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Growth and Yields of Upland Rice (*Oryza sativa* L.) Applied by Synthetic Zeolite and Catfish Liquid Organic Fertilizer

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ABSTRACT

The average productivity of upland rice in Indonesia is around 4.4 tons per ha, significantly lower than its potential yield of 8.5 Mg per ha. The utilization of synthetic zeolite as a soil amendment and liquid organic fertilizer (LOF) is one of the technologies that can be applied to increase the growth and yield of upland rice. This study was carried out by factorial experiment with 2 factors: synthetic zeolite application at 4 levels (0, 100, 150, and 200 kg per ha), and catfish LOF application at 3 levels (0, 200, and 400 ml per clump), and each combina- tion was repeated three times. The results showed that applying synthetic zeolite and catfish LOF at each dose had no significant effect on plant height, maximum number of tillers and productive tillers, panicle exit age, harvest age, and weight of milled dry grain per clump. The interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump increased the number of pithy grains per panicle by 70%, the weight of milled dry grain per clump by 68%, and the harvest index 37.5% significantly compared to control (no treatment).

Keywords: Liquid organic fertilizer, synthetic zeolite, upland rice

INTRODUCTION

Rice is a staple food for more than 90% of Indonesia's population, and the need for rice increases with the increasing population. On the other hand, the area of paddy fields is decreasing due to land use change; rice production to meet rice needs through planting upland rice in dry land must be a major concern, especially in increasing the rice productivity. The average productivity of upland rice in Indonesia is low, only 4.4 tons per ha (Badan Pusat Statistik, 2021). According to researchers, the productivity potential of superior upland rice ranges from 8.4 tons per ha (Malik, 2017). One of the efforts to increase productivity is applying synthetic zeolite and liquid organic fertilizer (LOF).

Synthetic zeolite can be made from various materials widely available in nature, including coal fly ash and rice husk ash. The potential availability of fly ash raw materials for the manufacture of synthetic zeolites in Indonesia, especially Riau, is enormous, namely as a by-product from palm oil, pulp, and paper mills with enormous production capacities per day, and Steam Power Plant Companies which as a whole use coal as the primary source of fuel in a steam boiler. The advantages of synthetic zeolite compared to other soil amendments (lime and organic matter) are that the dose needed is minimal (10–15 tons per ha), the effect on improving soil fertility and water availability in the soil is enormous because it has a very high cation exchange capacity (CEC), and referred to as a slow release agent (Suwardi, 2009). Synthetic zeolite is sufficient to be applied once because synthetic zeolite minerals are generally stable under normal conditions in the soil. According to Udhoji et al. (2005), coal fly ash can be used as a synthetic zeolite through a hydrothermal process. Johan et al. (2017) reported that synthetic zeolite from coal fly ash at a dose of 12,5 kg per are can increase lowland rice yields compared to without synthetic zeolite, has a very high CEC (> 250 Cmol per kg), which functions to increase the soil's ability to store water and nutrients in ionic form (cations and anions) and increase rice growth and yield.

The application of synthetic zeolite increases the soil CEC and causes the availability of water and nutrients during the plant growth phase. Thus, it encourages physiological processes and plant metabolism, spurring growth, and finally increase the upland rice yield. However, synthetic zeolites do not provide all the nutrients needed by plantsas fertilizer provided. One of the fertilizers that can provide nutrients is LOF.

LOF is a source of nutrients, carbon, and energy for microorganisms that can produce antibiotic compounds and growth regulators to improve plant growth and yield. Therefore, soil fertility can be balanced from a chemical, physical and biological point of view. One of the raw materials for making LOF is catfish. Catfish has a higher protein content than other freshwater fish, which is 17.7%, and also contains 4.8% fat, 1.2% minerals, and 76% water (Astawan, 2008).

Catfish LOF contains high protein as a source of amino acids, which contain the nutrients C, H, O, and N needed for plants (Hanum et al., 2013). Suartini et al. (2018) reported that the N content in LOF from fish waste was 3.74%. In contrast, Aditya et al. (2015) reported that the N content in solid organic fertilizer from fish waste contains N elements of 2.26%. Yuanita (2010) reported that LOF could increase crop production and the quality of plant products, reduce the use of organic fertilizers, and replace manure. This study aimed to determine the interaction of synthetic zeolite and catfish LOF and obtain a combination of synthetic zeolite and catfish LOF, which results in upland rice's highest growth and yield (*Oryza sativa* L.).

