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The Effect of Liquid Organic Fertilizer from Plant Waste, Livestock Waste, and Fish Waste on Growth of Marigold

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Abstract. This study used a completely randomized design with six treatments consisting of four types of liquid organic fertilizer, NPK Mutiara fertilizer, and control (without fertilizer) which was repeated four times. The results showed that the treatment of liquid organic fertilizer had a significant ($P < 0.05$) to very significant ($P < 0.01$) effect on the growth and yield of marigold flower plants. The highest weight of marigold flowers per plant was found in the treatment of liquid organic fertilizer mixed with plant waste, livestock waste, and fish waste of 79.70 g, followed by treatment of liquid organic fertilizer of fish waste at 59.13 g, liquid organic fertilizer from livestock waste at 51.43 g, NPK Mutiara fertilizer of 34.78 g, plant waste of 28.17 g, and the lowest flower weight per plant was found in the control (without fertilizer) of 25.57 g per plant. The mixed liquid organic fertilizer treatment gave the best effect, which was able to increase the number of marigold flowers up to 246 %, flower diameter 114 %, flower fresh weight 137 %, and flower weight per plant up to 311. 69 % compared to the control.

Keywords: Environmental friendly, *Tagetes erecta* L., soil fertility, waste recycle, waste utilization

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1 Introduction

Marigold (*Tagetes erecta* L.) including the Asteraceae family is native to Central and South America, especially Mexico. The genus name *Tagetes* comes from the word, "Tages", the name of the God Etruschi, who was known for his beauty. The name *Tagetes* first appeared in France, which was later adopted by others [1]. Marigolds were domesticated and used as ornamental plants during the pre-Columbian period before being introduced in Europe and Asia including India, Indonesia, and other Asian countries. The types of marigolds cultivated are African marigolds and French marigolds.

Marigold cultivation in Indonesia can be done at any time, either in the rainy season or dry season. Besides being short-lived and producing flowers quickly, marigolds are in great demand, attractive flower colors that are very attractive to growers. At first, marigolds were cultivated by many Balinese farmers in the highlands such as the Kintamani Bangli, Petang Badung, and Baturiti Tabanan areas of Bali province, but now it has expanded to the lower plains. Marigolds are easy to cultivate and bring high profits, besides that the aromatic oil extracted from marigolds is traded as "Tagetes oil" which is a fly repellent and larvicidal. Marigolds are also grown as trap crops in agriculture against some lepidopterans, coleopterans, and nematodes [2].

The success of marigold cultivation is influenced by various factors including the availability of nutrients in the soil which is one of the main requirements in increasing plant productivity. Marigold is a plant that requires more heavy nutrients, especially nitrogen and phosphorus [3, 4]. The minimal availability of nutrients causes stunted plant growth. Soil naturally contains nutrients, but their availability does not always support optimal plant growth. In conditions of minimal soil, nutrients need to be assisted with the addition of nutrients through fertilization, both organic and inorganic fertilizers. In addition, to maintain soil health physically, chemically, and biologically, the best fertilization effort is to add organic nutrients (and nature material) to the soil [5, 6].

The continuous and unbalanced use of inorganic chemical fertilizers causes damage to soil health, groundwater, atmospheric pollution, phosphorus deposition which results in decreased crop yields [7–9]. The use of inorganic fertilizers in intensively managed agriculture has been associated with reduced yields, soil acidity, and nutrient imbalances [10–12, 9]. Therefore, it is important to use balanced nutrient management in crop production, namely by utilizing various sources of organic fertilizers that are abundantly available around agricultural areas [13, 14, 9–12].

Organic fertilizer is a source of environmentally friendly nutrients that can provide a healthy environment, increase plant productivity, and also flower quality. Currently, the use of organic fertilizers has played an important role in crop cultivation [15, 16, 9–14]. Efforts are needed to find alternative sources of nutrients that are cheap and environmentally friendly so that farmers can reduce the investment made in fertilizers by maintaining good soil environmental conditions towards ecologically sustainable agriculture [17, 18, 9–16]. Many types of waste around farmers can be used for organic fertilizer. In this study, the waste used for organic fertilizer is plant waste (vegetables and fruits), livestock waste (bio urine and cow rumen contents), and waste from the sea (seaweed and fish waste). These wastes are fermented and made into liquid organic fertilizer. Provision of organic nutrients can be done by adding solid organic fertilizer or liquid organic fertilizer. The provision of organic nutrients to marigold plants can be done through watering plants. In connection with the application of liquid fertilizer, this study was carried out to analyze the effect of the type of organic liquid fertilizer on the growth and yield of marigold plants.

