergerak ke bawah melalui pelepah daun menuju kelopak daun di batang yang akan digerek, kemudian menetap di ruas-ruas batang. Larva dapatberpindah ke batang tebu yang lain dengan membentuk benang dari liurnya.Larva yang bergantung itu di hembus angin pindah ke batang tebu yang lain. Larva yang baru menetas ini berukuran antara 2,2-2,5 mm.Larva instar lima panjang tubuhnya dapat mencapai 4 cm dan lebar berkisar antara 4-5 mm.ukuran larva hama penggerek berkilat lebih kecil dari hama penggerek baang bergaris.

Selama masih di dalam daun, larva instar awal aktif menggerek jaringan epidermis daun, sehingga ketika daun membuka akan tampak luka-luka bekas gerekan.Luka gerekan di daun itu umumnya tidak sampai tembus atau menimbulkan lubang.Luka tersebut bila dilihat dari jauh nampak seperti bercak berwarna putih (Sutejo, 2008).

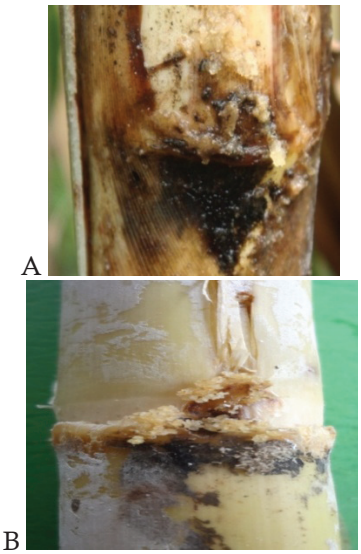
Hasil pengamatan terhadap pupa penggerek batang menunjukkan bahwa pupa terbentuk di dalam batang.Pupa terbentuk setelah larva membuat lobang khusus di bagian ujung lorong gerekan yang ditutupi oleh selaput epidermis sebagai tempat imago keluar.Pupa yang baru terbentuk berwarna putih susu. Menjelang menjadi imago pupa berwarna coklat kehitaman.Panjang pupa hama penggerek batang bergaris berkisar antara 1,4-1,7 cm, di ujung tidak terdapat tonjolan (Gambar 4a).Panjang pupa penggerek batang berkilat berkisar antara 1,3-1,6 cm, diujung pupa terdapat dua tonjolan kecil (Gambar 4b).Stadia pupa berkisar antara 11-13 hari (Achadian, 2007).



Gambar 4. Pupa dan imago serangga hama penggerek batang tebu

Imago penggerek batang bergaris berwarna kecoklatan tanpa bintik hitam di sayap belakang (Gambar 4c).Imago penggerek batang berkilat, disayap belakangnya terdapat dua bintik hitam (Gambar 4d). Sayap belakang kedua spesies penggerek batang tersebutmemiliki rumbai-rumbai.Imago aktif pada malam hari. Selama penelitian berlangsung, di lapangan tidak ditemukan imago penggerek batang, baik yang berkilat maupun bergaris. Hasil penelitian menunjukkan gejala serangan penggerek batang di lapangan tidak dapat dibedakan antara gejala yang disebabkan oleh serangan penggerek batang bergaris atau berkilat.Gejala yang disebabkan oleh kedua spesies serangga hama penggerek batang tersebut jelas terlihat setelah pelepah daun tebu diklentek.Pada bagian luar terdapat tepung bekas gerekan.Jika tepung gerekan masih basah (Gambar 5a), menandakan bahwa lobang

gerekan baru terbentuk, dan larva masih berada di dalam batang tebu.Sebaliknya jika tepung sudah mengering, umumnya hama sudah keluar dari batang tebu atau sudah menjadi imago (Gambar 5b).



