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Review Article

The Provision of Rubber Seedlings for Coal Post-Mining Land Revegetation with the Application of Retardant: A Review

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A b s t r a c t

Coal post mining area is a considerably potential land to be functioned as an agricultural land especially for the development of perennial crops. Revegetation is the function recovery of post mining land to agricultural land by replanting productive crops. This activity is one step in land reclamation that is most widely used and accepted for reclaiming coal post mining area. To utilize this area, the most suitable and applicable method is required because the land has suffered from soil quality deficiency such as quality and quantity of ground water content. Therefore, in revegetation activity, it is necessary to select crops that are highly adaptive to the coal post mining land condition and one of them is rubber plant. To utilise rubber plant as revegetation crops, the seedlings preparation as plantation material is critical. In particular, the preparation is to ensure that the seedlings are highly adaptive and able to grow and develop normally in marginal condition. For this reason, one applicable treatment is by adding retardant into the seedlings. Of the most widely applied are paclobutrazol and cycocel.

K e y w o r d s

Coal post-mining land
Retardant
Revegetation
Rubber seedlings

Introduction

Development activity frequently causes environmental damage and declines its quality. Ecosystem damage would threaten and jeopardize human life itself. Activities such as land clearing for forestry, mining, agriculture, or settlement are responsible for the damage because these activities lead to land quality degradation. According to Yassir et al. (2011), the effects of the damage are the increase in soil compactness, soil nutrient loss, the increase in heavy metal content in soul, and the decrease in the availability in ground water quality and quantity.

Hermawan (2011) explained that to tackle this issue, at least there are two solutions that can be applied. The first one is by controlling cultivation area function-shifting, and the second one is by improving critical land quality so that it can be refunctioned as agricultural area. This second alternative should be promoted to anticipate failure in controlling cultivation area function-shifting for other utilization apart from agricultural use.

One of potential critical land that can be utilised for agricultural purposes is coal post-mining land. Generally, coal mining is performed in two methods: open mining and underground mining. In Indonesia, large numbers of coal mining company apply open mining method which is highly potential in polluting environment. This method could decrease soil productivity and water quality, trigger erosion and sedimentation, diminish plant and animal diversity, cause health problem on humans, trigger micro climate change, and diminish organic material (Herdina et al., 2011).

Such this land condition is virtually incapable for supporting agricultural plant growth, therefore a serious attempt to recover this land to its original condition, or at least to close to it is required. This attempt is widely known as reclamation.

According to Hermawan (2011), one of steps in post mining land recovery to agricultural area is by planting reclamation vegetation or revegetation. Revegetation is the most widely accepted and applied method for reclaiming coal post mining land. This method should be applied by selecting crops based on its survival and regeneration ability on this type of environment, as well as its ability to stabilize soil structure.

The first step in revegetation is planting pioneer plant, a plant that can grow rapidly. After 2-3 years, this post mining land is ready to be cultivated with other types of crop such as sengon, kaliandra, angsana, mahoni, meranti, palm and cacao (http://galaksibimasakti. blogdetik.com/reklamasi-bekas-tambang-batu-bara).

According to the preceding passage, perennial crops such as palm and cacao can be utilised as revegetation plant. This indicates that another perennial crop such as rubber plant (*Hevea brasiliensis* Muel Agr.) can also be utilised. This statement is supported by some study reports explaining that rubber plant is highly adaptive on marginal land. Therefore, more elaborate study is required especially to rubber plant cultivation started from seedlings provision to production in coal post mining land.

One issue is the provision rubber seedlings that are highly adaptive on coal post mining area with low quality and quantity of ground water. To cope with this problem, one available treatment is by applying retardant such as paclobutrazol and cycocel through vegetative growth retardation mechanism. This method can improve plant adaptability on such coal post mining area without causing abnormal growth.

Revegetation of coal post-mining area with rubber plant

Mining activity, especially on open-pit, would diminish all vegetations on the area that will be mined, such as trees, bushes, plant roots, seedlings, microorganism, as well as migration of animals. This process would definitely lose functions of this vegetation area, such as providing forest yield, habitat of wild animals, food, and water absorber area or water resources (Zulkifli, 2013)

One important step in reclamation activity is revegetation (replanting). Setiadi (1999) defined revegetation as an effort to recover critical area outside of forest area in order that the area can be normally refunctioned. This recovery is implemented by an attempt of replanting activity on post-mining area which can decrease area covering (Lembaga Penelitian Universitas Jambi, 2013).

