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RHIZOME YIELD OF TEMULAWAK (*Curcuma xanthorrhiza* Roxb.) AT N, P, K VARIOUS LEVEL AND N, K COMBINATION

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ABSTRACT

The role of N, P and K on temulawak have not been clear enough to explain the need in temulawak rhizome in order to get high yield. The experiment was conducted in a screen house in Malang East Java with an altitude of 500 m asl. from Desember 2010 - August 2011. There were 4 experiments in series, consisting of N, P, K various level and N,K alone and combination on the growth and quantity of rhizome arranged in randomized block design comprising 7 levels of fertilizer per plant with 3 replications. The treatments of urea (N), SP36 (P) consisted of 0, 1,25, 2,5, 3,75, 5, 6,25 and 7.5 g. The KCl (K) comprised 0, 1,5, 3, 4,5, 6, 7,5 and 9 g. The N, K alone and combination treatments consisted of (No fertilizer, N, K, NK g /plant). The results of this research were N, P, K optimum dose of each 6.25 g N/plant, 6.25 g P_2O_5/plant, 7.5 g K_2O/plant increased temulawak rhizome dry weight. Combination 4.5 g N + 2.8 g K/plant could increase temulawak rhizome dry weight by 33% compared to the addition of N and 220% when compared to the addition of a single K harvesting age 6 months.

Keywords : *Curcuma xanthorriza*, rhizome, N, P, K

INTRODUCTION

The rhizome yield of temulawak plant (*Curcuma xanthorhiza* Roxb. Synm. *Curcuma javanica)* which is a medicinal plant native to Indonesia is still low. This plant is one of five types of seeded plants by the Directorate General of Food and Drug that has many benefits as efficacious ingredients and potential to be developed. The largest temulawak production center is Java island, which accounts for the production as many as 34,157,187 kg, approximately 92.75% of total national production of temulawak. Province that produces the greatest number of temulawak is East Java and it reaches 56.57%. Productivity of Temulawak in East Java reached 12.5 tons.ha^{-1}, while the potential for temulawak production can reach 20 - 30 ton per ha. Thus, it can be said that less than the maximum production of temulawak meets the needs of the pharmaceutical industry (Director General of Horticulture, 2010; Rahardjo, 2010).

Demand of the temulawak industry is quite high, which is about 1.355 tons.year^{-1}. Approximately 70% of herbal medicines on the market contain temulawak, and about 70% of the production of temulawak from Indonesia is exported overseas. The needs of temulawak for traditional medicine industry and traditional medicine in small industries ranked first in East Java at 3140.18 tons per year of fresh temulawak, and currently the Temulawak total uptake in the traditional medicine and phyto-pharmaceutical industry was estimated at 8750 tons per year (Bermawie *et al*., 2006; Rahardjo and Ajijah, 2007; Yusron, 2009).

A challenge faced in the development of temulawak is that production levels are still low. Generally, low production caused by the unavailability of improved varieties, lack of standardization of quality seeds and cultivation techniques that have not been doing well in terms of the needs of light, the optimal weight of planting material and fertilizer requirements although turmeric has spread in various areas (Devy, 2009). Low level of production has led to

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less maximal supply for the needs of traditional medicine and phytopharmaceutical industries in Indonesia. The farmers usually grow temulawak crops on small area land, and they are only grown as edging plants, resulting in lack of intensive fertilization treatment. Farmers fertilize the main crop only, so the nutritional needs of temulawak plant has not yet been supplied.

Yield of temulawak rhizome is influenced by growing environmental factors, the nature of superior seeds, nutrient availability, crop protection and post harvest handling (Rahardjo, 2010). Plants show different responses to the elements of a given fertilizer. Fertilization with an appropriate element of the need will improve growth and yield in quantity and quality of temulawak plant. Nitrogen is the element of macro nutrients that is mostly absorbed by temulawak plant and followed by the elements of Phosphor and Potassium (Rosita *et al*., 2005). Elements of Phosphor and Potassium both increased the turmeric rhizome, while Nitrogen give a remarkable effect in improving the rhizome yield compared to the application of Potassium (Akamine *et al*., 2007).

