JSAT
Journal of Science and Agricultural Technology
Research Article
https://doi.org/
e-ISSN 2730-1532, ISSN 2730-1524

Effects of leonardite and nutrient management on growth and yield of cowpea (*Vigna unguiculata* L. Walp.)

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Received: December 25, 2021. Revised: April 19, 2022. Accepted: May 5, 2022.

ABSTRACT

A study on the effects of leonardite and nutrient management on growth and yield of cowpea (*Vigna unguiculata* L. Walp.) was established in the greenhouse from July to October 2021 at the Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, Lampang, Thailand. The experimental design was a completely randomized design (CRD) with nine treatments and ten replications: (1) control, (2) 500 kg/rai leonardite, (3) 1,000 kg/rai leonardite, (4) 500 kg/rai leonardite + 100% chemical fertilizer based on soil analysis, (5) 1,000 kg/rai leonardite + 100% chemical fertilizer based on soil analysis, (6) 500 kg/rai leonardite + 75% chemical fertilizer based on soil analysis, (7) 1,000 kg/rai leonardite + 75% chemical fertilizer based on soil analysis, (8) 100% chemical fertilizer based on soil analysis and (9) 75% chemical fertilizer based on soil analysis. The result showed that the combination of leonardite with chemical fertilizers based on soil analysis affected the vegetative growth and yield of cowpea. The application of 500 kg/rai of leonardite in combination with 100% chemical fertilizer based on soil analysis gave the highest plant height, canopy width, stem diameter, leaf width, leaf length, leaf greenness (SPAD), fresh weight, and dry weight of pod per plant. Therefore, applying leonardite with chemical fertilizers based on soil analysis could enhance cowpea growth and yield.

Keywords: leonardite, nutrient management, cowpea

INTRODUCTION

Cowpea, scientifically known as *Vigna unguiculata* L. Walp, is a type of legume that is easy to grow and can be planted all over the year. The different cowpea varieties are also a source of protein and other nutrients essential for fresh food pods or as dry seeds in the industry (Enyiukwu et al., 2018). Cowpea seeds contain many bioactive compounds: bioactive peptides, dietary fibers, polyphenols, anti-oxidants, some vitamins and minerals that have important nutritional value to human health (Khan et al., 2007; Goncalves et al., 2016; Jayathilake et al., 2018). In Thailand, cowpea is widely grown for fresh vegetable food in the northern and northeastern regions of the country (Benchasri et al., 2014). Department of Agricultural Extension (2019) reported that the situation of the planting year 2018/19, the most planting areas in 5 provinces of Thailand, which are Lampang, Nakhon Ratchasima, Chiang Mai, Surin, and Sakon Nakhon, with 526 rai of total planted area, 384,210 kilograms total yield, 861 kilograms yield per rai and 13.44 Baht selling price per kilogram.

Department of Land Development (2015) reported that the land was used for agriculture with improper management, such as using chemical fertilizers without adding any organic matter or organic fertilizer to the soil. Some areas of the cultivation of the plant were the repeated planting or growing of the same plant for many years. The problem was that the amount of organic matter and soil fertility could be reduced. In addition, most of the soil in Thailand has too low (<1.5 %) to medium (1.5-3.5 %) organic matter. Soil organic matter is essential for water holding, cation exchange capacity, the ability of nutrient release, and absorption of positive ions (Faculty of the Department of Soil Science, 2006; Pompranee, 2017). Leonardite is a natural oxidation product of lignite coal; it is created through the decomposition of plants and animals by chemical and biological processes (Totirakul et al., 2009). Leonardite has high contents of humic substances: fulvic acid, humic acid, and humin (Ratanaprommanee et al., 2016) and also has a large amount of organic matter, high cation exchange capacity, and contains many plant nutrients (Pochadom et al., 2013; Landrot et al., 2020). However, leonardite contains low plant nutrient contents that may not be enough to enhance plant growth and yield. Therefore, this study aimed to evaluate the effects of leonardite and leonardite in combination with chemical fertilizers on the growth and yields of cowpea.

