Effectivity of adding some types of organic manure on red ginger (Zingiber officinale Rosc. var. rubrum)

Supriyono1, M W Astuti2*, Pardono1 and B Pujiasmanto1

1 Lecturer of Agrotechnology Study Program, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36 A, Surakarta 57126, Indonesia
2 Undergraduate Student of Agrotechnology Study Program, Faculty of Agriculture, Universitas Sebelas Maret, Jl. Ir. Sutami 36 A, Surakarta 57126 Indonesia

Corresponding author: jiamajias@student.uns.ac.id

Abstract. Red ginger (Zingiber officinale Rosc. var. rubrum) is a medicinal plant that belongs to the flowering family (Zingiberaceae). Indonesian potential production of red ginger was about 22 tons Ha⁻¹ within export volume up to 3,000 tons in 2018. This value is completely different from production yields, which decreased every year. Fertilization is one of the cultivation techniques that can increase production. This study aimed to determine the type of organic fertilizer that effectively increases the growth and yield of red ginger. The research was conducted in Jatiyoso, Karanganyar from March to August 2020 with one-factor RCBD and five treatments, it is T0 (Control), T1 (Marketed Manure), T2 (Cow Manure), T3 (Goat Manure), and T4 (Chicken Manure). Plants applied with goat manure (T3) resulted in the highest growth and yield of red ginger. The growth of red ginger in terms of plant height (72.77 cm), number of tillers (14.93), and weight of fresh straw (30.89 g) tended to be higher in plants applied with goat manure. The yield of fresh rhizome weight and stored rhizome weight applied with goat manure, which is 1033.8 g and 916.8 g, was the highest value above all treatments.

1. Introduction
Ginger (Zingiber officinale Rosc. var. rubrum) is a medicinal plant that belongs to the family of flowering plants (Zingiberaceae) [1]. There are three types of well-known ginger in Indonesia; big white ginger, small white ginger, and red ginger. The potential production of Indonesian red ginger reaches up to 22 tons Ha⁻¹ [2]. Harvested area in 2017 of Indonesian ginger decreased by 350,98 hectares, which resulted in a decrease in the production of 9.174,79 tons [3]. Sub-optimal production input is one of the reasons for reducing red ginger production in 2012 - 2014 [4]. The decrease in production affected unfulfilled market demand.

Fertilization, using intercropping cropping patterns [2], soil management, and using quality seeds are some cultivation techniques that can increase productivity. Fertilization in ginger cultivation commonly uses organic fertilizers. The addition of organic fertilizer to ginger plants on marginal land shows positive growth within rhizome production that reaches 19–28 tons Ha⁻¹ [5]. Organic fertilizers are rich in carbon, which is for organism respiration, and are a habitus for some soil microbes that can help provide nutrients to sufficient plant needs [6]. This study compares several types of organic fertilizers and analyses them to determine which organic fertilizer that effective for red ginger.
cultivation. Applying organic fertilizers with the right type is expected to increase red ginger production.

2. Materials and methods

The research was conducted from March to August 2020 in the research area of Universitas Sebelas Maret, Dusun Pelem, Wonorejo, Jatiyoso, Karanganyar. Growth test was carried out at The Ecology & Plant Production Management Laboratory (EMPT), while soil fertility and nutrient content test of fertilizers at The Soil Chemistry and Physics Laboratory, Faculty of Agriculture, UNS. The environmental design uses one-factor Randomize Complete Block Design with five treatments. The treatments include T0 (control), T1 (marketed manure), T2 (cow manure), T3 (goat manure), and T4 (chicken manure). The variables observed included plant height, number of tillers, number of leaves, the weight of fresh straw, weight of dry straw, weight of fresh rhizome, the weight of stored rhizome, rhizome size, and rhizome volume. The data obtained were then analyzed by variance (ANOVA) and continued with DMRT (Duncan Multiple Range Test) at 5% level if there was a significant positive.

3. Results and discussion

3.1. Soil condition

According to soil analysis, the pH value of the soil at the research area was 6.14 and classified as slightly acidic within 3.10% organic matter, 1.80% C-organic, and 8.57 C/N ratio. The nutrient content of P (0.02%) and K (0.06%) at the research area was very low within medium N (0.21%). The soil type in the research area in Jatiyoso is latosol, formed by intermediate volcanic tuff [7] with good porosity (55.45%). Soil physics analysis shows the particle density (2.11 g/cm$^3$) and bulk density (1.17 g/cm$^3$). According to the classification, the soil is also classified as soil and clay mineral [8] within 7.12% water value.

