The Effect of Organic and Inorganic Fertilizers on Growth and Yield of Red Ginger (*Zingiber officinale* Rosc.)

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Abstract

Ginger (*Zingiber officinale* Rosc.) has been used for medicinal purposes in Southeast Asia since ancient times. Yield of ginger is affected by soil where the crop grows, climatic conditions and its cultivation management. Similar to other tuber crops, ginger needs high nutrients on soil. The objective of this experiment was to investigate the growth and yield of red ginger plants grown in media suplemented with organic and inorganic fertilizers. The research was conducted in a glasshouse in the Research Center for Biotechnology LIPI. The treatments tested were factorial between the medium and fertilizers used, with the total of treatments was 16 with 5 replicates of each treatment. Treatment M1 was soil : manure : grit (1:1:1); M2 was soil : manure : chaff (1:1:1); M3 was soil : manure : grit (1:2:1); M4 was soil : manure : chaff (1: 2:1); P0 was no addition of fertilizer control treatment); P1 was NPK granule (18:9:10) at 5 g/plant; P2 was NPK (20:20:20) at 1 g/l given once a week; P3 was NPK (32:10:10) at 1 g/lt giving once a week. Growth and yield parameters measured were height, number of leaves, number of shoots, stem diameter (from 0 to 24 weeks), leaves fresh and dry weight, stem fresh and dry weight, root fresh and dry weight, and leaf area recorded at month 4 and 6. After 9 months, red ginger was harvested to determine its yield. The results indicated that treatment with M2P2 was the best treatment for height, number of leaves and stem diameter, of red ginger, meanwhile M4P3 resulted in the highest number of shoots among the others (11.25). The highest production of rhizome of red ginger plant after 9 month growth was achieved by M1P2 treatment (174.058 gr fresh weight/ polybag and 19.75 dry weight/ polybag). Physiological parameters showed that the highest Leaf Area Index (LAI) value was from M2P2 treatment (3.83 after 4 months of growth), and from M4P3 (6.415448, after 6 month of growth); M3P2 treatment produced the highest net assimilation rate (NAR) at 0.01, M3P1 had the crop growth rate (CGR) value at 0.031548. The best value of Harvest index (HI) was reached by M3P0 treatment at 2.038.

*Keywords :*Zingiber officinale *Rosc., red ginger, organic and inorganic fertilizers, growth, yield*

Introduction

Ginger (*Zingiber officinale* Rosc.), a monocotyledon belonging to family Zingiberaceae and in the natural order Scitamineae, is herbaceous perennial, usually grown as annually for its pungent rhizome. It is native of Southeast Asia and one of the earliest oriental spices known to Europe (Parthasarathy *et al*., 2003; Ravindran and Babu, 2005; Kandiannan *et al*., 2009). Ginger normally propagates by its rhizome. Ginger has been used for medicine purposes in Asia since the ancient times. For example, it is used as folk medicine, as a carminative, stimulant of the gastro-intestinal tract, and counter-irritant. The rhizome is believed to have diaphoretic and diuretic effects, and anti-inflammatory. Extracted ginger rhizome contains gingerol inhibits the growth of *Helicobacter pylori* CagA+ strains *in vitro*, and may contribute to chemopreventative effects (Mahady *et al*., 2003). Ginger is also widely used as a spice in forms of fresh ginger, dried whole or powdered ginger, and preserved ginger.

Crop yields is a function of three major factors; namely the soil where the crop is grown, climatic conditions and management practices. Like other root and tuber crops, ginger has a high

nutrient demand on soils. It does well in farmlands newly opened from long fallows, making use of nutrients reserves accumulated during the fallow period (Attoe *et al*., 2009)

Management practices used in agriculture will influence soil properties, nutrient use efficiency and crop production. Conventional crop management systems that rely on inorganic fertilizers and agrochemicals have, in recent years, increased agricultural productivity, albeit at a high environmental cost (Pimentel, 2005). Organic farming systems which depends on organic sources of nutrients (i.e., animal manure, crop residues, green manure crops and catch crops) may sustain productivity at reduced environmental cost by enhancing microbial nutrient turnover (Watson *et al*., 2002).

The objective of our study was to investigate the growth and yield of red ginger plants grown in media suplemented with organic compared with inorganic fertilizers.

Materials and Methods

The research was conducted in a glasshouse in the Research Center for Biotechnology LIPI. The treatments tested were factorial between the medium and fertilizers used, with the total of treatments was 16 with 5 replicates of each treatment. Table 1 showed the combination treatment of inorganic and organic fertilizers used in this experiment.

