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YIELD AND CURCUMIN CONTENT STABILITY OF FIVE UB CLONES OF TEMULAWAK (*Curcuma xanthorriza* Rox.)

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ABSTRACT

Interactions between genotype and environment is affect yield and curcumine content of temulawak (*Curcuma xanthorrhiza* Rox). The aims of the study was to determine stability of yield and curcumine content in diffrent enviromental condition. Field experiment was conducted during 12 month of year 2010, and Randomized block design with three replications was applied at four locations: Sragen, Malang, Pasuruan and Sumenep. The materials tested consists of five clones : UB1, UB2, UB3, UB4, UB5 included control (Balitro clone). The results showed that the stability of the rhizome yield in each locations, achieved by UB3 and UB4 clones. The highest rhizome weight was obtained by UB2 at 34,63 t/ha, while the constant high curcumin content was obtained by UB4. Clones UB1 and UB5 suitable to be developed on marginal lands and clone UB2 adaptive on high fertility environment.

Keywords : temulawak, adaptation, clones

INTRODUCTION

Curcuma xanthorrhiza Rox is a native medicinal crop of Indonesia and as a member of the Zingiberaceae (ginger family). This crop is particularly grow in Java Island, and then spread to several places in biogeography region of Indonesia. This beautiful plant is sometimes referred to as Javanese Turmeric or Temulawak. The rhizome of this plant contain beneficial constituents that have been used traditionally in the treatment of acne and skin inflammations. It is also used as traditional medicines, food, beverages and cosmetics. More recently studies have demonstrated that it also has antioxidative, detoxifying and anticarcinogenic characteristics. Park *et al.* (2008) obtained that the methanol extract of *Curcuma xanthorrhiza* possesses cancer chemopreventive potensial.

The main chemical compounds in temulawak is curcuminoid and xantrhoryzol (Taryono *et al.,* 1987). Curcumin is a secondary compounds belong to phenol group of the acetate –mevalonat pathway (Vickery and Vickery, 1981). Curcumin is a diferuloylmethane in plant extracts and it produce of yellow color in turmeric and ginger (Aggarwal *et al.,* 2005). Curcumin production is influenced by genetic and environmental factors (Chempakam and Parthasarathy, 1999; Kristina *et al.,* 2007). Environmental factors consist of sunlight, air temperature, atmospheric environment (CO_2, O_2 and humidity) and the root environment (chemical and physical properties of soil) and water availability in the soil (Nitisapto and Siradz, 2005). Instead of curcumin content, the rhizome weight is alo important factor for the farmers. Different soil type from different locations was also influenced growth, yield and curcumin content. Hossain and Ishimine (2005) found that dark-red soil type produced better plant growth, rhizome weight and curcumin content campared to gray and red soil types.

Collection of local clones of temulawak was conducted in University of Brawijaya, by Wardiyati *et al.* (2010) from 20 centers of temulawak production in Java. The collection were originated from East Java (Malang, Batu, Banyuwangi, Jember, Pasuruan, Pacitan, Trenggalek, Mojokerto, Sumenep and Pamekasan), Central Java (Sragen, Klaten and Boyolali), Yogyakarta (Bantul) and West Java (Subang and Cirebon), respectively. Local clone of Sumenep and Batu that had a high curcumin content, 1.26% and 0.96%. Local clone of Pasuruan and Jember that had the highest rhizome weight, 1709 g/plant and 1387 g/plant,

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respectively. Sumenep and Pasuruan were dry climate areas, while Batu and Jember were wet climate areas. From the results of the study showed that there were no influenced of temperature and altitude to the content of curcumin and rhizomes weight. Soil nutrition had more influenced to yield and curcumin content. This information was promising to the development of potential clones of temulawak.

The clones that having high curcumin content or high yield of rhizomes, could be developed as new superior clones in Indonesia. Prior to release to the public, these clones must be evaluated their adaptation to know the potency of adaptation and the yield potential. The process of adaptation test refers to the Guidelines for Release of Horticultural varieties (which have been repaired) from the Directorate of Seed and Horticulture Production and also Regulation by the Minister of Agriculture 37/ Permentan/OT.140/8/2006, about Testing, Evaluation and Release of Plant Varieties.