Status of nutrients in the soil affects the outcome of temulawak rhizome. Identification of the 20 locations of temulawak planting in Java and Madura obtained 15 and 12% of land with very low levels of N, P and K, low rhizome yield, on average of 0.56 kg.plant and 0.58% of yield compared to the other locations with the production of 1.7 kg plant^{-1}, which contained higher levels of N, P and K (Wardiyati *et al*., 2010). The results of multilocation trials showed that temulawak rhizome from Jember had the highest production and had a high adaptability to the fertile land (Kuswanto and Azizah, 2011). However, the addition of inappropriate fertilizers did not increase the production of temulawak. Increased dosage of urea, SP36 and KCl, each of 100 kg per ha to 300 kg per ha did not increase the production of fresh rhizomes of temulawak plants (Raharjo and Pribadi, 2010).

Nitrogen is required in the formation of chlorophyll and stomatal conductance as well as the efficiency of photosynthesis. Nitrogen is responsible for 26-41% of the crop yield (Kandiannan *et al*., 2009). Temulawak plant has two food storage organs. The first is the rhizomes, and then the second is the rounded and swollen root. The stored nitrogen in the rhizomes and roots is 10.0 and 90.9 mg per plant respectively. It is estimated that 90% of the total nitrogen is at the root of which is the source for the growth of new shoots. After two leaves perfectly open at 6 weeks after planting, approximately 28% and 7% nitrogen is distributed between the leaf and root hairs, and most of the nitrogen left in the rhizome and root tubers of 26% and 35% respectively (Ruamrungsri *et al*., 2006).

Phosphor is commonly found in greater amounts in the sink such as the root tubers and rhizomes when the plants are in vegetative phase as well as fruits and seeds when the plants are in reproductive phase (Liferdi, 2010). Ekelöf (2007) informed that the application of Phosphorus fertilizer was positively correlated with the quality of tubers. Application of adequate P fertilizer could encourage plants to produce maximum yield and increase concentrations of starch. Rahardjo and Pribadi (2010) informed that the commodity of temulawak had P content in the rhizome reaching 7-10 times as much as that in stems and leaves, but it showed no significant effect on rhizome production in the application of 100-200 kg per ha of Phosphorus fertilizer.

Potassium acts as a catalyst in plants in addition to being an integral part of the plant components. This element also regulates cell wall permeability and activity of various mineral elements. Adequate supply of potassium will increase the efficiency of crop N uptake because it is a stimulant to plant growth (Sadanandan *et al*., 1966). Potassium is absorbed in a large amount by plants that produce bulbs and rhizomes which serve as transportation of photosynthetic results, so that K fertilizer can increase the production of rhizomes (Sadanandan *et al*., 2010). Potassium is positively correlated with the weight of temulawak rhizome (Wardiyati *et al*., 2010). Availability of K is enough to increase the efficiency of decision-N (Marschner, 2012). The turmeric (*Curcuma longa*), which is in the same family of temulawak, had the dried rhizome growth that increased by 200% on the addition of N, K in combination (Akamine *et al*., 2007).

The research on the role of N, P, K various level and N,K alone and combination on temulawak plants was aimed to figure out the need for N, P and K in plants of temulawak rhizome in order to get high yield. Thus, it requires further study to get the information on the needs of N, P, K alone and N, K combination which can increase the maximum rhizome yield.

MATERIALS AND METHODS

The experiment was conducted in a screen house in the village of Tlogomas, Lowokwaru, in Malang district at an altitude of 500 m above sea level from January 2011 - August 2011.

Materials used were temulawak local variety of Jember at the age of 1 year old (Kuswanto and Azizah, 2011), polybag with diameter of 30 cm, soil planting media with N content of 0.23%, P of 2.88 mg per kg, K of 0.11 me.100 per g, pH 6.6, the texture of clay dust and SP36 as a source of P, urea as a source of N and KCl as a source of K.