MATERIALS AND METHODS

The research was conducted at the Technical Implementation Unit of the Experimental Garden and Laboratory of Soil Science, Faculty of Agriculture, University of Riau, Bina Widya Campus KM 12.5, Binawidya Village, Binawidya District, Pekanbaru. This research was carried out for seven months, from March to October 2021.

The upland rice seeds of the Inpago 9 variety was used. Podzolic soil samples were taken in Balam Jaya Village, Tambang District, Kampar, Riau. A synthetic zeolite was from coal fly ash. LOF was from a catfish. The fertilizers used were ZA, TSP, KCl as a source of N, P and K, goat urine enriched with NPK 16-16-16. The pesticides of insecticide Regent 50 SC, Stadium 18 EC, and fungicide Antracol 70 WP were used to control plant pests.

The research was carried out experimentally in the form of a 4 × 3 factorial using a completely randomized design (CRD). The first factor was a synthetic zeolite that consists of 4 levels (0, 100, 150, and 200 kg per ha). The second factor was catfish LOF with a ratio of catfish LOF: water = 1:5 that consists of 3 levels {(0. 200 (4 × 50 ml per week), 400 (4 × 100 ml per week) ml per clump}). Each combination was repeated three times.

Podzolic soil as a planting medium was air-dried for one week, sieved using a 25 mesh sieve, and mixed thoroughly, then put into a polybag of as much as 10 kg. Each polybag was arranged at a distance of 50 x 50 cm. Afterward, synthetic zeolite according to the treatment dose was given simultaneously with the application of essential fertilizers. The fertilizers used were ZA 200 kg per ha, TSP 125 kg per ha, 100 kg KCl per ha, and goat urine enriched with NPK 16-16-16 (20 L goat urine + 1 kg NPK). Then, all were diluted with 1 L goat urine: 10 L water, with a volume of 50 ml per experimental unit, then incubated for one week. Each unit was planted with a 18-day-old rice seed. Following this, the catfish LOF was given according to the dose four times, specifically when the plants were 21, 28, 35, and 42 days after planting (DAP) by pouring them on the ground. In addition, maintenance includes watering, weeding, and controlling pests and diseases, watering using well water two times a day. Weeding and pest control is carried out when weeds or symptoms of the attack appear.

Parameter observations were divided into three parts. Firstly, observation of initial soil chemical properties including pH H_2O and KCl, Al-exc and H-exc, Organic-C (Walkley & Black), N (HCl 25%), P (HCl 25%), K (HCl 25%), P-available (Bray 1), Ca-exc, K-exc, Mg-exc, Na-exc and CEC (NH_4-Acetat 1N pH 7), as well as base and aluminum saturation. Secondly, observation of plant growth, including the plant's height, the maximum number of tillers, and productivity. Thirdly, observations of plant yield included the age of panicles, harvest age, number of filled grains per panicle, the weight of milled dry grains per clump, percentage of filled grains, the weight of 1000 filled grains, and harvest index.

Data from initial soil chemical properties were not analyzed statistically. In contrast, data from observations of plant growth and yield were statistically analyzed using analysis of variance based on the F test and follow-up tests using Duncan's New Multiple Range Test (DNMRT) at 5% level.

RESULTS AND DISCUSSION

Initial Podzolic Soil Chemistry

The chemical properties of the Podzolic soil used for research have an acid reaction and are classified as having low fertility as indicated by the

