



Weed Fermentation in Islamic Agriculture: Improving Forage Production in Smallholder Farming

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ABSTRACT

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This study aimed to identify potential weed species suitable as raw materials for fermentation technology in producing nutrient-rich organic fertilizers, thereby linking sustainable agricultural innovation with Islamic environmental ethics. A Completely Randomized Design (CRD) was employed with four treatments based on the volume of fermented weed-based fertilizer (0, 30, 40, and 50 mL) and three replications, resulting in a total of 36 experimental units. Observed parameters included plant height, leaf area, and chlorophyll content, while forage quality was analyzed through neutral detergent fiber (NDF), acid detergent fiber (ADF), and acid detergent lignin (ADL) composition. Results showed that weed fermentation had no significant effect on plant growth ($P > 0.05$) but significantly improved forage quality ($P < 0.01$) across fertilizer doses. Fermented weed-based fertilizer thus proved effective for enhancing the nutrient quality of green fodder sustainably. This research introduces a novel integration of weed fermentation technology and Islamic ethical principles, providing an innovative model for eco-friendly and faith-aligned agricultural practices.

Keywords: Weed fermentation; organic fertilizer; forage quality; sustainable agriculture; Islamic agricultural ethics

INTRODUCTION

Forage is the primary source of food for ruminants because it contains essential nutrients to meet their basic life and production needs. The selection of forage species can be based on properties such as palatability, ease of digestion, a food substance content that meets the needs of livestock, ease of acquisition, ease of cultivation, a short growth cycle, and the ability to regrow after harvest. Grass is the primary source of feed for ruminants, providing the essential nutrients needed for basic life, growth, production, and reproduction, as forages contain the necessary food substances for livestock [1]. One factor that inhibits forage production and quality is weed

invasion. Weeds cause nutrients in the soil to decrease, which has an impact on the quantity and quality of plants. If essential nutrients are insufficient, plant metabolism will be disrupted, which can be visually observed through deviations in growth and quality [2]. Additionally, the quality is relatively lower, characterized by a high crude fiber content due to the intense sunlight.

Two major problems faced by farmers in the tropics, including Indonesia, in providing forage are 1) Weed invasion management, and 2) Provision of nutrients for pasture [3]. Weeds growing in pastures will compete with forage plants for light, water, and nutrients from the soil, resulting in grass that grows less lush and has a lower nutritional content [4].

One way to overcome weed invasion is to make liquid organic fertilizer. This liquid organic fertilizer is made from the basic ingredients of jonga-jonga weed, gamal leaves, and goat urine, as well as a combination of goat urine and tape yeast, and then fermented for 21 days. This method is an alternative that can enhance the physical, chemical, and biological properties of soil, while also promoting crop production, improving the quality of plant products, and reducing the reliance on inorganic fertilizers, thereby making the soil more fertile and conducive to plant growth [5].

In Islam, the concepts of "maslahah", meaning general welfare, and "tasharruf", meaning good management, show how important it is to use natural resources wisely and efficiently. The use of weeds as a base material for fermented fertilizer in this study demonstrates an attempt to optimize existing resources. Weeds, which are usually considered nuisance plants, can be turned into a good source of nutrients for fodder crops. Such management aligns with Islamic principles, which emphasize the importance of utilizing everything Allah SWT has optimally created on Earth without causing harm, as mentioned in the Qur'an, Surah Al-Baqarah, verse 205, which reminds us to avoid harming the Earth.

MATERIALS AND METHODS

Research Location

This research was conducted from June to August 2024, at the Faculty of Animal Husbandry, Hasanuddin University, Makassar. This research was conducted with six stages, namely: the first stage analyzing the content of soil organic matter (N, P, and K), the second stage of making weed fermentation fertilizer, the third stage of fermented weed fertilizer that has been fermented for 21 days, analyzing the quality of organic matter (N, P, K), the fourth stage of applying weed fermentation fertilizer to feed plants (natural grass, red elephant grass and pakchong grass), the fifth stage calculating the average growth of feed plants such as plant height, chlorophyll, leaf area given fermented fertilizer. The sixth stage, following grass harvest, involves laboratory tests for NDF, ADF, and ADL content at the Feed Chemistry Laboratory of the Faculty of Animal Husbandry, Hasanuddin University [6].

Tools and Materials

The tools used in this research include a hoe, a machete, a meter, a KWF meter, a SPAD meter, scales, a plastic drum, a plastic bucket with a lid, black insulation, clear insulation, a fertilizer filter, a 1000 ml measuring cup, and a fertilizer sprayer.

