The utilizations of solid waste originating from super intensive shrimp farm as organic fertilizers for natural feed productions

H S Suwoyo¹,², A Tuwo³, Haryati³, H Anshary³, and R Syah²

¹Agricultural Science Program Study, Graduate School, Hasanuddin University, Makassar, Indonesia.
²Research Institute for Coastal Aquaculture and Fisheries Extension, Maros, Indonesia.
³Faculty of Marine Science and Fisheries, Hasanuddin University, Makassar, Indonesia.

Email: hidayat7676@gmail.com

Abstract. Productions and utilizations of organic fertilizers originating from solid waste of super intensive shrimp farms to reduce the amount of wastewater released to the surrounding areas and its environmental impacts, are recommended to support both aquaculture and agriculture industries. This study was aimed to evaluate growth of natural feed (plankton and lablab) fertilized by organic fertilizer originating from super intensive shrimp farm and other different fertilizers. Completely randomized design was applied in this study with four treatments and three replications. The following treatments were urea + SP-36 + organic fertilizers originating from super intensive shrimp farm + isolated shrimp ponds bacteria ISO (A), urea + SP-36 + commercial organic fertilizer (B), Urea + SP-36 + chicken manure fertilizer (C) and control, (urea + SP-36) (D). The dosages of fertilizers were: urea 200 kg/ha, SP-36 100 kg/ha, and organic fertilizers (solid waste originating from super intensive shrimp farm, commercial organic fertilizer and chicken manure fertilizer) 2000 kg/ha. The measured variables were species composition and abundance of phytoplankton, biomass of lablab, and water quality. The results of this study indicated that treatments A and B resulted high in number of plankton genera, which was 19 genera, whereas treatments C and D only 10 genera. The highest mean abundance of plankter was found in Treatment A, which was 14,571 ind/L, followed by Treatment B, 9,489 ind/L; Treatment C was 8,717 ind/L and the lowest was found in Treatment D 5,066 ind/L. The dominant phytoplankton observed in this study was Oscillatoria sp. whereas the most observed zooplankton was Branchionus sp. The mean biomass of lablab produced from solid waste originating from super intensive shrimp farm was 4.35 g/100 cm² which was not significantly different (p>0.05) from Treatments B and C, but significantly different (p<0.05) from the control. The water quality variables measured during this study was within the acceptable values for natural feed productions.

1. Introduction

Superintensive vaname shrimp cultivation with high stocking densities fully relies on feed input in the form of pellets wreak 60-70% of total operational costs [1]. High stocking densities applied in the superintensive aquaculture system have consequences for waste load as a by-product of aquaculture...
activities that can affect the viability of shrimp habitat and the fisheries environment. Feed is suspected as a potential supplier of nutrient waste. Most of the feed given will be utilized by the shrimp through the digestive process obtain energy and nutrients stored in the shrimp network as biomass. The rest will be wasted as a result of excretion both in the form of dissolved and feces that are discharged into water bodies and undergo a process of dissolution, sedimentation, mineralization, and dispersion. [2] suggested that the remaining feed will produce sedimentary waste whose composition consists of organic and inorganic materials.

Organic matter that accumulates in ponds will increase with increasing age of maintenance. At the end of shrimp maintenance, the thickness of the organic material is 6.4 - 8.5 cm [3]. There was correlation between the rate of sediment accumulation and final shrimp density in 13 pond plots in New Caledonia [4]. There is a positive correlation between the amount of sediment and the final density of vaname shrimp and the total amount of feed. Shrimp density and amount of feed contributed 58.3% in determining the amount of sediment in vaname shrimp intensive ponds, the remaining 41.7% explained by other factors [1]. Sludge formed during the cultivation process can reach 35-60 t / ha / shrimp production cycle. Pond sediments are rich in nutrients and organic matter. Nutrient concentrations in pond ponds are much higher than those in water bodies, it is estimated that 1 cm in thickness of pond sediments is generally 10 times or more the amount of nutrients present in 1 m depth of water bodies [5]. Shrimp culture in Australia estimates that the amount of N and P produced is 290 and 16 kg / ha / year. The level of pond productivity of 6,376 kg / 1000 m², the organic TN, TP, and C waste load was 50.12 gTN / kg shrimp, respectively; 15.73 gTP / kg shrimp and 126.85 g organic C / kg shrimp. Whereas at the pond productivity of 8,407 kg / 1000 m², the organic waste TN, TP, and C load was 43.09 gTN / kg shrimp, respectively; 14.21 gTP / kg shrimp; and 112.85 gC organic / kg shrimp [6]. Pond waste has higher organic matter, total nitrogen and phosphorus values than normal soil. Shrimp pond solid waste contains 1.92% organic C, 0.54% N total and 1.70% [7]. The nutrient content of solid waste from shrimp ponds is quite high, such as total N 0.67%, P₂O₅ 4.78%, K₂O 1%, C-organic 17.84%. High levels of organic matter, nitrogen and phosphorus in sediments, making pond sediments a potential organic material for fertilizer. Organic fertilizer production from solid waste and subsequent use in agriculture and fisheries are highly recommended to reduce the volume of waste disposal and environmental degradation and increase land productivity.