There were 4 experiments conducted in series, which consisted of the role of N (Series 1), role of P (series 2), the role of K (series 3) and role of N, K alone and combination on the quantity of temulawak (*Curcuma xanthorhiza)*. This research was arranged in Randomized Block Design, which consisted of 7 levels of dose treatment repeated 3 times. The sample number of each treatment was 10 plants. The dose treatment of urea (N) per plant consisted of N0= control; N1 = 1.25 g; N2 = 2.5 g; N3 = 3.75 g; N4 = 5g; N5 = 6.25 g, N6 = 7.5 g. SP36 dose treatment (P) per plant consisted of P0 = control; P1 = 1.25 g; P2 = 2.5 g; P3 = 3.75 g; P4 = 5 g; P5 = 6.25 g; P6 = 7.5 g. The seven-dose KCl (K) per plant was given as follows: K0 = control; K1 = 1.5 g; K2 = 3 g; K3 = 4.5 g; K4 = 6 g; K5 = 7.5 g; K6 = 9 g. The 4th experiment was arranged with the same design with 4 treatments (P1 = no fertilizer, P2 = 4.5 g N/plant, P3 = 2.8 g K/plant, P4 = 4.5 g N and 2.8 g K / plant).

The planting material involved the Temulawak rhizome which was cut to have a fresh weight ± 15-20 g. The rhizome used was left for 3 weeks until the shoots emerged as high as 0.5 to 2 cm. the seedlings were then planted in polybags with one plant per polybag planted in a depth of ± 3 cm in a screen house with the shading of 25-30%.

Non-destructive observations were done every 2 weeks which included the following variables: plant length, number of leaf and leaf area. Plant length was measured from ground level to the tip of the longest plants by using a ruler or meter roll. Moreover, the number of leaf and leaf area were calculated as the leaves were still green and open perfectly. Leaf area was calculated using a correction factor method and the leaves of plants border were used as sample with the calculation using the formula of Sitompul (1995).

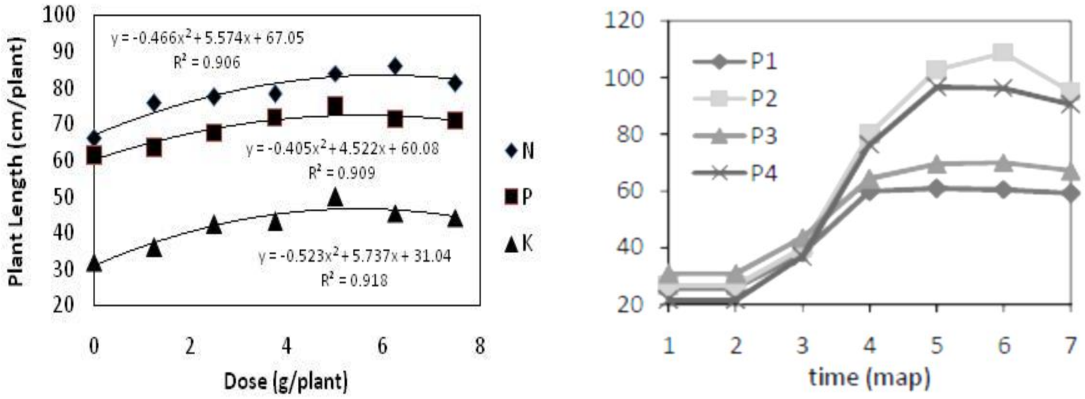
Destructive observations (harvest) were done at the Curcuma plant at the age of 6 months after planting. The number of plants was taken as many as 3 plants per treatment in each replication for each time of harvest, so the total number of harvested plants was as many as 63 plants at each harvest time. These observations included: 1). Fresh weight (FW) and dry weight (DW) per plant. 2). Analysis of the content of N, P and K of temulawak plant. This analysis aimed to determine the uptake of N, P and K elements at the age of 6 months after planting (Sitompul and Guritno, 1995). Results were observed by counting the rhizome fresh and dry weight per plant.

Statistical analysis applied analysis of variance (ANOVA). The tests were carried out using the F test at the level of 5%. When a significant difference between the treatments occurred, further tests using LSD at 5% level and regression analysis were applied.