2 Research methods

2.1 Location and materials

This research is experimental design and carried out in a greenhouse from September to December 2020, at Kesiman Petilan Village, East Denpasar Subdistrict, coordinates: S 8°38'46.5936", E 115°14'42.468". This study used a randomized block design (RBD) with six treatments consisting of four treatments of liquid organic fertilizer, control without fertilizer, and NPK Mutiara fertilizer. Each treatment was repeated four times so that there were 24 treatment units.

The materials used in this study were marigold seeds, soil, NPK Mutiara fertilizer, liquid organic fertilizer for fish waste, liquid organic fertilizer for plant waste, liquid organic fertilizer for livestock waste, a mixture of the three liquid organic fertilizers, polybags, measuring instruments, and scales. The data of soil analysis as polybag filling material, as follows: pH = 6.2, C organic = 2.32 %, N total = 0.13 %, P available = 13.5 mg kg⁻¹, K = 0.40 cmol kg⁻¹. Nutrients N and P are categorized as low, while organic K and C are categorized as moderate [11, 13].

2.2 Preparation of liquid organic fertilizer

Organic liquid fertilizer is made by fermentation of waste according to the type of liquid fertilizer tested in this study. Plant waste consists of vegetable and fruit waste, fish waste consists of fish boiled water and seaweed waste, livestock waste consists of bio urine and cow rumen. Each type of waste is put into a plastic barrel with a capacity of 200 L with 75 % portion of organic waste and 25 % part of the water that already contains microbial fermentation (EM4) and molasses. Plant waste is chopped to the size of about 1 cm² to facilitate the fermentation process. Fermentation is done semi-aerobic and harvesting of liquid organic fertilizer can be done after fermentation for 30 d.

Marigold seeds are planted after 2 wk of sowing. Seedlings are planted as deep as 3 cm in compost soil media (2:1) which has been previously prepared in polybags with the number of seeds of one plant per hole. The criteria for the seeds to be planted are healthy, grow uniformly, the seeds have four leaves, the height of the seedlings is at least 10 cm.

Liquid organic fertilizer treatment begins when the plant is 7 d old after being planted in polybags and then follow-up fertilization is carried out every 7 d. Fertilization is carried out until the plants are 8 wk old after planting. Each fertilizer treatment was diluted with water, namely NPK Mutiara (15 g L⁻¹ water), fish waste liquid organic fertilizer (100 mL L⁻¹ water), plant waste liquid organic fertilizer (100 mL L⁻¹ water), organic fertilizer liquid livestock waste (100 mL L⁻¹ water), and a mixture of the three Liquid Organic Fertilizers (100 mL L⁻¹ water). Fertilization was done by pouring 200 mL plant⁻¹ with diluted fertilizer for each treatment.

2.3 Observation variables

Observed variables were plant height, number of branches, number of leaves, number of flowers, flower weight, root weight, root length. Plant height measurements were carried out once a week starting after planting by measuring plant height from the soil surface to the highest tip. The number of branches was calculated by counting the number of primary branches that grew on each sample plant. Observation of the time the first flower appears on each shoot in each sample plant by counting the number of days it takes each plant since planting. The calculation of the amount of interest is carried out at each harvest. Observation of the total weight of fresh flowers per plant was carried out by weighing the flowers from

the first harvest to the last harvest. Oven dry weight was obtained after the plant parts were dried in an oven at 60 °C for 36 h.

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2.4 Data analysis

Data were analyzed by ANOVA (analysis of variance) test, if there was a significant difference, then continued with the LSD test (Least Significant Difference) at the 5 % level [19, 20].