Table 1. The average of red ginger (Zingiber officinale Rosc. var. rubrum) growth

| Treatment | Plant Height (cm) | Number of Tillers | Number of Leaves | Weight of Fresh Straw (g) | Weight of Dry Straw (g) |
|-----------|-------------------|-------------------|------------------|---------------------------|------------------------|
| T0        | 58.56$^a$         | 7.93$^a$          | 130.27$^a$       | 15.96$^a$                 | 5.12$^a$               |
| T1        | 64.11$^a$         | 11.87$^{ab}$      | 189.00$^{ab}$    | 26.41$^{ab}$              | 7.30$^{bc}$            |
| T2        | 60.66$^a$         | 11.40$^{ab}$      | 181.20$^{ab}$    | 16.14$^{a}$               | 5.58$^{bc}$            |
| T3        | 72.77$^b$         | 14.93$^{b}$       | 202.00$^{b}$     | 30.89$^{b}$               | 6.24$^{bc}$            |
| T4        | 64.69$^a$         | 11.93$^{ab}$      | 249.07$^{b}$     | 29.37$^{b}$               | 8.10$^c$               |

Notes: Numbers followed by the same letter in one column show no significant difference at 5% level DMRT.

3.2. Plant height

Changes in plant height indicate growth activity. The addition of several types of organic fertilizers was significantly positive for red ginger plant height. Table 1 shows that T3 (72.77 cm) was different from all treatments. The combination of livestock manure (FYM/Farmyard Manure) 50% + goat manure 50% optimally increased ginger plant height 108 cm, 1 cm lower than the combination of 50% pig manure + 50% chicken manure [9]. The C/N ratio value of T3 (19.17) was the highest, followed by T4 (17.02), T2 (15.94), T1 (14.20), and T0 (8.57). A high value of C/N ratio indicates a slow decomposition process, while a very low C/N ratio causes an excess of N (Nitrogen), which will eventually be oxidized or denitrified [10]. The slow decomposition process makes goat manure able to provide nutrients for a more extended period.

3.3. Number of tillers

Red ginger tillers consist of shoots that grow from the top of the rhizome. One rhizome of the red ginger can produce several tillers. The Anova shows that adding several types of organic fertilizers on red ginger was significantly positive on the number of tillers. According to Table 1, the number of
tillers in T3 (14.93) was not different from T1 (11.87), T2 (11.40), and T4 (11.93) but different from T0 (7.93). The application of goat manure produced the largest stem circumference in all samples of monoculture maize [11]. T1 and T2 have the highest value of P-available, followed by T3, T2, and T0. In rice, phosphorus (P) plays an important role in forming tillers, accelerating maturity in grain filling and root development [12]. The availability of P will help metabolic processes and transfer energy throughout plant tissues. Phosphorus (P) deficiency can inhibit plant growth, while phosphorus (P) toxicity can disturb the absorption of N content.

3.4. Number of leaves
Leaves are plant organs that contain chlorophyll which plays a vital role in the photosynthesis process. According to the Anova test, adding several types of organic fertilizers to red ginger was significantly negative on the number of leaves. Table 1 shows that all treatments are not different. Application of chicken manure, goat manure, and cow manure had the same effect in increasing the number of leaves. Table 1 shows that T4 (14.35) has a higher value compared to T3 (14.11) followed by T0 (14.01) and T2 (13.83). Phosphorus (P) deficiency can inhibit plant growth, while phosphorus (P) toxicity can disturb the absorption of N content.

3.5. Weight of fresh straw
The straw is a part of the plant that has no economic value. ANOVA test shows that adding several types of organic fertilizers was significantly positive to the weight of a red ginger fresh straw. The highest value was 129.37 g which was found in the application of chicken manure [13]. The highest treatment value showed by Table 1 was T4 (249.07), containing 1.76% nitrogen, closest to the organic fertilizer quality standard. The application of chicken manure fertilizer at a dose of 10 tons/ha produced 14.1 number of leaves. This value was lower compared to 25 tons/ha that produced 16.8 number of leaves [14].

3.6. Weight of dry straw
The increase in plant dry weight indicates the accumulation of inorganic compounds into organic compounds.

