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Application of legume cover crop and various vermicompost dosages on young cinchona in the marginal area

Abstract. Cinchona (*Cinchona ledgeriana* Moens) is one of the important medicinal plants that have the potential to cultivate as herbal medicine. This plant grows well in highland areas. Developing cinchona plants in the marginal area needs effort and modification techniques such as planting legume cover crop (LCC) to maintain the humidity and supply nutrition by fertilizing. Vermicompost is one of the organic fertilizers with rich nutrition to support plant growth. This research aimed to observe the effect of a combination of *Mucuna bracteata* as LCC and vermicompost dosage on young cinchona growth in a marginal area. This research was carried out from September 2019 to March 2020 at the Ciparanje Experimental Station, Faculty of Agriculture, Universitas Padjadjaran. The experimental research was conducted using a Randomized Block Design (RBD) method, which consisted of 12 treatments which were a combination of legume cover crop (*Mucuna bracteat*a) and vermicompost dosages (0 g, 200 g, 400 g, 600 g, 800 g, and 1000 g per plant), with four replications. The result showed that the doses of vermicompost fertilizer of 400 g per plant combined with *M. bracteata* as cover crop gave the highest value on the leaf number and stem diameter. In contrast, the best treatment for leaf chlorophyll content was 200 g per plant vermicompost without LCC planting. Thus, the application of vermicompost combined with the planting of *Mucuna bracteata* cover crop on young cinchona plants is strongly recommended.

Keywords: *Cinchona ledgeriana* · *Mucuna bracteata* · Organic fertilizer · Plant growth

Penggunaan kacang-kacangan penutup tanah dan berbagai dosis pupuk kascing terhadap tanaman kina di lahan marjinal

Sari Tanaman kina (*Cinchona ledgeriana* Moens) merupakan tanaman obat-obatan penting yang sangat berpotensi untuk dikembangkan sebagai obat bahan alam. Tanaman ini dapat tumbuh baik di dataran tinggi. Penanaman kina di wilayah marjinal memerlukan berbagai modifikasi seperti pemberian tanaman penutup tanah (LCC) untuk mempertahankan kelembaban tanah dan pemenuhan nutrisi melalui pemupukan. Tujuan dari penelitian ini untuk melihat pengaruh kombinasi dari penggunaan *Mucuna bracteata* sebagai LCC dan dosis pupuk kascing pada pertumbuhan tanaman kina belum menghasilkan di wilayah marjinal. Penelitian ini dilakukan sejak September 2019 hingga Maret 2020 di kebun percobaan Ciparanje, Fakultas Pertanian, Universitas Padjadjaran. Rancangan percobaan menggunakan rancangan acak kelompok (RAK) dengan 12 perlakuan yang terdiri dari kombinasi tanaman penutup tanah (LCC) yaitu *Mucuna bracteata* dan pupuk kascing (0 g, 200 g, 400 g, 600 g, 800 g and 1000 g) per tanaman yang diulang empat kali. Hasil penelitian menunjukkan dosis pupuk kascing 400 g/tanaman yang dikombinasikan dengan *Mucuna bracteata* menghasilkan jumlah daun dan diameter batang tertinggi dibandingkan perlakuan lainnya. Sedangkan 200 g pupuk kascing tanpa LCC merupakan perlakuan dengan nilai klorofil daun tertinggi. Berdasarkan hasil tersebut, penggunaan pupuk kascing yang dikombinasikan dengan *Mucuna bracteata* sebagai LCC dapat meningkatkan pertumbuhan tanaman kina belum menghasilkan.

Kata kunci: *Cinchona ledgeriana* · *Mucuna bracteata* · Pupuk organik · Pertumbuhan tanaman.

