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Vegetation Analysis and the Role of Growing Media on the Growth and Yield of *Physalis angulata* L. in Domestication

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ABSTRACT

Background: *Physalis angulata* L. is a member of the Solanaceae family and is known in Indonesia as "ciplukan" which has the potential to be used as a medicinal ingredient because it acts as an immunomodulator and antioxidant. This study aims to analyse the vegetation in the ciplukan growth environment and the role of growing media in domestication efforts on the growth and yield of ciplukan.

Methods: Vegetation analysis using the survey method at the survey locations was selected using a purposive random sampling method. Domestication used a completely randomized design with 1 factor, namely planting media with five levels, namely: Soil media, soil media + goat manure, soil + vermicompost media, soil + husk media, soil + charcoal husk media.

Result: Based on the vegetation analysis, there are 12 grass vegetations with an important value index of 71.270% in Cynodon dactylon grass. Meanwhile, in the analysis of plant vegetation, there was 25 vegetation with the highest relative frequency in *P. angulata*, namely 14.286%. In the analysis of tree vegetation, there were 12 trees, with the highest density being teak, namely 42.553%. Ciplukan growing wild so far, can be domesticated as a cultivated plant. The results of domestication with the treatment of soil + vermicompost growing media can encourage the growth and yield of *P. angulata* plants.

Key words: Important value index, Medicinal plants, Vegetation analysis, Vermicompost.

INTRODUCTION

Physalis angulata L. is one of the Solanaceae family in Indonesia known as "ciplukan" which has the potential as a medicinal ingredient because it acts as an immunomodulator and antioxidant. Ciplukan extract contains total phenols between (0.46-0.51) g^{-1} and antioxidant activity from 1575 $mg.g^{-1}$ to 4311 $mg.g^{-1}$ BHA (Kusumaningtyas *et al*., 2015). Antioxidant activity was positively correlated with phenol content. Phenol is an essential plant constituent because of its ability to scavenge free radicals due to its hydroxyl group (Tien *et al*., 2021; Anh *et al*., 2018). The leaves contain saponins, chlorogenic and flavonoids. The fruit of *P. anggulata* contains phenol, physalin, tannins, cryptoxanthin, ascorbic acid and sugar, while the seeds contain palmitic and stearic acid. The roots contain alkaloids and chlorogenic acids (Jaroslava *et al*., 2018; Pillai *et al*., 2022; Zhan *et al*., 2018). These chemical components are important for treating various diseases such as schistosomiasis, trypanosomiasis, inflammation, malaria, leishmania, asthma and tuberculosis (Abdul-Nasir-Deen *et al*., 2020; Oliveira *et al*., 2020).

Ciplukan is an annual herbaceous plant with a genus of 120 species (Iwansyah *et al*., 2022). The species commonly found is *Physalis angulata* L., native to Brazil and grows wild in all countries. This plant is cultivated commercially in southern Brazil, namely in Rio Grande do Sul (Leite *et al*., 2021; Figueiredo *et al*., 2020; Ramos *et al*., 2021). Ciplukan plants are widely distributed worldwide, namely in tropical and subtropical areas. However, ciplukan in Indonesia is a weed that is rarely cultivated. Ciplukan grows wild with a height of approximately 0.5-1.0 meters. This plant thrives in the lowlands to an altitude of 1,550 meters above sea level, spread over dry land and can be found in teak forests (Pinto *et al*., 2016). The flowers of *P. angulata* are yellow and the fruit is protected by a hood or petal called the calyx. Genetic and environmental factors or growing locations influence chemical compounds and pharmacological activities in plants (Vieceli *et al*., 2021). So that efforts are needed to domesticate ciplukan in Indonesia.

