Growth Analysis of Superior Clones of Temulawak (*Curcuma xanthorrhiza* Roxb.) Grown with Organic Fertilizers

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Abstract

Curcuma xanthorrhiza as a medicinal plant needs to be preserved and improved for its yield. The curcumin is very useful for human health. This species is useful to improve the body immune system. Curcumin of many genotypes of *C. xanthorrhiza* has been successfully evaluated for their potentials and its potential yield from genotypes throughout Java and islands for selection of superior clones. The research was done based on the Randomized Completely Block Design (RCBD), using superior clone types as the single factor obtained from Sragen, Jember, Sumenep, Pasuruan, Blitar, and Malang. The data were analyzed using F-test at significance level of 5% followed by Duncan Multiple Range Test (DMRT) at significance level of 5%. The results showed that Malang clone had the best vegetative growth and maximum yield compared with other clones. The plant height, leaves number, leaf width, leave area, leaf area index (LAI), dry weight of straw, fresh rhizome weight variables of Malang clone was the highes among other clones. The maximum vegetative growth pattern of plant height obtained by Malang clone that reached 155.13 cm, the highest fresh rhizome production of Malang clone was 22.31 tons/ha.

Keywords: growth analysis, temulawak, Curcuma xanthorrhiza*, organic fertilizer*

Introduction

Temulawak (*Curcuma xanthorrhiza* Roxb.) is one species of medicinal plants belonging to family Zingiberaceae is potential to be developed, and is one of nine types of seed plants from the Directorate General of POM as an ingredient. Utilization of this plant is varied. It is useful for maintenance and improvement of health and treatment of disease as well as raw materials for traditional medicines and cosmetics (Nurjannah *et al*., 1994). Temulawak rhizome can be used as hepatoprotector, increase the body's immune system, anti-bacterial, anti-diabetic, anti-hepatotoxic, anti-inflammatory, anti-oxidant, anti-tumor, diuretic, depressant, hipolipodemik, and as beverage as well as for natural dyes (Purnomowati and Yoganingrum, 1997; Raharjo and Rostiana, 2006).

All potentials should be evaluated to determine the type of temulawak with the most potential to be developed in certain areas. Several types of temulawak has been successfully evaluated its potential based on curcumin content and gowth characteristics for selection of all types of temulawak throughout Java. Kuswanto has been elected six best types of temulawak, including Sragen, Pasuruan, Blitar, Sumenep, Malang, and Jember.

Temulawak selected cultivars need to be tested in various production areas, in order to investigate their genetic capabilities grown in various areas. One of the evaluation was done by planting selected temulawak, the superior clones was then elected to be cultivated at the production centers of temulawak in the district of Sragen, Central Java.

Materials and Methods

This study was started in May 2010, at Karang Pong, Kali Jambe, Sragen, Cetral Java, located at 7° 30' LS and 110° 50' BT and altitude of 180 m above sea level. The soil type is vertisol. The materials used in this study were temulawak seeds, consisting of six clones derived from the superior selection of Java.

The design of the experiment was Randomized Completely Block Design (RCBD). Origin of clones was used as the single factor. The experiment had 6 standard of excellence e.i. 6 clones obtained from Java. Each treaatment had 3 replicates. Addition of organic fertilizer was of 15 tons/ha manure.

Observation variables included plant height, number of leaves per clump, number of tillers per hill, leaf width, leaf area, leaf area index, fresh weight of rhizomes per plant, dry weight of straw, specific leaf area, and relative growth rate. Data were analyzed using the F test at 5% level, if there was a significant difference, then it was followed by DMRT at the level of 5%.

Results and Discussion

Height of Plant

Malang clone temulawak observed at intervals of two weeks showed high growth rate of plants significant different compared with other clones (Figure 1). Malang clone growth at 5 WAP seemed to have the fastest plant height compared with five other clones. This shows the level of adaptation of Malang clone was very high, especially during the process of adding plant height.

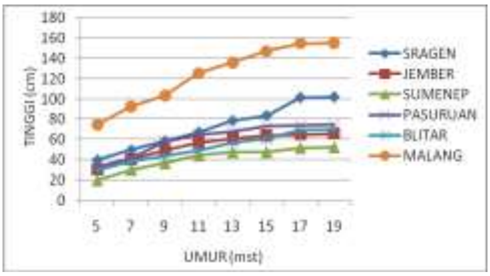


Figure 1. Plant height of six superior clones of temulawak (*Curcuma xanthorrhiza*).