Table 1. The plant height (cm) of upland rice applied with synthetic zeolite and catfish LOF at 56 DAP.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
0	90.83 b	97.43 a	97.16 ab	95.14 a
100	92.13 ab	96.40 ab	94.73 ab	94.42 a
150	91.60 b	91.90 ab	95.96 ab	93.15 a
200	92.63 ab	92.76 ab	97.63 a	94.34 a
Average	91.79 a	94.62 a	96.37 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

values of Ca-exc and K (HCl 25%) are very low, the values of Organic-C, Mg-exc, Na-exc, CEC, and base saturation were low, and N (HCl 25%), P-available, and K-dd classified as moderate, except for P (HCl 25%) and aluminum saturation which are very high, causing the soil to have low fertility. The same thing was reported by Antoro and Nelvia (2018) that Ultisol soil in Batu Belah, Kampar, Riau has an acidic reaction and has low fertility as shown by the Ca-exc value are classified as very low also, the values of Organic-C, N (HCl 25%), P-available, K-exc, Mg-exc, Na-exc, CEC, and base saturation are low unless the saturation of aluminum is very high. Zulputra et al. (2014) also reported that Podzolic in Pematang Berangan, Rambah, Rokan Hulu, and Riau reacted sourly and had low fertility. The application of basic fertilizers in the form of ZA, TSP, KCl, and goat urine enriched with NPK 16-16-16 in this research aimed to overcome the soil chemical conditions for not being a limiting factor.

Growth of Upland Rice

The Plant Height

Table 1 shows that the interaction of synthetic zeolite with catfish LOF at each dose had no significant effect on plant height of upland rice aged 56 DAP. In contrast, the interaction between synthetic zeolite doses of 0 and 200 kg per ha and catfish LOF doses of 200 and 400 ml per clump significantly increased plant height compared to control. Meanwhile, the main effect of synthetic zeolite and catfish LOF at each dose had no significant effect on the plant height of upland rice aged 56 DAP. The results are closely related to soil fertility, classified as low, and synthetic zeolite as a source of soil negative charge because it has a high CEC and only plays a role in absorbing nutrients, not donating nutrients. According to Johan et al. (2017), the CEC of synthetic zeolite from coal fly ash is very high, > 250 Cmol per kg. At the same time, the CEC of the synthetic zeolite used was 134.92 Cmol per kg. Furthermore, the contribution of catfish LOF in contributing nutrients to plants aged 56 DAP is still limited.

According to Astawan (2008), catfish contains 17.7% protein, 4.8% fat, 1.2% minerals, and 76% water. Due to the decomposition of proteins, fats, and minerals, Catfish LOF will contain N nutrients and minerals, and other organic compounds, which will be absorbed by the synthetic zeolite available to plants. However, the amount of water and nutrients absorbed by plants is limited due to limited root volume, where the height of upland rice plants was observed at 56 DAP. In contrast, root and plant canopy growth continued until the generative phase was entered. The results of the research by Turmanto et al. (2021) reported that applying LOF fish waste had no significant effect on the height of soybean plants aged 3 WAP. Marpaung (2019) also reported that the application of LOF fish waste had no significant effect on the height of the green bean plant at 4 WAP.

The Number of Maximum and Productive Tillers

Table 2 shows that the interaction of synthetic zeolite and catfish LOF at each dose and the main effect of synthetic zeolite and catfish LOF had no significant effect on the number of maximum and productive tillers of upland rice. The results are related to the absence of the contribution of synthetic zeolite in providing nutrients as previously described, and the contribution of LOF catfish in providing mineral nutrients other than N is meager. The mineral content in catfish LOF is 1.2%, while the protein is 17.7% (Astawan, 2008).

Nutrients P and K are primary macronutrients plants need in large quantities slightly lower than the requirement for N nutrients. According to Ratna

Table 2. The number of maximum and productive tillers (stem) of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
	The Number of Maximum Tillers			
0	45.66 a	46.33 a	53.66 a	48.55 a
100	47.00 a	38.33 a	49.00 a	44.77 a
150	42.66 a	39.67 a	53.33 a	45.22 a
200	45.00 a	42.00 a	39.33 a	42.11 a
Rata-rata	45.08 a	41.58 a	48.83 a	
Synthetic Zeolite (kg per ha)	The Number of Productive Tillers			Average
0	26.66 a	28.00 a	34.33 a	29.52 a
100	28.66 a	24.66 a	31.00 a	28.11 a
150	27.00 a	23.33 a	34.00 a	28.11 a
200	29.00 a	26.66 a	24.50 a	26.72 a
Average	27.83 a	25.66 a	30.96 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

(2021), nutrients N, P, and K are the primary essential nutrients plants need in large quantities compared to other nutrients. The results of the research by Turmanto et al. (2021) reported that the application of LOF fish waste had no significant effect on the number of leaves of soybean plants. Marpaung (2019) also reported that the application of LOF fish waste had no significant effect on the number of branches of the green bean plant.