3 Results and discussion

3.1 The height and number of marigold branches.

The treatment of organic liquid fertilizer gave a significant ($P < 0.05$) to very significant ($P < 0.01$) effect on plant height and the number of marigold branches (Table 1). The highest marigold plants were found in the treatment of fish waste liquid organic fertilizer, which was 94.25 cm and was not significantly different in the treatment of livestock waste liquid organic fertilizer (89.25 cm) and mixed liquid organic fertilizer (90.75 cm). However, unlike the case with the number of marigold branches, mixed liquid organic fertilizer had the highest number of branches, namely 46.75 branches, which was significantly different from all other treatments. Marigold plant height and the lowest number of branches were found in the control treatment of 72.5 cm and 23.5 branches, respectively, significantly different from all other treatments.

Table 1. Effect of type of organic liquid fertilizer on height, number of branches, fresh weight of stems, and oven-dry weight of marigold stems.

Treatment with liquid organic fertilizer	Plant height (cm)	Number of branches	Fresh weight of stem (g)	The dry weight of the steam oven (g)
Fish waste	94.25a	28.75b	108.51b	29.29a
Livestock waste	89.25ab	25.50c	127.32a	28.64a
Plant waste	79.50c	24.25c	91.80c	24.18b
Mix all waste	90.75ab	46.75a	104.86b	28.71a
Control	72.50d	23.50c	74.98d	20.96c
NPK Mutiara fertilizer	88.25b	28.75b	111.52b	17.57d

Note: the same letter behind the mean value in the same column shows a significant difference in LSD 5 %.

The type of liquid organic fertilizer had a significant ($P < 0.05$) to very significant ($P < 0.01$) effect on fresh weight and oven-dry weight of marigold stems. The highest weightof marigold stems was found in the treatment of livestock waste (127.32 g) and was significantly different from all other treatments. The highest oven-dry weight was found in the treatment of fish waste liquid organic fertilizer (29.29 g), not significantly different fromthe treatment of livestock waste liquid organic fertilizer (28.64 g) and mixed liquid organic fertilizer (28.71 g).

Figure 1 shows the increase in the height of marigold plants from the age of 20 d to the age of 60 d after planting which illustrates the different growth peaks in each treatment. In general, it can be stated that the exponential growth of marigolds reaches its peak at 50 d of age and then slows down after that age. The highest growth peak was in the treatment of liquid organic fertilizer for fish waste, followed by mixed liquid organic fertilizer, NPK Mutiara fertilizer, liquid organic fertilizer for livestock waste, liquid organic fertilizer for plant waste, and the lowest was in control.

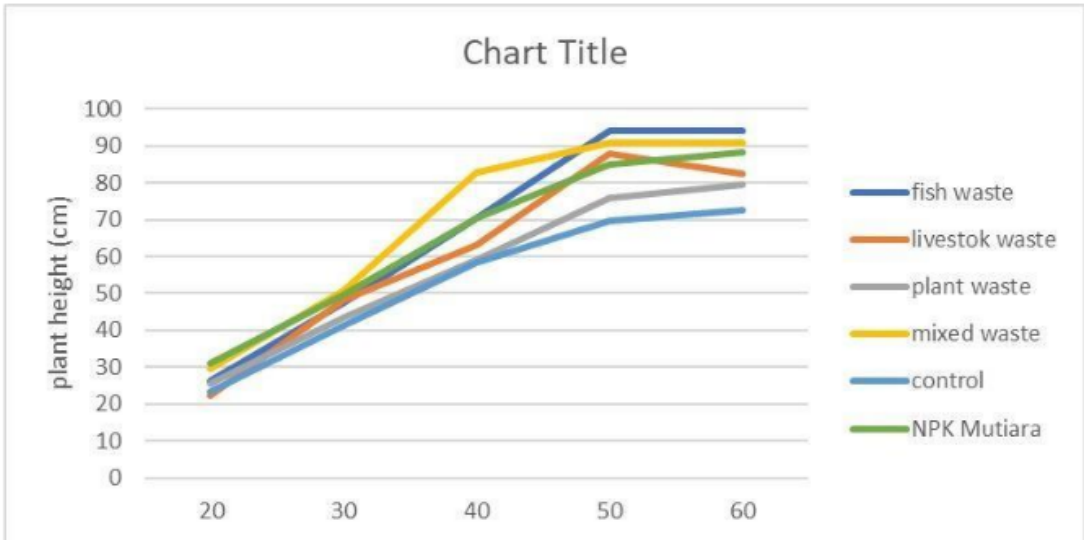


Fig. 1. Graph of marigold plant height growth on different types of liquid organic fertilizer treatment.