Table 1. The average plant height of six superior clones of temulawak (*Curcuma xanthorriza*) at 19 WAP

Clones	Plant height (cm)				
	I	II	III	Total	Average
Sragen	108.80	98.13	99.50	306.43	102.13 c
Jember	68.38	60.63	68.25	197.26	65.75 ab
Sumenep	45.00	59.38	53.75	158.13	52.71 a
Pasuruan	67.75	69.25	87.75	224.75	74.92 b
Blitar	86.50	61.75	61.25	209.50	69.83 ab
Malang	151.00	146.60	167.80	465.40	155.13 d

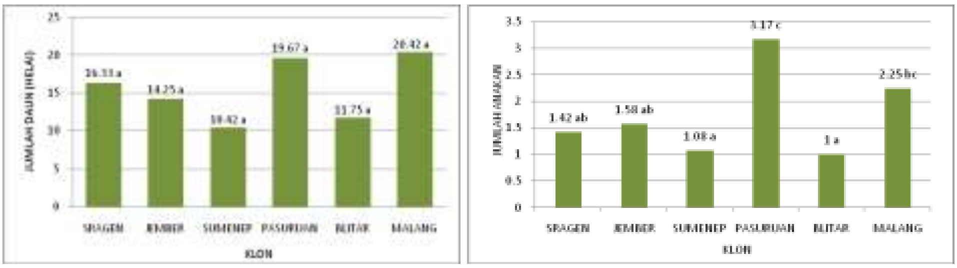
Note: Values followed by the same letter showed no significantly difference according to DMRT at 5%.

Increased plant height of Malang clone during vegetative growth was the highest among the clones. Sragen clone was the second having the plant height similar to Malang clone. At the late vegetative phase (19 WAP) height of Sragen clone was only 102.13 cm, which was much lower than that of Malang clone (155.13 cm) (Table 1). This would indicate that vertisol soil type is suitable for temulawak. Plant height among the clones was significantly different at 5% with Malang clone was the best.

Number of Leaves and Number of Tillers per Clumps

The number of leaves of the temulawak represents its during the vegetative phase. When the plants reach the generative phase, the existing leaves turns to dry. The increased of leaf number may also indicate the increase of rhozome production of temulawak. The more number of leaves formed, the better rhizome formation during the vegetative phase of the plants. The number of leaves produced by temulawak tuber is influenced by the number of tillers formed in a single clump of plants. The leaves formed by the temulawak having a lot of puppies will increase the number of leaves corresponded to the number of puppies available. Tillers per clump of temulawak are capable of producing 6-9 leaves which affects the increasing number of leaves in one plant.

Statistical analysis that there was no significant different among clones of temulawak in terms of leaf number. Figure 2A shows that the highest number of leaves found on the Malang clone, while the Sumenep clone produced the lowest of number of leaves. The number of tillers per hill shows that the Pasuruan and Malang clones had the highest number of tillers (Fig. 2B) the average number of tillers per hill reached 3.17. However, this amount was not significantly different with other clones



A B

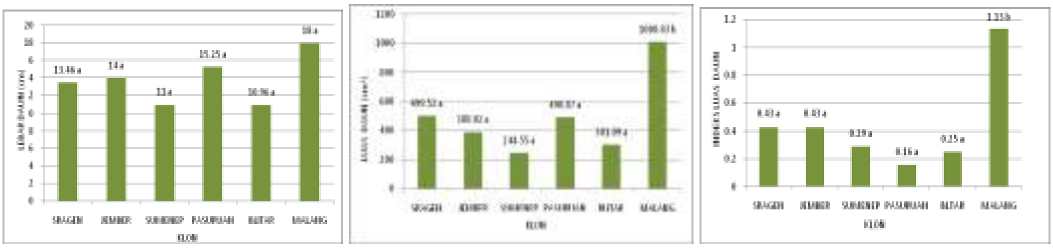
Note: Values followed by the same letter showed no significantly difference according to DMRT at 5%.

