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Effect of Addition of Urea and Zeolite on Rice Plants (*Oryza sativa* L.) for The Nitroxy Emissions on Peatlands

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Abstract

The purpose of this study is to analyze nitro oxide emissions as a result of adding urea and zeolite to rice plants (*Oryza sativa* L.) on peatlands. The treatments used were 2 factors, namely factor 1 using a dose of urea fertilizer from three levels of treatment N1 : 125 kg/ha; N2 : 250 kg/ha; N3 : 375 kg/ha and factor 2, the dose of zeolite consists of three levels of treatment Z1 : 125 kg/ha; Z2 : 250 kg/ha; Z3 : 375 kg/ha. Each combination was repeated as many as 5 phases (phase 1 = 15 DDP, phase 2 = 35 DDP, phase 3 = 55 DDP, phase 4 = 65 DDP and phase 5 = 90 DDP) so the number of units treatment 3 x 3 x 5 = 45 pots. Data analysis used linear regression test. The results showed the administration of a combination of urea doses and zeolite in rice plantations had not significant effect on nitrous oxide emissions produced at each observation. In this study, the highest nitrous oxide emissions were obtained in phases 1 and 2. From the results of the F test is Ho rejected. With this it is proven that the urea dose partially has not significant effect on nitro oxide emissions. The dose of zeolite (X2) is H0 is rejected, thus showing that zeolite has not significant effect on the availability of nitrous oxide emissions.

Keywords: Urea, Zeolite, Nitro oxide emissions peatlands

Abstrak (Indonesian)

Tujuan penelitian ini yaitu menganalisa emisi nitrooksida sebagai akibat penambahan urea dan zeolit pada tanaman padi (*Oryza sativa* L.) di lahan gambut. Perlakuan yang dipakai terdapat 2 faktor yaitu faktor 1 menggunakan dosis pupuk Urea dari tiga taraf perlakuan N_1 : 125 kg/ha ; N_2 : 250 kg/ha ; N_3 : 375 kg/ha. Faktor 2 yaitu dosis zeolite terdiri dari tiga taraf perlakuan Z_1 : 125 kg/ha ; Z_2 : 250 kg/ha ; Z_3 : 375 kg/ha. Setiap kombinasi diulang sebanyak 5 fase (fase 1 = 15 HST, fase 2 = 35 HST, fase 3 = 55 HST, fase 4 = 65 HST dan fase 5 = 90 HST) sehingga jumlah unit perlakuan 3 x 3 x 5 = 45 pot percobaan. Analisa data menggunakan uji regresi linier. Hasil penelitian menunjukan pemberian kombinasi dosis urea dan zeolit pertanaman padi tidak berpengaruh nyata terhadap emisi nitrooksida yang dihasilkan pada tiap-tiap pengamatan. Pada penelitian ini emisi nitrooksida tertinggi di peroleh pada fase 1 dan 2. Dari hasil uji didapat hipotesis (Ho) ditolak artinya dosis urea secara parsial tidak berpengaruh signifikan terhadap emisi nitrooksida. Dosis zeolit (X2) artinya H0 ditolak, sehingga menunjukan bahwa zeolit tidak berpengaruh nyata terhadap ketersediaan emisi *nitrooksida*.

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Kata Kunci: Urea, Zeolit, Emisi Nitrooksida, Lahan Gambut

INTRODUCTION

Increased population growth has resulted in decreasing dry land so that it shifts to peatland. The use of peat land for infrastructure or agriculture has received great attention from the government, the community and the researchers both the potential and constraints that exist on these peatlands. Indonesia's peatlands have a very wide peat expanse. Based on data from the Center for Bogor researchers in 1992, the peat expanse in Indonesia was 15.4 million hectares. In

2005, Wetland International stated that the forecast for peat area was 20.5 million hectares and 14.9 million hectares in 2011 based on data from the R & D of Agricultural Land Resources [1]. The difference in total area of peat is caused by differences in definition, the survey method for peat has a dynamic nature which result in fluctuations in the extent of peatland

The distribution of peatlands in Indonesia is centered on three large islands, i.e. Papua 30%, Kalimantan 32%, Sumatra 35%, and other islands 3% with a total expanse of more than 21 million ha. In Indonesia, these peatlands spread from the lowlands to the highlands [2]. The use of peat land has a great potential for food crop cultivation and supports national food production.

