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RESPONSE OF RED GINGER TO APPLICATION OF BIOFERTILIZER AND ROCK PHOSPHATE UNDER DIFFERENT AGROECOLOGICAL CONDITIONS

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ABSTRACT

In relation to the safety and efficacy of herbal medicinal plants, World Health Organization (WHO) has stated that each natural herbal production must be cultivated with good agricultural practices (GAP). Therefore, Indonesia is trying to develop regional and national guidelines for good agricultural practices, including organic farming. The objective of this experiment was to provide technical support for the GAP development to ensure product safety of raw material of medicinal herbal industry, especially on fertilization technique. The research was conducted at Cibinong (Bogor) and Sukamulia (Sukabumi) experimental stations from October 2005 to August 2006. Three promising lines of red ginger were planted, i.e. Balittro1, Balittro2, and Balittro3. The fertilizers applied were 10 ton compost + 90 kg bio fertilizer + 300 kg Zeolite + 300 kg rock phosphate per hectare. Results showed that fresh rhizome yield of red ginger depended on local conditions. Rhizome yields of red ginger cultivated in Sukamulia were 6.33; 5.91; and 7.31 t/ha for Balittro1, Balittro2, and Balittro3, respectively. These yields were higher than those cultivated in Cibinong, which were 3.82; 4.38; and 4.48 t/ha. The symplicia quality based on ginge-rols content and water soluble extract content, of red ginger cultivated in Cibinong produced better quality than that cultivated in Sukamulia.

Key words : Yield, quality, *Zingiber officinale var. rubrum* L., organic fertilizer

ABSTRAK

Respon Jahe Merah terhadap Pemberian Pupuk Bio dan Fosfat Alam pada Kondisi Agroekologi Berbeda

*Sehubungan dengan anjuran WHO untuk meningkatkan keamanan dan efikasi tanaman obat, perlu adanya panduan budidaya tanaman obat yang baik (*Good Agricultural Practices - GAP*). Saat ini Indonesia tengah berupaya mengembangkan panduan budidaya tanaman obat, termasuk juga pertanian organik. Penelitian ini bertujuan untuk memperoleh informasi pendukung penyusunan GAP, khususnya dalam teknik pertanian organik. Penelitian dilaksanakan di Kebun Percobaan Cibinong (Bogor) dan Sukamulia (Sukabumi) pada Oktober 2005 sampai Agustus 2006. Penelitian ini menggunakan tiga klon unggul jahe merah, yaitu Balittro1, Balittro2, and Balittro3. Perlakuan pemupukan mencakup 10 ton kompos + 90 kg pupuk bio + 300 kg Zeolite + 300 kg fosfat alam per hektar. Hasil penelitian menunjukkan bahwa produksi rimpang segar ketiga klon dipengaruhi oleh kondisi lingkungan tumbuh. Hasil rimpang segar di Sukamulia adalah 6,33; 5,91; dan 7,31 t/ha berturut-turut untuk Balittro1, Balittro2, dan Balittro3, sedangkan hasil rimpang segar di Cibinong adalah 3,82; 4,38; dan 4,48 t/ha. Berdasar kandungan gingerol dan ekstrak larut air, mutu simplisia jahe merah yang ditanam di Cibinong lebih baik dibandingkan simplisia yang ditanam di Sukamulia.*

Kata kunci *: Hasil, mutu,* Zingiber officinale var. rubrum *L., pupuk organik*

INTRODUCTION

Ginger (*Zingiber officinale* L) species belongs to Zingiberaceae family. This crop has been developed in some provinces of Indonesia. There are three ginger varieties, i.e. *Z. officinale* var. officinale (big white ginger), *Z. officinale* var. amarum (small white ginger), and *Z. officinale* var. rubrum (small red ginger). Among these three varieties may partly be differed from their essential oil contents. The essential oil content of the small red ginger is the highest one compared to other varieties. While the lowest one is the big white ginger, usually used for fresh (green) ginger products.