The success of raising shrimp and fish in semi-intensive and extensive farms is largely determined by the availability of natural food. The amount of natural food in ponds can be increased by fertilizer. Fertilization is intended to increase soil fertility, which results in the fertility of natural feed for shrimp / fish, especially in the form of clumps, masses that grow on ponds or living as plankton. Klekap or lab-lab is a complex basic blue-green alga, protozoa, diatoms, bacteria and detritus) is an important natural feed for fish and shrimp in brackish water ponds in Indonesia, especially in ponds that are managed with traditional and semi-intensive systems [8]. For the growth of natural feed, fertilizer application is intended to increase the nutrients Nitrogen (N), Phosphorus (P), and Potassium (K) needed by cultivation organisms [9]. Nutrient needs are intended to increase plant fertility by mixing or formulating (mixed fertilizer) several types of fertilizer into one part [10]. To support life, natural feed requires organic and inorganic materials taken from the environment [11]. The main function of nutrients is as a source of energy and cell building. In the cultivation of natural feed, it is needed a variety of organic compounds, namely macro and micro nutrients.

This study was aimed to evaluate the growth of natural feed (plankton and lablab) fertilized by organic fertilizer originating from super intensive shrimp farm compared to commercial organic fertilizer and chicken manure fertilizer combined with inorganic fertilizer.

2. Methods
2.1. Location
This research was conducted at Experimental Pond Installation, Research Institute for Coastal Aquaculture and Fisheries Extension in Manrimisi Lompo Village, Maros Baru Subdistrict, Maros Regency, South Sulawesi, Indonesia.
2.2. Experimental Design

The research containers used were 70 x 37 x 26 cm³ in size of 12 pieces. Completely randomized design (CRD) was applied in this study with four treatments and three replications. The following treatments were urea + SP-36 + organic fertilizers originating from intensive shrimp farm + isolated shrimp ponds bacteria ISO (A), urea + SP-36 + commercial organic fertilizer (B), Urea + SP-36 + chicken manure fertilizer (C) and control, (urea + SP-36) (D). The dosages of fertilizers were: urea 200 kg/ha, SP-36 100 kg/ha, and organic fertilizers (solid waste originating from super intensive shrimp farm, commercial organic fertilizer and chicken manure fertilizer) 2000 kg/ha.

2.3. Preparation of natural feed growing media

Prior to the application of fertilizer treatment, preparation of the growth media was done. The soil grower media taken from the pond, then stirred evenly to make it homogeneous, then placed into a 5 cm thick test container. The growth of natural feed started from drying the soil for 2-3 days until the soil was cracked, followed by application of fertilizers according to the treatment and filling of brackishwater (15-20 ppt) with 3 cm. During the process of growing the klekap/lab-lab, the water level was raised to 15 cm [10]. The samples were taken on the 14th day and 28th day after fertilization, using a 1 inch pralon pipe. The position of the samples was taken at the same three diagonal points. This study lasted for 4 weeks.

2.4. Observed Variables

The observed variables included the composition of species and abundance of plankton, the biomass of lablab and water quality. The production of lablab biomass refers to the mud dry weight method. The abundance of plankter was calculated under a microscope using the SRC (Sedgwick rafter counter cell) assisted with the modification of the APHA formula [12]. Measuring water quality variables included temperature, pH, salinity, dissolved oxygen, nitrate, and phosphate, carried out at the beginning, middle and end of research.