According to Government Regulation Number 57 of 2016 as a change to government regulation Number 71 of 2014 concern the protection and management of peat ecosystems. This regulation focuses on the preservation of the conservation of peat ecosystems, where peat ecosystems with a groundwater level of more than 0.4 meters below the surface of the peat include a damaged peat ecosystem. This regulation burdens the plantation and agriculture sectors.

Agriculture on peat land is influenced by farm management that can be applied and is not only predominantly determined by the physical, biological and chemical characteristics of the soil contained in peat. Plants can grow optimally if the soil has sufficient physical, chemical and biological properties to support plant growth. One determinant of the success of agricultural production is the presence of nutrient content in proportional soil needed by plants. The success rate of agricultural production on peatland also depends on the ability to manage water availability. If the water table is reduced, a rewetting process will be carried out, which serves to prevent fires and prevent subsidence on the land. This is expected to be an optimal and sustainable land resource and to achieve optimal agricultural production as well.

Potential peatlands in Sumatra, Kalimantan and Papua for rice plantations is 1,869,728 ha, including forest areas and existing land already used. This land consists of converted forest land called HPK covering area of 461,148 ha, land of other use areas called APL covers 416,431 ha and on production forest land called HP covering an area of 99,152 ha [3].

Data from the Central Bureau of Statistics states that national rice production reaches 50 % of 1711 kg per week of national rice needs. The population growth rate in 2005-2010 was 1.3% while the development of national rice production, especially in the last 6 years continued to decline. One of the causes of the decline in the level of national rice production is caused by the use of chemicals which results in the saturation of the level of land production [4].

The level of production is saturated due to a lack of organic matter in the soil. The intensification of agriculture with the use of inorganic fertilizers such as fertilizer N is no longer able to support crop yields. However, if only relying on soil organic matter over time there will be a decrease in the content of organic matter in the soil and agricultural yields will also decline significantly.

One alternative that can be taken to overcome this, is by providing balanced fertilizer [5]. In general, the efficiency of nitrogen uptake in irrigated rice fields can only reach 45% and the remaining around 55% can not be utilized by plants. As a result of this loss, nitrogen absorbed by plants is low.

Nitrogen is a limiting factor in efforts to increase rice production, especially new superior varieties [6]. Provision of balanced fertilizer can supply the availability of nitrogen for plants. Balanced fertilization is the provision of fertilizer to the soil to balance needs of essential nutrients in the soil to increase yield and quality of agricultural products, soil fertility, fertilizer efficiency, and avoid environmental emissions [7]. Types of soil nutrients that have reached optimum levels or high status, do not need to be added anymore, except as a substitute for nutrients transported during harvest. Balanced fertilization includes organic fertilizers and inorganic fertilizers. Organic fertilizers such as manure are intended to preserve the land because it can improve the chemical, physical and biological properties of the soil.

The provision of inorganic fertilizers in the soil is needed to support agricultural cultivation activities where the use must be adapted to soil conditions. Balanced fertilization will increase soil organic matter content. Balanced fertilization will increase soil organic matter content. Provision of manure will be able to meet the nutrient requirements of plants and affect N uptake, which has an effect on the high yield of rice plants. The plants will grow optimally if planted in a place that meets the requirements for growing the plants, namely climate factors, and soil properties. If environmental factors grow in optimal conditions, growth and yield will be limited by their genetic traits [8].

Addition of lime and urea fertilizer can supply N_2O emissions and CO_2 emissions. The emissions produced are methane gas (CH_4), carbon dioxide (CO_2) and nitro oxide (N_2O). Nitro oxide emissions as a result of microbial land transformation and an increase in the availability of nitrogen exceeding the N required by plants, especially when the conditions are saturated with water. Greenhouse emissions can be predicted to continue to grow in the future due to the increasing demand for food caused by increasing suboptimal land use. Generally, the availability of N_2O emitted to the atmosphere is smaller than CO_2, but because of its greater global warming potential, it will cause a higher global warming effect than CO_2 or CH_4 [9].