### Table 2. The average of red ginger (Zingiber officinale Rosc. var. rubrum) yield

| Treatment | Fresh Rhizome Weight (g) | Stored rhizome weight (g) | Rhizome size | Rhizome Volume (g) |
|-----------|--------------------------|---------------------------|--------------|-------------------|
|           |                          |                           | Length (cm)  | Wide (cm)         | Thickness (cm) |
| T0        | 516.00<sup>a</sup>       | 463.20<sup>a</sup>        | 11.10<sup>a</sup> | 4.85<sup>a</sup>  | 2.00<sup>a</sup> | 50.67<sup>a</sup> |
| T1        | 958.00<sup>b</sup>       | 844.60<sup>b</sup>        | 14.99<sup>b</sup> | 6.22<sup>b</sup>  | 2.63<sup>b</sup> | 66.67<sup>ab</sup> |
| T2        | 715.40<sup>ab</sup>      | 688.20<sup>ab</sup>       | 11.16<sup>ab</sup> | 5.04<sup>ab</sup> | 2.12<sup>a</sup> | 51.33<sup>a</sup>  |
| T3        | 1033.80<sup>b</sup>      | 916.80<sup>b</sup>        | 16.95<sup>b</sup> | 6.67<sup>b</sup>  | 2.27<sup>b</sup> | 86.00<sup>ab</sup> |
| T4        | 1025.40<sup>b</sup>      | 793.80<sup>ab</sup>       | 13.83<sup>b</sup> | 5.56<sup>b</sup>  | 2.38<sup>b</sup> | 90.53<sup>b</sup>  |

Notes: Numbers followed by the same letter in one column show no significant difference at 5% level DMRT.

According to the Anova test, the addition of several types of organic fertilizers to red ginger was significantly positive on the weight of dry straw. Table 1 shows that T4 (8.10 g) was not significantly different from T1 (7.30 g) and T3 (6.24 g) but significantly different from T2 (5.58 g) and T0 (5.12 g). The application of chicken manure had the highest average of the weight of dry straw with 15.34 g [15]. The percentage of the water content of goat manure is 12.55% lower than chicken manure which has 14.35% of water content. The water availability in the soil will facilitate the transportation of
nutrients and photosynthate to all parts of the plant. Water is also one of the main components in the photosynthesis process. The plant dry weight of soybean on day 21 experienced a reduction because the plants lost quite a lot of water during that period [18].

3.7. Weight of fresh rhizomes
The ginger rhizome is a modified form of the stem. The addition of several types of organic fertilizers was significantly positive to the weight of red ginger fresh rhizomes. According to Table 2, the weight of fresh rhizome of T3 (1033.80 g) was not significantly different from T1 (958.00 g), T2 (715.40 g), and T4 (1025.40 g), but significantly different from T0 (516.00 g). The K-available in goat manure of 2.16% has filled up the standard quality of organic fertilizer. Application of KCl fertilizer has a rhizome weight range of 158.49 – 271.51 g/plant due to the function of K as the transport of photosynthetic products, water, and nutrients [19]. Good aggregation of soil structure, good water holding capacity, and good air permeability will help rhizomes development that can increase the weight of fresh rhizomes [9]. Good porosity in the research area shows the ability of the soil to hold water and can be easily penetrated by roots because of the well-balanced ratio of water and air pores. The range of porosity 48.46% - 77.75% is well to porous [20].

3.8. Weight of stored rhizomes
The addition of several types of organic fertilizers was significantly negative to the weight of stored rhizomes. Nutrients in soil or organic fertilizers are factors that can affect the rhizome organic compounds. The accumulation of carbohydrates and assimilates translocation from source to sink, which was influenced by growing media and nutrients, can increase fresh and dry rhizomes weights [21]. Table 2 shows that there is no significant difference between each treatment. Storage time and temperature have more influence on the weight of stored rhizomes. One week in the storage is unable to reduce the water content to reach the optimum value. A total of 85.9 ± 2.3% content of ginger rhizome in the final phase of its life cycle is water [22]. The decrease in water content in the ginger rhizome is related to the evaporation process during storage time [23].

3.9. Rhizomes size
The addition of several types of organic fertilizers positively affected the rhizome length but negatively affected the width and rhizome diameter. Environment, nutrition, genetics, and their interactions are some factors that affect plant growth and yield. Table 2 shows that T3 was significantly different from other treatments in the rhizome length variable, while the rhizome width and diameter variables were not significantly different from all treatments. The addition of goat manure produced longer rhizomes than other treatments within 16.95 cm (Table 2). Genetic factors are more influential than the application of organic fertilizer on the variable width and thickness of red ginger rhizome. Genetic composition and its interaction with the environment play a role in ginger yield distinction [24]. According to Table 2, the average ginger rhizome thickness is 2 cm. Two varieties of red ginger, namely Jahira 1 and Jahira 2, have an average rhizome size of 2.62 ± 0.26 cm [25] with an almost circular or oval fresh rhizome shape [26].

3.10. Rhizomes volume
The amount of space or space capacity that an object can occupy is called volume. The addition of several types of organic fertilizers was significantly negative on the rhizome volume. Table 2 shows that all treatments were not significantly different. The sloping land condition is one of the factors the rhizome development was not optimal. The quality of red ginger from Cipanas with 0 – 10% land slope level is better than red ginger from Cipicung with 10 – 20% level of land slope [23]. Table 2 shows that T4 is the highest rhizome volume value (90.53 ml), followed by T3, T1, T2, and T0. Chicken manure is faster in providing nutrient compositions such as N, P, K, and Ca than goat and cow manure [27].
4. Conclusion

According to the results and discussion, it is concluded that goat manure is the most effective type of organic fertilizer to increase the growth and yield of red ginger (Zingiber officinale Rosc. var. rubrum).