Plant domestication is an evolutionary process mediated by manufactured selection and evolutionary forces in plant populations (Montero *et al*., 2021). Domestication supports compatibility in cultivated plants through changes in their survival, reproductive strategies and several reproductive parameters associated with domestication (McKerrow *et al*., 2021). The treatment of plant spacing and chicken manure and chemical fertilizers in the domestication of *P. angulata* shows that the wider the spacing, which is 40 × 60 cm, can increase the number and weight of fruit

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planted by up to 463-843% (Zawani and Nikmatullah, 2021). Domestication with organic chicken fertilizer and a dose of 0.2 g/polybag produced the highest leaf growth and plant biomass (Indriani *et al*., 2022). The chemical fertilizer type composition of 20 tons/ha and 60 kg/ha of cow manure produced the highest number of fruit and fruit weights in *P. angulata* domestication (Oliveira *et al*., 2023). There are no differences in morphology and physiology between *P. angulata* plants that grow wild and those that have been domesticated (Goecke *et al*., 2020). Differences in the location do not show the morphological and physiological characteristics of the plant and if cultivated can have a production per hectare of 11-14 and up to 28 t ha^{-1}. Variations in vegetative and fruit traits show a broad genetic basis in *P. angulata* (Saavedra *et al*., 2019). Domestication is also an effort to conserve biodiversity, emphasizing the potential long-term evolutionary consequences of species loss. Several recent studies warn of potential ecosystem disturbances due to species loss (Lazzaro *et al*., 2020). This study examines the analysis of vegetation in the ciplukan growth environment and the role of growing media in domestication efforts on ciplukan growth and yield.

MATERIALS AND METHODS

The research was carried out in the Sukoharjo and Karanganyar areas with locations of 6 plots namely Jatimalang Village (134 meters above sea level, 7°35′42″S and 110°53′01″E), Gementar (507 meters above sea level, 7°40′35″S and 111°02′30″E and 7°40′35″S and 111°02′31″E), Bandardawung (802 meters above sea level, 7°40′17″S and 111°066′01″E), Nglebak (890 meters above sea level, 7°39′47″S and 111°06′48″E) and Matesih road (345 masl, 7°37′11″S and 111°00′59″E).

Domestication was carried out from June 2021 to August 2021 in the greenhouse of the Experimental Laboratory of the Faculty of Agriculture, Sebelas Maret University, Sukosari Village, Jumantono, Karanganyar, Central Java with an altitude of 196 meters above sea level and coordinates 7°37′8″S and 100°56′52″E. This study used a survey method, the survey location was selected using a purposive random sampling method. The determination of the sample plots and the vegetation analysis used was the transect method. Transect lines were made of observation plots of 20 × 20 meters (tree vegetation), 5 × 5 meters (herbs/shrub vegetation) and 1 × 1 meter (grass vegetation). The variables observed were: plant density, relative density, frequency, refative frequency, dominance, relative dominance, important value index, distribution pattern and diversity index. Vegetation analysis data was carried out descriptively.

The design used in domestication was a completely randomized design with 1 factor, namely planting media in five treatments and 5 replications. Planting media factors with a ratio of 1:1 are: soil without mixture, soil + goat manure, soil + vermicompost, soil + husk, soil + husk charcoal. Plants were planted using polybags with growing media according to the treatment. Variables observed in domestication were: plant height, number of leaves, root length, number of flowers, number of plants, fruit weight, plant fresh weight, plant biomass. Harvesting is done after the ciplukan is 6 weeks after planting. Vegetation data with descriptive analysis and domestication data were analyzed using analysis of variance with a level of 5% if significant further testing with 5% DMRT.

RESULTS AND DISCUSSION

Vegetation analysis of ciplukan original habitat

Vegetation analysis is a method used to determine the distribution of various species in a habitat (Munroe *et al*., 2021). Short non-woody plants are called grasses. Grass is often found as ground cover vegetation. The results of the analysis of grass vegetation at the research site showed that the highest relative density value was found in creeping grass (*Festuca rubra*) with a value of 30.496% so that this grass was found more often than other types of grass. Wudelan grass (*Cyperus kyllinga*) has the lowest relative density value of all grass vegetation, namely 0.709% (Table 1). The highest relative frequency was found in grintingan (Cynodon dactylon) with a value of 26.667% while other types of grass had the same value of 6.667%. The distribution of grintingan (Cynodon dactylon) is wider than other grass types.