Zeolite has properties as a high ion exchanger and can release nutrients so it is expected that the nutrients given through fertilization can be bound by zeolites and not easily lost before being used by plants so that it can increase fertilizer efficiency [10]. Zeolite is a mineral that has a very high cation exchange capacity (CEC). This is because zeolite has a cavity that is related to one another, which are empty channels in all directions in which there are easily exchangeable ions.

Administration of ameliorant material on peatlands can significantly increase the degree of acidity [11]. The material used can be in the form of manure, zeolite, lime, husk ash and rat purun (Eleocharis dulcis).

Zeolite minerals are hydrated alumina minerals which are commonly used as catalysts, molecular filters, water softeners, cation exchangers and drying materials. In general, zeolite is divided into two, namely natural zeolite and synthetic zeolite. Natural zeolite is more rich in cations which contain K^+, Na^+, Ca^{2+} and Mg^{2+} [12]) and for synthetic zeolites only contain two types of cations namely K^+ and Na^+ [13].

With the administration of urea, it is expected that nitrogen in the soil and plants is available properly without excessive and N_2O emissions can be suppressed maximally. Based on this description so this studied the effect of adding urea and zeolite on rice plants (*Oryza sativa* L.) on nitro oxide emissions on peatlands.

MATERIALS AND METHODS

Materials

The material needed in this study is water used to keep peat soils inundated. Ciherang rice is a type of hybrid rice which is the result of crossing from a type of superior local rice variety to produce superior rice varieties.

The extraction of peat soil used for the experiment is peat soil located at the Arboretum of the Faculty of Agriculture, Sriwijaya University Inderalaya. The 1 kg of peat soil taken is used to extract soil samples for initial analysis.

Urea fertilizer and zeolite were given 3 times. one third of the dose is given at the beginning of planting, one-third of the dose is given 4 weeks after planting, one-third of the dose is given 7 weeks after planting. Lime administration is carried out 1 week before planting by homogenizing it with peat soil. Provision of SP-36 base fertilizer and KCL is carried out 1 time at the beginning of planting

Methods

Penetration activities consist of several stages, namely take the land, made planting media, setting the experimental layout, giving dolomite and basic fertilizers, administering urea and zeolite fertilizer, sowing and planting rice, maintaining rice and catching N_2O emissions.

The extraction of peat soil used for the experiment is peat soil located at the Arboretum of the Faculty of Agriculture, Sriwijaya University Inderalaya. Peat soil taken as needed is 4 kg/pot x 9 treatment combinations x 5 groups = 180 kg peat soil. Plant media have been made in pots with a size of 10,072.69 cm3. Before the soil is inserted into the pot, the soil is cleaned first of the trash and dirt which will interfere with the planting process and plants. The peat soil used is 4 kg/pot with the condition of the field capacity.

The application of agricultural lime, namely dolomite, is carried out 1 week before planting, adding dolomite as much as 2-4 tons/ha can increase soil pH between 1-2, so that the soil can reach pH 5.29 – 6.29. Giving basic fertilizer SP-36 135 kg/ha and KCl 100 kg/ha was done 1 time at the beginning of planting.

Dosage of urea and zeolite fertilization treatment is listed in table 1. Provision of Urea fertilizer is given 3 times. One-third of the dose is given at the beginning of planting, one-third of the dose is given 4 weeks after planting, one-third of the dose is given 7 weeks after planting. Effective administration of urea fertilizer is done by sowing on the ground [14], the application of fertilizer by sowing or through fertigation is not significantly different. The administration of zeolite is carried out by stirring it evenly with peat soil according to the dosage set according to table 1.

Table 1. Combination of doses of urea and zeolite treatment

Doses of urea fertilizer (N)	Doses of Zeolite (Z)		
	Z_1 (125 kg/ha)	Z_2 (250 kg/ha)	Z_3 (375 kg/ha)
N_1 (125 kg/ha)	N_1Z_1	N_1Z_2	N_1Z_3
N_2 (250 kg/ha)	N_2Z_1	N_2Z_2	N_2Z_3
N_3 (375 kg/ha)	N_3Z_1	N_3Z_2	N_3Z_3

Seeding of rice plants (*Oryza sativa* L.) before planting for 20 days. Then the rice seedlings are transferred to the prepared plant pots. The characteristics of rice seedlings are ready to be transferred to the planting media, namely rice seeds that have a height of about 20 cm and leaves of 5-6 strands.