Table 1. Treatment of Combination between organic and inorganic fertilizer

Code	P0	P1	P2	P3
M1	M1P0	M1P1	M1P2	M1P3
M2	M2P0	M2P1	M2P2	M2P3
M3	M3P0	M3P1	M3P2	M3P3
M4	M4P0	M4P1	M4P2	M4P3

Note: M1: soil : manure : grit (1:1:1) M2: soil : manure : chaff (1:1:1)
M3: soil : manure : grit (1:2:1) M4: soil : manure : chaff (1: 2:1)
P0: no addition of fertilizer (control treatment) P1: NPK granule (Decastar 18:9:10) at 5 g/plant
P2: NPK (Hyponex 20:20:20) at 1 g/l given once a week P3: NPK (Growmore 32:10:10) at 1 g/l giving once a week

Seedlings of 1 month old were used in this experiments. Seedlings were grown in polybags of 25 x 30 cm. Each polybag contained growth medium with different trreatment of fertilizers as shown at Table 1. Growth and yield parameters measured were height, number of leaves, number of shoots, stem diameter recorded from 0 to 24 weeks. However, since the data were plenty, only data at week 24 was presented. After 9 months, red ginger was harvested to determine its yield as fresh and dry weight of the rhizomes.

Results and Discussion

Growth of red ginger after 24 weeks planting on different combinations of fertilizer types and concentratitons was shown at Table 2. The results indicated that treatment with M2P2 was the best treatment for height, number of leaves and stem diameter, of red ginger (Table 2), meanwhile M4P3 resulted the highest number of shoots among other treatments. This indicated that the best medium for growing red ginger until 24 weeks was a combination between M2; soil: manure: chaff (1:1:1) and NPK fertilizer containing NPK (20:20:20) at 1 g/l that was given once a week.

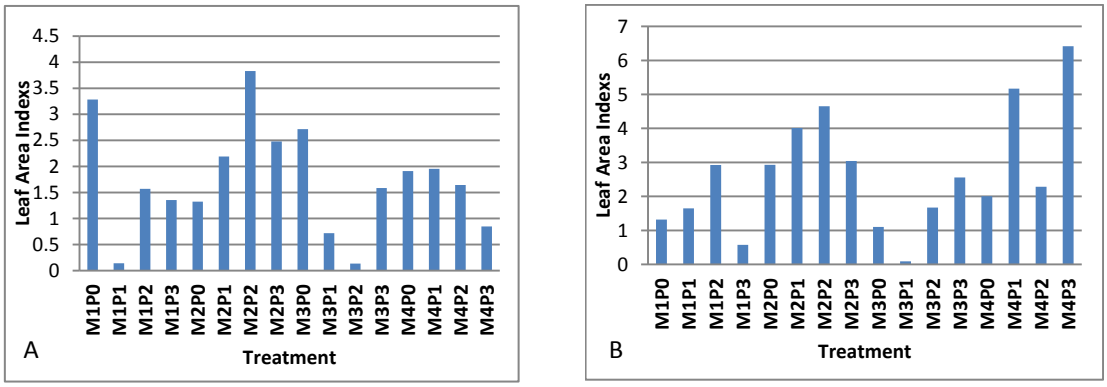
Unlike the case with other treatments, Slow Release fertilizer (P1: NPK granule (18:9:10) at 5 g/plant) actually had no significant effect on shoot growth performance, which were indicated by the low values of plant height, leaves number, shoots number and the plant diameter. Ginger is an herbaceous plant that needs nutrient appropriately. When it was fertilized with the low supply of nutrients from the granular fertilizer, the optimum vegetative growth could not be achieved.

Nutrient management is always an important consideration for ginger since large quantities of nutrients is required for optimal growth, especially for N, P and K nutrients. However, farmers generally overuse N, P and K and ignore manure fertilization. They are not used to apply appropriate fertilization in many crops, therefore they need knowledge about balanced fertilization between inorganic and organic fertilization (Li *et al*., 2010). Organic and conventional farming practices differ in the use of several agriculture management strategies, including the use of cover crops, green manure, and fertilization, which may influence soil properties, greenhouse gas emissions and productivity of agroecosystems.

Table 2. Growth of red ginger after 24 weeks of planting treated with different combinations of fertilizer type and concentration

Treatment code*	Height of plant (cm)	Number of leaves	Number of shoots	Stem diameter (cm)
M1P0	70.33	36.00	5.67	0.50
M1P1	54.07	42.00	4.33	0.37
M1P2	82.38	94.75	9.00	0.58
M1P3	74.83	63.75	6.00	0.48
M2P0	82.33	50.33	5.33	0.50
M2P1	99.13	111.00	10.00	0.55
M2P2	100.63	104.25	9.00	0.63
M2P3	80.025	99.00	9.50	0.55
M3P0	79.23	66.67	7.33	0.57
M3P1	34.00	18.00	4.00	0.30
M3P2	75.63	53.00	6.75	0.48
M3P3	63.38	42.75	7.50	0.48
M4P0	81.83	84.00	8.00	0.57
M4P1	82.13	98.25	9.50	0.63
M4P2	94.50	116.25	9.00	0.63
M4P3	93.25	123.50	11.25	0.53

Note : *description of each code of treatment is shown at Table 1.