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Introduction

Cinchona is one of Rubiaceae and also known as Peruvian bark has 23 species that are widely spread over the world. This commodity is planted in Asia countries such as India, Indonesia, Vietnam,and Sri Lanka, some African countries, and South America like Bolivia, Venezuela, and Colombia (Jeger, 2011; Gurung and De, 2017). Cinchona plant has many functions as a medicine for diseases like malaria, gastric inflammation, intermittent neuralgia, and preventing cardiovascular disease (Gachelin *et al.*, 2017). Based on Santoso *et al.* (2016), it contains more than 20 alkaloids with four alkaloids as the main composition, namely cinchona, quinidine, cinchonine, and cinchonidine. *Cinchona ledgeriana* is one cinchona plant species with high alkaloids, especially for cinchona compounds. Another function of cinchona as a part of beverages ingredient and the textile industry because of its bitter sensation and solid fluorescence (Kacprzak, 2013). It also has the potential as both cosmetic and food ingredient (Ratnadewi *et al.*, 2016).

The problem to develope cinchona in tropical countries, including Indonesia, is the less suitable habitat because this plant is originated from a high altitude and cold temperature growing areas in Andes Mountain, the South America (Central of Tea and Cinchona Research Gambung, 1995). Cinchona plants will grow well on andosol soil with rich nutrition, low bulk density, and high water holding capacity (Marbun *et al.*, 2018). Meanwhile, the majority of the area in Indonesia is low-medium land with inceptisol soil type. This soil has a high clay content, low porosity, and lack of C-organic (Puslittanak, 2000). Due to those limitations, only certain locations in Indonesia is suitable for cinchona cultivation, such as in the mountainous highland of West Sumatra and West Java, which have many mountains (Mayerni *et al.*, 2015).

Encouraging the young cinchona plant (YCP) growth in the marginal area needs modification of cultivating technique, including manipulating the microenvironment. Conducting the fertilizer combination between organic fertilizer and NPK incline the stem diameter on YCP, which plants at low altitude (Maxiselly *et al.*, 2017). A plant Growth Regulator (PGR) that contains gibberellin and cytokines is one stimulation for growing YCP (Maxiselly *et al.*, 2021). YCP also was influenced by coconut water treatments because of the composition of this material, which has nutrition and natural plant hormone (Ariyanti *et al.*, 2020).

Another technique for improving soil fertility and humidity in the marginal area is applying legume cover crop (LCC) that enhances sustainability. *Mucuna bracteata* is one of the LCCs that decreases the weed and elevates N in the soil by fixation activity (Herath *et al.*, 2017). This legume has been applied in some plantations, such as oil palm and natural rubber (Herath *et al.*, 2017; Wawan *et al.*, 2019). At the same time, vermicompost is an organic fertilizer that also supports soil sustainability because it has a significant role in maintaining the physic, chemical, and soil biology [16]. Furthermore, this fertilizer contains a lot of nutrition (N, P, C-organic), including some micronutrients (Fe, Zn, Cu) (Kartini, 2005; Shrimal *et al.*, 2017). According to the explanation, this research aims to observe the effect of a combination between *mucuna bracteata* as LCC and vermicompost dosage on young cinchona growth in a marginal area that potentially increases plant growth related to plant production.

Method

Location, material, and tools. The research was conducted from September 2019 to March 2020 at Experimental Field, Ciparanje, Faculty of Agriculture, Universitas Padjadjaran, with an altitude of around 750 meters above sea level with Inceptisol as soil type (the marginal location for the habitat of cinchona plant) and rainfall type C based on Smith and Fergusson. The young cinchona plant (*Cinchona ledgeriana* Moens. that grafted with *Cinchona succirubra* as rootstock) aged 18 months old, with a plant distance of 1 m x 1 m among plants, 250 g of *mucuna bracteata* seeds, soil, and sand as the planting media of LCC, NPK and KCl as a base-fertilizer, vermicompost fertilizer (200 g, 400 g, 600 g, 800 g, dan 1000 g). The composition of vermicompost is shown in Table 1. The equipment used in this experiment were digital calipers, meters, an analytic scale, and a chlorophyll meter SPAD.