RESULTS AND DISCUSSION

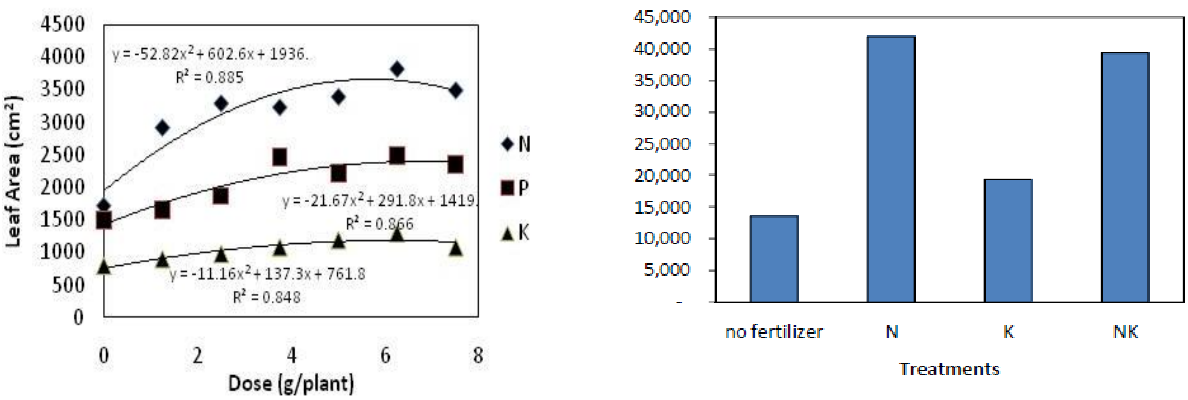
Response of Temulawak Plant Growth in N, P and K Various Levels, N,K Alone and Combination of N,K

Single application of N, P and K significantly affected the growth of Temulawak. The addition of N significantly increased the plant length and leaf area compared to the application of P and K (Figure 1a and 2a). N, K added in combination produced a similar plant length and leaf area of temulawak to the single addition of N but higher when compared with a single K (Figure 1b and 2b). N was a necessary constituent of plant growth, so that it could more significantly improve the vegetative growth of turmeric plants than any other element (Behura, 2001).



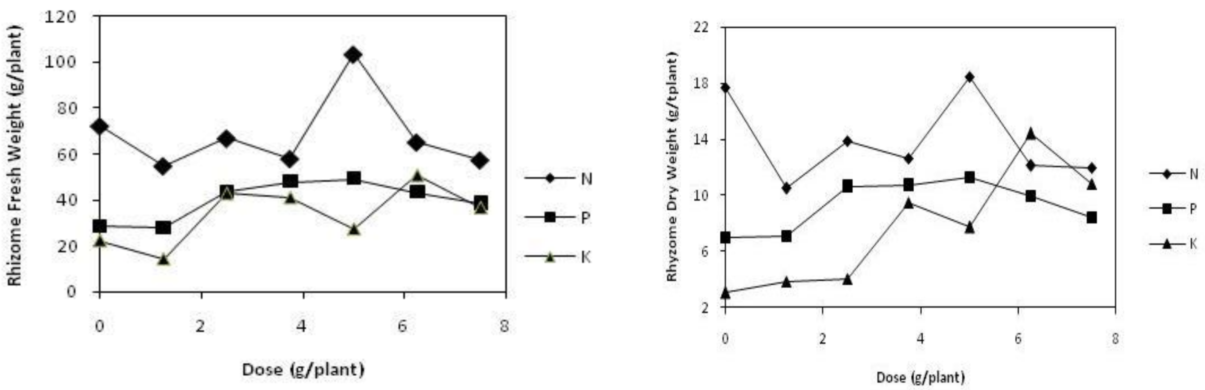
(a) **(b)**

Figure 1. (a) Plant length growth pattern of the fertilizer N, P, K of Temulawak at 6 months after planting (b) Plant length growth pattern of no fertilizer (P1), N (P2 (P3), NK (P4)