Actually, ginger has been used for medicine purposes in Asia since 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 which 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.

Because of its wide range uses, there has been a significant increase in ginger demand within the last decade. Food and Agriculture Organization (2004) reported that during period of 1992-2001 ginger world trade increased from 117,500 to 242,300 tons. To meet the demand of ginger, farmers mostly rely on the application of chemical fertilizers in the cultivation. Some others even apply fertilizers excessively to obtain high yield as well as quality. Many evidences show that excessive use of chemical fertilizers may create environmental as well as economic problems. High dosage of fertilizers may result in increase nutrient losses from soil system, which in turn may cause environmental contamination.

To reduce negative impact of chemical fertilizer uses, World Health Organization (2003) has given more attention on chemical fertilizer uses, particularly for herbal medicinal productions. Non chemical fertilizers like compost, zeolite, rock phosphate, and phosphate-solubilizing bacteria have been used as alternative nutrient sources for plants. The use of rock phosphate, zeolite, and biofertilizers increased in yields of ginger (Januwati dan Yusron, 2003) turmeric (Yusron dan Januwati, 2005), and east indian galangal (Yusron and Januwati, 2003). Application of rock phosphate and P solubilizing bacteria is a promising resources of phosphorous nutrient (Supanjani *et al*., 2006).

The aim of this experiment was to study application of biofertilizers and rock phosphate as alternative nutrient resources in providing technical support of GAP in ginger.

MATERIALS AND METHODS

Three promising lines of *Zingiber officinale var. rubrum* L, i.e. Balittro 1, Balittro 2, and Balittro 3, were grown in Cibinong and Sukamulia experimental stations from October 2005 to August 2006. These experimental stations represent two different agroecological conditions. The first site (in Cibinong) is located in 220 m above sea level (asl.), soil type is classified as Latosol and the soil fertility was low. The second site (in Sukamulia) is located in 450 m asl. Type of soil is Latosol, and the soil fertility was medium. Some characteristics of soils are presented in Table 1.

The crops were planted with standard operational procedures of good agricultural practices for ginger, except for fertilizers application. Fertilizers applied were 10 ton compost + 90 kg bio fertilizer + 300 kg Zeolite + 300 kg rock phosphate per hectare. The treatments were arranged in Randomized Block Design with 3 treatments and 9 replications. The planting space was 60 x 40 cm. Observed parameters were crop yield (fresh and dry weights) and quality of dried rhizome.

RESULTS AND DISCUSSIONS

Crop yield

Yields of three promising lines of ginger were significantly affected by ecological conditions (Table 2). Yield of ginger grown at Cibinong ranged from 3.82 to 4.48 ton fresh ginger/ha, while those at Sukamulia ranged from 5.91 to 7.31 tons fresh ginger/ha. These differences may be due to soil conditions of each experimental site (Table 1). Some characteristics of Sukamulia soil are relatively higher in C-organic content (2.15%) and its sand fraction (50.62%) compared to those of Cibinong soil. These are likely to be main factors and resulting in the difference in yield of rhizomes. Sudiarto and Gusmaini (2004) reported that organic material content of soil play an important role on the rhizome growth. In addition,

Table 1. Some physical and chemical characteristics of soils at two experimental sites

Tabel 1. Karakteristik fisik dan kimia tanah di dua lokasi penelitian

Parameter/*Parameter*	Sukamulia	Cibinong
pH H_2O	4.60	5.21
pH KCl	3.89	4.88
C-organic (%)	2.15	0.89
N total (%)	0.17	0.09
C/N ratio	12.65	9.89
P-available (ppm)	1.39	2.97
Exc. Cations (me/100 g)		
Ca	5.76	9.28
Mg	1.20	0.27
K	0.79	0.30
Na	0.18	0.41
Soil texture (%)		
Sand	50.62	45.40
Silt	22.20	14.41
Clay	27.18	40.19

high sand fraction of soil texture in Sukamulia induces more loose soil aggregation. The rhizome usually grows and expands optimally in loose soil.