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Table 1. Composition of vermicompost

No.	Parameter	Unit	Result	SNI 19-7030-2004	
				Min	Max
1	Water content	%	48.63	-	50.00
2	pH	%	8.21	6.80	7.49
3	Ash	%	40.98	-	-
4	N-total	%	1.26	0.40	-
5	C-Organic	%	25.95	-	-
6	C/N ratio	%	21.00	10.00	20.00
7	P-total	%	5.53	0.10	-
8	K-total	%	0.73	9.80	32.00
9	Ca-total	%	0.587	-	-
10	Mg-total	%	0.011	-	0.60
11	S-total	%	1.00	-	-
12	Fe	%	0.02562	-	2.00
13	Cu	ppm	45.90	-	100.00
14	Zn	ppm	128.80	-	500.00
15	B-total	ppm	334.40	-	-
16	Heavy Metal (Pb)	ppm	53.60	-	150.00

Source: Agro Cikole Chemical Laboratory, Lembang (2010).

Experimental Design. The Randomized Block Design (RBD) experiment consisted of 12 treatments with four replications. One young cinchona plant was used as a sample for each treatment per repetition. The combination of treatments showed below:

A: no vermicompost + no *M. braceata* (control)
B: no vermicompost + *M. Bracteata*
C: 200 g vermicompost plant^{-1} + no *M. bracteata*
D: 400 g vermicompost plant^{-1} + no *M. bracteata*
E: 600 g vermicompost plant^{-1} + no *M. bracteata*
F: 800 g vermicompost plant^{-1} + no *M. bracteata*
G: 1000 g vermicompost plant^{-1} + no *M. bracteata*
H: 200 g vermicompost plant^{-1} + *M. bracteata*
I: 400 g vermicompost plant^{-1} + *M. bracteata*
J: 600 g vermicompost plant^{-1} + *M. bracteata*
K: 800 g vermicompost plant^{-1} + *M. bracteata*
L: 1000 g vermicompost plant^{-1} + *M. bracteata*

All data were analyzed by variance (ANOVA) F-test analysis followed by Duncan Multiple Range Test (DMRT) 5% for significant data. The results of the data analyses are presented in the tables.

Treatment Application. Preparing the field by fertilizing NPK (5 g/plant) and KCL (3 g/plants) in the sample of cinchona plant two weeks before treatments application, with the standard dose for young cinchona plant (Wibowo, 1995). The next step was putting the vermicompost in the cinchona plant two weeks before planting *Mucuna bracteata* as LCC. It was continued by mixing the soil and sand as the planting media for *Mucuna bracteata* between 2 plant rows around 50 cm among the plants with 20 cm x 25 cm as the planting distance between LCC. The growth variable was observed, such as stem characters (addition of stem diameter and addition of main stem height) and leaf characters (leaf numbers and chlorophyll contents observed by chlorophyll meter SPAD). Both characters were counted on 3 Months After Treatment (MAT) and 6 MAT. The field is also maintained with weeding, cleaning frequently, and watering during the dry period.

Results and Discussion

The results are divided into two tables based on the traits. Table 2 reveals the stem characters, and table 3 reports the leaf traits. Table 2 shows two stem variables: adding stem diameter and adding main stem height on 3 MAT and 6 MAT. The application of vermicompost and *M. bracteata* as LCC did not show a significant effect for elevating the addition of stem diameter on 3 MAT but had a positive influence at 6 MAT. The best treatment to uplift the stem diameter on 6 MAT was 400 g vermicompost combined with *Mucuna bracteata*. On the other hand, all treatments did not influence increasing main stem height on young cinchona.

In contrast to stem characters, vermicompost and *Mucuna bracteata* significantly affected leaf growth on 3 MAT and 6 MAT. The leaf number in Table 3 showed improving the number by application of vermicompost and LCC on 3 MAT and 6 MAT. The highest leaf number on 3 MAT was 1000g vermicompost without LCC, even though only slightly different from 400 g vermicompost + LCC. Meanwhile, 400g vermicompost + LCC also had the highest leaf number on 6 MAT. For chlorophyll contents, both treatments were the lowest values, while the highest chlorophyll contents were 200 g vermicompost without LCC and 1000 g vermicompost with *mucuna bracteata*. The increasing leaf number and chlorophyll contents were affected by improving soil nitrogen value through fertilizer and LCC application. Ahmad *et al.* (2022) reported that improving plant yield by N utilization will reduce leaf senescence. The treatments with high leaf numbers but the lowest

chlorophyll contents caused by the leaf phase are still immature, assuming the chlorophyll contents are not improving yet.