MATERIALS AND METHODS

The effects of leonardite and nutrient management on growth and yield of cowpea were investigated. A cowpea plantation was established in the greenhouse from July to October 2021 at the Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, Thailand. The experiment was assigned in a completely randomized design (CRD) with nine treatments and ten replications as follows:

(1) control
(2) 500 kg/rai leonardite
(3) 1,000 kg/rai leonardite
(4) 500 kg/rai leonardite + 100% chemical fertilizer based on soil analysis
(5) 1,000 kg/rai leonardite +100% chemical fertilizer based on soil analysis
(6) 500 kg/rai leonardite + 75% chemical fertilizer based on soil analysis
(7) 1,000 kg/rai leonardite + 75% chemical fertilizer based on soil analysis
(8) 100% chemical fertilizer based on soil analysis
(9) 75% chemical fertilizer based on soil analysis.

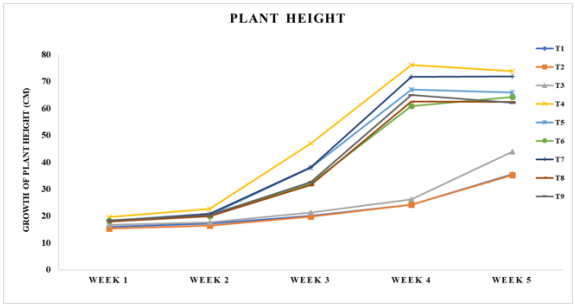
The soil sample of the experimental was collected at a depth of 0-20 centimeters from the Agricultural Technology Research Institute, Rajamangala University of Technology Lanna, Lampang, Thailand, for analysis of some chemical properties. Soil chemical analysis contains the amount of organic matter (% OM) was 0.73, available phosphorus was 2.11 mg $kg^{-1,}$ and extractable potassium contents were 72.63 mg kg^{-1} with the soil pH (1:1) of 7.5. Leonardite was combined with the soil before growing the plants. Cowpea was planted in a pot with a size of 30 x 22.86 centimeters and had a capacity of 8 kilograms of soil per pot. Four seeds were planted per pot in the first week with a 1-2 centimeters depth. Seven days after planting, one healthy plant was left per pot. According to soil analysis results, chemical fertilizer formulas 46-0-0, 0-46-0, and 0-0-60 were mixed and used in the experiment. Fertilizer was applied by the conventional schedule two times during the growing period of cowpea, the first time at 7 days and the second time at 20 days after growing by sowing the soil around 10 centimeters from the stem and covering it with soil. Irrigation was performed with a drip irrigation system. Weed control was carried out by hand depending on weed density.

Measuring attributes of the physiology character of cowpea were recorded from 10 plants per treatment. Plant height, canopy width, and stem diameter were recorded every week after growing until harvesting. Leaf number per plant, leaf width, leaf length, leaf greenness values (SPAD), internode, and peduncle length were recorded during the flowering period. Fresh and dry weight of stems, leave, roots, and pod were harvested and recorded after planting for 56 days. The dry weight was recorded after being kept in the oven at 70 ^{o}C for 72 hours.

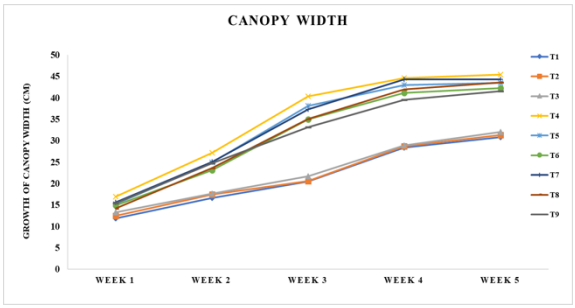
The data were analyzed for variances (ANOVA). Statistical differences with p-values less than 0.05 and 0.01 were considered significant, and the means were compared by Duncan's multiple range test (DMRT).