The way to capture the gas is carried out using a closed cylinder-shaped hood with a volume of 117,970 cm^3. The lid must be closed and the condition is impermeable and does not leak, so that all gas escapes from the surface of the soil and plants are trapped inside the hood. The measurements of the air temperature outside and inside the closed chamber are measured before and after gas capture. Before carrying out gas extraction, the fan on the lid is rotated for 30 seconds by flowing electric current on a 12 volt dry battery.

This gas extraction is carried out in the vegetative and generative phases. Gas extraction is carried out after the lid is closed and left for 24 hours in a plant pot. Gas extraction is carried out using a syringe device equipped with a regulator to open and close the pinhole. The syringe with the position of the open regulating faucet is injected into the rubber hole, and then the needle is pulled to suck the gas.

Suction and release of gas with a syringe are carried out several times (at least 3 times), then pull the syringe on the scale needed to suck the gas and the regulating faucet is immediately closed and pull the needle from the lid. The syringe that has been filled with gas from the hood is then injected into an available vacuum tube and labeled an observation sample, open the regulating faucet and push the tip of the syringe to insert N_2O gas from the syringe into the vacuum tube to the tube base position. Perform closure of the regulating faucet and pull out the syringe from the vacuum tube. All gas in the syringe has been inserted into the vacuum tube.

Figure 1. *Closed chamber* and taking N_2O gas

The working principle of measuring N_2O gas is using a closed chamber method, where N_2O gas extraction in the field is taken from a closed chamber using a syringe in Figure 1, then injecting gas into a tight and safe vacuum bottle then the gas concentration was analyzed using Gas Chromatography (GC) in the laboratory. Calculation of N_2O emissions is carried out after obtaining results from the laboratory in the form of gas concentration. The following equation is used to calculated the gas emissions using the closed chamber technique:

$$E = \frac{dc}{dt} \times \frac{Vch}{Ach} \times \frac{mW}{mV} \times \frac{273.2}{T+273.2}$$

E = gas emissions ($mg/m^2/day$)
Vch = closed chumber volume (m^3)
Ach = broad base of closed chumber (m^2)
T = average air temperature in closed chumber (°C)
dc/dt = rate of change in gas concentration (ppm/second)
mW = molecular weight of gas in standard conditions (44.013 g/mol)
mV = gas volume under conditions stp is standar temperature and pressure which is 22.41 L at 273 K.

Data Analysis

The treatment used in this study uses 2 factors, namely Factor 1 = dose of N (Urea) fertilizer from three levels: Treatment N1: 125 kg/ha; Treatment of N2 : 250 kg/ha and N3 : 375 kg/ha treatment. Factor 2 = dose of zeolite consists of three levels, namely treatment Z1 : 125 kg/ha; Treatment of Z2: 250 kg / ha and treatment Z3 : 375 kg/ha. Each combination was repeated as many as 5 (five) series so that the number of treatment units was 3 x 3 x 5 = 45 experimental pots.

Analysis of the data used to determine the effect of treatment in this study is by using multiple linear regression tests. For the 45 pot experiment design is carried out in the order in Table 2.

Table 2. Experimental Design

Fase				
1	2	3	4	5
N1Z1	N1Z1	N1Z1	N1Z1	N1Z1
N1Z2	N1Z2	N1Z2	N1Z2	N1Z2
N1Z3	N1Z3	N1Z3	N1Z3	N1Z3
N2Z1	N2Z1	N2Z1	N2Z1	N2Z1
N2Z2	N2Z2	N2Z2	N2Z2	N2Z2
N2Z3	N2Z3	N2Z3	N2Z3	N2Z3
N3Z1	N3Z1	N3Z1	N3Z1	N3Z1
N3Z2	N3Z2	N3Z2	N3Z2	N3Z2
N3Z3	N3Z3	N3Z3	N3Z3	N3Z3
15 HST	35 HST	55 HST	65 HST	90 HST

The following are photos taken from the field during the study.

Figure 2. Experiment in the field

RESULT AND DISCUSSION

The results of the analysis of the effect of urea and zeolite on the amount of N_2O emissions in rice plants showed that the treatment had a significant effect on N_2O emissions produced at each observation. Fluctuations in nitro oxide emissions are shown in the following figure 3.