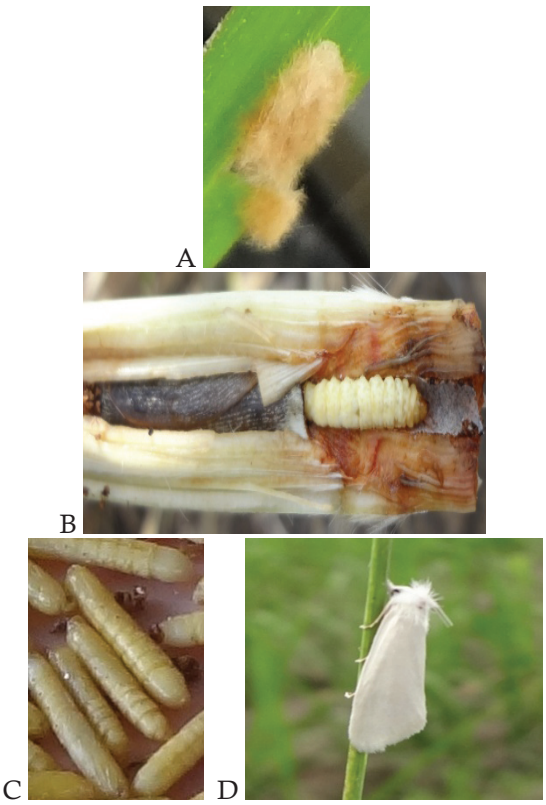
Gambar 5. Gejala luar serangan hama penggerek batang.

Hama penting lainnya adalah penggerek pucuk tebu (*S. nivella*).Pada penelitian ini telur penggerek pucuk mulai ditemukan pada tanaman tebu berumur 1,5 bulan.Gejala serangan penggerek pucuk baru terlihat pada tanaman tebu berumur 2 bulan.Telur diletakkan secara berkelompok di permukaan atas atau permukaanbawah daun.Kelompok telur ditutupi oleh sisik berwarna coklat kekuningan yang berasal dari abdomen imago betina (Gambar 6a).

Larva yang baru menetas bergerak menuju daun yang masih muda dengan cara menggantung pada benang-benang halus yang dikeluarkan dari mulutnya. Larva akan menggerek daun dan menuju ibu tulang daun, larva menggerek menuju titik tumbuh batang dan menembus batang. Hasil penelitian ditemukan bahwa larva dapat menembus batang tebu sampai 3 atau 4 ruas teratas.

Selama perkembangannya larva berada di dalam batang tebu. Setiap batang berisi satu ekor penggerek pucuk.MenurutKalshoven, 1981, di bagian pucuk tanaman tebu yang terserang, hanya terdapat 1 ekor larva penggerek pucuk. Larva instar awal berwarna kelabu, kemudian berubah warna kuning kecoklatan dan pada saat mendekati stadium pupa berwarna kuning putih (Gambar 6b).

Pupa berwarna putih kekuningan (Gambar 6c), dan terbentuk di dalam batang di bagian atas ruas.Di sisi tepi pupa terdapat selaput yang dibentuk oleh larva sebagai jalan keluar imago.



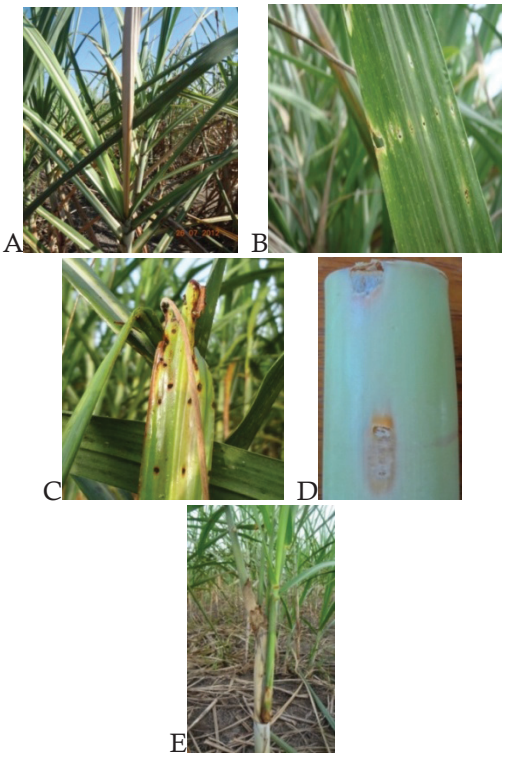
Gambar 6. Telur (a), larva (b), pupa (c), dan imago (d) hama penggerek pucuk tebu

Imago memiliki ciri yang khas.Sayap dan tubuhnya berwarna putih.Pada bagian atas kepala terdapat kumpulan rambut seperti jambul yang berwarna merah (Gambar 6d). Imago penggerek pucuk dengan ciri yang jelas tersebut menyebabkan ia mudah ditemukan di pertanaman tebu.Siklus hidup penggerek pucuk tebu yang jantan lebih pendek daripada yang betina.