RESULTS AND DISCUSSION

The combination of 500 kg/rai leonardite with 100% chemical fertilizers based on soil analysis increased plant height, canopy width, and stem diameter at all planting periods after being treated with only leonardite (Figure 1)



a.



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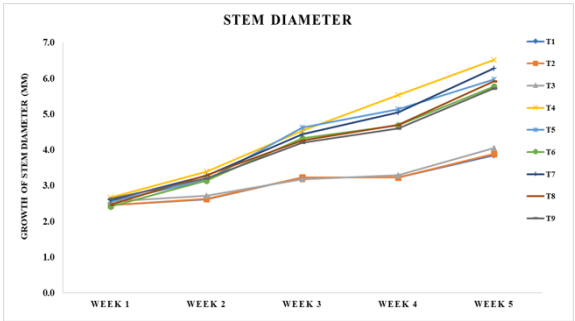

c.

Figure 1. Effect of leonardite and nutrient management on growth of cowpea (a) plant height, (b) canopy width, and (c) stem diameter

The number of leaves, leaf width and length, and leaf greenness (SPAD) were significantly different among the treatments (P≤0.01). The results showed that the highest number of leaves, leaf width and length, and leaf greenness were observed using 500 kg/rai leonardite combined with 100% chemical fertilizers based on soil analysis (Table 1).

During the flowering period, the internode and peduncle length was also significantly different among the treatments (P≤0.01). Internode and peduncle length of plants treated with only leonardite and untreated control was lower than an application with chemical fertilizers and leonardite with chemical fertilizers based on soil analysis (Table 1).

Table 1. Effect of leonardite and nutrient management on growth of cowpea during the flowering period

Treatments	Leaf number	Leaf width (cm)	Leaf length (cm)	SPAD	Internode (cm)	Peduncle length (cm)
Control	5.20^{b}	3.41^{c}	7.83^{d}	50.68^{c}	6.10^{b}	4.20^{b}
Leo 500	5.50^{b}	3.40^{c}	7.84^{d}	51.43^{c}	4.50^{b}	3.79^{b}
Leo 1,000	5.30^{b}	3.69^{bc}	7.90^{d}	52.33^{c}	6.47^{b}	4.70^{b}
Leo 500 + CF 100%	7.30^{a}	4.14^{a}	9.40^{a}	60.67^{a}	10.78^{a}	16.55^{a}
Leo 1,000 + CF 100%	7.00^{a}	3.89^{ab}	8.76^{cd}	58.26^{a}	11.75^{a}	15.22^{a}
Leo 500 + CF 75%	7.10^{a}	4.01^{ab}	8.87^{abc}	56.87^{ab}	10.32^{a}	15.69^{a}
Leo 1,000 + CF 75%	7.40^{a}	4.02^{ab}	9.29^{ab}	59.18^{a}	10.88^{a}	18.72^{a}
CF 100%	7.10^{a}	3.77^{b}	8.62^{c}	57.00^{ab}	12.00^{a}	18.01^{a}
CF 75%	7.00^{a}	3.87^{ab}	9.18^{abc}	53.46^{bc}	11.70^{a}	14.47^{a}
F-test	**	**	**	**	**	**
C.V. (%)	7.30	8.81	7.43	8.18	22.91	32.39

Leo- Leonardite, CF- Chemical Fertilizer, **, significant at P≤0.01 by DMRT

The combination of leonardite with chemical fertilizers based on soil analysis affected the fresh and dry weight of stems, leaves, and cowpea roots. The highest fresh and dry weight stem, leave, and root was obtained from the treatment of 500 kg/rai leonardite in combination with 100% chemical fertilizers based on soil analysis (Figures 2 and 3).

