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Growth and Yield of Intercropping between Carica (*Carica pubescens*) and Sweet Potato (*Ipomoea batatas* L.) and Leeks (*Allium fistulosum* L.)

Adi Rastono[1*], Sugiyarto[2], Marsusi[2]
[1]Politeknik Pertanian dan peternakan Mapena.
Jalan Imam Bonjol, Singgahan, Tuban Regency, East Java, 62361, Indonesia
[2]Pascasarjana Universitas Sebelas Maret,
Surakarta 57126, Jawa Tengah, Indonesia
*Email:adirastono3@gmail.com.

ABSTRACT

Carica pubescens needs a climate and edapic environment similar to that of its native Dieng plains in order to thrive. Due to these circumstances, measures must be taken to facilitate its diffusion. Another option is transplanting to regions with nearly identical edaphic and climatic characteristics. The growth of C. pubescens planted in monoculture and intercropping, as well as the degree of crop competition in intercropping and the effectiveness of the land used, the slopes of Mount Lawu are advised for transplant. The study's planting treatments were as follows: (1) C. pubescens monoculture; (2) Sweet Potato Monoculture; (3) C. pubescens and Sweet Potato Combination; (4) Leek Monoculture; and (5) C. pubescens and Scallions Combination. The study was set up in a randomized block design (RBD) with five replications. The ANOVA analysis of the growth characteristics, which comprised planting height, leaf area, and the number of leaves, was then proceeded using Duncan's test at the 5% level. Utilize the competition ratio (CR) formula to determine plant competition and the land equivalent ratio (LER) formula to determine productivity. The number of leaves parameter in the C. pubescens and sweet potato combination indicated a significant difference in the results. When grown alongside sweet potatoes, C. pubescens tends to be less competitive, with plant height values of 0.86: 1.27, 0.83: 1.72 for leaves, and 0.94: 1.10 for leaf area. The intercropping system is more lucrative with a value of plant height: 1.84, number of leaves: 1.89, and leaf area: 1.99 compared to plant height: 2, number of leaves: 2, and leaf area: 2, 25.

Keywords: *C. Pubescens, Transplantation, Mount Lawu, Tumpangsari, Land Productivity*

1. INTRODUCTION

Carica pubescens Lenne & K. Koch is a characteristic Dieng Plateau, Central Java plant, known as "karika" (Laily et al., 2018). Not all Highlands locations are appropriate for cultivating C. pubescens. C. pubescens can thrive at altitudes between 1400 and 2400 meters above sea level (asl), with temperatures between 15-20°C and annual precipitation between 2000 and 3000 mm (Laily et al., 2012). In Indonesia, the distribution of C. pubescens is still limited due to climatic and edaphic conditions; therefore, efforts are required to influence the distribution and production of C. pubescens. This can be accomplished by transplanting plants to climate-appropriate highland regions that support the growth of C. pubescens. This transplant is a conservation and development endeavor to preserve the existence of C. pubescens so that it can be reproduced in a sustainable manner.

Mount Lawu slope area in the border region between East Java (Regency of Magetan) and Central Java (Regency of Karang Anyar) is the recommended location for transplanting C. pubescens. (Rastono et al., 2018) consider the slopes of Lawu to have nearly identical climatic and edapic conditions, allowing them to be used as a transplant destination. Local farmers cultivate horticultural crops such as vegetables, fruits, and flowers in the Cemoro Cage region, which is situated on the foothills of Mount Lawu at an altitude of 1800 meters above sea level.

Horticultural commodities such as scallions, carrots, mustard greens, shallots, garlic, sweet potatoes, and chilies dominate the land in the Mount Lawu region. (Horticultural Agriculture Statistics of Karanganyar Regency 2019-2021.) In 2021, vegetable and fruit crop production increased significantly, reaching 4,244,856 quintals. The rise in vegetable and fruit production parallels the increase in land area, necessitating an intercropping planting system for plant transplantation. (Warman and Kristiana, 2018) Intercropping is the simultaneous planting of two or more varieties on the same piece of land to maximize the utilization of the production factors owned by farmers. Intercropping is regarded as more profitable than monoculture because land productivity is higher, the commodities produced are diverse, the use of production facilities is more efficient, and the risk of failure is reduced (Lestari et al., 2019). Do not rule out the possibility that intercropping crop systems cause plants to compete with one another. Plant spacing density will result in competition for nutrients, water, and light for photosynthesis; conversely, if the spacing is too loose, crop yields will be reduced due to the small number of plant populations per unit land area. (Ceunfin et al., 2017). Intercropping combinations necessitate the use of suitable plant species. The primary crop in this intercropping system is C. pubescens, with sweet potato (Ipomoea batatas L.) and leek (Allium fistulosum L.) serving as intercrops.