3.2 Root length, fresh weight, and oven-dry weight of marigold roots

The treatment of organic liquid fertilizer gave a significant ($P < 0.05$) to very significant ($P < 0.01$) effect on root length, fresh weight, and oven-dry weight of marigold roots (Table 2). The longest marigold roots were found in the treatment of liquid organic fertilizer of livestock waste (20.25 cm) and were not significantly different from the treatment of liquid organic fertilizer of fish waste (20.00 cm) and treatment of mixed liquid organic fertilizer (19.75 cm). The highest fresh weight of roots was found in the treatment of liquid organic fertilizer of livestock waste (1.86 g) not significantly different from the treatment of liquid organic fertilizer of fish waste (1.78 g), and significantly different from all other treatments. The highest root oven-dry weight was found in the treatment of liquid organic fertilizer of livestock waste (0.38 g), not significantly different from the treatment of mixed liquid organic fertilizer (0.19 g), but significantly different from all other treatments.

Table 2. Effect of liquid organic fertilizer on root length, fresh weight, and oven-dry weight of marigold roots.

Treatment with liquid organic fertilizer	Root length (cm)	Root fresh weight (g)	Root oven-dry weight (g)
Fish waste	20.00a	1.78a	0.33b
Livestock waste	20.25a	1.86a	0.38a
Plant waste	15.25b	0.80d	0.24c
Mix all waste	19.75a	1.64b	0.34ab
Control	10.75c	0.63e	0.19d
NPK Mutiara fertilizer	12.50c	1.40c	0.25c

Note: the same letter behind the mean value in the same column shows a significant difference in LSD 5 %

3.3 Number of flowers, flower diameter, flower fresh weight, and flower weight per plant

Liquid organic fertilizer treatment had a significant ($P < 0.05$) to very significant ($P < 0.01$) effect on the number of marigold flowers, flower diameter, flower fresh weight, and flower

weight per plant (presented in Table 3). The highest number of flowers was found in the mixed liquid organic fertilizer treatment (38.75 units) and significantly different from all other treatments, followed by fish waste treatment (28.5 units). The lowest number of flowers was found in the control treatment (15.75 units), not significantly different from the treatment of NPK Mutiara (18.25 units) and plant waste liquid organic fertilizer (16.00 units).

Table 3 shows that the widest marigold flower diameter was found in the mixed liquid organic fertilizer treatment (4.93 cm) and was significantly different from all other treatments, followed by the NPK Mutiara fertilizer treatment (4.70 cm) not significantly different from the fish waste liquid organic fertilizer treatment (4.55 cm), and liquid organic fertilizer from livestock waste (4.58 cm). The highest fresh flower weight was found in the mixed liquid organic fertilizer treatment (2.11 g), not different from the liquid organic fertilizer treatment of fish waste (2.10 g), liquid organic fertilizer from livestock waste (2.05 g), and NPK Mutiara (1.81 g). The lowest flower weight was found in the control treatment (1.54 g) which was not significantly different from the pearl NPK fertilizer (1.81 g) and plant waste liquid organic fertilizer (1.65 g). The effect of liquid organic fertilizer on marigold flower weight per tree showed that the treatment of mixed liquid organic fertilizer (79.70 g), was significantly different from all other treatments, followed by the treatment of fish waste liquid organic fertilizer (59.13 g) which was significantly different from all other treatments. The lowest flower weight per tree was found in the control treatment (25.57 g) and was not significantly different from the liquid organic fertilizer treatment of plant waste (28.17 g).

Table 3. Effect of liquid organic fertilizer on number of flowers, flower diameter, flower fresh weight, and flower weight per tree.