According to Zulkifli (2013), the first step in revegetation on post-mining area is the planting of rapidly-growing pioneer plants that can adapt faster with environment condition. Some generally-used rapidly-growing plants for revegetation are Sengon laut (*Albizia falcata*), Acacia (*Acacia mangium, Acacia crassiacarpa*), Lamtoro (*Leucaena glauca*), Turi (*Sesbania grandiflora*) and Gamal (*Gliricidia sepium*). Some of these plants are grown as protection trees that protect the base plant and as windbreaker, and some others are grown to reduce light intensity and temperature, increase air humidity and maintain soil humidity, and increase the amount of organic substances. These plants have a function to create microclimate which is suitable for forest ecosystem.

Generally, plants other than forestry plants need more difficult growth requirement. Therefore, land preparation for planting, seed preparation, seedlings and plant care need better handling compared to reclamation for forest area. For horticultural plants, palm tree and rubber are two kinds of plants that can relatively grow easily on marginal land like post-mining area, but palm tree requires relatively high rainfall intensity (Zulkifli, 2013).

According to research, scope of reclamation technology in the master plan of Pengembangan Pusat Unggulan IPTEK Pusat Penelitian Teknologi Reklamasi Lahan 2014 – 2015, it is emphasized that the second focus of

research on reclamation technology is optimizing the utilisation of critical and marginal land through land reclamation for the development of multi-use plants (economic and conservation goal) with rubber plant as the prioritized commodity. It is also emphasized in Profil Lembaga Riset Unggulan Puslitek-RekLa Jambi that rubber plant as conservation commodity has economic value that makes this commodity potential as post-reclamation commodity. Besides, rubber plant is also an environment-friendly and highly-economic plant. In addition, it is also traditional commodity that has been developing for a long time in Jambi Province.

From the explanation above, it can be concluded that post-mining land revegetation with rubber plant (*Hevea brasiliensis* Muel Arg.) is critical for some reasons. On the one hand, it acts as a milestone to design a cultivation technology to recover the land's condition to the original condition, and improve socio-ecomic condition of inhabitants who live around the area.

On the other hand, it is stated from the experiment results and experiences of researchers and practitioners that rubber plant is one of plants that have high adaptability on marginal land. Tistama et al. (2009) reported that rubber plant could adapt easily on rocky land in Palangisang, South Sulawesi, Indonesia. In this condition, the plant could yield a high production: 1,500 kilograms per hectar per year. Suhendry et al. (1996) explained that rubber plant even has the ability to reach high productivity on sandy area in confirmed dry season compared to other areas that do not have any dry season.

Tistama et al. (2009) explained that another advantage of rubber plant the ability to fix its physical properties through nutrient enrichment by utilising the physiological properties deciduous. A study in Malaysia reported that every year rubber's leaves can recover 45-90 kg/ha N, 3-7 kg/ha P, 10-20 kg/ha K, and 9-18 kg/ha Mg. This is a characteristic that only belongs to rubber plant. Besides, it also has carbon fixation ability that put this plant as an industrial plant that has ecological use. The sun radiation usage efficiency on rubber plant with closed canopy is around 2.8% (Templeton, 1969).

According to the preceding explanation, it is clear that with the advantageous properties of rubber plant, it can be considered as an alternative for post-mining land revegetation. One emerging issue is how to guarantee the provision of high quality rubber seedlings that can adapt well on marginal land. This paper is attempting to offer a brief description of seedlings provision for post-mining area by utilising growth-regulator substance namely retardant.

Provision of rubber plant seedlings by retardant application to coal post-mining land

As a marginal land, coal post-mining area needs to be recovered and reused optimally through land revegetation. One of the most suitable plants for the revegetation, according to the passage above, is rubber plant. This is because it has wide adaptability and is also one of commodity of society plantation that has been becoming source of living for the people and the raw materials for latex and woods.

Coal post-mining land contains high proportion of sand and clay at 80-90%. Compact soil from mine tailing reduce the amount of pore in the soil to facilitate water and air flow, and root system (Istianto et al., 2009), so that it causes water barrier capacity to lower. Therefore, the main problem faced by land revegetation on coal-post mining land is the low content of aquifer especially in dry season. As a result, the cultivated plant would be in jeopardy due to the drought that would affect its growth ability.

To overcome this, rubber plant seedlings tolerant of drought are required. The availability of the adaptive seedlings is an issue that needs to be tackled.

One solution to the problem is utilising growth-regulator substance (retardant). This mechanism will not only decrease the possibility of water loss through transpiration, but also, on some types of retardant, enable the higher allocation of photosynthate from leaves to roots. This leads to a faster seedling growth because it is expected that with the well root growth, the seedlings can extract water faster.