The results in Table 1 show that the distribution pattern of all species is uniform except for the creeping grass (Festuca rubra), which is clustered. Creeping grass is clustered because it has a V/M value >1 while other species are uniform because the V/M value is <1. A uniform distribution pattern can be produced from high or low frequency values as well as a clustered distribution pattern. The value of the diversity of grass vegetation at the research site is moderate because it has a total h value of 1,994. The amount of diversity (H') is said to be moderate if the total value is 1≤H′≥3.

This analysis aims to determine which herbaceous plants or shrubs have a high ability to play a role in an environment or community. The herbaceous vegetation or shrubs at the study site contained 25 plant species. The results of the analysis obtained were the highest relative density of sidaguri (*Sida acuta*) with a value of 17.226% so that this plant was found more often than other types. The smallest value was found in sawdust (*Serratula tinctoria*) and kesum (*Persicaria odorata*) with the same value of 0.224%. The highest relative frequency was found in ciplukan (*Physalis angulata*) which was 14.286% (Table 2).

Trees are included in plant vegetation other than grass, herbs and shrubs. Trees are plants whose trunks are woody and grow large. The results of Table 3 value density and the highest relative dominance of tree vegetation are owned by teak, namely 42.553% and 79.84%, respectively. Tree vegetation is a large group because it has a larger size than grass, herbs and shrubs. Teak is categorized in groups because the results of the calculation of V/M>1 are 2.432. The tree vegetation diversity index is included in the medium category because it has a value of 1,929 (1≤H′3). Density is

the number of each individual in the species present in the sample plot. Relative density describes the number of individuals of each species found in the plot (Pujiasmanto and Rumia Manurung, 2022). A high relative density value can be interpreted as the number of individuals of each species found in the research location and vice versa. While the frequency is the number of occurrences of each species in the plots that have been made. The relative frequency describes the size of the distribution of a species. The larger the value, the wider the species distribution and vice versa.

Dominance serves to determine how much influence species have with each other in an ecosystem. The plant

Table 1: Analysis of grass vegetation at the research sites.

Latin name	RD	RF	RD	IVI	v/m	Distribution patternn	H'
Cyperus rotundus	17.021	6.667	1.292	24.980	0.834	Uniform	0.301
Digitaria ischeum	9.929	6.667	1.247	17.843	0.486	Uniform	0.229
Oplismenus undulatifolius	2.837	6.667	6.929	16.433	0.139	Uniform	0.101
Brachiaria decumbens	5.674	6.667	6.515	18.856	0.278	Uniform	0.162
Cyperus odoratus	0.709	6.667	5.351	12.727	0.035	Uniform	0.035
Cynodon dactylon	19.149	26.667	25.454	71.270	0.938	Uniform	0.316
Eleusine indica	4.255	6.667	6.515	17.437	0.209	Uniform	0.134
Axonopus compressus	1.418	6.667	1.247	9.332	0.07	Uniform	0.060
Leersia virginica	2.128	6.667	0.159	8.953	0.104	Uniform	0.082
Cyperus kyllinga	1.418	6.667	0.229	8.314	0.07	Uniform	0.061
Festuca rubra	30.496	6.667	5.351	42.514	1.494	Group	0.362
Digitaria ternata	4.965	6.667	39.710	51.341	0.243	Uniform	0.149

Information: RD = Relative dominance (%), RF = Relative frequency (%), RD = Relative density (%), IVI = Important value index, v/m = Distribution pattern value, H' = Diversity value.

Table 2: Analysis of vegetation of herbs or shrubs at the research sites.