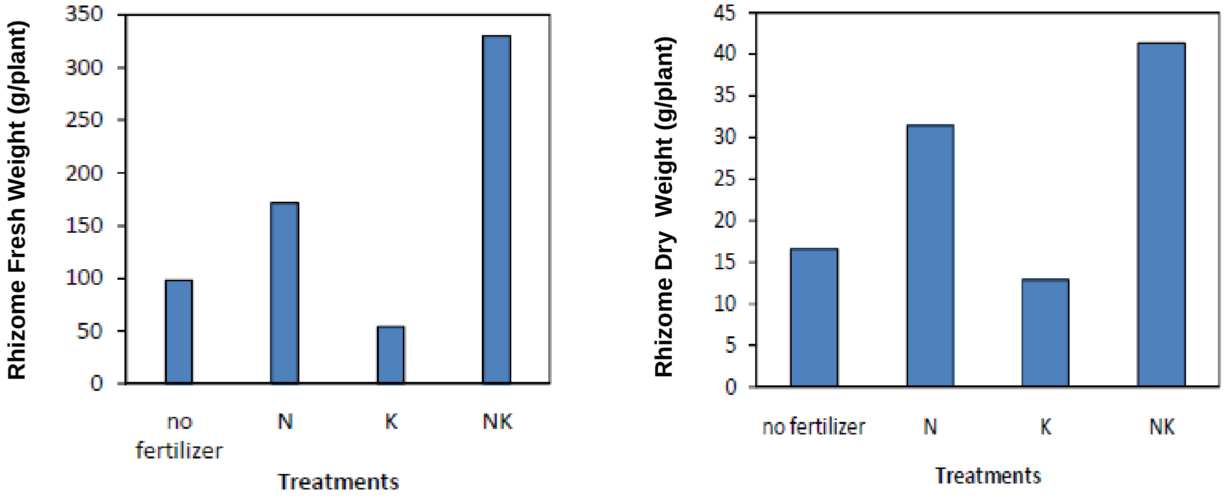
(a) **(b)**

Figure 2. (a) Leaf area growth patterns in the fertilizer urea, SP 36, and KCl at level 0 to 9 g / plant Temulawak (b) Leaf area of Temulawak no fertilizer, N, K, NK at 5 month after planting



(a) **(b)**

Figure 3. Fresh weight growth patterns (a) and rhizome dry weight (b) on Urea fertilizer, SP 36, and KCl at level 0 to 9 g /plant of Temulawak at 6 months



(a) **(b)**

Figure 4. Rizhome fresh weight (a) and dry weight (b) of temulawak with no fertilizer, N, K and NK 6 month after planting

Response of Temulawak Rhizome at Various Levels of N, P and K at Different Ages of Harvest

In addition to the application level of N, P and K, the results were influenced by the age of temulawak rhizome harvested. Fresh weight and dry weight of rhizome at 6 months showed that all doses of N addition had wet and dry rhizome weight which were higher than those of any level of the single addition of P, K optimum dose for ginger rhizome dry weight by 6.25 g N/plant, 6.25 g P_2O_5 and 7.5 g K_2O/plant at harvest 6 months (Figure 3a and 3b). Wet weight of Temulawak at 6 months was higher in the addition of N and K in combination (329.9 g/plant) than the single addition of N (171.4 g/plant) and K (31.4 g plant^{-1}) (Figure 4a and 4 b). Moreover, the dry weight with a combination of NK was 41.33 g/ plant, N 31.40 g/plant, K 12.90 g/plant (Figure 4a and 4b).

The largest rhizome was obtained when plants were given a balanced NPK, because the plants would be green much longer with greater biomass, resulting in more turmeric (Ishimine *et al*., 2004; Hossain, 2010; Hossain and Ishimine, 2005). Application of P alone could not improve the results of turmeric, and giving K alone also could not improve the results of turmeric. Turmeric results would slightly increase when P was combined with N, and a 3-fold the turmeric if K was combined with N (Akamine *et al*., 2010). Behura (2001) also reported that application of K alone could not increase the yield of turmeric, but when K was combined with N and P, it would increase the turmeric significantly.

Another study reported that nutrient imbalances might not be able to accelerate growth and increase yield (plant nutrition). The amount of nutrients is not the only factor that makes the growth and yield better, nutrient imbalances that interfere with normal function and ultimately lead to growth and yield of turmeric on the decrease. Giving N alone can increase the yield of turmeric significantly, these results indicate that application of N itself can increase the yield of turmeric compared to P and K (Chandra *et al*., 1997). N has been shown to be better than P or K in increasing turmeric results.

Uptake of N, P and K on The Temulawak at Various Levels of N, P And K in Correlation with The Growth or Production

An increase in N, P and K describes different uptake pattern on temulawak plant (Fig. 4). N and K uptake increased more sharply than P, this proves that the availability of P in the media is longer than the N and K (plant nutrients). Model uptake of N, P and K in the leaves of the plant Curcuma dose 0-9 g / plant, shows: 1). The higher the dose the higher K uptake of K in the leaves, 2). Uptake of N in leaves increased up to a dose of Urea 5 g / plant, followed by a decrease and an increase in N uptake, 3). P Uptake in leaves with the same fertilizers, SP 36 doses of 0 to 5 g / plant. This suggests that one factor associated with the production and quality with active ingredient in turmeric was the availability of nutrient elements (Raharjo, 2010).