Table 2. Vermicompost and LCC (*Mucuna bracteata*) effect on the increase of stem diameter and stem height of young cinchona at 3 MAT and 6 MAT.

Treatments	The increase of stem diameter (cm)		The increase of main stem height (cm)	
	3 MAT	6 MAT	3 MAT	6 MAT
A	1.88a	3.77ab	1.25a	2.00a
B	1.90a	3.97ab	1.13a	2.00a
C	1.76a	3.74ab	1.25a	1.88a
D	1.68a	3.66a	1.00a	1.88a
E	1.77a	3.88ab	1.00a	2.00a
F	1.80a	3.92ab	1.25a	1.88a
G	2.36a	4.21ab	1.00a	1.75a
H	2.16a	4.17ab	1.13a	2.00a
I	2.27a	4.36b	1.00a	1.88a
J	1.94a	3.95ab	1.00a	1.88a
K	1.72a	3.68a	1.00a	2.00a
L	1.92a	4.06ab	1.13a	1.88a
CV (%)	**20.90**	**9.99**	**17.54**	**10.32**

Note: Mean followed by a different alphabet in the same column is significantly different based on the DMRT test at " 5%

Table 3. Vermicompost and LCC (*Mucuna bracteata*) effect on leaf number and leaf chlorophyll content in young cinchona at 3 MAT and 6 MAT.

Treatments	Leaf Number		Chlorophyll content (unit)	
	3 MAT	6 MAT	3 MAT	6 MAT
A	11.50ab	24.25bc	44.10cd	48.40cd
B	10.50a	23.00a	37.95a	43.23ab
C	12.50bc	23.50ab	47.05d	52.78e
D	13.25cd	25.00cde	43.83cd	47.93cd
E	13.25cd	24.75cd	41.48bc	47.93cd
F	13.75cd	25.25cdef	46.18d	50.28de
G	19.25h	26.00defg	37.65a	41.43a
H	16.00ef	26.25efg	39.65ab	44.03ab
I	18.25gh	27.00g	37.28a	42.30a
J	14.75de	25.50cdef	40.58ab	45.58bc
K	17.25fg	26.50fg	44.95d	50.73de
L	12.75bc	25.00cde	46.08d	52.48e
CV (%)	**6.70**	**3.18**	**4.92**	**3.97**

Note: Mean followed by a different alphabet in the same column is significantly different based on the DMRT test at " 5%

A combination of vermicompost and mucuna bracteata affected YCP growth. The composition of vermicompost is one reason for this possibility. Based on Table 1, this fertilizer contains various nutrients such as N, P, and C-organic that are needed for plant development. N-total and P-total are much larger than the minimum standard for developing the vegetative phase, especially the leaf character like leaf number and chlorophyll content.

According to Olle (2019), the application of vermicompost on the plant can incline crop production in potato, eggplant, and green pea. Based on some reports, 200 g vermicompost application per plant increased the plant dry weight of young natural rubber (Nugroho and Karyudi, 2006), while 400 – 1200 g vermicompost dose per plant improved all the plant growth on young tea plants including leaf length, width and total leaf yield. (Chaudhuri and Jamatia, 2021). Moreover, vermicompost can improve porosity and aeration in the soil, including for soil with high clay content like Inceptisol (CERİTOĞLU *et al.*, 2018). Arancon and Edwards (2005) supported that the soil composition after applying vermicompost has higher biochemical and physical properties.

Meanwhile, applying *Mucuna bracteata* positively affects plant growth, such as on coconut and oil palm plantations. *Mucuna bracteata* treatment elevated nitrogen content on coconut plantations (Herath *et al.*, 2017). Furthermore, the *Mucuna bracteata* cover crop was depressing the soil erosion and the washing of fertilizer rate on oil palm plantations (Saragi *et al.*, 2020).

Conclusion

The vermicompost application at a dose of 400 g plant^{-1} combined with the planting of *M. bracteata* cover crops gave the highest value on leaf number and the increase of stem diameter, while the best treatment for leaf chlorophyll content was 200 g plant^{-1} vermicompost without LCC. Thus, the application of vermicompost and *Mucuna bracteata* on young cinchona plants was strongly recommended.

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