Serangan penggerek pucuk dapat terjadi pada tanaman tebu yang masih muda dan belum membentuk ruas.Daun yang terserang akan menggulung dan kering.Gejala mengeringnya daun pucuk tersebut dikenal dengan istilah mati puser (Gambar 7a).Gejala serangan pada tanaman tebu yang sudah membentuk ruas terdapat ciri yang khas.Pada helai daun yang terserang terdapat lubang-lubang yang tersusun dari sisi tepi sampai ke sisi lainnya melintasi tulang daun.Lubang-lubang bekas gerekan itu berwarna coklat (Gambar 7b). Apabila batang yang menunjukkan gejala serangan penggerek pucuk dibelah, akan terlihat lorong gerekan. Lorong gerekan itu dimulai dari titik tumbuh terus mengarah ke bawah menembus ruas-ruas batang.

Dari luar akan tampak bayangan letak larva dan lobang untuk jalan keluar imago (Gambar 7d).

Serangan berat pada tanaman yang telah membentuk ruas, dapat menyebabkan daun di bagian pucuk menjadi busuk (Gambar 7c), dan menyebabkan pucuk tanaman mati. Tanaman yang mati pucuk tersebut masih dapat membentuk tunas baru, yang dikenal dengan nama siwilan (Gambar 7e).Tunas baru tersebut akan menyebabkan pertumbuhan batang menjadi kerdil dan tidak sempurna.



Gambar 7. Gejala mati puser dan serangan pada daun.

Intensitas serangan penggerek batang dan pucuk

Hasil penelitian menunjukkan bahwa gejala seranganpenggerek batang dan pucuk tebu baru ditemukan pada umur tanaman sekitar 2 bulan.Kelompok telur mudah didapatkan pada bulan Maret sampai Juni.Mulai dari bulan Juli sampai September sulit didapatkan telur di pertanaman tebu.

Kondisi lahan dapat mempengaruhi serangan awal penggerek batang dan pucuk tebu. Pada penelitian ini lahan yang digunakan adalah lahan yang baru dibuka dan baru pertama kali ditanami tebu.Hasil monitoring petugas EWS menunjukkan pada lahan yang selalu ditanam tebu gejala seranganpenggerek batang dan pucuk tebu sudah dapat ditemukan pada tanaman tebu mulai dari umur 1 bulan hingga menjelang panen.

Kerusakan akibat serangan penggerek batang dan pucuk tebu bervariasi, tergantung pada beberapa faktor, antara lain pola tanam, varietas, umur tanaman, iklim, dan tindakan pengendalian yang dilakukan. Kerusakanjuga berhubungan dengan keberadaan musuh alami yang mengendalikan hama tersebut (Meidalima, 2014).

Tingginya intensitas serangan penggerek batang dan pucuk tebu erat kaitannya dengan pola tanam tidak serentak, sehinggatersedia makanan bagi penggerek secara terus menerus dalam berbagai tingkat umur.Pengamatan yang dilakukan oleh Samoedi & Suhartawan (1993), tingkat serangan penggerek pucuk di PG Subang dan Jatitujuh cenderung lebih tinggi dibanding PG lain disebabkan selalu adanya tanaman tebu sepanjang tahun dalam berbagai umur.Rata-rata serangan pada saat tebang mencapai 45 persen. Kerugian gula diperkirakan sebesar 6 kuintal per hektar.Hasil wawancara dengan sinder kepala tanaman, periode tanam tebu berlangsung selama 6 bulan mulai dari bulan Februari sampai Julisehingga ketersediaan tanaman tebu sepanjang tahun dalam berbagai umur.

Pada penelitian ini intensitas serangan penggerek batang dan pucuk tebu tinggi pada umur tebu berkisar antara 3-5 bulan atau pada awal bulan Mei sampai akhir Juli.Tanaman tebu yang berumur 3-5 bulan, merupakan fase anakan dan pertumbuhan utama yang memiliki struktur batang dan pucuk ideal untuk perkembangan kedua hama ini.Pada umur 3-5 bulan terjadi fase anakan dan perpanjangan batang (Chen & Chou, 1993).Selain itu, kondisi iklim pada bulan Mei sampai Juli juga mendukung perkembangan penggerek batang dan pucuk tebu. Data klimatologi yang dicatat pada bulan Mei sampai Juli, rata-rata suhu, curah hujan, jumlah hari hujan, dan kelembaban nisbi berturut-turut adalah 26,6^{O}C, 245,5 mm, 17 hari dan 97,8%. Kondisi iklim ini mempengaruhi parasitasi parasitoid.Parasitasi parasitoid dapat menurun pada daerah yang memiliki kelembaban nisbi diatas 85%.Kelembaban yang tinggi berhubungan dengan curah hujan tinggi,sehingga parasitoid berukuran kecil kesulitan bergerak pada kondisi basah (Murtiyarini *et al*. 2006)Aktifitas parasitoid dalam mencari inang sangat menurun pada kondisi basah(Speight *et al.*, 1999).Suhu sangat berpengaruh terhadap parasitoid, terutama terhadap parasitoid Trichogrammatidae.Sekitar 70-80% parasitoid terbang pada suhu 25-30^{0}C (Forsse *et al.*, 1992).Kemampuan beradaptasi dengan iklim merupakan salah satu faktor penentu keberhasilan parasitoid mengendalikan