MATERIALS AND METHODS

Plant material for evaluation were consists of clones UB1, UB2, UB3, UB4, UB5, respectively. The control clone was a superior one of the Research Institute for Medicinal and Aromatic Plants, namely Balitro Clone. Adaptation test site was suitable agro-ecological regions for the cultivation of temulawak and represent the characteristics of agro-ecological regions of temulawak production centers, namely Kromengan Malang (altitude 324 m asl, average temperature of 26ºC) , Prigen Pasuruan (altitude 321 m asl, average temperature of 28ºC), Sumenep (altitude 50 m asl, average temperature 35ºC) and Sragen (altitude 112 m asl, average temperature of 34ºC).

Clones that recommended for planting in rainy season, test of adaptation must be conducted in rainy season. Clones recommended for planting in dry season, the adaptation test should be conducted during dry season. Temulawak was planted in rainy to dry season, with 9-12 months of growth periode. Actually, the evaluation should be conducted 2 season and 2 units each other, so the total test were 4 units. But, temulawak had 12 months of age, the adaptation tests conducted at 4 units of location, throughout the rainy to dry season. Field experiment was conducted during 12 month of year 2010 at four locations: Sragen, Malang, Pasuruan and Sumenep. The materials tested consists of five clones: UB1, UB2, UB3, UB4, UB5, and Balitro clone as a control. Randomized complete block design with 3 replications was used in each location. Replications nested within location, named Nested Design. The treatment was the expected clones.

Observation variables were the number of leaves, number of tillers, weight of rhizomes per clump and per plot, number of rhizome and curcumin content. The analyses of curcumin content was conducted in Laboratory of Biology at Polytechnic Malang by using HPLC. Analysis of variance was a randomized block design for each locations and combine analysis of nested design among locations, which replication nested within location. Stability analysis based on regression of Eberhart and Russell (Singh and Chaudary, 1979), $\mathbf{bi = \sum Yij\ lj\ /\ \sum l^2,}$ (*where* $Y\mathbf{ij}\ x\ l\mathbf{j}$ *: product matrix with the vector average of the environmental index and* $\sum l^2$*: sum of squares*). If the regression coefficient b close to or equal to 1 indicating the average stability and thus clones had good general adaptability. If the regression coefficient b more than 1 showed below average stability and thus clones are very sensitive to environmental changes and adapted to productive environments. If the regression coefficient b smaller than 1, indicating above average stability and thus clones specifically adapted to marginal environments.

RESULTS AND DISCUSSION

Genotype - Environment Interaction

Data analyzed using the combined analysis of variance based on the nested design. This analysis aims to determine the interaction between the genotype with the environment. There are genotypes-environment interaction on leaves number and tillers number. Interaction of genotypeenvironment required for adaptation and stability analysis of tested clones. However, the growth variables, was not analyzed for adaptation and stability. Adaptation test was only required to know the stability of results among the tested clones. Interactions of genotypes-environment on growth variables had no impact on the stability of the rhizome.

Number of main rhizomes were different in each location (Table 1). The number of

produced main rhizome was determined by environmental factors. There were differences of rhizome number among clones in Sumenep. However, based on the combined analysis of variance, planting location was more influential.

Rhizome weight per plant was also different in each planting site. Each location had different environmental conditions, and these differences lead to different weights rhizome. This shows the interaction between the clones with planting environment. Table 2 and Figure 1 showed that the highest weight of rhizomes produced by clones UB3 grown in Sumenep. Rhizome weight was not significantly different from the clone Balitro. Clone UB5 most suitable to be developed in the Sragen region, was cloned UB1 suitable to be developed in Pasuruan. Planting sites in Sumenep was productive land, because all clones had a lot of the main rhizome. The next evaluation in different seasons will be able to choose the potential of the tested clones. Theoretically, if the main rhizome weights which obtained from different seasons produce a different pattern, then the potential of clones in the test will be known.