Yield of Upland Rice

The Age of Panicles Out

Table 3 shows that the interaction of synthetic zeolite with catfish LOF at each dose had no significant effect on the age of panicles out of upland rice. In comparison, the interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump significantly accelerated the age out panicles compared to zeolite synthetic doses of 0 and 100 kg per ha with catfish LOF doses of 400 and 0 ml per clump. The main effect of synthetic zeolite at a dose of 150 kg per ha was not significantly different from other doses but significantly different than without synthetic zeolite. In contrast, the main effect of catfish LOF had no significant effect on the age-out panicles of upland rice. It is closely related to the nutrient N widely available from catfish LOF, so it does not affect the age of panicles.

The high availability of P and K nutrients affects plants entering the generative phase. At the same time, catfish LOF contributes to low P and K nutrients because the mineral content in catfish LOF

Table 3. The age-out panicles (DAP) of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
0	68.33 abc	68.66 abc	69.66 ab	68.88 a
100	71.00 a	65.33 c	65.00 c	67.11 ab
150	65.66 bc	65.33 c	66.66 bc	65.88 b
200	67.33 abc	66.66 bc	65.66 bc	66.55 b
Average	68.08 a	66.50 a	66.75 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

is relatively low, at 1.2% (Astawan, 2008). Baon (2017) states that the internal organs of fish have P levels of 1-1.9%. Andriyani et al. (2017) also reported that LOF from catfish farming wastewater contained P 1.89–3.40% and K 0.10–1.03%.

The Harvest Age

Table 4 shows that the interaction of synthesis and catfish LOF at each dose and the main effect of synthetic zeolite and catfish LOF had no significant effect on the harvest age of upland rice. It is closely related to what has been explained that synthetic zeolite does not contribute nutrients, and the low contribution of catfish LOF in donating P and K nutrients is due to low mineral content. In contrast, the nutrient that plays a role in the generative phase is the P nutrient.

According to Hidayati and Sugiyanta (2010), the nutrient P plays a role in fruit ripening. Even though P plays a role in the fruit ripening process, the availability of P in these fish is low, which is 1–1.9% (Baon, 2017). Moreover, the available P nutrient is also absorbed by synthetic zeolite so that it does not affect the harvest age of upland rice.

The Number of Filled Grains per Panicle

Table 5 shows that the interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump increased the number of filled grains per panicle of upland rice significantly compared without treatment, which increased by 70%, as well as compared to the interaction of synthetic zeolite and other doses of catfish LOF, which increased by around 10.92%–40.93%. The increase in filled grains per panicle of upland rice is closely related to N nutrients resulting from protein decomposition from catfish LOF.

Nutrient N is available in NH_4^+ and is not oxidized to NO_3^- under anaerobic conditions; the O_2 decomposition process becomes amino acids and then becomes ammonium. Thus the nitrification process does not run nor produce NO_3^-, while the negatively charged synthetic zeolite adsorbs NH4+. The more synthetic zeolite is used; as a result, the more N is absorbed, causing low N mobility, so plant roots must be in direct contact so that plants can absorb nutrients. In contrast, in the synthetic zeolite dose of 100 kg per ha, the N nutrients are only

Table 4. The age of harvest (DAP) of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
0	95.00 a	93.33 a	94.33 a	94.22 a
100	93.00 a	92.00 a	93.66 a	92.89 a
150	93.66 a	93.33 a	94.00 a	93.66 a
200	94.33 a	94.00 a	93.33 a	93.89 a
Average	94.00 a	93.17 a	93.83 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

Table 5. The number of filled grains per panicle (grain) of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
0	139.06 c	195.99 ab	175.02 bc	170.02 a
100	181.54 bc	170.77 bc	236.51 a	196.27 a
150	172.10 bc	182.67 bc	159.90 bc	171.56 a
200	154.25 bc	167.82 bc	174.83 bc	165.63 a
Average	161.74 b	179.31 a	186.57 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

partially absorbed, and some others can mobilize to the roots through diffusion and mass flow. Therefore, the availability of N for plants is more remarkable, where N is needed to form new cells, namely grain cells.