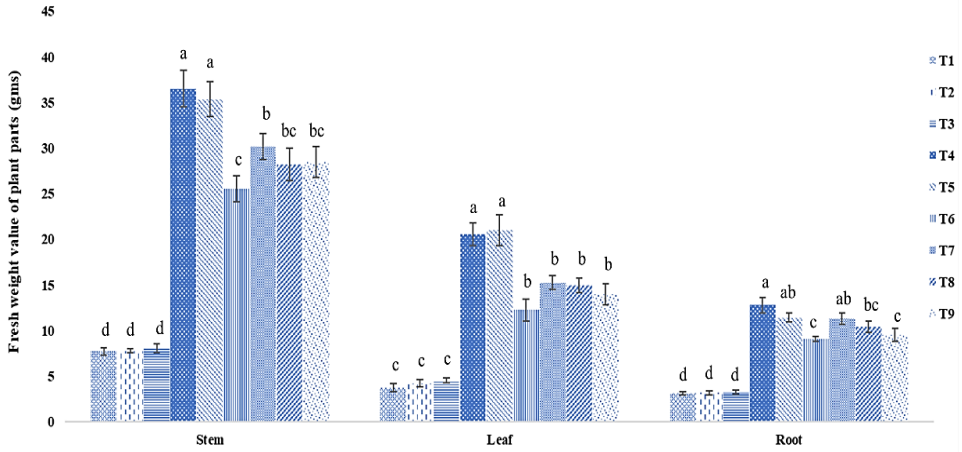

Figure 2. Effect of leonardite and nutrient management on fresh weight of stems, leave, and roots of cowpea

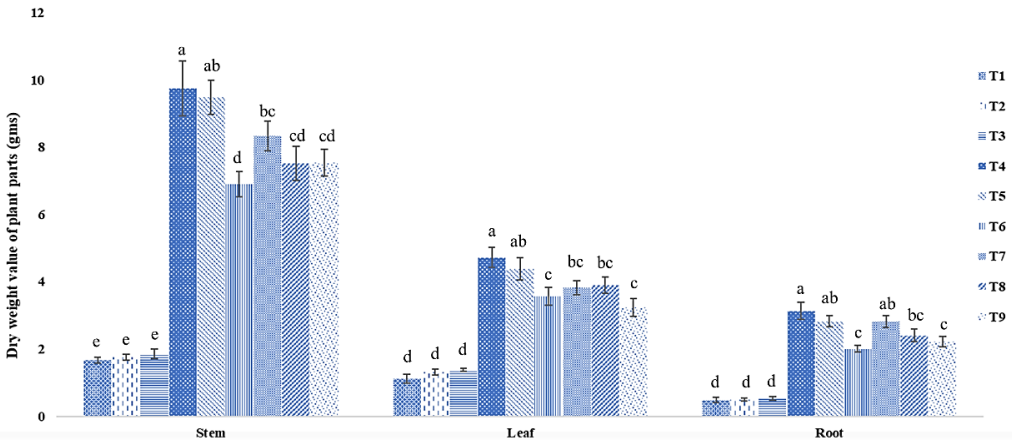

Figure 3. Effect of leonardite and nutrient management on dry weight of stems, leave, and roots of cowpea

The fresh and dry weights of pod per plant were significantly different among the treatments (P≤0.01). Application of 500 kg/rai leonardite with 100% chemical fertilizers based on soil analysis gave the highest fresh and dry weight of pod per plant. (Figure 4).