Table 3 and Figure 1 showed that UB4 is the superior clone compared to others in almost all locations. As mentioned in previous research (Wardiyati et al., 2010) that curcumin content did not influenced by environment but genetically expression. It means that UB4 has a superior curcumin synthase gene that adaptable to different locations.

Table 1. The average number of main rhizome

Clones	Sumenep	Sragen	Pasuruan	Malang	Mean
UB1	2.03 a	1.36	1.02	1.46	1.47
UB2	2.43 ab	1.00	1.06	1.42	1.48
UB3	3.23 b	1.06	1.47	1.68	1.86
UB4	2.03 a	1.22	1.19	1.48	1.48
UB5	2.23 a	1.40	1.09	1.98	1.68
Balitro	2.60 ab	1.98	1.27	1.50	1.84
Mean	2.43	1.3	1.2	1.6	

Table 2. The weight of main rhizome (g/plant)

Clones	Sumenep	Sragen	Pasuruan	Malang	Mean
UB1	201.40 b	19.44 a	105.60 b	90.00	104.11
UB2	216.77 b	18.06 a	26.97 ab	47.93	77.43
UB3	311.50 c	7.72 a	35.27 ab	50.67	101.29
UB4	179.27 b	19.93 a	64.07 ab	48.67	77.98
UB5	51.90 a	161.36 b	8.07 a	105.33	81.66
Balitro	230.03 bc	46.78 a	40.53 ab	120.43	109.45
Mean	198.48	45.50	46.80	77.20	

Table 3. Curcumin content (% of rhizome dry weight)

Clones	Sumenep	Sragen	Pasuruan	Malang	Mean
UB1	6.21 ab	5.28 a	5.93 ab	6.71	6.03
UB2	5.73 ab	4.36 a	7.39 b	7.31	6.20
UB3	7.55 ab	7.87 b	6.05 ab	6.19	6.92
UB4	8.08 b	9.67 b	7.29 b	7.39	8.11
UB5	4.83 a	7.17 b	4.43 a	5.57	5.50
Balitro	6.24 ab	7.27 b	5.60 ab	5.58	6.17
Mean	6.44	6.94	6.12	6.46	

Table 4. Analysis of stability and adaptability based on yield of rhizome

Clones	Yield average (t/ha)	b_i	S_eb	S_d^2	Notes
UB1	15.63 a	0.65	0.12*	-11.05	Adaptive on marginal environment
UB2	34.63 b	1.74	0.21*	16.08	Adaptive on productive environment
UB3	19.81 ab	0.93	0.19	8.84	Stable
UB4	18.47 ab	0.80	0.21	15.89	Stable
UB5	14.39 a	0.48	0.09*	-18.29	Adaptive on marginal environment
Balitro	30.82 ab	1.40	0.39*	111.16*	Not Stable