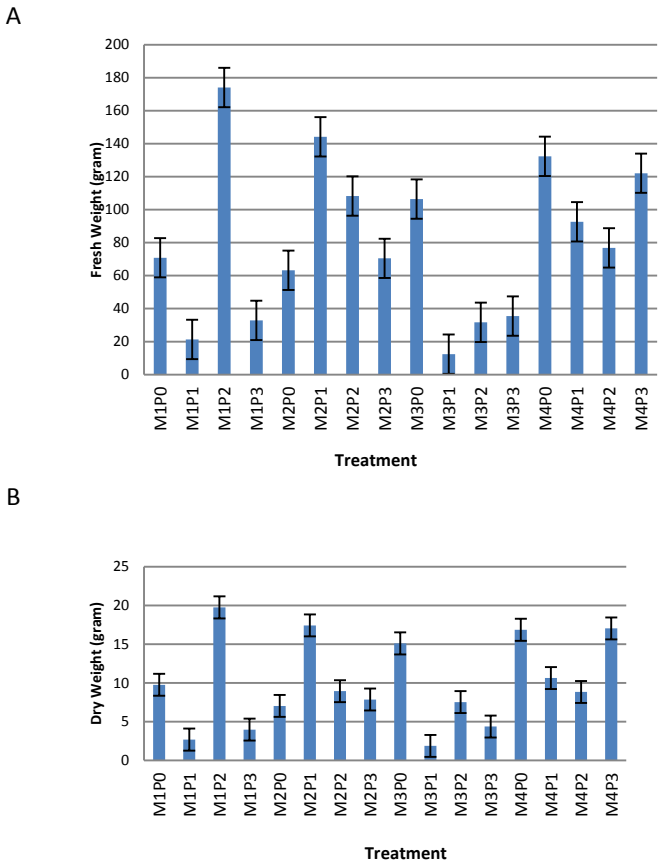
Note : each code of treatment is presented on Table 1.

Figure 1.Leaf Area Index (LAI) of red gingeron 4 (A) and 6 month (B) of age.

Leaves are important organs of the plant. Leaf area (LA) is a variable key for most agronomic and physiological studies involving plant growth, light interception, photosynthetic efficiency, evaporation, and responses to fertilizers and irrigation (Blanco & Folegatti, 2005). Therefore, LA strongly influences growth and productivity. Estimating LA is a fundamental component of crop growth models (Lizaso *et al*., 2003). Figure 1 showed that the M4P2 treatment to

ginger resulted the highest value of leaf area index (LAI) at 4 months after planting. However, at 6 month old plant, the highest LAI was achieved when treated by M4P3 treatment combination.

The perennial rhizome of the ginger plant is a specialized segmented stem structure that grows horizontally just under the soil surface. Upright-growing shoots are produced from the tips of lateral rhizome branches. Adventitious roots and lateral growing points emerge from the nodes of the rhizome stem. In ginger, the roots emerge from the lower rhizome sections. For commercial purposes, ginger is grown as an annual crop, the rhizomes are harvested after seven to nine months when the rhizome is physiologically ripened (Wilson &Ovid, 1993).



Note : each code of treatment is presented on Table 1.

Figure 2. Fresh weight (A) and Dry Weight (B) of red ginger rhizomes after 9 months old grown on various fertilizer application.

Figure 2 showed that the highest fresh and dry weight of rhizomes produced by treatment M1P2. M1 was soil: manure: grit (1:1:1) medium with the addition of NPK fertilizer supplement (Hyponex 20:20:20) at 1g/l given once a week (P2). While the lowest weight of rhizomes was produced on the M3P1 treatment, where M3 was soil: manure: grit (1:2:1) medium and P1 was a slow release NPK granules (with N:P:K ratio of 18:9:10) with the dose of 5 g/plant. This result indicated that the slow release fertilizer (P1) provided less amount of nutrient than what ginger plant required during the maximum vegetative growth and generative phase.

Ginger plants, that was grown in soil containing more manures increased ginger plant growth and rhizome production. The use of humic acid as a fertilizer could directly affect physiological processes in plants. Besides its role as an auxin, humic acids directly influence the

metabolic processes of plants such as respiration, synthesis of nucleic acids, and ion absorption. The highest rhizome production of red ginger plant after 9 month growth was achieved by M1P2 treatment (174.058 gr fresh weight/ polybag and 19.75 dry weight/ polybag). In addition to that, the best value of Harvest index (2.038) was reached by M3P0 treatment.

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