Treatment with liquid organic fertilizer	Number of flowers (units)	Diameter of flowers (cm)	Fresh weight of flowers (g)	Weight of flowers per plant (g)
Fish waste	28.50b	4.55bc	2.10a	59.13b
Livestock waste	25.00b	4.58bc	2.05a	51.43c
Plant waste	16.00c	4.43cd	1.65b	28.17e
Mix all waste	38.75a	4.93a	2.11a	79.70a
Control	15.75c	4.30d	1.54b	25.57e
NPK Mutiara fertilizer	18.25c	4.70b	1.81ab	34.78d

Note: the same letter behind the mean value in the same column shows a significant difference in LSD 5 %.

Marigold cultivation is very dependent on many factors such as climate, soil, irrigation, fertilization, plant density per unit area, growing season, and other factors. Nutrient factors play an important role in the growth, yield, and quality of flowers. Plant nutrients obtained through organic sources have a profound effect on plant growth and productivity either by accelerating the respiratory process by increasing cell permeability and hormonal growth action or by a combination of all of these processes. Through the process of biological decomposition, organic nutrient sources supply nutrients to plants in an available form. Organic nutrients are also rich in micronutrients besides having plant growth-promoting substances, namely hormones, enzymes, and humus to form beneficial microbes [17, 18].

The results showed that a mixture of liquid organic fertilizer from the plant, fish, and livestock waste was able to provide 38.75 units of interest per plant and flower weight per plant of 79.70 g, or an increase of more than 200 % from the treatment of NPK Mutiara chemical fertilizer. The results of this study have proven that efforts to increase marigold productivity do not have to depend on nutrient sources from chemical fertilizers. This refutes the results of previous studies conducted by Nata *et al.* [21] which states that the benefits of chemical fertilizer treatment are irreplaceable compared to organic fertilizers, there is no single nutrient source that can supply plant nutrients insufficient and proportional quantities. However, there is great potential if fertilization is carried out in an integrated manner between

organic fertilizers and inorganic chemical NPK. Therefore, integrated nutrient management is a strategy to advocate the wise and efficient use of chemical fertilizers with the addition of suitable organic fertilizers [22, 11–18].

The addition of organic fertilizers to the soil can improve soil physical properties such as aggregation, aeration, permeability, and water capacity that encourage plant growth and development [23, 9, 14]. The addition of organic fertilizers is proven to help in improving the physicochemical properties (pH, EC, organic carbon, macro, and micronutrients), such as sources of organic nutrients from poultry manure [24, 9]. It has also been experimentally demonstrated that a large amount of N present in poultry manure consists of uric acid, which is available to plants. The C:N ratio of poultry manure was reported to be less than others, which attenuated nitrogen release [25]. Organic fertilizers added to soil improve loose soil texture, increase water holding capacity and increase humus status which maintains optimum conditions for microbial activity [5, 6, 9, 11–18].

Liquid organic fertilizer from fish waste contains elements of nitrogen (N) 0.035 %, phosphorus (P) 4.233 mg L⁻¹ and potassium (K) < 0.001 mg L⁻¹, calcium (Ca) < 0.001 mg L⁻¹, magnesium (Mg) 9.879 mg L⁻¹, with a C/N ratio of 18.571 % [26]. Nitrogen plays an important role in the formation of green leaves which is very useful in the process of photosynthesis, the N element in organic fertilizers plays a role in accelerating the vegetative phase because the main function of the N element itself is the synthesis of chlorophyll [27, 28]. Chlorophyll serves to capture sunlight which is useful for the formation of food through the process of photosynthesis, sufficient chlorophyll content can form or stimulate plant growth, especially stimulating plant vegetative organs [29, 30]. According to Hardjadi [31], photosynthesis is the process of converting inorganic substances into organic substances, namely the change in CO₂ and H₂O by leaf green substances with the help of sunlight converted into carbohydrates, oxygen (O₂), and energy. The results of photosynthesis are then used to meet the food needs for plants, respiration, and the growth process. Some of the carbohydrates produced are stockpiled as biomass fertilization and partly for plant growth and the preparation of plant tissues, including for increasing plant height and the rate of increase in the number of branches [32].

