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STUDY OF FERTILIZER (ORGANIC + INORGANIC) FORMULATION TO IMPROVE *GUBAL* AGARWOOD FORMATION IN *KETIMUNAN* TREE (*Gyrinops versteegii*)

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ABSTRACT

A study of fertilizer formulation (organic + inorganic) to increase the formation of sapwood (*gubal*) on agarwood plants (*Gyrinops versteegii*), had done to find the best fertilizer formulation that capable of increase and accelerate either growth and agarwood formation of sapwood on agarwood trees. The first year of study was conducted in Marga Tabanan Village. The field research was Randomized Block Designed (3 groups) with single factor of treatment. The tested treatment were 6 formulation of compound fertilizers and a control (unfertilized treatment). The compound fertlizers consisted of urea, SP-36, KCl, local compost, and dolomite in varying doses. The fertilizer formulations were applied on 21 agarwood trees that previously inoculated with mixed inoculant of *Fusarium solani* and *Rhisopus* sp. Three months after inoculation, the data from the following parameters were measured and statistically analyzed: plant height, stem circumference, sapwood weight, resin content and soil chemical properties.The results showed that the tested fertilizer compound had significant effect on plant height, sapwood weight, and resin rendement. No significant effect of fertilizer compound measured on the stem circumference. The highest sapwood weights was obtained on C treatment (14.39 g). The highest resin yield was obtained on B treatment (3.91%) which was relatively the same as that on C treatment (3.85%). Thus, the best fertilizer formulation for either plant growth, agarwood formation or agarwood resin was C treatment (100 g urea + 100 g SP-36 + 100 g KCl) + (7.5 kg compost) + (75 g Dolomite) per tree.

Keywords: fertilizer formulations (organic + inorganic), agarwood sapwood

INTRODUCTION

Agarwood plant (*Gyrinops versteegii*) is a high-value commodity of non-timber forest products (HHBK), classified as an export commodity and a potential source of income for the community (Pasaribu et al., 2013). Therefore, Indonesian government has considered to include agarwood plants into national commodities of non-timber forest sustainable products (Santosa, 2009). The export volume of agarwood from Indonesia since 2000-2002 only reached 30 tons priced at USD 600.000. Agarwood are used for many purposed including perfume, cosmetics, medicines and for religious ritual purposes so that their worldwide needs continuous increasing (Tarigan, 2004). However, the production of Indonesia's agarwood is relatively low and decreasing with an average production of about 45 tons per year. The decline of agarwood production probably due to the relative high intensity harvesting of natural agarwood, without sufficient conservation efforts. Thus, conservation and sustainability of agarwood production needs to be maintained in order to produce good quality of sapwood without relying solely on natural agarwood production.

The cultivation of agarwood in Indonesia has carried out in various regions such as West Nusa Tenggara, Java, Kalimantan, Papua, and Bali. Cultivation ofagarwood in Bali Province has been carried out since 2003 in the following districts: Tabanan, Bangli, and Buleleng (Susila and Mega, 2012). Unfortunately, agarwood cultivation mostly done on less fertile soils under impropper agriculture practices that lead to very low and slow growth and formation of sapwood.

Application of balanced fertilizer formation between organic, natural, and artificial fertilizers (inorganic) is important to increase the growth and formation of sapwoods on agarwood trees. Organic fertilizers have complete nutrients content in low quantities, but able to improve the physical and biological soil properties. Inorganic fertilizers capable of provide more nutrients and more readily available to plants, whereas natural fertilizers (dolomites) considered to be a very important sources of Ca and Mg for plants (Rosmarkam and Yuwono, 2002). The acceleration and increase of sapwoods formation on agarwood trees can be done through inoculation with mixed inoculant of *Fusarium* sp. and *Rhisopus* sp. (Mega et al., 2012). To obtain an appropriate and balanced organic or inorganic fertilizer formulation, then it is important to study the Formulation of fertilizer (organic + inorganic) to increase the formation of sapwood agarwood on *Ketimunan* tree (*Gyrinops versteegii*).

The results of this study would be suggested to the government (Forest Service) as the best fertilizer technology to improve the agarwood plant yield. The intensive use of fertilizer compound is expected to accelerate and enhance the formation of sapwoods, resin content and farmer’s income.