Figure 2. Number of leaves (A) and of six clones of temulawak (*Curcuma xanthorrhiza*) at 19 WAP.

Pasuruan clones into clone with the highest number of suckers, is due to the number of seedlings have buds more when compared with the five other clones. This will impact on the growth of temulawak, number of shoots that emerged after the primary buds more so it appears as a leafy plant with a number of seedlings in a clump of more than one. The number of chicks that many of the temulawak will have a negative effect form of competition for the acquisition of nutrients and light. For the competition in terms of food reserves during early growth, the number of chicks that more will tend to have stronger competition because it has only one rhizome pieces that serve as the seed.

Leaf Width, Leaf Area and Leaf Area Index

Leaf width of all clones were not significantly difference (Figure 3A), and there was no difference on their leaf morphology. The width of the leaf ranged from 10.96 cm to 18.00 cm. The leaf area was significantly difference among the clones with the Malang clones was the best. Malang clones had the highest leaf area with an area of 1,008.83 cm2, while for the lowest on Sumenep clones with only 244.55 cm^2 leaf area (Figure 3B). The leaf area index is related to photosynthetic ability of plants. Widiastuti *et al*., (2004) reported that at low light intensity plants produce larger leaves, thinner with a thin layer of epidermis. It has slight palisade tissue, wider spaces between cells, and more number of stomata. Meanwhile, plants that received high-light intensity produces smaller leaves, thick, compact with fewer number of stomata, the cuticle layer and a thicker cell wall with space between cells is smaller and hard texture of leaves.



A B C

Note: Values followed by the same letter showed no significantly difference according to DMRT at 5%.

Figure 3. Leaf width (A), leaf area (B) and leaf area index (C) of six clones of temulawak (*Curcuma xanthorrhiza*) at 19 WAP.

Greater leaf area may be harmful, it can also be beneficial to plants. Large leaf area would be advantageous for plants because it will enhance the ongoing process of photosynthesis. Optimal photosynthesis caused photosynthesis product formed also increased, so plant growth will be optimal. Irwanto (2009) revealed that the products of photosynthesis are proportional to the total active leaf area that can perform photosynthesis. Widiastuti et al. (2004) reported that with increased leaf area, assimilates generated will also be greater. Narrow leaf area beneficial for plants because it can reduce water loss through excessive transpiration.

Leaf area index obtained after the analysis was performed to Malang clone has a real difference when compared with leaf area index of the other five clones. Temulawak was obtained from leaf area index is not too large. Of the six clones of temulawak only five clones are at rates below one. Malang clones became the most extensive high-leaf area index reached 1.13 (Figure 3C). This shows that for the Malang clones had interaction especially among the leaves of shade plants. Meanwhile, other five clones had a smaller leaf area index, which was about 0.5. No interactions occur among the clones because of wide spacing used in the experiment was higher than the leaf area produced of temulawak.

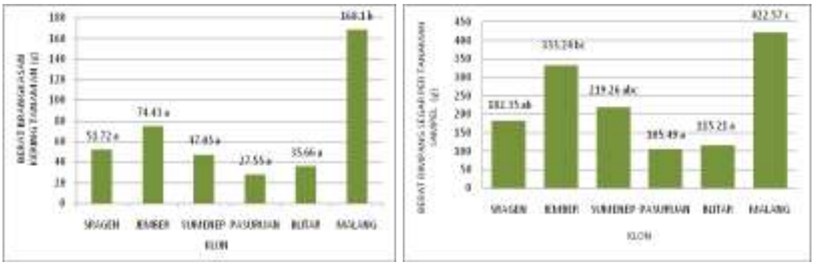
The higher of leaf area index (LAI) was beneficial. Sitompul and Guritno (1995) reveal that the density of the leaves is closely related populations of plants or plant spacing. The closer the distance between plants, the higher the density between the leaves and fewer quanta of radiation (light) is to layers of lower leaves.

Biomass Dry Weight and Fresh Rhizome Weight per Plant

The statistical analysis showed that Malang clone had the highest biomass production significantly different with other clones (Figure 4A). Dry weight of Malang clones was 168.1 g, the lowest was Pasuruan clone having 27.55 g. This indicated that with increasing leaf area of temulawak was total plant dry weight increase corresponded to the crop yields increase.