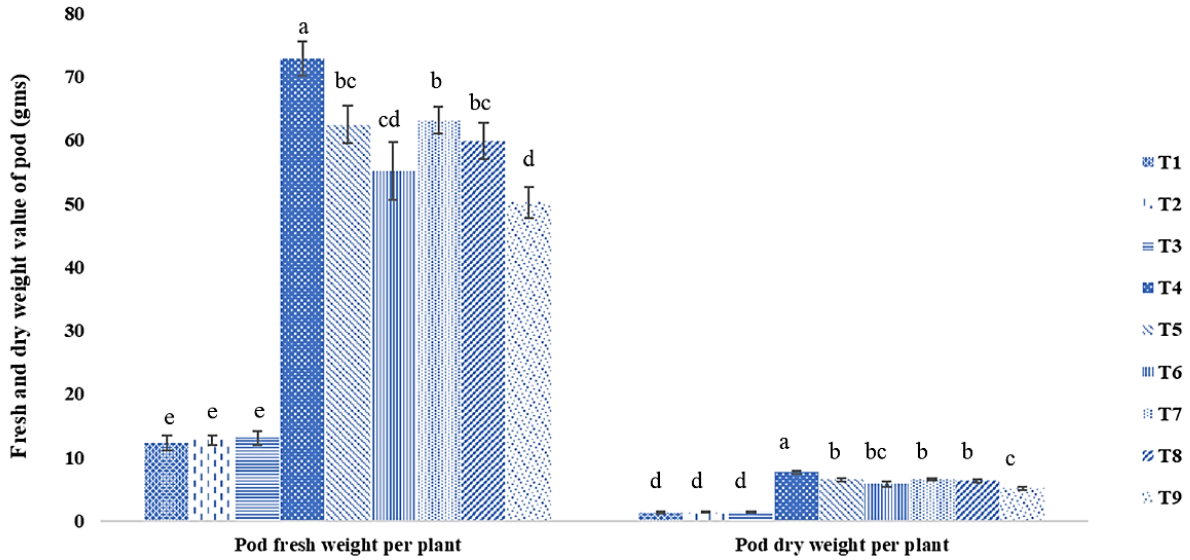

Figure 4. Effect of leonardite and nutrient management on fresh weight and dry weight of pod per plant

The vegetative growth and yield of cowpea treated only with leonardite were lower than those applied with leonardite combined with chemical fertilizers based on soil analysis because leonardite contained low plant nutrient contents (Pochadom et al., 2013). Therefore, leonardite could not replace chemical fertilizers (Totirakul et al., 2009). Rinnarong et al. (2016) reported the vegetative growth and yield of Chinese cabbage in the treatment without leonardite was the lowest among the treatment.

In addition, the vegetative growth and yield significantly increased after leonardite was applied with chemical fertilizers based on soil analysis. The highest plant height, canopy width, stem diameter, leaf width, leaf length, leaf greenness, and fresh and dry weight of pod per plant were received after applying 500 kg/rai leonardite with 100% chemical fertilizers based on soil analysis. The results from this experiment were in agreement with Ngennoy et al. (2014), who reported that humic substances extracted from leonardite mixed with chemical fertilizers enhanced plant nutrient absorption and promoted growth and yield of maize. Sariyildiz (2020) also reported that the most incredible garlic yields were observed when applying leonardite at different doses or the mixture of leonardite with the mineral fertilizer. In addition, leonardite has a high cation exchange capacity (Rittirat, 2017; Pochadom et al., 2013) and has a large amount of organic matter (Totirakul et al., 2009). Soil organic matter enhances water holding capacity and cation exchange capacity, absorption of available nutrients, and increases available plant nutrients and nutrient uptake from soil (Faculty of the Department of Soil Science, 2006; Pompranee, 2017). Sanli et al. (2013) revealed that leonardite could increase available nitrogen, potassium, and phosphorus availability in soil. Thus, applying leonardite and chemical fertilizers based on soil analysis effectively increased the vegetative growth and yield of cowpea.

CONCLUSIONS

The application of 500 kg/rai of leonardite in combination with 100% chemical fertilizer based on soil analysis gave the highest plant height, canopy width, stem diameter, leaf width, leaf length, leaf greenness (SPAD), fresh weight, and dry weight of pod per plant.

ACKNOWLEDGMENTS

The author would like to thank the Agricultural Technology Research Institute Rajamangala University of Technology Lanna, Lampang Province, Thailand, for assisting and supporting this research.

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