The materials used in this study were water, a weed-based liquid fertilizer consisting of jonga-jonga (*Chromolaena odorata*) at 50 kg/25 litres of water, gamal leaves, and goat urine at 15 litres, along with tape yeast at 125 grams. The mixture was fermented for 21 days.

Prepare three types of grass in the form of cuttings, namely: (1) Natural grass or mini elephant (*Pennisetum purpureum cv mott*), (2) Red elephant grass (*Pennisetum purpureum cv Red*); (3) Pakchong grass planted in polybags and each grass was given liquid fertilizer at the level of 30, 40, 50 ml/polybag consisting of 3 replications.

Research Plan

This study employed a completely randomized design (CRD) consisting of four treatments, with each treatment repeated three times. The treatment consists of Sriyono and Irwanto [7]:

P0 = 0 ml + 100 ml of water (control)

P1 = 30 ml/polybag + 100 ml water

P2 = 40 ml/polybag + 100 ml water

P3 = 50 /polybag + 100 ml water

Table 1. The treatment placement plan

Treatment	Control	Dose 30	Dose 40	Dose 50
Natural Grass	RAK1	RA301	RA401	RA501
	RAK2	RA302	RA402	RA502
	RAK3	RA303	RA403	RA503
Red Elephant Grass	RGMK1	RGM301	RGM401	RGM501
	RGMK2	RGM302	RGM402	RGM502
	RGMK3	RGM303	RGM403	RGM503
Pakchong grass	RPK1	RP301	RP401	RP501
	RPK2	RP302	RP402	RP502
	RPK3	RP303	RP403	RP503

Research Implementation

Before planting the seedlings, the planting media was prepared. The soil used as planting media weighed approximately 10 kg in each polybag. The number of polybags used was 36 for each treatment as a replicate. After the plants were 14 days old, they were uniformed and then fertilized. Fertilization was carried out twice: once when the plants were 2 weeks old and again after they were 4 weeks old. Fertilization was done by watering around the plants. Plant maintenance was carried out until the plants were 55 days old. During the maintenance, the plants were cleaned of any nuisance plants growing in the polybags. Watering was done twice a day, in the morning and evening.

Observed Parameters

The parameters observed in this study included the growth of plant height, leaf area, chlorophyll content, and fiber content of grass, which consisted of NDF, ADF, and ADL.

Data Retrieval

Sampling was done at the end of the study, when the plants were 55 days old. Measurement of plant height, leaf area, and chlorophyll per plant was done for each treatment (polybag). Meanwhile, to calculate data on the content of NDF, ADF, and ADL, all plants in polybags were harvested with a cutting height of 10 cm above ground level and then dried in an oven until the percentage of dry matter was obtained. After drying, the samples were pureed and analyzed at the Feed Chemistry Laboratory to determine the content of NDF, ADF, and ADL.

Data Analysis

The data obtained were then analyzed using SPSS statistical software and further tested with Duncan's multiple range test. Data were analyzed using SPSS software version 20.

RESULTS AND DISCUSSIONS

Results of Soil Chemical Analysis

N content is shown in Table 2. The analysis results indicated that the soil at the study site had a relatively low nitrogen content of 0.10%. This is because nitrogen in the soil is often dynamic and can change chemical forms, which may lead to nutrient loss from the soil-plant system. The low nitrogen level in the soil is caused by three factors: leaching, evaporation, and plant uptake [8]. Nitrogen in the soil exists as ammonium (NH_4^+) and nitrate (NO_3^-) [9]. The process of nitrification converts ammonium into nitrate, a highly soluble form of nitrogen in water. This suggests that nitrate can be easily leached from the root zone of plants, especially in overly wet soil conditions.

Table 2. Results of soil chemical analysis

Treatment	Parameters		
	N (%)	P ₂ O ₅	K (%)
Organic	0.10	10.61	0.12

Source: Unhas Soil Chemistry and Fertility Laboratory, 2024.

The analysis shows that the soil at the research site has a relatively high phosphorus (P) content of 10.61. This is very helpful for supporting plant growth, especially for plants that need large amounts of phosphorus, such as legumes. Phosphorus plays a vital role in the formation of DNA, RNA, and ATP, and is essential for cell division and root system development. Soil P availability is closely linked to soil acidity (pH) [10]. In most soils, maximum P availability occurs in the pH range of 6.0-7.0. Phosphorus availability decreases when soil pH is below 6.0 or above 7. Phosphorus is essential because it is a nutrient plants need in large quantities to stimulate root growth, especially at the start of plant growth and production. If plants lack phosphorus (P), their growth and production are disrupted [11, 12, 13].