Latin name	RD	RF	RD	IVI	v/m	H'
Physalis angulata	2.908	14.286	11.896	29.09	0.297	0.249
Spigelia anthelmia L.	2.237	2.381	1.997	6.615	0.228	0.161
Commelina benghalensis	1.566	2.381	2.103	6.05	0.16	0.192
Synedrella nodiflora	11.633	2.381	1.329	15.343	1.187	0.153
Phyllanthus urinaria	12.081	4.762	1.743	18.585	1.233	0.134
Sida acuta	17.226	7.143	7.168	31.537	1.758	0.219
Achyranthes aspera	2.013	2.381	12.218	16.613	0.206	0.278
Ageratum conyzoides	9.396	9.524	3.429	22.349	0.959	0.177
Crassocephalum crepidioides	1.790	4.762	0.343	6.895	0.183	0.077
Amaranthus	0.447	2.381	1.792	4.62	0.046	0.157
Mimosa pudica	10.067	4.762	2.844	17.673	1.028	0.155
Eleuthoranthera ruderalis	2.461	2.381	0.234	5.075	0.251	0.072
Bidens pilosa	0.895	2.381	1.893	5.169	0.091	0.151
Solanum nigrum	0.671	4.762	1.416	6.849	0.069	0.144
Persicaria odorata	0.224	2.381	0.796	3.401	0.023	0.114
Satureja montana	3.579	2.381	0.700	6.660	0.365	0.114
Serratula tinctoria	0.224	2.381	0.183	2.788	0.023	0.069
Ipomeae batatas	7.606	4.762	6.115	18.483	0.776	0.208
Zea mays	2.461	4.762	32.795	40.017	0.251	0.338
Arachis hypogaea	4.922	4.762	1.203	10.887	0.502	0.119
Deschampsia cespitosa	1.566	2.381	1.163	5.11	0.16	0.132
Urtica diocica	2.013	2.381	2.103	6.498	0.206	0.192
Cleome viscosa	0.447	2.381	0.271	3.099	0.046	0.079
Choromolaena odorata	0.671	2.381	3.597	6.649	0.069	0.134
Oxalis barrelierei	0.895	2.381	0.669	3.945	0.091	0.114

Information: RD = Relative dominance (%), RF = Relative frequency (%), RD = Relative density (%), IVI = Important value index, v/m = Distribution pattern value, H' = Diversity value.

Table 3: Analysis of tree vegetation at the research site.

Local name	Latin name	RD	RF	RD	IVI	v/m	H'
Jati	*Tectona grandis*	42.553	7.692	79.840	130.086	2.432	0.363
Kanon	*Couroupita guianensis*	2.128	5.882	0.200	8.210	0.122	0.081
Mangga	*Mangifera indica*	2.128	5.882	0.200	8.210	0.122	0.081
Jambu biji	*Psidium guajava*	2.128	5.882	0.200	8.210	0.122	0.081
Waru	*Hibiscus tiliaceus*	4.255	5.882	0.798	10.936	0.243	0.134
Lamtoro	*Leucaena leucocephala*	12.766	5.882	7.186	25.834	0.73	0.262
Mahoni daun lebar	*Swietenia mahagoni*	2.128	5.882	0.200	8.210	0.122	0.081
Johar	*Senna siamea*	12.766	5.882	7.186	25.834	0.73	0.262
Kersen	*Muntingia calabura*	4.255	5.882	0.798	10.936	0.243	0.134
Pinus	*Caribbean pine*	4.255	5.882	0.798	10.936	0.243	0.134
Nangka	*Artocarpus heterophyllus*	6.383	11.765	1.796	19.944	0.365	0.175
Kelapa	*Cocos nucifera*	4.255	5.882	0.799	10.937	0.243	0.134

Information: RD = Relative dominance (%), RF = Relative frequency (%), RD = Relative density (%), IVI = Important value index, v/m = Distribution pattern value, H' = Diversity value.

Table 4: Plant height, number of leaves ciplukan 6 weeks after planting.