MATERIALS AND METHODS

A field research had been conducted in farmer's agarwood field in Marga Dauhpuri Village, Marga Sub-district, Tabanan from June to October 2016. The materials being used were including: mature compost (compost *Simantri*), 21 of 5 months old agarwood trees, *Fusarium sp*, *Rhisopus* sp,plastisin, cotton, paper label, urea fertilizer, SP-36 and KCl, as well as natural

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fertilizer Dolomite. The equipment's were used including pH stick, wood drill, hoe, sickle, stationery, plastic strap, and knife.

The study was designed using Randomized Block Design (RCB) 3 groups. The single factor treatment tested consisted of 7 fertilizer formulas applied on 21 agarwood plants. The tested fertilizer compounds per tree were:

A = without fertilizer (control)

B = (25% inorganic fertilizer) + (100% compost + (50% Dolomite). (50 g urea + 50 kg SP-36 + 50 kg KCl + 10 kg compost) + 50 g Dolomite).

C = 50% inorganic fertilizer + 75% compost) + 75% Dolomite.(100 g urea + 100 g SP-36 + 100 g KCl) + (7.5 kg of compost) + (75 g Dolomite).

D = (75% inorganic fertilizer + 50% compost + 75% Dolomite). (150 g urea +150 g SP-36 + 150 g KCl) + 5 kg of compost) + 75 g Dolomite).

E = 100% inorganic fertilizer + 25% compost + 100% Dolomite) (200 g urea + 200 g SP-36 + 200 g KCl) + 2.5 kg of compost + 100 g Dolomite.

F = (200 g urea + 150 g SP-36 + 150 g KCl) + 7.5 kg compost) + 100 g Dolomite.

G = (200 g urea + 100 g SP-36 + 100 g KCl) + 7.5 kg compost) + 75 g Dolomite

The following parameters were measured three months after fertilizer application. The growth of agarwood and formation of sapwood measured based on plant height (cm), stem circumference (mm), agarwoodsapwoods weight (g), and the level resin rendemen (%). The percentage of resin content was measured by extracting sapwood using each 150 ml of N Hexane, Acetone and Methanol for 3 hours. The yield of the resin was calculated by dividing the weight of the extracted resin with the weight of extracted sapwood and multiply by 100 (Pasaribu et al., 2013). Measurements of soil chemical properties were performed for the following parameters:Soil pH using pH meter, DHL using Conductometer, CEC (NH4OAc extract pH 7), C-organic (Walkley and Black), total N content (macro kjeldhal), available-P (Spectrophotometer), and available-K (Flamephotometer) were analyzed in the Soil and Environment Laboratory of Agriculture Faculty, Udayana University. The data were statistically analyzed by ANOVA followed by Duncan's multiple Range test at 5% level.

RESULTS AND DISCUSSION

The results showed that three months after application, fertilizer compounds significantly affected plant growth (plant height), sapwoods agarwood, and the rendementof agarwood resin (Table 1). The highest increase of plant height was obtained at G treatment (200 g urea + 100 g SP-36 + 100 g KCl) + 7.5 kg compost) + 75 g Dolomite per tree (24.33 cm). The value was significantly different compare to that on control (without fertilizer) which was reach 6,50 cm. The value was significantly different to that on E treatment (200 g urea + 200 g SP-36 + 200 g KCl) + 2.5 kg of compost + 100 g Dolomite per tree) ie (10.33 cm), and F ((200 g urea + 150 g SP-36 + 150 g KCl) + 7.5 kg compost) + 100 g Dolomite per tree) ie 6.33 cm (Table 2). The highest sapwood weight was obtained on the C treatment (14.39 g) which was relatively the same as that on D treatment (11.85 g). The highest resin yield was obtained on B treatment (3.91%) but not significantly different compare to C treatment (3.85%). The increase of resin rendement in B and C treatments compared to control (A) were 12.36% and 10.63% (Table 2), respectively.

Table 1. The signification effect of treatments on measured parameters in this study

No.	Parameters	Significations
1.	Plants height (cm)	*
2.	Stem circumference (mm)	ns
3.	The weight of agarwood sapwood (g)	*
4.	Rendemen of agarwood resin (%)	*

Note : * = significant ns = non significant

Compound fertilizers improved soil chemical properties indicated by the increase of pH value and the content of N-total, available-P and available-K on three months of application. The highest content of N, P, and K were found on B treatment, in amount of 0.29%, 512.45 ppm, and 557.26 ppm,respectively. The levels of N, P, K in the B treatment were slightly higher than thaton C treatment with the consecutive levels of 0.28%, 327.37 ppm, and 438.12 ppm. The formulated fertilizer slightly increased soil pH (6.1) ton early neutral in all tested fertilizers. The same patterns were also measured on the levels of organic-C, total-N, available-P and available-K (Table 3).