Potassium (K) content is presented in Table 2. The analysis reveals that the soil at the study site has a relatively low K content of 0.12%. Low K levels can lead to suboptimal plant growth, brown edges, reduced plant yields, and increased susceptibility to disease and

environmental stress. Based on the research of Nursyamsi et al. [14] in "Soil Fertility and Fertilizers," the researchers found that the soil's K content is low.

Potassium levels in soils that are good for plants range from 0.2-2% depending on the type of soil, plant, and soil conditions. The availability of K in the soil is highly dependent on external additions, such as the use of organic fertilizers, fixation by the soil, or the addition of K itself. In the Islamic perspective, humans as khalifah on earth have the responsibility to maintain soil fertility so that it can continue to be used for the welfare of mankind. Managing the soil by paying attention to its content of N, P, and K is one way to fulfill the responsibility as a khalifah. The Qur'an often emphasizes that the earth and everything in it were created for humans, but humans are responsible for maintaining and managing it (QS. Al-Baqarah: 30).

Growth of Feed Forage

The results of the average forage study, which consisted of natural grass, red elephant, and pakchong grass, are presented in Table 3.

Table 3. Average growth of natural grass, red elephant grass, and pakchong grass, consisting of plant height, leaf area, and leaf chlorophyll

Grass Type	Treatment	Parameters		
		Plant Height (cm)	Leaf Area (cm)	Chlorophyll (unit)
Natural Grass	P0	118.00 ^b	3.500 ^b	27.3667 ^e
	P1	166.33 ^{ab}	4.167 ^{ab}	34.8000 ^d
	P2	129.17 ^{ab}	4.000 ^{ab}	36.5000 ^d
Red Elephant	P3	131.67 ^{ab}	3.833 ^{ab}	41.4333 ^d
	P0	140.17 ^{ab}	4.167 ^{ab}	4.20159 ^d
	P1	134.83 ^{ab}	3.900 ^{ab}	0.94516 ^c
	P2	140.33 ^{ab}	3.833 ^{ab}	1.22202 ^c
Pakchong	P3	133.00 ^{ab}	3.833 ^{ab}	1.80370 ^{bc}
	P0	146.33 ^{ab}	4.333 ^{ab}	2.19317 ^{bc}
	P1	134.00 ^{ab}	4.500 ^a	2.59808 ^{bc}
	P2	138.00 ^{ab}	4.667 ^a	2.60576 ^b
	P3	146.33 ^a	4.667 ^a	2.65141 ^a

Note: Different superscripts in the same column indicate significant differences ($P < 0.05$). Treatment P0 = No fertilization, P1 = Liquid fertilizer with a dose of 30 ml, P2 = Liquid fertilizer with a dose of 40 ml, P3 = Liquid fertilizer with a dose of 50 ml.

Plant Height

Variance analysis showed that the application of weed fermentation fertilizer did not have a significant effect ($P > 0.05$) on plant height in the three types of grass. In Natural Grass, treatment P1 (30 ml) produced the highest plant height (166.33 cm), while the control treatment (P0) produced the lowest plant height (118.00 cm). This research aligns with Sudarsono et al. [15], which states that the plant height and stem length of Super Napier grass in plots treated with are significantly different. The application of weed fermentation fertilizer at a dose of 30 ml can be considered the optimal dose for natural grass, as it provides nutrient improvements in the soil, which in turn affects plant height. According to Walida et al. [16], weed fermentation fertilizer

can play a role in increasing the value of soil nutrients needed for plant growth rates. This opinion is also supported by Boti et al. [17], who state that the application of weed fermentation fertilizer can significantly improve soil conditions, thereby increasing the growth rate of natural grass.

The plant height of Red Elephant Grass (REG) in the P0 treatment is 140.17 cm, indicating that the natural growth of REG occurs without the intervention of weed-fermentation fertilizer. In the P1 treatment, the plant height decreased slightly to 134.83 cm, then increased again in the P2 treatment to 140.33 cm, and the plant height again decreased in the P3 treatment, which was 133.00 cm. Fluctuations in REG plant height at various doses of weed fermentation fertilizer indicate that this plant has a certain tolerance threshold for weed fermentation fertilizer. The 40 ml dose is the most favorable for vegetative growth. In contrast, lower or higher doses can cause less optimal conditions for plants, either due to adaptation stress, changes in soil microbiota, or nutritional imbalances.

Pakchong grass (PG) plant height in the P0 treatment is 146.33 cm. In the P1 (134.00 cm), P2 (138.00 cm), and P3 (146.33 cm) treatments, there was a significant increase, but in the P3 treatment, the plant height was the same as that of the control treatment. At a dose of 50 ml, the plants may have reached the threshold or saturation point in terms of nutrient absorption provided by the weed fermentation fertilizer. In other words, despite the increase in fertilizer, the plants were unable to absorb or utilize the additional nutrients more effectively. This could be because the absorption capacity of the plant roots or the availability of other nutrients in the soil is sufficient, so the additional nutrients no longer enhance growth.