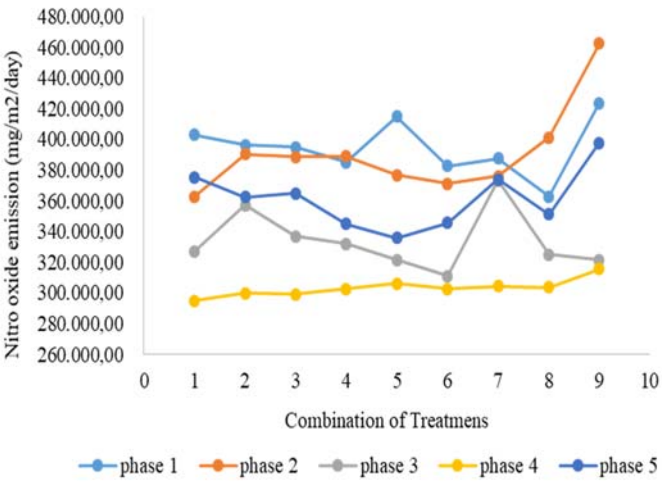

Figure 3. Nitro oxide Emission Fluctuations

Figure 3 shows that nitro oxide emissions produced by rice plants (oryza sativa l.) in phase 1 (15 days) and phase 2 (35 days) are the highest emission rates. N_2O emissions in the active tillering phase (15 days after planting), maximum tillering phase (35 days), flower primordia phase (55 days after planting), panicle or flowering out phase (70 days after planting), and grain filling phase (90 days).

In rice plants (*Oryza sativa* L.) in phase 15, the N needs of the soil are still sufficient while in the phases of the age of 30 and 45 days in the soil the need for N elements is insufficient so that these elements are needed for plant growth [15]. While the use of zeolite can save the use of inorganic fertilizers by 20-25 % [16]. In the final phase (90 days), the soil fertility crop decreases[17] so that the availability of N in the soil also decreases so that emissions are smaller.

It can be seen that the average N_2O emissions at the plant growth phase appear to be higher and tend to decrease more when the plants are about to be harvested (Figure 1). N_2O emissions range from 295,061 - 462,314 mg/m^2/day. In phase 1, which is 15 days when planting, the number of N_2O emissions is at 362,739 - 423,431 mg/m^2/day. Phase 2 (35 days at planting) N_2O emissions are in the number 362,579 - 462,314 mg/m2/day. Phase 3 (55 days when planting) N2O emissions are in the number 311,162 – 373,136 mg/m^2/day. Phase 4 (65 days when planting) of N_2O emissions is in the number 295,061 - 315,726 mg/m^2/day. And the last phase is phase 5 (90 days when planting) N_2O emissions are in the number 335,945 - 397,682 mg/m^2/day.

The administration of urea affects the increase in N_2O emissions, where the most important problem was the absenced of balanced fertilization and inefficient fertilization. Rice plants have the ability to absorb N 20% - 40% of fertilization. The remaining N that is not absorbed will occur denitrification, volatilization and washing [18]. The increase or increase in emissions in phase 2 on the combination of N3Z3 because of the continued supply of fertilizer 1/3 dose. The application of this fertilizer affects the nitrification and denitrification activities resulting in an increase in N2O emissions.

The highly variable N_2O emissions in Figure 3 are caused by nitrate content, carbon content, denitrification bacteria population and microbial activity in the soil. A decrease in N_2O emissions can be caused by zeolite administration which has the ability to control greenhouse gas emissions up to 25% [19]. This N_2O emission is a by product of NH_4^+ to NO_3^- neutralization and the result of NO_3^- being converted to N_2O or nitrogen (N_2).

N_2O emissions vary between rice varieties (*Oryza sativa* L.) at all ages of observations which reflect the diversity of microbial activity around the roots of rice plants (*Oryza sativa* L.). Peat land has the potential to increase N_2O gas emissions when the amount of N is available for microbial transformation is increased by fertilizing inorganic urea. Maximum N_2O emissions are 462,314 mg/m^2/day and minimum N_2O emissions are 295,061 mg/m^2/day while the average daily N_2O emissions are 303,299 - 394,554 mg/m2/day. High N_2O emissions are produced as a result of the transformation of N fertilizer through a non-inhibited nitrification and denitrification process so that nitrates are produced as bacterial substrates in the process of nitrification and denitrification in releasing N_2O gas into the atmosphere [20].