The application of fertilizer compounds had significant effect on plants height, sapwood weight, and rendement of resin, but not to the growth of stem circumference. The highest increment of stem circumference and highest weight of sapwood were achieved on C treatment (25,67 mm and 14,39 g, respectively). The best effect of C treatment on stem circumference and weight of

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sapwood were possibly due to its effect on improvement of soil chemical properties.

Table 2. The average effect of treatments on the increase of plants height, stem circumference, weight of sapwood, the rendemen of agarwood resin

No.	Treatments	the increase of plants height (m)	the increase of stem circumference (mm)	weight of sapwood (g)	Rendemen of agarwoodresin (%)
1.	A	6,50 a	5,93 a	6,68 a	3,48 ab
2.	B	14,83 ab	6,73 a	6,87 a	3,91 b
3.	C	13,00 ab	25,67 a	14,39 b	3,85 b
4.	D	13,50 ab	12,83 a	11,85 ab	3,05 ab
5.	E	10,33 a	11,0 a	7,82 a	2,83 ab
6.	F	6,33 a	23,33 a	10,74 a	2,19 ab
7.	G	24,33 b	16,00 a	7,69 a	1,35 a

Note : The value on the same column followed by the same letter indicated statistically insignificant according to Duncan's Multiple Test on 5%

Table 3. The effect of treatments on selected soil chemical properties measured on this study on three months following treatments on agarwood cultivation

No.	Treatments	pH	Org-C (%)	Total-N (%)	Available-P (ppm)	Available-K (ppm)
1.	A	6,3	3,06	0,19	73,12	154,34
2.	B	6,5	4,32	0,29	512,45	557,26
3.	C	6,7	3,46	0,28	327,37	438,12
4.	D	6,8	4,51	0,22	235,86	312,57
5.	E	6,7	4,56	0,21	247,49	328,88
6.	F	6,7	4,67	0,23	337,28	379,56
7.	G	6,5	4,75	0,24	408,19	512,53
8.	Initial Soil	6,1	3,04	0,19	69,45	138,77

Soil receiving C treatment had nearly neutral pH (6.7), high organic-C content (3.46%), moderate total soil N (0.28%), and both very high available P and K (327.37 ppm and 438.12 ppm, respectively). This finding wasin accordance with Erfandi and Kasno (2000) which was stating that soil chemical properties greatly increase the growth of plants, stem circumference, and plant height. Increased growth of agarwood plant and stem circumference will provide good conditions for the development of

Fusarium solani and *Rhisopus* sp. in infecting the agarwood trees, so that sapwoods development were increased and reached the highest weight on C treatment (14.39 g). Susila and Mega (2012) published that NPK fertilizer as much as 0.30 kg per tree and composted bokhasi as much as 5.0 kg to 7.5 kg per tree significantly increased plant height and agarwood stems circumference. Setyorini et al. (2003) mentions that the concept of balanced fertilization aimed to determine the optimal dosage of fertilizer based on the level of soil fertility and nutrients required by plants. C treatment provides the best nutrient balance derived from organic and inorganic fertilizers, thereby promoting the highest plant height and stem circumference of agarwood trees.

The formation of sapwood is determined by agarwood infection by *Fusarium solani* and *Rhisopus* sp. which was inoculated at some points on the stems of agarwood plant. Mixture of *Fusarium solani* and *Rhisopus* sp. developed the best sapwood on agarwood trees (Mega et al.,2012). In this research, the highest of sapwood formation was found on C treatment (14,39 g). C treatment promoted stem circumference and facilitated the development of extensive and intensive infection of agarwood stems by *Fusarium solani* and *Rhisopus* sp. and followed by forming the highest weight of sapwood. Sapwood Agarwood contains furan compounds and ester groups that can be measured from the formation of agarwood resin extract (Pasaribu et al., 2013). The highest resin content of agarwood in this study was obtained in B treatment (3.91%) but it was relatively the same as the resin content of onC treatment (3.85%). The formation of sapwood and agarwood resin was strongly supported by the higher content of available nutrients in soil caused by C treatment. The C treated soil had moderate content oftotal-N and very high availability of P and K which were higher than other treatments. This finding supported the opinion of Affandi *et al*. (2003). Development of good and high quality of sapwood can be indicated by the color change of sapwood from light brown to dark brown and blackish. In addition, good quality of agarwood sapwood can be known from the fragrant aroma because of the high resin rendement containing furan compounds, and other ester groups (Pasaribu, *et al*., 2012).

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