Leaf Area

Variance analysis showed that the application of weed fermentation fertilizer did not have a significant effect ($P > 0.05$) on leaf area. The P2 and P3 treatments had a significant effect on the leaf area of PG, but had no significant effect on the leaf area of Natural Grass (NG) and REG. This suggests that the response to weed fermentation liquid fertilizer may vary by grass type, with PG showing greater responsiveness to increasing doses of liquid fertilizer compared to NG and REG. This follows the opinion of Hidayat [12], Alvarez et al. [18], and Budiman et al. [19], which states that each type of grass has different genetic characteristics that affect how they absorb and utilize nutrients. Pakchong grass has a greater capacity to absorb nutrients from weed fermentation liquid fertilizer and is more efficient in converting those nutrients into physical growth, such as increased leaf area.

Leaf Chlorophyll

Variance analysis revealed that the application of weed fermentation fertilizer had a significant effect ($P < 0.01$) on chlorophyll content, as measured using the SPAD Meter. In NG, the chlorophyll content in treatment P0 (without fertilizer) was the lowest value among all treatments at 27.3667 units. In the P1, P2, and P3 treatments, a significant increase was observed compared to the control treatment (P0). The highest chlorophyll content is in the P3 treatment (41.4333 units). This indicates that the treatment of weed fermented liquid fertilizer has a high nutrient content, and the higher the dose of fertilizer given, the more likely it is to accelerate the reaction in the soil when given to plants to produce higher leaf chlorophyll. This is according to

the opinion of Sharma et al. [20]. Liman et al. [21] state that administering higher doses of fertilizer will accelerate the mineralization process and increase the availability of nitrogen in the soil, resulting in higher chlorophyll content in the leaves. This is because nitrogen is a key component of chlorophyll, which is essential for its formation.

The chlorophyll content in REG in the P0 treatment showed the highest value (4.20159 units), but overall, it was significantly lower than that of NG and PG. In the P1 treatment, the chlorophyll content decreased dramatically to 0.94516 units. This decrease suggests that the 30 ml fertilizer dose is not optimal or may even inhibit chlorophyll synthesis in REG Red. In the P2 and P3 treatments, there was an increase in chlorophyll content; however, it remained significantly lower than in P0, indicating that the weed fermentation fertilizer was not effectively utilized to increase chlorophyll content in REG. This is in line with the opinion of Wang et al. [22] and Dumadi et al. [23], who stated that the response of plants to liquid fertilizer varies significantly depending on the type of plant and the composition of the fertilizer. They found that some plants exhibited a decrease in chlorophyll content when given a non-optimal dose of fertilizer, which could be attributed to an imbalance of nutrients or the presence of certain compounds in the fertilizer that inhibit chlorophyll synthesis in plants.

The chlorophyll content in PG in the P0 treatment was lower than that of NG but higher than REG, with the same fertilizer dose of 2.19317 units. The P3 treatment was higher than the P2 and P1 treatments, indicating that PG was more responsive to weed fermentation fertilizer compared to NG and REG, especially in increasing chlorophyll content. Compared to NG and REG, PG has a better ability to absorb and utilize nutrients from weed-fermentation fertilizer. PG also exhibits a better adaptation mechanism for utilizing nutrients from fermented fertilizer more efficiently, and its chlorophyll content increases to a greater extent [24, 25, 26].

Neutral Detergent Fiber (NDF) Content

Variance analysis showed that the application of weed fermentation fertilizer had a significant effect ($P < 0.01$) on the NDF content of the three types of grass. NDF content in the P0 treatment showed the highest value among all treatments. In the P1, P2, and P3 treatments, there was a significant decrease in line with the increasing dose of weed fermentation fertilizer applied to the three types of grass tested. The provision of high doses of fertilizer can change the biochemical composition of plants, especially in reducing fiber content, such as NDF. This is the opinion of Zhang et al. [27], who stated that the application of liquid organic fertilizer containing active microorganisms significantly reduced the NDF content in several types of fodder plants. This decrease is caused by the increased activity of microorganisms in the soil, which facilitates the decomposition of complex organic matter into simpler components that plants can easily absorb.

Quality of Feed Crops

The results of the study on the average quality of feed plants, including NDF, ADF, and ADL content in feed plants (NG, REG, and PG), are presented in Table 4.

