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Domestication of Ciplukan (*Physalis angulata* L.) from Three Altitudes Using Watering Treatment

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ABSTRACT

Ciplukan (*Physalis angulata* L.) is a plant that is often considered a weed but contains secondary metabolites that can be used as traditional medicine. This supports the domestication of ciplukan at various altitudes using watering treatments. The research aims to examine the growth and yield of ciplukan from various heights for domestication using watering treatments. The research used a complete factorial randomized block design with 2 factors, namely the height of the seed origin and the watering volume. The altitude factor consists of three levels, namely lowland, medium land and highland. Watering volume factor with four levels, namely 100%, 75%, 50%, and 25% field capacity. The treatment of the height of the seed origin has an effect on plant biomass, namely that the highland seed origin shows the highest plant biomass. Watering volume affects plant height, number of leaves, root length, fresh weight and plant biomass. The growth and yield of ciplukan decreases as the watering volume decreases. The combination of treatment from midland seeds with a watering volume of 25% showed the lowest plant height. Domestication of ciplukan shows that the height of the seed origin and the volume of watering have a significant influence on the growth and production of ciplukan.

1. INTRODUCTION

Ciplukan (*Physalis angulata* L.) is a wild herbaceous plant often considered a weed. In Indonesia, this plant is also known as "ground cherry" or "ceplukan" is a plant that has been used in traditional medicine in several cultures [1, 2]. This plant has many potential medicinal properties because it contains various secondary metabolite compounds. The content of secondary metabolites with medicinal properties can be found in the roots, stems, leaves, fruit, and skin, as well as ciplukan seeds [3, 4]. The metabolites contained in these plant parts include vitamin C, citric acid, tannins, saponins, flavonoids, chlorogenic acid, elaidic acid, and other chemical contents [3-7]. Ciplukan has antioxidant activity in the 1,1-diphenyl-2-picrylhydrazyl test with the types of compounds identified, including alkaloids, flavonoids, steroids, and saponins [8, 9]. Several scientific studies have been conducted to identify the potential content of ciplukan in warding off influenza viruses or other diseases [10-13]. The diverse secondary metabolite content of ciplukan can be utilized by the community through cultivation activities [14].

Efforts to increase the population of ciplukan can be done by domestication. Domestication can be interpreted as a stage of plant selection to obtain plants that can adapt to specific environmental conditions, especially in the daily human environment [15, 16]. Domestication was carried out on ciplukan from various heights to determine its response to new field conditions [17, 18]. Ciplukan has high adaptability so it can be found in almost all regions in Indonesia with diverse topography, namely growing at an altitude of 0 to 1600 meters above sea level. Ciplukan plants require a temperature of 20-25°C with high humidity and full sunlight. However, the formation of secondary metabolite compounds in ciplukan plants involves various complex biosynthetic pathways that are influenced by various factors, including genetics, environment and nutrition [19-21]. Differences in height can produce seeds of different quality [22]. Altitude is a determining factor that impacts morphological diversity, leading to alterations in the arrangement of vegetation and the spread of plant species [23, 24].

One of the critical factors to fulfill in plant cultivation technology is water availability for plants. Water stress can cause a decrease in plant biomass and an increase in secondary metabolites, which are helpful as medicinal ingredients [25, 26]. Water deficit treatment of up to 25% field capacity can reduce plant growth and yield due to a decrease in photosynthetic pigments, but water deficit treatment can increase secondary metabolite activity [27, 28]. Watering volume treatment is an effort to determine the stress level of ciplukan plants on water volume to support growth and production of secondary metabolites. Ciplukan that grow at various altitudes have the potential to have different abilities in absorbing and utilizing available water [29]. The research aims to study the growth and yield of ciplukan from various altitudes using watering treatments.

2. MATERIALS AND METHODS

The research was carried out in December 2022-February 2023 in the Greenhouse, Faculty of Agriculture, Sebelas Maret University, Indonesia with coordinates 7°33'41.7"S and 110°51'32.4"E and an altitude of 96 meters above sea level. The air temperature in the greenhouse is around 25-39℃, air humidity is 60-95%, light intensity was 1202 lux and average rainfall during the research based on PUPR BBWS Bengawan Solo is 369.67 mm. The condition of the alfisol soil used in the study is that it has a total nitrogen value of 0.96%, available phosphate 2.77 ppm, available potassium 0.63 me/100 g of soil, pH 6.09, moisture content 17.45%, CEC 24.7 me/100 g soil, C-organic 3.27%, organic matter 5.62%, and C/N ratio 3.4.

The tools and materials in this research are seedling trays, polybags, measuring cups, analytical scales, oven, camera, ciplukan seeds, alfisol soil, manure and water. The study used a factorial complete randomized block design with two treatment factors. This design was chosen because this research was carried out in a greenhouse with environmental conditions that were not homogeneous and used different treatments of seed origin. The first factor is the height of the place of origin of the seeds which consists of three levels, namely: lowlands (< 400 meters above sea level (masl)), medium plains (400–800 masl) and highlands (> 800 meters above sea level). The second factor is the watering volume with four levels, namely 100%, 75%, 50% and 25% field capacity. This was repeated three times.