Nitrogen is one of the most nutrient elements absorbed by the plant roots (Kandiannan, 1996). Because N as an important component of organic compounds in plants, giving N will encourage the growth of the plant length ($y = -0.47x^2 + 5.57x + 67.05$) and organs associated with photosynthesis i.e leaf area ($y = -52.02x^2 + 602{,}6x + 1936$) (Figure 1a and 2a). Providing optimum N will not cause a decrease in rhizome weight (Fig. 4). Because the N at planting media is easily and quickly available to plants, the availability of N in the urea dose of 5 g / plant when it is not balance by the addition of other macro elements (P and K) will decline (Figure 5).

Phosphor is the second macro element needed in temulawak because of its role in the constituent components of the molecular structural energy transferor ADP, ATP, NAD, NADP, and the compound system of genetic information of DNA and RNA (Marschner, 1986). Fertilization SP 36 0 to 7.5 g / plant affecting the plant length ($y = -0.405x^2 + 4.52x + 60.08$) and leaf area ($y = -11.16 + 291.8x^2 + 1419x$) was quadratic (Fig. 1 and 2). At the age of 6 months, P uptake in the leaves on the provision of SP 36 doses of 0 - 7.5 g / plant P uptake in the leaf was the same. This is because the available P takes a long time (Figure 4).

Unlike N and P, potassium is a macro element which does not form bonds with carbon and oxygen, so it is not a constituent of proteins and other organic compounds (Zhang *et al*., 2000). Potassium is needed as cation in the activities of photosynthetic enzymes, transports proteins and starches, increases resistance as water shortages and crop pests and diseases. In relation to the influence of K on the length and leaf area of plants the uptake increased until the dose of KCl 5 g / plant and then decreased ($y = -0.523x^2 + 5.737x + 31.04$ and $y = -11.16x^2 + 137.3x + 761.8$) (Fig.1a and 2a). In Temulawak, potassium plays a role in support of the formation of rhizomes which is a part of cation actively in the process of photosynthesis. This is related to the role of potassium in regulating the rate of translocation of assimilate from source to sink, which causes the plant to be able to form rhizomes with optimal weights supported by optimal growth (Onwueme, 1978). So the higher the K level, the higher the K uptake in the leaves (Figure 5).

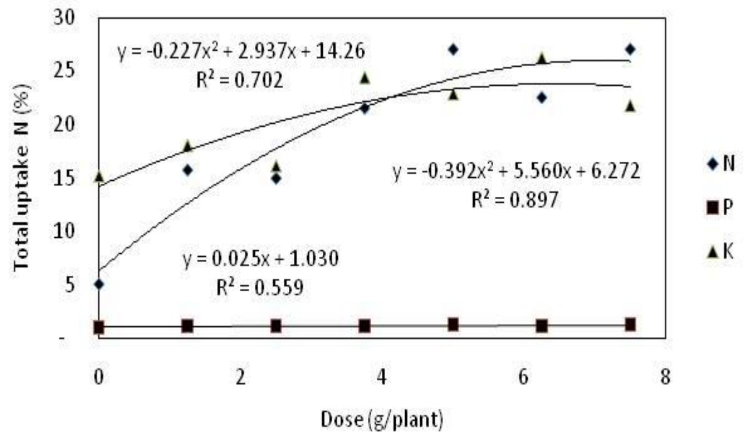


Figure 5. Uptake of N, P and K in the leaves on the fertilizer urea, SP 36, and KCl at level 0 up to 7.5 g / plant Temulawak at 6 months after planting

CONCLUSIONS

The optimum dose NPK fertilizer of each 6.25 g N/plant, 6.25 g P_2O_5/plant, 7.5 g K_2O/plant increased temulawak rhizome dry weight. Combinatfion of 4.5 g N + 2.8 g K / plant increased dry weight of temulawak rhizome by 33% and 220% compared to application of N K single application which were harvested at 6 months after planting.

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