Treatment	Plant height (cm)	Number of leaves (strands)
Soil	14.84a	27a
Soil + goat manure	25.24b	130b
Earth + vermicompost	27.80b	158c
Soil + husk	18.35a	27a
Soil + husk charcoal	20.54c	40a

Note: Numbers followed by the same letter notation indicate not significantly different in the 5% DMRT.

Table 5: Number of flowers, fruit and weight of ciplukan fruit per plant.

Treatment	Number of flowers	Number of fruit	Weight fruit
Soil	10a	7a	2.788a
Soil + goat manure	17b	38b	48.748b
Earth + vermicompost	26c	55c	58.122b
Soil + husk	7a	7a	4.406a
Soil + husk charcoal	10a	11a	11.47c

Note: Numbers followed by the same letter notation indicate not significantly different in the 5% DMRT.

area and plot area affected the relative dominance value (Winter *et al*., 2018). The significance index of a species describes the role of a species in its environment. The greater the important value index according to Nesbitt *et al* (2019) means that the plant has an important role in an ecosystem (Nesbitt *et al*., 2019). The value of the diversity of herbaceous vegetation or shrubs at the study site is high because it has a total H value of 3.931. The diversity of H' is said to be high if the total value of H'>3. Species diversity is one of the factors to state the community structure (Rhif *et al*., 2021). The value of H' also describes community stability, namely the community's ability to protect itself remains stable even though there are disturbances in its components (Zhou *et al*., 2020).

Domestication of ciplukan

The temperature in the greenhouse is 34-38 C. Light intensity 12930-15700 lux. Soil belongs to the type of alfisol. The soil is acidic because the pH value is 5.29 (pH 6.5) and the moisture content is 10.1%. The C-organic value of this soil is 2.25% and organic matter is 3.92%. Organic matter has a role in increasing the availability of nutrients, fertility and increasing the population of soil microorganisms (Vuković *et al*., 2021). The results showed that the planting medium had an effect on the height and number of leaves of ciplukan plants (Table 4). The lowest height with a value of 14.84 cm in the soil media treatment. This shows that ciplukan can grow with soil media without fertilizer. However, with the addition of organic vermicompost fertilizer, the highest plant yield was 27.80 cm. The lowest number of leaves was found in the soil media and soil + husk media. While soil treatment + vermicompost fertilizer showed the highest number of leaves, which was 158 strands. This is because vermicompost can improve soil structure and stabilize soil aeration. Worm fertillizer contains nutrients (N, P, K and Ca) and *Azotobacter sp* (N-fixing bacteria) which can help plant growth. If the nutrients are sufficient, the plant growth will be faster (Mahmud *et al*., 2018).

The results showed that the planting medium affected the number of flowers, fruit and fruit weight (Table 5). The highest average number of flowers and fruits was found in the treatment of soil planting media: vermicompost, namely 26 flowers and 55 fruits. Based on the results of the study, the number of flowers and the number of fruit in the soil treatment was not significantly different from that of soil: husk and soil: husk charcoal. The lowest fruit weight was 2.788 g in soil planting media treatment and the highest fruit weight was 58.122 g in soil media treatment: vermicompost. Plants that have a small number of fruit, the volume and weight of the fruit per unit are greater.

Planting media had a significant effect on root length (Table 6). The longest root length was found in the soil treatment: husk charcoal, which was 23.36 cm. Husk

Table 6: Root length, plant fresh weight and plant biomass.

Treatment	Root length (cm)	Plant fresh weight (g)	Plant biomass (g)
Soil	19ab	10.28a	1.05a
Soil + goat manure	16.6b	148.6b	13.128b
Earth + vermicompost	14.4b	183.4b	19.094c
Soil + husk	14.8b	10.8a	1.056a
Soil + husk charcoal	23.36a	29.6c	2.98d

Note: Numbers followed by the same letter notation indicate not significantly different in the 5% DMRT.

charcoal acts as an organic material to fertilize the soil. While the soil treatment: husks showed the shortest root length, which was 14.4 cm. The cause of the increase in root length according to Ardiansyah (2017) occurs because the roots try to reach deeper places to find water sources. The results showed that the growing media had an effect on fresh weight and plant biomass (Table 6). Soil media showed the lowest fresh weight and biomass, namely 10.28 g and 1.05 g. Meanwhile, fresh weight and high biomass in soil: vermicompost were 183.4 g and 19,094 g, respectively. This is due to the availability of nutrients that play a role in the biomass of a plant. Sufficient nutrients will increase the biomass of a plant.