hama sasaran (Van Driesche *et al.* 2008).

Pada bulan Agustus-September, tebu sudah berumur lebih dari 5 bulan, serangan penggerek batang dan pucuk tebu menunjukkan tren menurun.Hal ini karena batang tebu yang sudah tua lebih keras, sehingga larva sulit masuk ke dalam batang.Pada umur tebu lebih dari 5 bulan memasuki fase pemasakan, dimana pertumbuhan vegetatif sudah sangat berkurang dan jaringan batang yang terbentuk sudah keras, sehingga mempersulit larva penggerek batang dan pucuk tebu untuk menembus batang.Fase ini kurang lebih terjadi pada bulan Agustus (Chen & Chou, 1993).

Kondisi iklim juga berpengaruh terhadap intensitas serangan penggerek batang dan pucuk tebu. Pada bulan Agustus-September sudah memasuki musim kemarau.Pada bulan Agustus sampai September rata-rata suhu, curah hujan, jumlah hari hujan, serta kelembaban nisbi berturut-turut adalah 28,3^{O}C, 15 mm, 6 hari dan 86,8%.

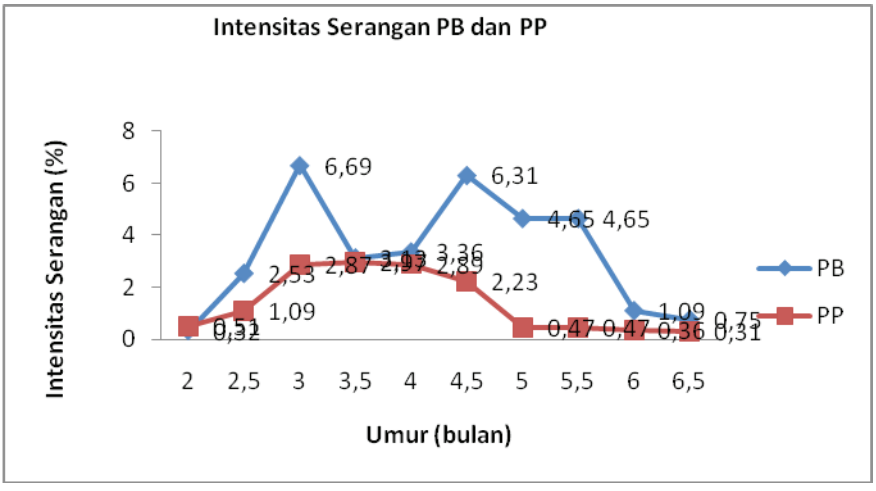
Dilaporkan olehPramono (2005), bahwapenggerek batang dan pucuk merupakan hamapaling dominan dijumpai pada tanaman tebu dataran rendah yang basah dan memiliki tingkat kelembaban udara relatif tinggi.

Intensitas seranganpenggerek batang tebu tertinggi terjadi pada umur tebu 3 bulan sebesar 6,69%.Pada umur 3 bulan terjadi fase pemanjangan batang tebu (Chen & Chou, 1993) sehingga sangat menguntungkan bagi perkembangan hama penggerek batang. Intensitas seranganpenggerek batang tebu selama pengamatan berfluktuasi.

Uji statistik berbeda nyata dengan intensitas serangan pada umur 2; 6 dan 6,5 bulan, tetapi berbeda tidak nyata dengan intensitas serangan pada umur pengamatan 2,5; 3,5; 4; 4,5; 5 dan 5,5 bulan.Grafik intensitas seranganpenggerek batang tebu selama pengamatan berfluktuasi(Gambar 8). Serangan mulai terjadi pada umur tebu 2 bulan dan mencapai puncaknya pada umur tebu 3 bulan.Pada umur tebu 3,5 bulan intensitas serangan menurun dan meningkat kembali pada umur 4 dan 4,5 bulan.Pada umur tebu lebih dari 5 bulan intensitas serangan terus menurun. Intensitas serangan yang berfluktuasi ini diduga berhubungan dengan keberadaan parasitoid.