Table F Test Results

Data analysis in data processing of this research was carried out by using multiple linear regression analysis and using software namely SPSS version 23.0. Based on multiple linear regression analysis, the F test results in the Anova table 4 can be obtained as follows.

From the results of the F test in this study, the calculated F value was 0.287 with a significant number of 0.752 with a significance of 95 %. The number of significance is 0.752 > 0.05.

Table 4. Test result F (Anova)

		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	937425312	2	468712656	0.287	0.752[b]
	Residual	68684244405	42	1635339152		
	Total	69621669717	44			

a. Dependent Variable: Nitro oxide emissions
b. Predictors: (Constant), zeolite dose, urea dose

Based on the data above, the sig value is obtained. F is 0.287 (p > 0.05) means that the hypothesis (Ho) is rejected. From this it can be concluded that the doses of urea and zeolite have a jointly significant effect on nitrous oxide emissions.

Test Result T Table

If we want to see the closeness relationship in this multiple regression, then we use the T test. Based on multiple linear regression analysis, we can get the results of the T test in Table 5.

Table 5. Test Result T Table

	U. Coefficients		S.Coeff	t	Sig.
	B	Std. Error	Beta		
(Constant)	339141	24598.793		13.787	0
Urea Dose	8.288	13.039	0.097	0.636	0.528
Zeolit Dose	5.363	13.039	0.063	0.411	0.638

a. Dependent Variable: Nitro oxide emissions

Table 5 is a significance test (T statistic test), which functions to find out whether the independent variable regression models (X1 and X2), namely urea doses and zeolite doses partially have a significant influence on the dependent variable (Y) namely nitro oxide emissions

The value of t count is 0.636 for the dose of urea and 0.411 for the dose of zeolite and when compared with the probability of 0.05, the greater the significance value, there is no effect of the dose of urea and zeolite on nitrous oxide emissions.

In this T test the initial hypothesis and alternative hypothesis will be formulated, namely

H0: Partially there is no significant effect between giving urea doses and zeolite doses to nitrous oxide emissions H1: There is a significant effect between giving urea doses and zeolite doses to nitrous oxide emissions.

It is known that the value of t table with df (free degree) = n-k, with the value of k the number of independent variables and the level of trust (alpha value) is 5% two-sided test = 0.025. So from that the value of t table can be 2.01669 so that t count > t table
a. The dose of Urea (X1) is equal to 0.636 > 2.01808, so that H0 is rejected. With this it is proven that the urea dose partially has a significant effect on nitro oxide emissions.
b. The dose of zeolite (X2) is 0.411 > 2.01808 so that H0 is rejected. From this it was concluded that zeolite doses significantly affected the availability of nitro oxide emissions.

Addition of zeolite minerals to nitrogen fertilizers will absorb the ammonium released by fertilizer. When the concentration of nitrate in the soil decreases, ammonium, which has been absorbed by zeolite, will be released back into the soil solution. This will have an impact on the N given into the soil can be available in longer time. This also has an impact on reduced nitro oxide emissions.

CONCLUSION

The results of the study showed that the combination of urea dose and zeolite dose in paddy planting (Oryza sativa L.) had a significant effect on the nitrous oxide emissions produced at each observation. In this study the highest nitrous oxide emissions were obtained in phases 1 and 2.

From F test, the calculated F value was 0.287 a significant number of 0.752 with a significant of 95 %. and it was concluded that the doses of urea and zeolite had a significantly significant effect on nitrous oxide emissions

The value of t table obtained 2.01808 which t count > t table. The dose of Urea (X1) is equal to 0.636 > 2.01808, so that Ho is rejected. With this it is proven that the urea dose partially has a significant effect on nitro oxide emissions. The dose of zeolite (X2) is 0.411 > 2.01808 that H0 is rejected. From this research was concluded that zeolite doses significantly affected the availability of nitro oxide emissions. For this reason, the recommended treatment to be applied by rice farmers (*Oryza sativa* L.) is the treatment of zeolite and fertilization of urea with an intensive management system.