2.5. Analysis of data

The data of biomass of lablab obtained were analyzed by analysis of variance (ANOVA) using SPSS program version 21.00 followed by a Tukey test at 95% level of confidence. The composition and the abundance of plankton and water quality data were analyzed descriptively.

3. Results and Discussions

3.1. Composition of species and Abundance of Plankton

The types of plankton obtained during the study consisted of phytoplankton and zooplankton in which the number of types and individual phytoplankton were greater than those of zooplankton. The highest number of phytoplankton types obtained in treatment B were 12 genera, following treatment A for 10 genera, then treatment C for 6 genera and the lowest in treatment D for 5 genera. While the highest number of zooplankton genera obtained in treatment A was 9 genera, then treatment B was 7 genera, following treatment D for 5 genera and the lowest in treatment C was 4 genera (Figure 1). The types of plankton obtained during research were namely: Amphipora sp, Aphanothoea sp, Gymnodinium sp, Oscillatoria sp, Pyrophacus sp, Pleurosigma sp, Synchocystis sp, Surirella sp, Thallasionema sp, Ceratium sp, Chaetoceros sp, Coscinodiscus sp, Pleurosigma sp, Clindropyxis sp, Cyclotella sp, Ditylum sp, Eutreptia sp, Guinardia sp, Globigerina sp, Gyrodinium sp, Lyngbia sp, Strombidium sp, Thallassiorira sp, Branchionus sp, Acartia sp, Apocylops sp, Echinocamptus sp, Naupli Copepoda sp, Onychocamptus sp, Balanus sp, Copepoda sp, Nitoeca sp, Polychaeta sp, Schamackeria sp, Tintinnopsis sp. The type of phytoplankton was dominated by genera Oscillatoria sp, whereas zooplanton species were dominated by Brachionus sp which is a type of natural feed favored by aquaculture organisms. The many types of plankton obtained during this study indicated that these
materials can be used as an alternative, organic fertilizer to support the increase in plankton abundance in ponds as shown as figure 1.

![Image of Number of Genera for each Fertilizer Application](image_url)

**Figure 1.** Number of genera phytoplankton and zooplankton for each treatment.

The observation results of the highest number of phytoplankton obtained in treatment A ranged from 30-19,974 ind / L, following treatment B ranged from 30-6,425 ind / L; treatment C ranged from 31-5,517 ind / L and treatment D ranged from 63-2044 ind / L. While the highest number of zooplankton individuals was obtained in treatment C ranged from 125-9,096 ind / L, following treatment A ranged from 28-7,388 ind / L, treatment B ranged 30-5,511 ind / L and treatment D ranged from 63-3,366 ind / L (Figure 2). The highest average abundance of plankton was obtained in treatment A of 14,571 ind / L, then B 9,489 ind / L, treatment C of 8,717 ind / L and the lowest treatment obtained at treatment D was 5,066 ind / L. Plankton growth patterns in all treatments were relatively same, where at the beginning of maintenance was relatively low, then increases and reaches a peak in the second week, then decreases in the fourth week. Plankton growth patterns were the same as those obtained in tilapia aquaculture ponds.

The average abundance of plankton individuals obtained in this study was not much different from previous studies. Abundance of plankton in tiger shrimp ponds ranging from 6,535-8,064 ind / L. The average abundance of plankton individuals during the study with a combination of urea + SP-36 + chicken manure treatment of 740 ind / L, consisted of phytoplankton 616 ind / L and zooplankton 124 ind / L, then the combined treatment of urea + SP-36 fertilizer + cow dung of 1048 ind / L, consisted of phytoplankton 856 ind / L and zooplankton 192 ind / L, and a combination treatment of urea + SP-36 + fine bran fertilizer, was to 542 ind / L, consisted of phytoplankton 364 ind / L and zooplankton 178 ind / L. The average number of plankton ranging from 6,389 to 14,889 ind / L with the application of liquid organic fertilizer at a dose of 0.025-2 mL / m³. The number of plankton individuals in the modular shrimp culture pond system of 2,788-3,643 Ind / L. Plankton abundance in ponds with the application of organic fertilizer combination of seaweed, rice straw, cow manure and commercial organic fertilizer (petroganik), each of which were 208 ind / L and 99 ind / L. The abundance of plankton in intensive ponds ranged from 702-4,269 ind./L with a number of genera of 6-14 genera. Whereas in traditional ponds, plankton abundance was around 134-776 ind / L and the number of genera is 3-10 genera [13]. The highest number of phytoplankton in the fishpond ponds in Gresik that was 8,425 ind./L with fertilizer application with an N and P ratio of 4 (N 8.6 kg and P 2.3 kg). The results of observations abundance of plankton during intensive milkfish cultivation obtained as much as 599-887 ind / L. The abundance of phytoplankton in the maintenance media of 10, 15 and 20 ppt salinity each of 9,531 ind / L, 12,549 ind / L and 11,576 Ind / Ls. Abundance of plankton in black tiger ponds ranging from 35-1,399 individuals / L.
Figure 2. Abundance of phytoplankton and zooplankton for each treatment.