Table 5 shows that the main effect of LOF catfish doses of 200 and 400 ml per clump was significantly increasing the number of filled grains per panicle compared to catfish LOF. It is closely related to the availability of N nutrients, as described above. With the availability of a lot of N nutrients, as a result, many grain cells are formed too. The grain components consist of starch, carbohydrates, and protein, so the availability of N to support protein becomes a component of grain content and will affect the amount of filled grain. The results of research Marpaung (2019) reported that the application of fish waste LOF at a dose of 105 ml increased the number of filled pods per green bean plant compared to without treatment.

Table 5 shows that the main effect of synthetic zeolite at each dose has no significant effect on the number of filled grains per panicle. It is related to synthetic zeolite, which only absorbs nutrients, not donating nutrients as described above.

The Weight of Milled Dry Grains per Clump

Table 6 shows that the interaction of synthetic zeolite with catfish LOF at each dose and the main effect of synthetic zeolite and catfish LOF had no significant effect on the weight of dry milled grains per clump of upland rice. Although the weight of dry milled grains per clump was not affected by synthetic zeolite and catfish LOF, the interaction of synthetic zeolite doses of 100 and 150 kg per ha with catfish LOF dose of 400 ml per clump increased by 68% compared without treatment while in other interactions the increase was lower, that is around 2.7%–48.6%. The increase in grain weight is closely related to the number of filled grains per panicle; the higher the number of grains. As a result, the greater the grain weight. It relates to the role of catfish LOF as an energy source for microbes. It can increase the population and activity of soil microbes in providing nutrients for plants, such as *Azotobacter* bacteria which are growth regulators producing soil microbes in the rhizosphere, as well as *Pseudomonas* sp. and *Penicillium* sp., namely phosphate solubilizing microbes which are commonly found in the soil rhizosphere (Rohmah et al., 2013).

The availability of nutrients produced by catfish LOF and assisted by microbial activity will be absorbed by synthetic zeolite. According to Johan et al. (2017), synthetic zeolite can increase the soil's ability to absorb nutrients and retain water. The weight of milled dry grains per clump will increase by providing the nutrients plants need. Rosmaiti et al. (2019) reported that fish waste fertilizer increased the cob weight of sweet corn plants compared to without treatment.

The Percentage of Filled Grains

Table 7 shows that the interaction of synthetic zeolite with catfish LOF at each dose had no significant effect on the percentage of filled grains of upland rice, except for the interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump significantly increased the percentage of filled grains of upland rice compared to synthetic zeolite at doses of 0 and 200 kg per ha without catfish LOF. The main effect of synthetic zeolite and catfish LOF at each dose had no significant effect on the percentage of filled grains of upland rice. It is closely related to the role of synthetic zeolite in absorbing nutrients and catfish LOF, which produce nutrients and contain amino acids that makeup proteins that decompose into a source of N nutrients. Nutrients and amino acids adsorbed on synthetic zeolite are available, can be

Table 6. The weight of milled dry grains per clump (grain) of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump) 0	200	400	Average
0	62.95 a	93.56 a	76.29 a	77.60 a
100	83.05 a	80.46 a	105.88 a	89.80 a
150	74.97 a	64.67 a	100.71 a	80.12 a
200	82.20 a	73.19 a	85.46 a	80.28 a
Average	75.79 a	77.97 a	92.09 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

Table 7. The percentage of filled grains (%) of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
0	73.98 c	78.44 abc	81.18 abc	77.87 a
100	82.78 abc	79.60 abc	87.55 a	83.31 a
150	80.91 abc	84.89 abc	80.92 abc	82.24 a
200	74.51 bc	77.50 abc	87.10 ab	79.70 a
Average	78.05 a	80.11 a	84.19 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

absorbed by plants, and will be used for plant growth. Furthermore, it plays a role in physiological processes and plant metabolism and stimulates grain growth, formation, and filling.