Intercropping systems can result in plant interactions requiring sufficient space to maximize cooperation and minimize competition at the ecological level (Pangaribuan et al., 2021). The competition ratio (CR) can be used to assess the intensity of plant competition (Supriatna et al., 2022). The aggressiveness of each plant to obtain resources causes competition between

plants and between species (Ceunfin et al., 2017). Even though there are indications of competition in the intercropping system, it is anticipated that this planting pattern will be advantageous. If the land equivalent ratio (LER) is greater than one, intercropping is more profitable than monoculture (Aminah et al., 2014). In his research, Lestari et al. (2019) combined corn and green bean plants in planting using an intercropping system that produced an LER > 1, indicating that ecologically and agronomically it is still profitable, but there is no evidence of plant competition. This study seeks to determine the growth of C. pubescens planted in intercropping, as well as the level of crop competition and the productivity of the intercropping system's land.

2. MATERIAL AND METHODS

From August to November 2014, the investigation was conducted on the slopes of Mount Lawu in Nglurah village, Tawangmangu subdistrict, Karang Anyar district. Exact coordinates of 111o04'00"-111o12'00" East Longitude (BT) and 07°37'30"-07°42'00" South Latitude (LS), 1800 MDPL. Overall, this investigation is depicted in Figure 1's flowchart:

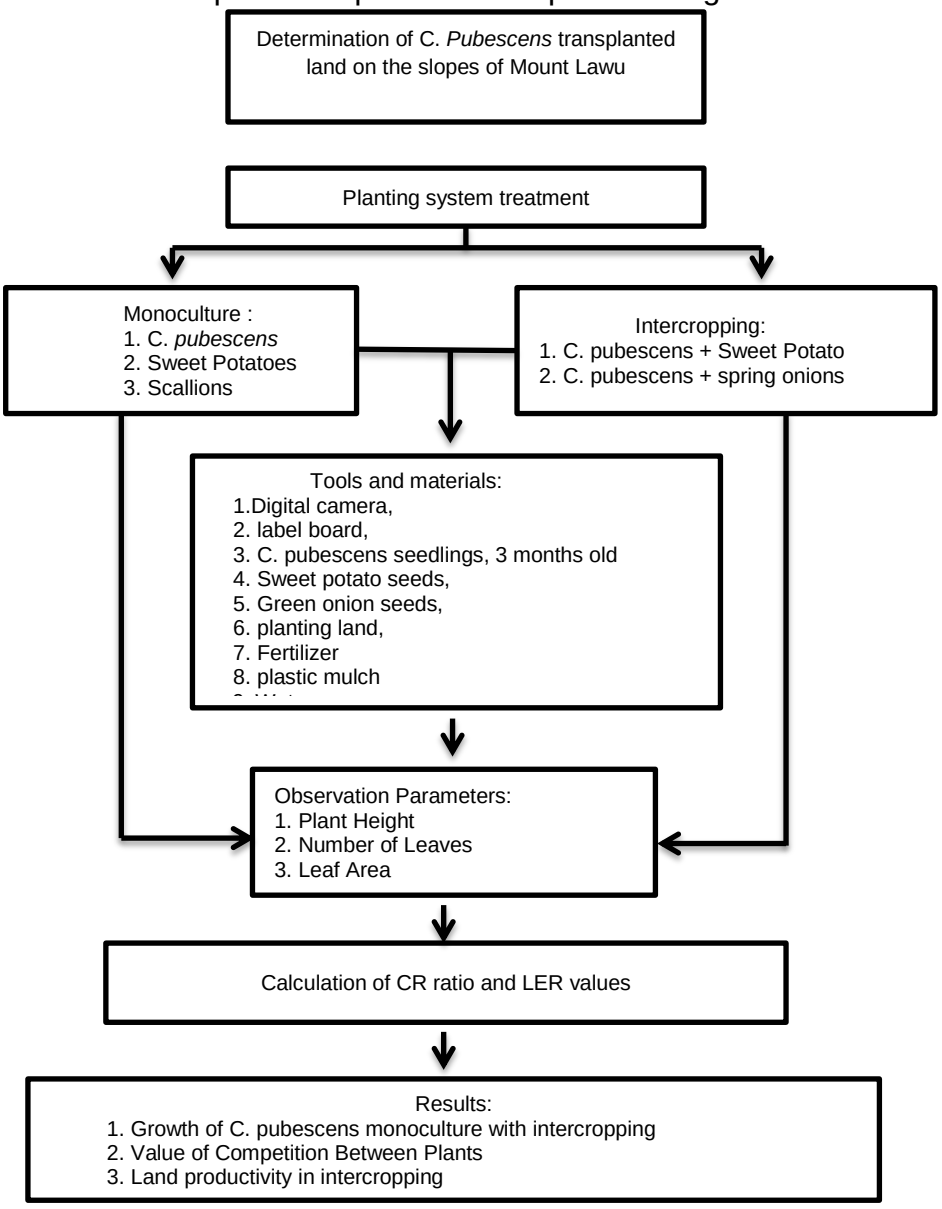

Figure. 1. Research Design

This study employed a randomized block design (RBD) with the following treatments: (1) C. pubescens monoculture (C); (2) sweet potato monoculture (U); (3) Leek monoculture (B); (4) the combination of C. pubescens and sweet potato (CU); and (6) the combination of C. pubescens and Leek (CB). Beds measuring 1.2 m by 1.2 m accommodate monoculture and intercropping vegetation. Susila (2006) suggests spacing scallions at 20 cm x 20 cm and sweet potatoes at 40 cm x 30 cm. Each experiment was repeated five times, resulting in 30 test plots. The sowing layout is depicted in Figure 2 below:

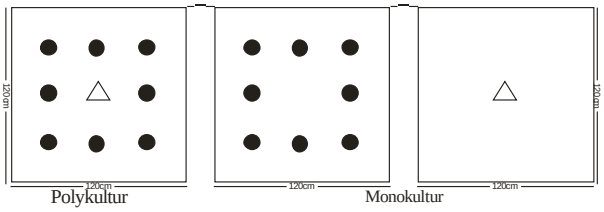

Figure 2. Planting Design

Note:

△ = Carica plant

● = Sweet Potatoes and Leeks

Maintenance was performed for 12 weeks until the conclusion of the study. The plant's height, number of leaves, and leaf area were measured to ascertain its growth. The plant's height and number of leaves were measured at (3, 6, 9, and 12) weeks after sowing (MST). While the leaf area is computed 12 weeks after planting using the gravimetric method and the accompanying formula, the leaf area is determined at six weeks:

$$\mathrm{LD} = \frac{\mathrm{Wr}}{\mathrm{Wt}} \times \mathrm{LK}$$

(Sitompul & Guritno, 1995).

Note :

LD = leaf area (cm^2)

LK = total paper area (cm^2)

Wr = paper replica weight (g)

Wt = total paper weight (g)

The obtained research data were analyzed using ANOVA. If the treatment provides a significant benefit, it is continued using the Duncan Multiple Range Test (DMRT) at a test level of 5%.

The level of competition between plants in the intercropping system can be calculated using the formula from Supriatna et al., (2022). :

$$CRa = \frac{Yab}{Yaa\ x\ Zba} : \frac{Yba}{YbbxZba}$$

$$CRb = \frac{Yba}{YbbxZba} : \frac{Yab}{Yaa\ x\ Zba}$$

if CRa > CRb means plant "a" is more competitive than plant "b", and if CRa < CRb then plant "b" is more competitive than plant "a".