The low yield of ginger rhizome at Cibinong site was also caused by pest infestation. During the growing period, about 25% of ginger population was infested by *Phylosticta* sp. As a result, ginger yield at Cibinong decreased about 30% compared with ginger yield at Sukamulia.

Table 2 also shows that actual yields of three promising lines were relatively different. The difference was noted when ginger was cultivated in optimal condition. The yields of three promising lines in Cibinong were not different. On the other hand, yields of three promising lines cultivated in Sukamulia were significantly different, where Balittro 3 showed higher yield (7.31 ton fresh rhizome/ha or 1.07 ton dried rhizome/ha) than the other two lines.

The result also showed that ginger yield treated with biofertilizer and rock phosphate were below of their potential yield. Bermawie *et al*. (2004) reported that potential yields of the three tested clones were about 10 tons/ ha that is mean the ginger yield only reached about 70% of its potential yield if treated with biofertilizers and rock phosphate. This result demonstrates that the use of organic fertilizers and natural minerals may substitute the use of chemical fertilizers. It seemed that application of 10 tons compost + 90 kg bio fertilizer + 300 kg Zeolite + 300 kg rock phosphate per hectare provide ginger nutrient requirement. Application of rock phosphate combined with phosphate-solubilizing bacteria in the form of biofertilizer increased P availability. Some active microorganisms of the biofertilizers are *Azospirillum lipoferum* Beijerincki, *Azotobacter vinelandii* Beijerincki, *Aeromonas punctata* Zimmermann, and *Aspergillus niger* van Tiegham (Yusron dan Januwati, 2005). Supanjani *et al*. (2006) reported that integration of P rocks with inoculation of P-solubilising bacteria increased P availability from 12 to 21% in the soil as compared with control, and subsequently improved nutrient (N, P, and K) uptake by the plant.

Table 2. Yield of three promising lines as response of biofertilizers and rock phosphate application

Tabel 2. Hasil tiga nomor harapan jahe merah dengan pemberian pupuk bio dan fosfat alam

Accession	Cibinong (ton/ha)		Sukamulia (ton/ha)	
	Fresh weight	Dry weight	Fresh weight	Dry weight
Balittro 1	3.82 a	0.40 a	6.33 a	0.80 a
Balittro 2	4.38 a	0.54 b	5.91 a	0.98 a
Balittro 3	4.48 a	0.55 b	7.31 b	1.07 b

Note : Numbers followed by the same letters in the same column are not significantly different at 5% probability test by Duncan

Keterangan : Angka yang diikuti oleh huruf sama pada masing-masing kolom tidak berbeda nyata pada uji DMRT taraf 5%.

The availability of applied nutrients was the dominant factor affecting to rhizome growth. Compost and rock phosphate are categorized as slow release fertilizers, so all the nutrients given can not be taken optimally by the crop. Some of nutrients might be in form of organic compounds, which are not readily available for crop growth. On the other hand, chemical fertilizers are rapid release fertilizers, so nutrients can be used by plant efficiently.

Ginger quality

Table 3 showed that quality of dried rhizomes of three promising lines of Z. *officinale* var. *rubrum*. The essential oil content in ginger cultivated in Cibinong ranged from 4.17 to 4.43%, while in Sukamulia from 2.78 to 3.35%. The similar pattern was also found in gingerols content. Gingerols content of ginger grown in Cibinong was higher (0.188-0.225%) compared to those in Sukamulia (0.016-0.109%). This indicated that syntheses of essential oil and gingerols were strongly affected by crop growth conditions. It seems that under environmental stress conditions plant synthesizes more constituents.