Pada saat populasi hama tinggi, ditunjukkan oleh tingginya intensitas serangan, diduga populasi parasitoid juga tinggi.Populasi parasitoid tinggi menyebabkan tekanan terhadap populasi hama juga tinggi, akibatnya populasi hama menurun dan intensitas kerusakan juga menurun.Sejalan dengan pernyataanSimanjuntak *et al.*, 2013, bahwa persentase parasitasi tergantung pada umur parasitoid dan jumlah serangga hama inang.Menurut Yaherwandi *et al* (2006), parasitoid merupakan komponen penting dalam ekosistem pertanian, karena parasitoid dapat mengatur populasi serangga hama secara bertautan padat.

Umur tanaman tebu dapat mempengaruhi intensitas serangan penggerek batang dan pucuk. Intensitas seranganpenggerek pucuk tebu tertinggi terjadi pada umur tanaman tebu 3,5 bulan yaitu sebesar 2,97%.Intensitas seranganpenggerek pucuk mulai terjadi pada tanaman berumur 2 bulan.Intensitas serangan penggerek pucuk tebu mencapai puncaknya pada tanaman tebu berumur 3,5 buan.Setelah tanaman tebu berumur 3,5 bulan intensitas serangan penggerek batang dan pucuk cenderung menurun seiring dengan bertambahnya umur tanaman tebu.Pada saat pengamatan intensitas serangan dan populasi ini, umur tebu sudah memasuki fase anakan dan pertumbuhan utama, yaitu pada bulan Maret sampai Juni. Fase pertumbuhan utama terjadi proses pertambahan ruas batang tercepat, yaitu



Gambar 8. Grafik Intensitas Serangan Penggerek Pucuk dan Batang Tebu

Tabel 1. Pengaruh Umur Tanaman Tebu terhadap Intensitas Serangan dan Populasi Penggerek Batang dan Pucuk

Umur(bulan)	Rerata		
	Intensitas Serangan PB (%)	Intensitas Serangan PP(%)	Populasi PP (ekor)
2,0	0,32 a	0,51a	7,60a
2,5	2,53 abc	1,09ab	16,40 ab
3,0	6,69 c	2,87b	43,00 b
3,5	3,13 abc	2,97b	44,60 b
4,0	3,36 abc	2,89b	43,40 b
4,5	6,31c	1,23ab	18,40ab
5,0	4,65 bc	0,47a	7,00a
5,5	4,65 bc	0,47a	7,00 a
6,0	1,09 ab	0,36a	5,40 a
6,5	0,75 a	0,31a	4,60 a
BNJ 0,05	4,26	1,93	28,93

Tabel 2. Standar Serangan Hama

Tanaman umur <6 bulan	Penggerek Pucuk	Penggerek Batang
Ringan	<3%	<4%
Sedang	3-5%	4-7%
Berat	>5%	>7%
Tanaman umur >6 bulan		
Ringan	<7%	<10%
Sedang	7-10%	10-15%
Berat	>10%	>15%

4-5 ruas/bulan.Pada kondisi ini, morfologi tebu sangat mendukung untuk perkembangan hama, terutama penggerek batang dan pucuk tebu.

Populasi hama penggerek pucuk tertinggi terjadi pada umur tebu 3,5 bulan yaitu sebesar 44,60 larva.Secara statistik berbeda nyata dengan populasi umur 2;5; 5,5; 6 dan 6,5 bulan. Berbeda tidak nyata dengan populasi umur 2,5; 3; 4 dan 4,5 bulan (Tabel 1). Tanaman tebu memasukifase pertunasan dimulai dari umur 5 minggu sampai umur 3,5 bulan (Chen & Chou, 1993).Kondisi tanaman tebu ini sangat mendukung bagi perkembangan hama penggerek pucuk.

Saat umur tanaman masih muda populasi dan gejala penggerek batang dan pucuk masih sangat sedikit, sedangkan pada umur tebu tua, diatas 5 bulan populasi dan gejala serangan penggerek batang dan pucuk sudah sangat menurun.

StandarLitbang UU Cinta Manis (2012) intensitas serangan penggerek batang ini termasuk kriteria serangan sedang, dan intensitas serangan penggerek pucuk termasuk kriteria ringan (Tabel 2).