Remarks: *b significantly different on 1, or S_d^2 significantly different on 0

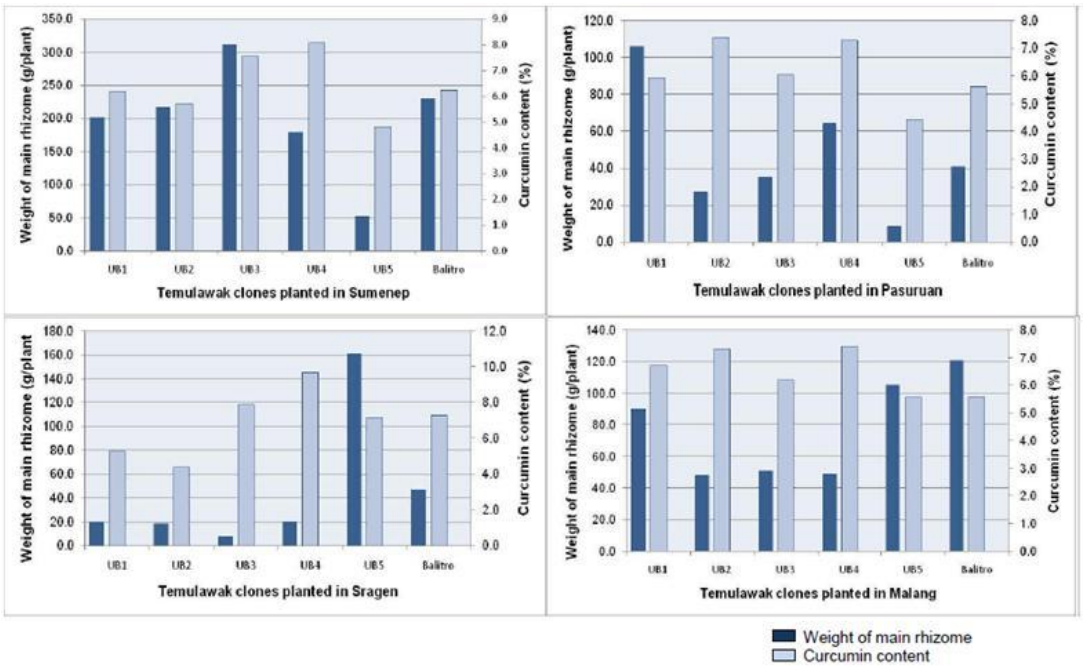

Figure 1. The histogram of the weight of main rhizome and curcumin content of temulawak planted in different locations

Table 5. Analysis of stability and adaptability based on curcumin content of rhizome

Clones	Curcumin content average (%)	bi	Seb	Sd2	Notes
UB1	6.03 ab	-0.96	1.04	-0.18	Stable
UB2	6.20 ab	-3.73	1.47 *	0.19	Adaptive on productive environment
UB3	6.92 ab	2.16	1.2	-0.06	Stable
UB4	8.11 a	2.99	0.89	-0.28	Stable
UB5	5.50 b	3.44	0.70 *	-0.39	Adaptive on marginal environment
Balitro	6.17 ab	2.1	0.74	-0.37	Stable

Remarks: *b significantly different on 1, or S_d^2 significantly different on 0

Balitro clone as a selected clone from the Medicinal and Aromatic Crop Research Institute at Bogor still has lower curcumin content than UB4 (Figure 1). This promising clone could be release as national variety with the characteristic of high curcumin content.

Stability and Adaptability

The objective of adaptation test was to predict the stability and adaptability of each clone. Stability analysis performed on variables that had a significantly interaction between the genotypes with environment. However, evaluation of stability and adaptability was more focused on yield variables. The main result of temulawak was the rhizome, so the stability analysis done on the variables of rhizome weight per plant. Eberhart and Russell applied regression coefficient (bi) as a measure of stability (Singh and Chaudary, 1979).

Table 3 shows that the rhizome yield of UB4 and UB5 clones were stable in various locations. Both clones could be recommended as candidates for new superior clones (varieties) with high total rhizome yield. Clones of UB1 and UB5 were suitable to be developed on marginal lands or lands that were less productive. The ability of these clones can be used for planting on dry land or less fertile. Clone of UB2 suitable to be developed on land productive. This clone will had a high response to the fertile land. The more fertile land, the higher the response.

Rhizome yield stability can be interpreted that the stable clones always had a different rhizome weight in accordance with the environmental potential. If the rhizome weight stable clones were highest in one environment, it also has the highest rhizome weight in other environments. The rhizomes plant, testing of yield stability will be perfect if conducted in the rainy season and dry season. Planting in the rainy and dry season able be characteristic variations in climate and weather, so that genetic differences from each clones will be more clearly. Variance of genetic will be more pure because the genotype-environment interaction had been eliminated.

CONCLUSSION

There was interaction of genotypes-environmental on rhizome weight. The stability of the rhizome yield in every locations unit, achieved by UB3 and UB4 clones. Clones UB1 and UB5 suitable to be developed on marginal lands and clone UB2 adaptive to be developed on productive environment. The highest yield was obtained by UB2 clone at 34,63 t/ha, while the highest curcumin content was constantly obtained by UB4 both in marginal as well as in productive area.Both clones had different superior characters.

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