Growth pattern of shoot and root *Mucuna bracteata* from seeds and cuttings

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Abstract. *Mucuna bracteata* is a legume crop commonly used as a cover crop in plantations. In order to better understand the growth patterns of *Mucuna* sourced from seedling or cutting, studying shoot-root growth and biomass allocation are an important step that needs to be done. Biomass is divided into shoot and root, while to study the assimilate allocation is done by observing the shoot-root ratio. An increase in the number of leaves was also observed to see the potential assimilation of plants. This research used a non factorial randomized design with 5 replications. The planting media used is top soil: manure: sand with a ratio of 1:1:1. The results of the research showed that the shoot and root biomass from cuttings were higher than seedlings. The shoot root ratio was higher in seedlings. The increase number of leaves was higher in seedlings than cutting up to the age of 8 weeks after plating.

1. Introduction
*Mucuna bracteata* is one type of perennial legumes plant that is used as soil cover on the cultivation of palm and rubber plantations in Indonesia. Compared to conventional LCC, this plant has advantages including: rapid growth rate, high biomass production, resistance to shade, disliked livestock, tolerant to pest and disease, compete with weeds and control soil erosion well.

*Mucuna* is cultivated in two ways, vegetative and generative. The main problem of cultivating *Mucuna* from seeds were the limited availability of seeds because they had to be imported and the price of seeds was quite expensive. Therefore, plantation farmers currently prefer vegetative propagation with the cutting method. Another research [1] showed that there was no difference in the percentage of success of live for both methods.

Growth is an increase in the size and number of cells and intercellular tissue, which means an increase in physical size and partial or overall body structure, so that it can be measured in units of length and weight [2]. Growth is usually associated with development (specialization of cells and tissues) and reproduction (production of new individuals). Plant growth in a limited sense refers to an irreversible increase in size, reflecting the increase in protoplasm and dry weight. Therefore, dry weight is often used to identify plant growth. Growing plants showed the increase in dry materials per unit of time [3].

Plant parts such as roots, leaves, stems and flowers are important structures of plant growth. All of these parts are a development of the meristem [4]. The root system constantly provides water and nutrients for upper parts such as stems and leaves. The roots must grow and develop to support plants growth. The main function of roots is to absorb nutrients from a heterogeneous soil environment.
including the ability to form associations with microbes [5]. Major changes in the physiological properties of the root can occur due to tissue aging and differentiation. Therefore, variations in root functions such as nutrient uptake rates can differ with increasing distance from the root tip [6].

The difference in the number and size of plant leaves is an important part of light interception and formation of carbon compounds. There are many theories related to the growth of leaves and stems, which are more prioritized between leaves and stems [7]. The comparison of the number and size of leaves in plants is a represent of the ability to intercept light. This is because both of these parameters have a relationship of metabolic and mechanistic consequences that affect leaf energy balance and assimilate formation [8].

Dry weight is a parameter that states the amount of biomass produced by plants per unit of time. There are differences in the characteristic of biomass produced by plants from seedlings and cuttings. Seed seedlings are more sensitive to environmental changes, in contrast to cuttings that already have fully developed of stems, leaves and roots. This difference will later affect the ability of plants to adapt to their environment.

Therefore, these researches were conducted to study the difference growth of seedling compared to cuttings. This study will describe the pattern of biomass accumulation and translocation from two different sources.

2. Materials and methods
The nursery trial was conducted in Cengkeh Turi Binjai. The study on growth and development of Mucuna was carried out using Mucuna seeds and stem cuttings from PTPN 3 Silau Dunia Estate. Cuttings are obtained by a stem with diameter of 2.0-2.5 and length of 25 cm. The planting media used was top soil: manure: sand with 1:1:1 ratio. The size of the polybags used for planting containers is 7x13cm. Dry weight observation was carried out by drying the plant material in an oven at 80°C for 24 hours, after the weight was constant then weighing was carried out.

3. Results and discussion
3.1. Root and shoot dry weight, and shoot root ratio
In General, growth and development of root are basically the same for all plant species. The difference is the rooting morphology systems that depending on the type of species [9]. The results of the research of shoot and root dry weight and shoot root ratio are shown in table 1.

| Treatment | Root dry weight (g) | Shoot dry weight (g) | Shoot root ratio |
|-----------|---------------------|----------------------|-----------------|
| Cutting   | 15.68               | 25.56                | 1.64            |
| Seedling  | 1.09                | 5.71                 | 5.23            |

Root dry weight from the cuttings were greater than seedlings. This is natural because the source of the cuttings has had fully developed of stems and roots (table 1). The stems of seedlings are vegetative propagation relatively larger than seeds, in other words having higher energy reserves. Therefore, the energy needed for leaf formation is quite available, while in seedlings plants must share besides for the formation of leaves, as well as stems and other organs.

However, the shoot root ratio from seedlings was higher than cuttings. This result describes that more assimilate accumulation patterns are translocation to shoot than root. The shoot root ratio in plants is highly determined by environmental conditions. The relationship of shoots and roots is more emphasized in terms of morphology so that the more roots make the better plants growth. The shoot root ratio could change in different environmental. The optimal growth schedule of plant with two vegetative parts is studied to investigate the balance between shoot and root. The shoot root ratio was used to estimate the amount of shoot and root biomass as well as the amount of assimilate inputs in plants [10,11]. Variations in shoot and root growth varies between plants, and are highly depend on
environmental conditions. The range of shoot ratio is due to varying depending on soil and climate conditions between regions and the period of plant growth [12]. Another research [13] reported that the shoot ratio of natural grassroots in the United States ranged from 0.57 to 6.25, while in other was reported to range from 0.18 to 2.44 [10].

3.2. Increase in the number of leaves
The increase in the number of leaves is an overview of how many leaves are formed per unit of time. The results of the increase in the number of cuttings and seedlings are showed in table 2.

Table 2. Number and percentage increase of Mucuna leaves from seeds and cuttings

| Treatment | 7 WAP | 8 WAP | Percentage increase 7-8 WAP (%) | 9 WAP | Percentage increase 8-9 WAP (%) |
|-----------|-------|-------|----------------------------------|-------|----------------------------------|
| Cutting   | 21.25 | 22.50 | 1.25                             | 27.45 | 4.95                             |
| Seedling  | 12.13 | 14.93 | 2.8                              | 17.40 | 2.47                             |

The results of this research (table 2) showed that at the age of 7-8 weeks after plating the increase in the number of leaves from seedlings is higher than cuttings. However, at the age of 8-9 weeks after planting the number of leaves from cuttings was higher. The increase in the number of leaves in seedlings was thought to be due to the fact that new plants sourced from seeds, were in a rapid phase. Illustrations of plant growth are always depicted with sigmoid curves.

The sigmoid curve is a curve that characterizes plant growth patterns [10]. Based on sigmoid curve, each stage of plant growth is divided into four. The initial phase is a slow phase, then rapid growth, to a certain point due to the increase in plant cells then slows down and eventually decreases in the senescence phase. The results indicated that at the age 8 weeks after planting the seedling were in a rapid phase, which then slowly slowed down in line with the increasing time.

4. Conclusions
Mucuna from cuttings had the characteristics of root and shoot growth, number of leaves are greater than seedling. The increase in the number of seed leaves from seedling is faster than vegetative propagation at the observation age of 8 weeks after planting.

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