SIMPULAN

Hasil penelitian menunjukkan serangga hama penting yang menyerang tanaman tebu di perkebunan tebu Cinta Manis Sumatera Selatan ada 3 spesies, yaitu penggerek batang *Chilo auricillius*, *Chilo sacchariphagus*, dan penggerek pucuk *Scirpophaga nivella.* Serangan tertinggi di lapangan ditemukan pada tebu berumur sekitar 3-5 bulan atau bulan Mei sampai dengan Juli, hal ini berkaitan dengan kondisi iklim.Populasi akan semakin menurun seiring dengan bertambahnya umur tanaman tebu dan kondisi iklim yang kemarau.

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f. Pendahuluan

Menjelaskan tentang latar belakang, permasalahan, nilai penting penelitian, kajian

pustaka singkat yang berkait langsung dengan penelitian atau temuan sebelumnya yang perlu dikembangkan, rumusan masalah dan diakhiri dengan tujuan penelitian. Pendahuluan dipaparkan secara terintegrasi dalam bentuk paragraf-paragraf dengan panjang maksimal 1,5 halaman.

g. Metode Penelitian

Berisi informasi teknis yang cukup jelas sehingga pembaca dapat melakukan ulang penelitian dengan teknik yang disampaikan. Menjelaskan bahan dan spesifikasi alat yang digunakan, pendekatan atau cara kerja yang dilakukan, serta analisis data yang digunakan. Bagian metode ditulis dengan panjang maksimal 1 halaman.

h. Hasil dan Pembahasan

Menyajikan hasil penelitian dan pembahasan sebagai satu kesatuan yang tidak terpisah dalam bentuk uraian. Hasil penelitian dapat dilengkapi tabel dan atau gambar (grafik) untuk memperjelas hasil secara verbal. Hasil penelitian dibahas dikaitkan dengan perumusan masalah, tujuan dan hipotesis penelitian. Pembahasan sangat disarankan mampu menjelaskan mengapa dan bagaimana hasil penelitian dapat terjadi, makna serta aplikasi hasil penelitian tersebut dalam pemecahan masalah yang relevan.

i. Simpulan

Simpulan didasari hasil yang diperoleh, menjawab permasalahan dan tujuan penelitian. Simpulan ditulis dalam bentuk essay satu paragraf dan bukan dalam bentuk numerikal.

j. Ucapan terima kasih

Ucapan terima kasih (jika ada) ditulis secara singkat, ditujukan kepada orang atau lembaga yang berjasa dan berkontribusi dalam penelitian, misalnya kepada penyandang utama dana penelitian.

k. Daftar Pustaka

Daftar pustaka disusun berdasarkan urutan abjad nama akhir penulis pertama. Nama penulis pertama dan berikutnya merupakan nama akhir yang diikuti nama pertama dan nama tengah (disingkat) tanpa dipisahkan tanda koma atau titik. Disusun berdasarkan urutan alfabet. Sumber rujukan diharapkan sekurangnya 80% berupa pustaka terbitan 10 tahun terakhir. Rujukan minimal 50% berupa artikel-artikel penelitian dalam jurnal atau laporan penelitian. Hanya pustaka yang disitasi dalam naskah yang ditulis dalam daftar pustaka. Contoh penulisan:

1. Artikel dalam jurnal:

   Ehsanpour, A. A., & Amini, F. (2003). Effect of salt and drought stress on acid phosphatase activities in alfalfa explants under in vitro culture. *African J Biotechnol,* 2(5),133-135

2. Artikel dalam prosiding:

   Rahayu, E. S. (2001). Potensi alelopati lima kultivar padi terhadap gulma pesaingnya. Dalam: *Prosiding Konferensi Nasional XV Himpunan Ilmu Gulma Indonesia.* Buku 1. Surakarta, 17-19 Juli 2001. Surakarta: Himpunan Ilmu Gulma Indonesia. Hlm 91-98.

3. Buku dengan editor:

Arnim, A. G. (2005). Molecular Aproaches to the Study of Plant Development. Dalam: Trigiano RN & Gray DJ. *Plant Development and Biotechnology*. Washington DC: CRC Press.

4. Skripsi, tesis, disertasi dan laporan penelitian:

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Hsu, Y. H & To, K. Y. (2000). Cloning of cDNA (Accesion No AF183891) encoding type II S-adenosyl-L-methionine synthetase from Petunia hybrida. *Plant Physiol* 122:1457. (PGROO-33). Retrieved from http://www.tarweed.com/pgr/PGROO-033.html.

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