References

[1] Auliani A, Fitmawati and Sofiyanti N 2014 J. Online Mhs. Bid. Mat. dan Ilmu Pengetah. Alam 1 526–33
[2] Rostiana O, Bermawie N and Rahardjo M 2016 Standar Prosedur Operasional Budidaya Jahe vol 12 (Jakarta: Balai Penelitian Tanaman Rempah dan Obat)
[3] BPS (Badan Pusat Statistik) 2019 Statistik Tanaman Biofarmaka Indonesia 2018 (Jakarta: Badan Pusat Statistik)
[4] Prabawa B A T and Dewi R K 2019 J. Manaj. Agribisnis 7 1–12
[5] Syukur C and Baru S 2014 Pros. Semin. Nas. Pertan. Organik (Bogor: Balai Penelitian Tanaman Rempah dan Obat) pp 483–8
[6] Prasad L, Saravannan S, Lall D and Singh V K 2017 Environ. Ecol. 35 929–32
[7] Bappeda Kabupaten Karanganyar 2015 Profil Kabupaten Karanganyar (Karanganyar: Pemerintah Kabupaten Karanganyar) pp 1–16
[8] Kurnia U, Agus F, Adimihardja A and Darjaya A 2006 Buku Petunjuk Teknis Analisa Fisika Tanah (Jakarta: Balai Besar Penelitian dan Pengembangan Sumberdaya Lahan Pertanian)
[9] Lepcha B, Avasthe R, Singh R, Singh N J and Phukan P 2019 Indian J. Agric. Sci. 89 1103–7
[10] Purnomo E A, Sutrisno E and Sumiyati S 2017 J. Tek. Lingkung. 6 1–15
[11] Mbah E U, Keke C and Ogidi E G O 2020 Agric. Trop. Subtrop. 53 215–28
[12] Zubaiddah Y and Munir R 2007 J. Solum 4 1–4
[13] Samanhudi S, Yunus A, Pujiasmanto B and Rahayu M 2014 IOSR J. Agric. Vet. Sci. 7 1–5
[14] Yaduma J et al. 2018 Proc. 36th Annu. Conf. Hortic. Soc. Niger. (Hortson), Lafia (Keffi: Faculty of Agriculture Shabu-Lafia Campus, Nasarawa State University) pp 376–81
[15] Putra D T, Samanhudi S and Purwanto P 2014 Agrosains J. Penelit. Agron. 16 44–8
[16] Sarira A, Tambing Y and Lasmini S A 2020 Agrotekbis E-Jurnal Ilmu Pertan. 8 658–67
[17] Rosyidah A 2017 Respon pertumbuhan dan hasil tiga varietas kentang (Solanum tuberosum L.) akibat aplikasi pupuk kalium di dataran medium J. Folium 1 80–9
[18] Meitasari A D and Wicaksmono K P 2017 PLANTROPICA J. Agric. Sci. 2 55–63
[19] Rahardjo M 2020 J. Penelit. Tanam. Ind. 18 10–6
[20] Surya J A, Nuraini Y and Widiyanto 2017. Tanah dan Sumber. Lahan 4 463–71
[21] Supriya G S, Bhoomika H R, Ganapathi M and Nataraj S, Kand R C S 2020 J. Pharmacogn. Phytochem. 9 2004–7
[22] Rusmin D, Suhartanto M, Ilyas S, Manohara D and Widajati E 2018 Bul. Penelit. Tanam. Rempah dan Obat 29 9–20
[23] Sukarman S, Rusmin D and Melati M 2020 J. Penelit. Tanam. Ind. 14 119–24
[24] Chukwudi U P, Agbo C U, Echezona B C, Eze E I, Kutu F R and Mavengahama S 2020 Res. Crop. 21 634–42
[25] Supriadi, M.Yusron and Wahyuno D 2011 Jahe (Zingiber officinale Rosc.) (Bogor: Balai Penelitian Tanaman Obat dan Aromatik)
[26] Nair K P P 2013 The Agronomy and Economy of Turmeric and Ginger (Kerala: Springer Nature Switzerland AG) pp 225–92
[27] Hartatik W and Widowati L 2006 Pupuk Kandang Pupuk Organik dan Pupuk Hayati (Bogor: Balai Besar Litbang Sumberdaya Lahan Pertanian) pp 59–82