The research implementation included seed preparation by taking seeds from ciplukan that grows at three heights, sowing the seeds, preparing planting media with soil and cow dung fertilizer in a ratio of (1:1). Planting is carried out using seeds that are four weeks old after sowing. Planting was carried out using polybags measuring 30 × 30 cm with a distance between polybags of 40 × 50 cm. Next, water treatment and maintenance are carried out. Water supply calculations use the field capacity formula, namely:

$$\text{Field capacity} = (b-c)/(c-a) \times 100\%$$

where,

a = weight of weighing bottle

b = initial weight of soil and weighing bottle

c = weight of soil and weighed bottle after oven

The variables observed were plant height, number of leaves, root length, plant fresh weight, and plant dry weight. Observation variables were carried out when the plants were 8 weeks after planting (WAP). This observation data was analyzed using Analysis of Variance (ANOVA), and if there was a real effect, it was continued with the Duncan Multiple Range Test (DMRT) of 5%.

3. RESULTS AND DISCUSSION

3.1 Plant height

The results showed that the height of the seed origin had no effect on plant height. These results show that ciplukan plants have high adaptability so that differences in seed origin have the same growth potential. However, watering volume treatment affected plant height. Plant height decreases as watering volume decreases. This is because water is an important factor in the process of photosynthesis and nutrient transport in plants [30, 31]. Watering with sufficient water volume, plants can absorb nutrients more efficiently through the roots and transport them to the top of the plant, including stems and leaves. This will allow plants to grow well and reach optimal height because sufficient nutrition supports cell growth and overall plant structure.

The interaction between the height of the place where the seeds originate and the volume of watering has a significant effect on the height of the ciplukan plant (Table 1). The combination of seed treatment from low and high altitudes with a watering volume of 25% showed results that were not significantly different from the treatment with a watering volume of 50%. This shows that seeds from low and medium altitudes can survive and adapt to drought levels of up to 25% of field capacity. However, the combination of seed treatment from medium height with a watering volume of 25% showed the lowest plant height. This is because the amount of water given may not be sufficient for the plant's needs for optimal growth. The results of this research indicate that internal factors that can influence the response to plant height growth are genetics and food reserves in seeds which regulate the ability of seeds to grow [32, 33]. Different altitudes will produce seeds that have other internal characteristics depending on the plant's genetics and growing environmental factors [34, 35]. An adequate amount of water for plants is an external limiting factor that also influences plant growth, so it must be met by providing moisture [36, 37]. Seeds that are of good quality and come from different heights, accompanied by providing sufficient water, can produce plants with better plant height. Quality seeds with sufficient food reserves can grow plants with high water absorption capacity and resistance to drought conditions.

Table 1. Height of ciplukan plants (cm) at 8 WAP with several heights of origin of seeds and volume of water application

Height of Seed Origin (masl)	Field Capacity				Average
	100%	75%	50%	25%	
0-400	51.39 ab	34.39 cde	47.72 abc	34.17 cde	41.92
401-800	57.56 a	50.72 ab	47.67 abc	19.50 e	43.86
>800	57.17 a	54.22 ab	40.94 bcd	28.33 de	45.17
Average	55.37 a	46.44 b	45.44 b	27.33 c	

Note: Numbers followed by the same letter on the same line indicate that they are not significantly different according to DMRT 5%.

3.2 Number of leaves

The results showed that the height of the seed origin had no effect on the number of plant leaves. However, watering volume treatment affected the number of plant leaves (Table 2). Watering volume at 100% field capacity showed the highest number of leaves, namely 46.93 pieces. Leaf growth was reduced in the lower watering volume treatment, namely

75% -25%. This is because lack of water can reduce cell turgor so that the plant's metabolic capacity becomes low. Conditions of lack of water can cause osmotic stress and toxic ions, causing a biophysical response in plants, namely inhibiting cell growth and development, thus affecting the number and size of plant leaves [38, 39]. One of the plant adaptations to water deficit conditions is to shed leaves to reduce the respiration rate so that the plant can survive in these conditions. Plants will change the direction of their growth so that the photosynthesis process becomes more efficient, namely by reducing leaf growth and stimulating root growth to absorb water and nutrients [40-42].

Table 2. Number of ciplukan leaves (strands) at 8 WAP with several heights of seed origin and volume of water application

Height of Seed Origin (masl)	Field Capacity				Average
	100%	75%	50%	25%	
0-400	30.67	20.11	23.11	6.67	20.14
401-800	48.11	37.67	31.22	1.11	29.53
>800	62.00	51.56	44.78	4.44	40.69
Average	46.93 a	36.44 b	33.04 b	4.07 c	

Note: Numbers followed by the same letter on the same line indicate that they are not significantly different according to DMRT 5%.