REFERENCES

[1] S. Wahyunto, S. Ritung, and S. Hardjo. *Peat Distribution and Carbon Content in Sumatra and Kalimantan*. 254. Wetlands International - Indonesia Program, 2005, Bogor, Indonesia.

[2] Wahyunto and I.G.M. Subiksa. Genesis of Indonesia's Peatlands. *Soil Research Center*, 2011, Bogor. 3-14 p.

[3] Center for Research and Development of Agricultural Land Resources. Technical Report No. 1 / Doc. / BBSDLP / 2014. Area, *Distribution and Potential of National Agricultural Land Resources*. Agricultural Research and Development Agency. 2014.

[4] Husnain, Nursyamsi, Dedi, and J. Purnomo. *Use of Agrochemical Materials and Their Impact on Environmentally Friendly Agriculture*, Agricultural Research and Development Agency. Ministry of Agriculture. 2014. Jakarta.

[5] M.M. Sutedjo. A.G. Kartasapoetra. *Introduction to Soil Science*. Rineka Cipta, 1999, Jakarta.

[6] H.S. Taslim, Partohardjono, Subandi. *Rice Book II. Rice Paddy Fertilization*. Food Crop Research and Development Center, 1989, Bogor.

[7] Balittan, 2013. Definition of Balanced Fertilizer. Ministry of Agriculture. Jakarta. http://balittanah.litbang.pertanian.go.id/pupuk/index.php/publikasi. (accessed on January 28, 2019).

[8] Sufardi. *Know Plant Nutrients*. Universitas Syiah Kuala, 2010, Banda Aceh.

[9] S.T. Risnandar, *Study of IPCC (Intergovernmental Panel on Climate Change)*. http://kehutanan.risnandarweb.com/. Accessed on December 29, 2018.

[10] A. Widyanto, H. T. Sambayang, S. Soekartomo. "The Effect Of Zeolite Application And Urea Fertilizer On Growth And Result Of Sweet Corn (Zea mays L. saccharata Sturt.)", *Journal of Plant Production*, vol. 1, no. 4, 2013.

[11] H.I. Susilawati, M. Ariani, R. Kartikawati and P. Setyanto. *Peatland Amelioration Increases Rice Production and Suppresses Greenhouse Gas Emissions*. Agricultural Environment Research Center, 2011, Jakenan. Starch

[12] S. Bogdanov, "External Aplications of Honey" in *Book of Honey,* Chapter 8. Bee Product Science, 2009, August.

[13] M. Akimkhan, *Structural and Ion-Exchage Properties of Natural Zeolite*, 2012, Licensee In Tech Open Science

[14] R. Tedjasarwana, E.D.S. Nugroho, and Y. Hilman. "How to Apply and Measure Fertilizers to Chrysanthemum Growth and Production", *Ornamental Plant Research Center and Horticulture Research and Development Center*, 2011, Jakarta.

[15] Jamilah dan N. Safridar. "Effect of Urea, Active Charcoal, and Zeolite on Growth and Yield of Rice(*Oryza sativa* L.)", *Journal of Agrista*, vol. 16 No. 3. 2012.

[16] A. Jufri, and M. Rosjidi. "Effect of zeolite in fertilizers on the growth and production of lowland rice in Badung Regency, Bali Province", *Indonesian Science and Technology Journal* 14(3):161-166, 2013.

[17] W. Annisa and D. Nursyamsi. "Effects of Ameliorants, Fertilzers, and Management Regimes of Acid Sulphate Soils on Rice Yield and Methane Emission" *Land and Climate Journal*, vol. 4, no. 2, 2016.

[18] A. Singh, N. Aggarwal, G.S. Aulakh and R.K. Hundal. "Ways to maximize the water use efficiency in field", *Greener Journal of Agricultural Science,* vol. 2, no. 4, pp. 108-129, 2012.

[19] G. Delahay and B. Cog. *Pollution Abettement Using Zeolits : State pf Art and Further Need* Catalytic Science Series – Vol 3. London, 2012, 60 : 30-32

[20] A. Wihardjaka, S. Djalal Tandjung, B. Hendro Sunarminto and Eko Sugiharto. "Emisi gas dinitrogen oksida pada padi gogorancah oleh pemberian jerami padi dan bahan penghambat nitrifikasi", *Food Crop Agricultural Research,* vol. 29, no. 3, 2010.