Some chemical substance groups are found capable of reducing stem length. These groups are named by retardant or growth-regulator substance. Retardant in a plant acts as an organic matter apart from nutrients that on small quantity can support, slow, and change physiological process. Wattimena (1988) explained that retardant is a synthetic organic matter that can slow the cell growth on sub-apical meristem when it is induced to a responsive plant. It can also reduce stem growth without affecting leaves growth and causing abnormal growth. Retardant are widely used in horticultural plant

cultivation as growth-regulator substance. Some of retardant products are *Phosphon D, Amo-1618, paclobutrazol, cycocel,* and *ancymidol.*

In research, the most widely used type of retardant is Paclobutraol (Pbz.). Christov et al. (1995) and Chaney (2004) explained that paclobutrazol is categorized as a growth-regulator substance that can retard plant growth, improve green colour of leaves, and increase yield without causing abnormal growth. Mazher et al. (2014) explained that Paclobutrazol is a growth retardant namely Cultar, Bonzai and PP333 derived from herbicide, and it is proven effective to control plant growth. The morphological response of paclobutrazol is the reduction in internode length.

Paclobutrazol activity has opposing effect against GA3. Bultynck et al. (2004) explained that induction of GA3 can improve biomass allocation on leaves, particularly on leaf sheaths but it will decrease allocation on roots. Mean while, application of paclobutrazol decrease allocation on leaves and improve biomass allocation on roots. Therefore, this would strengthen root growth that will make the plant more tolerant in dry land.

Paclobutrazol is also capable of reducing water pressure on plant by affecting synthesis of abscisic acid hormone. Abscisic acid is created through terpenoid track. Effect of paclobutrazol treatment will promote abscisic acid production. One of the function of abscisic acid is that it causes stomata to close therefore it reduces the loss of water through transpiration (Chaney, 2004). The increase in water connection in tree can emerge from the combination of increase in abscisic acid content that reduces stomata opening. Therefore it will reduce shoot growth and on the stem surface for transpiration and it leads to more effective water absorption. Gardner et al. (1991) reported that the stomata closing will reduce the amount of transpiration, and therefore minimize water losing.

In a study by Ghosh et al. (2010) on sandy soil, the effect of soil surface treatment at 2.0 g dose of paclobutrazol disappeared totally for 3 years. On heavier soil that contains silt and organic material, the effect remained until the fourth and fifth season. Another type of retardant that can be used to prepare rubber seedlings in coal post-mining area is cycocel. Cycocel or Chlormequal is a retardant that can retard the formation of kaurene, an intermediary in the formation of gibberellin from mevalonate (Krishnamoorthy, 1981).

Cycocel is a retardant that can improve plant tolerance against threat of drought through retardation mechanism of vegetative grow, but it keeps the yield (Irianto et al., 2013).

Sharif et al. (2007) suggested that the injection of cycocel (*chlormequat chloride*) 0 to 3000 $mg.L^{-1}$ on barley plant is proven to be able to reduce the plant's height but can improve relative water content. Inducing cycocel in dry season (without stress) can improve ratio of dry weight for root and shoot.

Nejadsahebi et al. (2010) explained from his research that cycocel can improve the endurance of stomata, reduce transpiration and help water use efficiency. As a result, Cycocel is capable of neutralizing negative effect from threat of drought.

The result of study conducted by Eristo et al. (2014) stated that root dry mass that increase followed with ratio of root and tall shoot by the induction of cycocel is expected to be able to improve the ability of mangosteen seedling to absorb water and nutrient available in the ground. These substances then can be utilized as main material in the formation of carbohydrate needed by seedlings to grow. Temporary vegetative growth retardation of seedling is conducted until root development reaches its optimal level so that it will have ability to absorb water and high nutrient. It seems that this condition can only be monitored by extending observation time and adding a new variable: profile of mangosteen seedling root development.

In conclusion, based on research reports and statements regarding retardation mechanism and the function of retardant especially paclobutrazol and cycocel, there is a high possibility that these kinds of retardant can solve the issue about growth problem in drought condition. This can also be applied as a milestone to utilize retardant as one of alternatives to prepare rubber seedlings for coal post-mining land revegetation.

Conclusion and suggestion

Coal post-mining land is considerably potential to be utilised as agricultural area. To make it ready for utilisation, it is required an effort to recover the land condition to the initial condition, or at least close to it. To reach this condition, reclamation is the best method to be applied. One of the most important steps of reclamation is revegetation. Revegetation is human effort to recover

critical land by replanting the land with adaptive crop. One of the most suitable and highly adaptive crops for such condition, particularly marginal land, is rubber plant.

Revegetation by using rubber plant requires drought tolerant seedlings because one of the problems faced by farmers on post-mining land is ground water shortage. One promising alternative to make rubber seedlings to have adaptability on dry land is by the induction of retardant such as paclobutrazol and cycocel. It is because these two retardant are capable of increasing plant's tolerance against threat of drought through vegetative growth retardation mechanism without causing abnormal growth.

It is advised to conduct step-by-step and multi-year research to get more concrete data in order to achieve the best method for coal post-mining land revegetation by utilizing rubber plant as pioneer plant.

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