When leaf area was higher then its dry weight, this will correspond directly to the total dry weight of the plants. Similarly, the weight of rhizomes that produced was also high. High weight of biomasss showed that the assimilation process may also rearchs to maximum.

Statistical analysis of rhizome fresh weight showed that there was significantly difference among the clones. Malang clone obtained the highest rhizome fresh weight per plant (422.57 g) (Figure 4B), meanwhile Pasuruan clones was the lowest, only reached 105.49 g. Conversion into yield per hectare Malang clones was 22.31 tons. Other temulawak clones was reported to have less then 20 tons per hectare. Therefore, Malang clone was potential to be promoted as the best clone. This clone is best when it grows intensively on the vertisol soil.



A B

Note: Values followed by the same letter showed no significantly difference according to DMRT at 5%.

Figure 4. Dry weight of biomass (A) and rhizome fresh weight (B) of six clones of temulawak (*Curcuma xanthorrhiza*) at 19 WAP

Specific Leaf Area

Specific leaf area of six different clones showed no significantly different when they were observed until 17-23 WAP. At 17 WAP, Pasuruan was the best, significantly different compared with other clones, but only Sragen clone was significantly different compared with Sumenep clone at 23 WAP (Table 2).

Table 2. Specific leaf area of temulawak (cm^2)

Clones	Age (WAP)			
	17	19	21	23
Sragen	4,033.3 a	3,136.7 a	8,143.3 a	8,033.3 b
Jember	3,806.7 a	1,930.0 a	3,760.0 a	2,710.0 ab
Sumenep	2,556.7 a	886.7 a	1,620.0 a	1,556.7 a
Pasuruan	9,533.3 b	7,083.3 a	24,360.0 a	6,656.7 ab
Blitar	4,033.3 a	1,736.7 b	1,780.0 a	1,993.7 ab
Malang	4,526.7 a	2,863.3 a	4,150.0 a	3,336.7 ab

Note: Numbers followed by same letter on the same column are not significant at different levels of multiple range tests of Duncan's 5%.

Relative Growth Rate (RGR)

RGR on almost all clones of temulawak at the age of 19-21 weeks after planting tend to reduce. The high reduction occurred when plants were 21 weeks old, except for Pasuruan and Blitar clones lowest RGR occurred at the age of 23 weeks after planting (Table 3). This occurs because the plant entered generative phase. After entering the generative phase of growth, clones Malang, Jember, Sumenep, and Sragen increased in RGR. This showed that the clones were ble to produce a new dry matter per unit at initial dry material. Meanwhile, Pasuruan and Blitar clones was not able to produce new dry matter per unit at initial dry material.

Table 3 shows that clones of temulawak from Malang has the highest RGR than the other clones both at the beginning of growth or to close to maximum vegetative growth.

Decline in RGR indicated the differences in rates of photosynthesis. The process of photosynthesis will be disrupted if water is not enough to plants. A low rate of photosynthesis may decrease to growth of vegetative organs, especially to the plant height. The decrease in photosynthesis may be due to increase of stomata diffusion and non-stomata barrier. Decrease of

RGR may also due to the slow growth of vegetative organs (leaf area, plant height, number of tillers, dry weight, and root dry weight of plants).

Table 3. Relative growth rate (RGR) of temulawak (g/week)

Clones	Age (WAP)		
	19	21	23
Sragen	2.17 ab	1.37 a	1.40 a
Jember	2.40 ab	1.52 ab	1.61 ab
Sumenep	2.46 ab	1.60 ab	1.68 b
Pasuruan	1.75 a	1.77 ab	1.65 b
Blitar	2.09 ab	1.78 ab	1.55 ab
Malang	2.83 b	2.21 b	2.44 c

Note: Numbers followed by same letter on the same column are not significant at different levels of multiple range test of Duncan's 5%.

Conclusions

Malang superior clone had the maximum vegetative growth and yield of its fresh rhizome. This clone also had the highest of the plant height, leaf number, leaf width, leaf area, leaf area index (LAI), dry weight of straw, rhizome fresh weight, specific leaf area, and RGR. The maximum plant height of Malang clone was 155.13 cm, the fresh rhizomes of temulawak was 22.31 tons/ha.

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-- back to Table of Content --