Table 4. Average feed crop consisting of NDF, ADF, ADL

Grass Type	Treatment	Parameters		
		NDF	ADF	ADL
Natural Grass	P0	64.7667 ^d	39.0333 ^d	8.3667 ^c
	P1	63.5000 ^c	38.3333 ^c	8.2000 ^c
	P2	61.4333 ^b	37.5000 ^b	7.5000 ^b
	P3	60.5333 ^a	36.2333 ^a	7.1000 ^a
Red Elephant	P0	66.5000 ^d	41.1667 ^d	9.1333 ^d
	P1	65.3000 ^c	40.5000 ^c	8.6667 ^c
	P2	64.2333 ^b	39.5000 ^b	8.1667 ^b
	P3	63.2334 ^a	38.4667 ^a	7.5333 ^a
Pakchong	P0	63.3333 ^d	35.1667 ^b	7.6333 ^c
	P1	62.4333 ^c	36.3667 ^c	7.2000 ^b
	P2	61.3667 ^b	35.5333 ^b	7.2333 ^b
	P3	59.4333 ^a	34.2333 ^a	6.2667 ^a

Note: Different superscripts in the same column indicate significant differences ($P < 0.05$). Treatment P0 = No fertilization, P1 = Liquid fertilizer with a dose of 30 ml, P2 = Liquid fertilizer with a dose of 40 ml, P3 = Liquid fertilizer with a dose of 50 ml.

Acid Detergent Fiber (ADF) content

The analysis of variance revealed that the application of weed fermentation fertilizer had asignificant effect ($P < 0.01$) on the ADF content of natural grass. There was a consistent decrease as the dose of weed fermentation fertilizer increased. The results showed that the ADF content was sequentially highest to lowest: P0 (39.03%), P1 (38.33%), P2 (37.50%), and P3 (36.23%). The highest ADF content was obtained from the control treatment, while the lowest ADF content was obtained in the P3 treatment. This decrease in ADF content indicates that the application of weed fermentation fertilizer is effective in reducing the fiber content, which consists of cellulose and lignin, the main components of the plant cell wall that are difficult to digest. These components are used as an indicator to assess the quality of fiber in animal feed.

Red Elephant Grass has the highest ADF content among the three types of grass at 41.17%. In NG and REG, the ADF content also decreased as the dose of weed fermentation fertilizer increased. In the P1, P2, and P3 treatments, a significant decrease was observed compared to the control treatment (P0). This indicates that R E G also responds well to increasing doses of weed fermentation fertilizer, with decrease in ADF content suggesting an improvement in digestibility potential.

Pakchong grass exhibited a decrease in ADF content, albeit with a slightly different pattern, compared to the other two types of grass. In the P0 treatment (without fertilizer), the lowest value was among the three types of grass at 35.17%. In the P1 treatment, the ADF content increased slightly to 36.37%. The decline was first observed in the P2 and P3 treatments. This decrease indicates that in PG, increasing the dose of weed fermentation fertilizer effectively reduces ADF content, as it improves the quality of fiber that is more easily digested. This is the opinion of Kim et al. [28], which states that the enzymatic activity of microorganisms in fermented fertilizers can reduce the fiber content in plants and increase digestibility in feed

crops.

Acid Detergent Lignin (ADL) content

Variance analysis showed that the application of weed fermentation fertilizer had a significant effect ($P < 0.01$) on the ADL content of the three types of grass. ADL content showed a consistent decrease along with the increase in the dose of weed fermentation fertilizer. The results showed that the highest to the lowest ADL content was sequentially P0, P1, P2, and P3. The highest ADL content was obtained from the control treatment, while the lowest was obtained in the P3 treatment. The decrease in ADL content in the three types of grass indicates that the application of weed fermentation fertilizer is effective in reducing the lignin content, which is difficult to digest. The decrease in ADL, along with the increase in weed-fermentation fertilizer dosage in NG, REG, and PG, indicates an improvement in feed quality, as lower lignin is usually associated with increased digestibility. This is the opinion of Kafle et al. [29] and Khaerani et al. [30], who stated that a decrease in ADL content is generally associated with an increase in digestibility. Feed digestibility is improved when lignin levels are lower, making the feed more digestible for livestock and enhancing nutrient absorption efficiency.

CONCLUSIONS

The use of fermented weed fertilizer is effective in increasing the production and quality of green fodder sustainably.

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AUTHORS' CONTRIBUTIONS

All researchers were involved in this research, including manuscript preparation, revision, and publication.

COMPETING INTERESTS

The authors have to declare that they have no competing interests.

ETHICAL CLEARANCE

No direct contact with animals. No ethical clearance required.

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