The results of the study that the ciplukan plant which has been growing wild so far can be domesticated as a cultivated plant. This needs to be done considering that this plant has the potential as a medicinal plant, so its existence needs to be protected and its production increased as pharmaceutical raw material (Purugganan, 2019). Domestication is the adoption of plants and animals from wild life into the environment of human daily life (Tomar *et al*., 2021). Domesticated plants will experience changes in both their shape and character. The domestication process is to tame biota to human condition with its needs and capacities (Farooq *et al*., 2021). The growing environment is an important factor because it is related to plant growth and production. Domestication was carried out in this study by using a variety of growing media. Planting media has an effect on the growth of ciplukan leaves. Based on the results of the study showed that soil:vermicompost media was able to encourage growth and yield of ciplukan. This is because vermicompost contains nutrients N, P, K, Ca, Mg, S, Fe, Mn, Al, Na, Cu, Zn, Co and Mo so that vermicompost can improve soil structure and stabilize soil aeration (Hu *et al*., 2021). Vermicompost contains nutrients (N, P, K and Ca) and *Azotobacter* sp (N-fixing bacteria) which can help plant growth. If the nutrients are sufficient, the plant growth will be faster. Element N is one of the content contained in vermicompost. The benefits of element N are to encourage the development of stems, leaves and vegetative growth of plants (Srivastava *et al*., 2020).

The results showed that soil treatment: vermicompost produced the highest number of fruits and fruit weight. While the lowest number of ciplukan fruit was found in the treatment of soil and soil: husk, which was 7 pieces. The number of fruits is affected by the leaves and flowers. The leaves will carry out the process of photosynthesis where the more leaves, the more photosynthetic results (Morales *et al*., 2020). The results of this photosynthesis will be distributed to help the process of forming flowers and fruit. The heaps of plant photosynthesis are stored in fruit and efforts to optimize photosynthetic results require organic materials and sufficient water for plants (Karmegam *et al*., 2021). The soil media treatment caused the lowest fruit weight to be 2,788 gr. The decrease in fruit size with the number of fruits was caused by insufficient photosynthesis to increase fruit size (Li *et al*., 2018). While the soil treatment: vermicompost had the highest fruit weight, which was 58,122 gr. Vermicompost has a high organic C content and that increasing microorganisms is the soil formed with worm droppings. Increased soil fertility makes plant growth and yields better (Blouin *et al*., 2019).

Soil media: vermicompost also showed the highest wet weight supported by the nutrient content of vermicompost. The availability of nutrients plays a role in the biomass of a plant. Sufficient nutrients will increase the biomass of a plant. The application of organic fertilizers increases the available nutrients, the nutrients absorbed by plants affect the growth of wider leaves (high photosynthesis) (Yatoo *et al*., 2021). The results of photosynthesis are used for the development of stem cells, leaves and roots (Jannoura *et al*., 2014).

CONCLUSION

Based on the vegetation analysis that there are 12 grass vegetation with an important value index of 71.270% in *Cynodon dactylon* grass. While the analysis of herbal vegetation contained 25 vegetation with the highest relative frequency found in ciplukan (*Physalis angulata*) which was 14.286% and tree vegetation analysis contained 12 trees with the highest density being teak, which was 42.553%. Ciplukan which have been growing wild so far can be domesticated as cultivated plants. The results of domestication with planting media treatment that soil media+vermicompost can encourage growth and yield of ciplukan.

Conflict of interest: None.

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