The high number of phytoplankton in a water was influenced by several environmental parameters and physiological characteristics. The composition and abundance of phytoplankton will change at various levels in response to changes in environmental conditions both physical, chemical, and biological. Supporting phytoplankton growth factors are very complex and interact with water physical-chemical factors such as light intensity, dissolved oxygen, temperature stratification, and availability of nitrogen and phosphorus nutrients, while the biological aspect is the activity of predation by animals, natural mortality, and decomposition. Physical-chemical factors such as temperature, light intensity, salinity, pH and pollutants in the waters play an important role in determining the abundance of plankton species. While biotic factors such as the availability of feed, the number of predators and the presence of competitors can affect the composition of this. There are differences in the composition and abundance of plankton (natural feed) in milkfish ponds during the dry season and rainy season. Diatom dominated population of lablab during the dry season, and Cyanobacteria during the rainy season. The density of algae (plankton) is higher in the dry season than the rainy season. There was a decrease in the abundance of natural feeds in milkfish ponds during high rainfall.

The large number of plankton individuals obtained in treatment A (a combination of inorganic fertilizer with organic fertilizers originating from super intensive shrimp farm) compared to other treatments because the composition of nutrients (macro and micro nutrients) of the applied fertilizer is more complete so that it can support the growth of natural feed in the maintenance container. The shrimp pond solid waste has the potential to be used as organic fertilizer because it has a high nutrient content [7]. Addition of organic fertilizer to getting macro nutrients such as N, P, K, Ca, Mg, and S also micro nutrients such as Zn, Cu, Mo, Co, B, Mn, and Fe, although the amount is relatively small.

The abundance of plankton especially phytoplankton in a waters is influenced by the entry of nutrient content for the growth of phytoplankton such as nitrate, phosphorus, and organic matter [14]. High and low abundance of phytoplankton in a waters depends on nutrient content in the waters including nitrate and phosphate. One of the main needs of phytoplankton in growth is the availability of sufficient nutrients in the waters. Light is an important factor because it has a direct impact on the distribution and number of organisms, especially phytoplankton in water bodies. Phytoplankton growth in pond are determined by the conditions of the pond preparation. Fertilization of the subgrade cause the pond bottom to be fertile so that aquatic plants, especially blue algae, can grow well. Fertility decrease with increasing maintenance period. Therefore, the fertility of pond water should also be monitored so that it can be known when the right time for re-fertilization. Plankton really needs a variety of organic compounds both as macro nutrients (N, P, K, S, Na, Si and Ca) and micro nutrients (Fe, Zn, Mn, Cu, Mg, Mo, Co, B and others). Each nutrient has special functions, N, P and S are
important for the formation of protein, K functions in carbohydrate metabolism, Fe and Na play a role in the formation of chlorophyll, while Si and Ca are materials for the formation of cell walls or shells.

3.2. Biomass Production of Lablab

The results of observations on the production of biomass of lablab for four weeks of cultivation vary and increase with increasing rearing time for all treatments (Figure 3). The highest average of biomass production of lablab in the second week was obtained in treatment C (urea + SP-36 + chicken manure fertilizer) of 3.26 g / 100 cm² and then followed by treatment A (urea + SP-36 + organic fertilizers originating from super intensive shrimp farm + isolated shrimp ponds bacteria) of 3.25 g / 100 cm², then treatment B (urea + SP-36 + commercial organic fertilizer) of 3.15 g / 100 cm², and lowest in treatment D (control. urea + fertilizer SP-36) that is 2.31 g / 100 cm². Whereas in the fourth week, there was an increase in the production of dark biomass in all treatments. The highest average of biomass production was found in treatment A (urea fertilizer + SP-36 + organic fertilizers originating from super intensive shrimp farm + isolated shrimp ponds bacteria) of 4.35 g / 100 cm², then treatment C (urea fertilizer + SP-36 + chicken manure fertilizer) which is 4.15 g / 100 cm², then followed by treatment B (urea + SP-36 + commercial organic fertilizer) of 4.10 g / 100 cm², and treatment D (control. urea + SP-36 fertilizer) of 2.84 g / 100 cm².