3.3 Root length

The results showed that the height of the seed had no effect on root length. However, watering volume affected root length (Table 3). Water stress has a notable inhibitory effect on the growth of plant roots. It can result in slower root growth, shallower roots, or root mortality. The reduced capability to absorb water and nutrients due to water stress hampers root development [43]. Under such conditions, plants may prioritize essential functions like maintaining leaf turgor pressure over root growth. Prolonged water stress ultimately diminishes root biomass, leads to shallower root systems, and negatively impacts overall plant health and productivity [44]. The watering volume of 100% field capacity showed the highest root length, namely 24.58 cm. However, root length at 100% watering volume was not different from 50% watering volume. This shows that the roots will get longer in the initial dry conditions so that the roots can get water. However, in prolonged dry conditions, the roots will shrink, changing shape and reducing their ability to grip the soil. This condition is triggered because the rate of photosynthesis decreases so that less photosynthesis is produced for root growth. Ciplukan requires a sufficient volume of water to allow root growth [45, 46]. Continuously low water volume can cause stunted root growth of ciplukan. This is in line with this research which shows that a watering volume of 25% shows the lowest root length, namely 16.33 cm. This is because root length can be hampered due to limited root growth area. Drought stress conditions, the soil becomes dry so that the roots cannot penetrate and causes the root tips to die. Sufficient water volume can keep the physical properties of the soil loose so that the roots can grow well [47].

Table 3. Length of ciplukan roots (cm) with several heights where the seeds originate and the volume of water applied

Height of Seed Origin (masl)	Field Capacity				Average
	100%	75%	50%	25%	
0-400	24.16	12.56	16.99	17.20	17.73
401-800	22.16	14.82	22.79	13.97	18.43
>800	27.42	22.40	20.57	17.83	22.06
Average	24.58 a	16.59 b	20.11 ab	16.33 b	

Note: Numbers followed by the same letter on the same line indicate that they are not significantly different according to DMRT 5%.

3.4 Fresh weight

The height of the place where the seeds originate does not have a significant effect on the fresh weight of the ciplukan plant. Watering volume had a significant effect on plant fresh weight (Table 4). The highest fresh plant weight in the watering volume treatment of 100% field capacity was 13.96 g and was significantly different from the other treatments. This shows that 100% watering volume is better in increasing overall plant photosynthesis so that plants have a higher weight. Water plays an important role in determining the rate of photosynthesis which can accelerate plant growth if its needs are met. The results of this study showed that root weight decreased with reduced watering volume. A water volume of 25% of field capacity produced the lowest fresh weight compared to other treatments because the growth of other parts also showed the lowest results. A limited amount of water can reduce growth speed so that it can reduce the fresh and dry weight of plants [48, 49].

Table 4. Fresh weight of ciplukan (g) with several altitudes where the seeds originate and the volume of water applied

Height of Seed Origin (masl)	Field Capacity				Average
	100%	75%	50%	25%	
0-400	12.75	5.11	8.74	3.41	7.50
401-800	16.49	8.04	8.15	2.87	8.89
>800	12.66	11.19	7.64	5.79	9.32
Average	13.96 a	8.11 b	8.18 b	4.02 c	

Note: Numbers followed by the same letter on the same line indicate that they are not significantly different according to DMRT 5%.

Table 5. Biomass of ciplukan plants (g) with several altitudes where the seeds originate and the volume of water applied

Height of Seed Origin (masl)	Field Capacity				Average
	100%	75%	50%	25%	
0-400	1.04	0.42	0.69	0.47	0.65 b
401-800	0.98	0.68	0.66	0.38	0.68 b
>800	1.12	1.17	0.86	0.54	0.92 a
Average	1.05 a	0.75 b	0.74 b	0.46 c	

Note: Numbers followed by the same letter on the same line indicate that they are not significantly different according to DMRT 5%.

3.5 Plant biomass

The height of the seed origin and the volume of watering influence the biomass of ciplukan plants (Table 5). Plant biomass refers to the total amount of organic material produced by plants through photosynthesis. This biomass includes all parts of the plant, such as roots, stems, leaves, and fruits. It is a crucial component of ecosystems as it serves as a source of energy and nutrients for various organisms [50-54]. Ciplukan seeds originating from the low and medium plains showed biomass that was not significantly different. However, ciplukan seeds originating from the lowlands showed the highest plant biomass. This shows that plants originating from the highlands have better seed quality for the growth of plant organs so they can produce better dry weight. Ciplukan is included in plants with the C3 photosynthesis type which has a more efficient photosynthesis rate in places with low air temperature and humidity with sufficient light intensity [31, 32]. Plant stomata will close when the air temperature is hot and dry, thereby inhibiting respiration, resulting in a decrease in the rate of photosynthesis. This can cause the ovule filling to be hampered and the seed's ability to survive will decrease [33].

4. CONCLUSION

The treatment of the height of the seed origin has an effect on plant biomass, namely that the highland seed origin shows the highest plant biomass. Watering volume affects plant height, number of leaves, root length, fresh weight and plant biomass. The growth and yield of ciplukan decreases as the watering volume decreases. The combination of treatment from midland seeds with a watering volume of 25% showed the lowest plant height. Domestication of ciplukan shows that the height of the seed origin and the volume of watering have a significant influence on the growth and production of ciplukan. The results of this research can be used as a guide in research for various types of ciplukan that grow at various altitudes.

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