Medicinal plant species mostly react to their environment by secreting secondary metabolites (Pedneault *et al.*, 2005). Environmental stresses arise from conditions that are unfavorable for the optimal growth and development of organisms (Levitt, 1972; Guy, 1999). Environmental stresses can be classified either as abiotic or biotic. Abiotic stresses are produced by inappropriate levels of physical components of the environment, including water stress. Pedneault *et al*. (2005) reported that phenolic compound concentration from *T. officinale* was 6.2 times higher in fiels (31.2 mg/g dry weight) compared to hydroponics (5.0 mg/g dry weight).

Table 3. Quality of dried rhizomes of three promising lines as affected by biofertilizers and rock phosphate

Tabel 3. Mutu simplisia tiga nomor harapan dengan pemberian pupuk bio dan fosfat alam

Accession	Water soluble extract content	Alcohol soluble extract content	Essential oil content	Ash content	Starch content	Fiber content	Gingerols content
				(%)			
Cibinong							
Balittro 1	24.39	14.50	4.43	5.66	34.93	10.10	0.210
Balittro 2	24.82	16.43	4.33	6.12	27.34	10.11	0.188
Balittro 3	24.06	15.01	4.17	5.65	32.28	9.86	0.225
Sukamulia							
Balittro 1	21.87	11.77	2.78	6.06	45.70	6.03	0.016
Balittro 2	21.32	9.68	3.35	5.99	46.46	5.89	0.109
Balittro 3	22.11	11.23	3.35	6.4	46.10	5.80	0.101

Table 4. Constituents content of rhizome extract of three promising lines

Tabel 4. Kandungan kimia ekstrak rimpang tiga nomor harapan

Accession	Gingerols content (%)	Compounds							
		Alkaloids	Saphonine	Tannins	Phenolic	Flavonoide	Triterpenoide	Steroids	Glycosides
Cibinong									
Balittro 1	0.472	++++	++	+	++++	++++	++++	+	++++
Balittro 2	0.564	++++	++	+	++++	++++	++++	+	++++
Balittro 3	0.602	++++	++	+	++++	++++	++++	+	++++
Sukamulia									
Balittro 1	0.337	++++	++	+	++++	++++	++++	+	++++
Balittro 2	0.251	++++	++	+	++++	++++	++++	+	++++
Balittro 3	0.205	++++	++	+	++++	++++	++++	+	++++

Note : + = low ++ = medium ++++ = very high

Keterangan : + =*rendah* ++=*sedang* ++++=*sangat tinggi*

Biotic stresses are caused by pathogen, parasite, predator, and other competing organisms. Many metabolite act in defense mechanisms against pests such as insect, pathogenic fungi, and bacteria. These metabolites are generally derived from secondary metabolism, such as the phenylpropanoid, isoprenoid, alkaloid, or fatty acid/polyketide pathways (Dixon, 2001). Due to pest infestation, essential oil content in ginger increased of about 37% compared to uninfected crop in Sukamulia, while gingerols content increased almost threefold.

Table 4 presents gingerols content and constituents in ginger extract. It is shown that ginger extract contain several constituent such as alkaloid, phenolic, flavonoide, steroid and glycoside. Gingerol content in ginger extract in Cibinong ranged from 0.472 to 0.602%, where the highest value was reached from clone Balittro 3 (0.602%). Gingerol content in ginger extract in Sukamulia was found lower than that of Cibinong, and the highest gingerol content (0.337%) was found in Balittro 1. These results also showed that phytochemical compound of the three promising lines was similar. From a qualitative analyses, it was found that major active constituents of ginger extract were alkaloid, phenolic, flavonoide, steroid, and glycoside.

CONCLUSIONS

Based on this experimental results, the conclusions are as follows :

1. Yield of *Z. officinale var. rubrum* L using biofertilizer and rock phosphate was 70% of its potential yield. Ginger yield was significantly affected by environmental conditions.
2. Quality of *Zingiber officinale var. rubrum* L. depended upon environmental conditions. Under environmental stress ginger tends to produce more essential oil and gingerols.
3. The essential oil content of the ginger grown in Cibinong ranged from 4.17 to 4.43%, while in Sukamulia it ranged from 2.78 to 3.35%.

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