According to Abidin (2013), amino acids can increase the amount of chlorophyll, photosynthetic activity, and root growth. Amino acids optimally regulate stomata by controlling transpiration and increasing CO_2 reduction to be converted into carbohydrates as a grain component in the form of starch. The most significant part of rice is 85–90% starch and only a tiny portion of pentoses, cellulose, hemicellulose, and sugar. In addition, water also plays a vital role in increasing grain yield. Water transports substances (photosynthesis and nutrients) from cell to cell and organ to organ. Water availability in the soil is sufficient due to synthetic zeolite, which can hold water. Sufficient water will not cause water drought so that the process of photosynthate translocation in plants is not disturbed, and filling grain is more efficient.

The Weight of 1000 Filled Grains

Table 8 shows that the interaction of synthetic zeolite with catfish LOF at each dose had no significant effect on the weight of 1000 filled grains of upland rice. In comparison, the interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump significantly increased the weight of 1000 filled grains of upland rice compared to control. The main effect of synthetic zeolite and catfish LOF at each dose had no significant effect on the weight of 1000 filled grains of rice upland rice. Although the effect was not significant, the weight of 1000 filled grains exceeded the description, that is ± 25.6 g compared without treatment, and there was an increase in the interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump.

The increase in weight of 1000 filled grains occurred due to good grain filling from photosynthate, which was converted into various components of grain fillers. It is closely related to the weight of dry milled grains per clump, where each grain is filled perfectly. It is also indicated by the percentage of filled grains above 80%, where the interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump showed higher results than without treatment.

Table 8. The weight of 1000 filled grains (g) of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
0	25.06 b	26.13 ab	27.32 ab	26.17 a
100	27.93 ab	26.15 ab	28.63 a	27.57 a
150	27.86 ab	28.09 ab	26.22 ab	27.39 a
200	26.67 ab	27.58 ab	28.22 a	27.49 a
Average	26.88 a	26.99 a	27.60 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

Table 9. The harvest index of upland rice applied with synthetic zeolite and catfish LOF.

Synthetic Zeolite (kg per ha)	Catfish LOF (ml per clump)			Average
	0	200	400	
0	0.40 c	0.52 ab	0.51 ab	0.48 a
100	0.43 bc	0.51 ab	0.55 a	0.50 a
150	0.50 abc	0.51 abc	0.51 ab	0.51 a
200	0.50 abc	0.50 abc	0.48 abc	0.49 a
Average	0.46 a	0.51 a	0.51 a	

*)The numbers followed by the same lowercase letter in the same row and column are not significantly different according to the DNMRT test at the 5% level.

The Harvest Index

Table 9 shows that the interaction of synthetic zeolite with catfish LOF at each dose had no significant effect on the upland rice harvest index. In contrast, the interaction of synthetic zeolite dose of 100 kg per ha with catfish LOF dose of 400 ml per clump increased the harvest index significantly compared to synthetic zeolite doses of 0 and 100 kg per ha without catfish LOF and increased the harvest index by 37.5%. The main effect of synthetic zeolite and catfish LOF at each dose had no significant effect on the harvest index of upland rice. Although the main effect was insignificant, there was an increase in the interaction of synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump compared without treatment.

The increasing was significantly related to the weight of 1000 filled grains, the percentage of filled grains, and the weight of dry milled grains per clump. The combination of applied synthetic zeolite at a dose of 100 kg per ha with catfish LOF at a dose of 400 ml per clump showed the highest yield so that the harvest index was also high. Moreover, the harvest index is also related to the number of maximum and productive tillers that produce biomass. The higher the biomass produced, as a result, the higher the harvest index value.

CONCLUSIONS

The application of synthetic zeolite and catfish LOF at each dose had no significant effect on the height of the plant, the number of maximum and productive tillers, the age-out panicles, the age of harvest, and the weight of milled dry grains per clump. The interaction of a synthetic zeolite dose of 100 kg per ha with a catfish LOF dose of 400 ml per clump increased the number of filled grains per panicle by 70%, the weight of dry milled grains per clump by 68%, and the harvest index by 37.5% significantly compared without treatment.

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