The nutrient content of N in fish waste liquid organic fertilizer is 0.035 % higher than seaweed (0.014 %) vegetable waste (0.021 %), and fruit waste is 0.014 % [26]. Thus, the N content in fish waste organic fertilizer is 2.5 times higher than the N content in organic fertilizer from seaweed and fruit waste, and 1.67 times higher than the N content in vegetable waste organic liquid fertilizer. The high N content in marine waste organic fertilizer affects the vegetative growth of marigolds, which causes the highest marigold growth, stem oven-dry weight, wet weight, and root dry weight the highest compared to other liquid organic fertilizers treatments [33].

Phosphorus contained in organic fertilizers has many important functions for plants, one of which is being a source and transfer of energy in plants. ADP and ATP are high-energy phosphate compounds that control many reactions in plants such as photosynthesis, respiration, protein and amino acid synthesis, and nutrient transport through plant cells [34, 35]. The potassium element in organic fertilizers functions in plant physiological processes, such as enzyme activity, regulation of cell turgor, photosynthesis, transport of photosynthetic products, transport of nutrients and water, the opening of stomata, influencing the absorption of other elements, increasing soil resistance to drought, and functioning in metabolism. starch and protein [36–38]. The element potassium (K) also functions in the permeability of plant cell walls. Lack of K elements will reduce stem strength and plant resistance to pests and diseases [39, 40, 13, 5, 6].

According to Hanafiah [41], calcium (Ca) plays a role in shoot formation, plant cell division, and growth points such as root growth so that plant growth is not hampered, and the formation of leaves and roots will increase leaf weight. According to Budi and Sari [42], Ca

prevents leaf loss. Liquid organic fertilizer in addition to containing elements of N, P, K, and Ca, also contains elements of Mg. Magnesium (Mg) is a secondary macronutrient that is absorbed by plants in the form of Mg^{2+} . Magnesium functions as the main mineral constituent in the chlorophyll molecule help plants to form sugars and starches plays a role in phosphorus translocation and helps plant enzyme functions [43].

The highest weight of marigold flowers was found in the treatment of mixed liquid organic fertilizers from liquid organic fertilizers of plant waste, livestock waste, and fish waste. This is probably due to the most complete and balanced nutrient content found in the mixed liquid organic fertilizer. The availability of complete and balanced nutrients will affect the metabolic processes in plant tissues [44]. The metabolic process is the formation and overhaul of nutrients and organic compounds in plants. The low yield of marigold flowers was found in the treatment of liquid organic fertilizer of plant waste. This is presumably because the nutrient content of plant waste is lower than that of liquid organic fertilizer from other organic wastes. The results of the research by Widnyana *et.al.* [26], show that the phosphorus nutrient (P) content of organic vegetable waste fertilizer is 2.520 mg L^{-1} , much lower than the P content in fish waste liquid organic fertilizer of 4.233 mg L^{-1} , and 4.689 mg L^{-1} in organic fertilizer from seaweed. This is in line with the statement of Sutedjo [45] and Iskandar [46] which states that plants will not provide maximum results if the nutrients are lacking or not available according to plant needs.

In future research, liquid organic fertilizers should be combined with plant growth-promoting rhizobacteria (PGPR), especially on soils with low P and N nutrients (as research material in sub-chapter 2.1.). Several previous studies [47, 13, 17, 37, 38] reported the success of Arbuscular Mycorrhizal Fungi. Likewise, the combined use of solid and liquid fertilizer by-products from the biogas digester, connected to the lavatory, restroom or toilet, and kitchen waste [48–51, 11–14, 17, 18], should be studied. With the implementation of this integrated system, several positive impacts were obtained, *i.e.*, improvement of environmental sanitation, biogas as clean- renewable energy, and solid and liquid fertilizer from digester anaerobic decomposition [52–55].

4 Conclusion

Liquid organic fertilizer from different organic waste sources has a different effect on the growth and yield of marigold flower plants. Mixed organic liquid fertilizer from plant waste, livestock waste, and fish waste gave the best effect on the number of flowers, flower diameter, fresh flower weight, and marigold flower weight per plant. This treatment was able to increase the number of marigold flowers by 246 %, flower diameter by 114 %, fresh flower weight by 137 %, and flower weight per tree by 311.69 % compared to the control.

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