![Figure 3. Average of biomass production of lablab with different types of fertilizers application during the experiment.](image)

The results of the analysis of variance showed that the treatment application of fertilizer had a significant effect (P <0.01) on the biomass production of lablab. Further test results, showed that treatments A, B, and C were not significantly different (P> 0.05), but treatment A was significantly different (P <0.05) to the treatment (D) with the lowest production of lablab that was 2.84 g / 100 cm². The average production biomass of lablab obtained tends to increase from the second week to the fourth week. Production of lablab biomass has been increasing since the beginning of the experiment and reaching its peak in the third week, then decreasing in the following weeks. Organic fertilizers originating from super intensive shrimp farm which is applied in a mixture with urea and SP-36, results in the performance biomass production of lablab that is not different than commercial organic fertilizer and chicken manure fertilizer. This indicates that organic fertilizers originating from super intensive shrimp farm can be used as an alternative organic fertilizer for traditional ponds for growing natural feed. Kelekap or lablab is one type of natural feed in an extensive cultivation system. There are 4 types of natural feed in extensive aquaculture systems namely kelekap/lablab (bentic mat, cyanobacteria, diatoms and associated fauna), Ruppian mantima, filamentous green algae and plankton [15].

The production of lablab biomass obtained in this study was not different from the results of previous studies. Average production of lablab biomass of 4.88 g/100 cm² during the rearing period of
tiger prawns for three weeks and average production of lablab biomass decreased in the fifth week of 3.00 g / 100 cm². The highest production of lablab in acid sulphate soil pond of 2.32 g / 100 cm² with soil improvement and application of phosphorus fertilization [8]. The highest lablab biomass production in traditional pond of 3.33 g / 100 cm². Average production of lablab biomass produced from organic fertilizer shrimp pond waste of 3.94 g / 100 cm² [1]. The average yield of lablab biomass obtained from this study is lower than the research of [16], who get an average production of lablab biomass in each treatment of lime application 600 kg / ha, 800 kg / ha, and 1,000 kg / ha is 6.38 g / 100 cm²; 10.18 g / 100 cm² and 8.95 g / 100 cm². The dosage of lime paper mill waste that is applied has a significant effect on the production of lablab biomass. Production of lablab is one of the factors that influence the growth and production of vaname shrimp in traditional ponds. The average of lablab production in vaname shrimp ponds with supplementary fertilization systems ranges from 13.5 to 18.6 g / 100 cm².

Some factors that influence the growth of lablab are availability of nutrients, season, environmental conditions. Environmental parameters affect changes in abundance, diversity and evenness of the amount of periphyton such as salinity, nitrate, inorganic phosphate, and dissolved oxygen during the dry season. The structure of the periphyton community, species composition, and succession response are related to environmental conditions. The composition and number of phytobenthos making up the lablab more in the dry season than in the rainy season. The interaction between soil remediation and phosphorus fertilization has a significant effect on lablab production. For good lablab growth, soil pH is needed between 7.0-8.0 due to the availability of soil nutrients and microbial activity maximum in this pH range [17].

3.3. Water Quality
Water quality has an important role because it is one of the supporting factors for the growth of plankton. The type of phytoplankton that can dominate a waters can be influenced by environmental conditions such as physical and chemical factors [17]. Plankton abundance and distribution in a waters are influenced by factors such as temperature, salinity, pH, DO, nitrate, and phosphate. The results of observations of several water quality parameters during the study are presented in Table 1.

Table 1. The range of water quality variables observed during the study

| Variable               | Different types of fertilizers application |
|------------------------|-------------------------------------------|
|                        | A          | B          | C          | D          |
| Temperature (°C)       | 23.7 – 28.8 | 23.3 – 29.0 | 22.7 – 29.1 | 23.3 – 29.2 |
| Salinity (ppt)         | 19 – 27    | 19 – 27    | 20 – 27    | 20 – 27    |
| pH                     | 7.5 – 8.5  | 7.5 – 8.5  | 7.5 – 8.5  | 7.5 – 8.5  |
| DO (mg/L)              | 2.60 – 3.61| 2.31 – 3.59| 2.61 – 3.50| 2.13 – 3.41|
| PO₄-P (mg/L)           | 0.0021 - 0.7404| 0.1227 – 0.6903| 0.3343 – 0.7458| 0.0105 – 0.2566|
| NO₃-N (mg/L)           | 0.0909 – 6.7200| 0.1035 – 6.3031| 0.2492 – 3.6679| 0.0894 – 2.222|

The results of water temperature measurements in each container during the study ranged from 22.7–29.2°C. This temperature range is considered suitable for plankton growth. The good temperatures for the life of plankton generally range between 20-30°C [18]. Phytoplankton and diatoms grow well in the temperature range of 20°C-30°C.

Salinity measurements during cultivation range from 19-27 ppt. This range value can still be tolerated for plankton growth. Brackish waters usually concentrate salinity between 0.5-30 ppt. Salinity values above 20 ppt allow phytoplankton to survive, reproduce themselves and be able to actively carry out the process of photosynthesis. The pH values obtained during the study ranged from 7.5 to 8.5. The pH value can support the life of aquatic organisms including phytoplankton. Phytoplankton can live in waters that have a neutral pH value with a tolerance range between weak acids to weak bases. The appropriate pH range for the life of aquatic organisms is 6.5-9. The pH value
is in accordance with the standard quality of sea water for marine biota, which is 7.0-8.5 [75], so it has an effect against plankton abundance. Waters with a pH between 6-9 are high fertility waters and are classified as productive because they can encourage the process of dismantling organic material in the waters into minerals that can be utilized by phytoplankton for growth [19].

Dissolved oxygen content obtained during the study ranged from 2.13-3.61 mg / L. Low oxygen was found at the beginning of cultivation because the conditions were still adapted to the initial fertilizer application, but after entering the second week until the end of cultivation, the oxygen value increasing to 3.40-3.61 mg / L. The optimal oxygen content for aquatic organisms in ponds> 3 mg / L. Dissolved oxygen levels added> 3.0 mg / L are still sufficient to support the life of aquatic biota, including plankton.

Nutrients that have an important role in phytoplankton growth and metabolism are N and P [20]. Nitrogen is an important part in the formation of proteins in organisms, while phosphorus is the most important element for growth and contributes to the formation of protein and cell metabolism in organisms. Phytoplankton require the elements N and P in the production of body fat and protein elements N and P are often the limiting factors in the primary productivity of phytoplankton. The element can only be utilized by phytoplankton directly if it is in the form of nitrates and orthophosphates. The results of observations of nitrate content ranged from 0.0894-6.7200 mg / L. The levels of nitrate are still feasible to support the growth of natural feed. Nitrate content in milkfish ponds in Banggi Village, Rembang ranged from 1.53-1.83 mg / L. Nitrate levels for optimum growth of phytoplankton range from 0.90-3.50 mg / L. Nitrate content during milkfish nursery distribution range between 0.06-2.10 mg / L [1].

Besides N, P is a macro nutrient that is needed by natural food in ponds which is the main natural feed for traditional brackish water commodities which are managed traditionally. P is an essential nutrient that has a major role in biochemical reactions including photosynthesis and respiration. Phosphate measurements during the study ranged from 0.0021-0.7458 mg / L. This value is still feasible to support the growth of natural feed. Optimal growth of phytoplankton requires orthophosphate content ranging from 0.09 to 1.80 mg / L. The lowest limit of phosphate concentration for optimum growth of algae ranges from 0.018-0.090 mg / L P-PO4 and the highest limit ranges from 8.90-17.8 mg / L P-PO4 if nitrogen is in the form of nitrate. The optimum phosphate content for phytoplankton growth ranged from 0.27 to 5.51 mg / L .

4. Conclusions
The application of organic fertilizers originating from super intensive shrimp farm combined with inorganic fertilizer produced a growth response of natural feed (plankton and lablab) which is relatively the same as commercial organic fertilizer and chicken manure fertilizer. Water quality variables measured during this study was within the acceptable values for natural feed productions.

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