Land productivity can be calculated by Land Equivalent Ratio (LER). Intercropping can increase agricultural land productivity if the LER value is > 1 (Aminah et al., 2014). The LER calculation formula is as follows:

$$LERab = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Note:

CR : *competition ratio*

LER : *Land equivalent ratio*

Y : Results

Z : area

Aa : C. Pubescens monoculture

bb : monoculture sweet potato / leeks

ab : C. Pubescens in intercropping with sweet potato/Leeks

ba : Sweet potato / leeks in intercropping with C. Pubescens

3. RESULT AND DISCUSSION

The growth of C. pubescens in the intercropping system depends on the

suitability of the combination for life to interact with each other. . Furthermore, to determine the interaction effect on the growth of C. pubescens, which was planted in monoculture and intercropping, the following data were obtained:

Table 1. Growth of C. pubescens monoculture and intercropping

Treatment	Plant Height	Leaves Qty.	Leaf Area
Carica	47,18[a]	9,60 [b]	321,7960[a]
Carica + Sweet Potato	38,86 [a]	7,00 [a]	305,8700[a]
Carica + Leeks	46,60 [a]	10,00[b]	366,0720[a]

Note: Numbers followed by different letters in the same column show a significant difference in Duncan's test results at the 5% test level.

Twelve weeks after planting (MST), C. pubescens' height growth in monoculture and intercropping did not differ significantly. C. pubescens monoculture had an average plant height of 47.18a cm, C. pubescens intercropped with sweet potato had an average plant height of 38.86a cm, and C. pubescens intercropped with Leeks had an average plant height of 46.60a cm. Figure 3 depicts the development of C. pubescens plant height via a graph of plant height.

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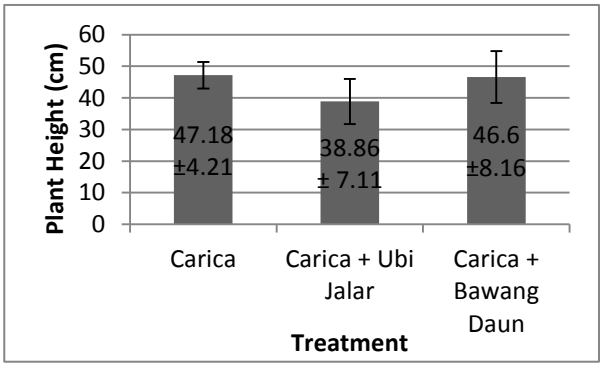

Figure 3. Graph of growth in height of C. pubescens in monoculture and 12 WAP intercropping. (± Eror Bar)

Based on the graph of C. pubescens planted alongside sweet potatoes, the lowest value was 38.86a, indicating that sweet potatoes were marginally more competitive. Plants can still develop well in an intercropping system due to their ability to adapt to growth and production-limiting factors (Paulus, 2016). C. pubescens, whose canopy is taller than sweet potato, can still obtain light for photosynthesis, so competition for nutrients and water can still be avoided between C. pubescens and sweet potato.

Toibba et al. (2023) note that the number of leaves influences the plant growth rate because leaves are organs that participate in photosynthesis. The intercropped C. pubescens and sweet potato had seven leaves (table 1). This phenomenon demonstrates that sweet potato has a negative effect on the leaf production of C. pubescens. This research is consistent with the findings of Paulus (2016), who intercropped two sweet potato clones with maize plants and found that the sweet potato was more competitive than the corn. The calculation of the number of leaves is depicted in the following graph (Figure 4).

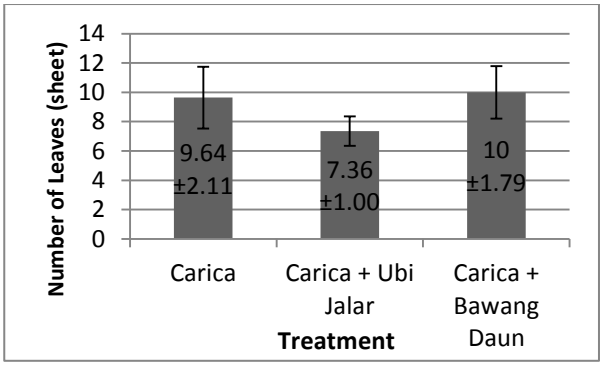

Figure 4. Graph of the number of leaves of C. pubescens in monoculture and 12 WAP intercropping, (± Eror Bar)

Competition for light between C. pubescens and sweet potato can still be avoided. Still, because sweet potato has a larger growing space and will be followed by a greater number of leaves, it has the potential to absorb more water than C. pubescens does. When plants receive light, it affects transpiration and evaporation, affecting water loss for plant growth (Silaen, 2021).

Since sweet potato is an annual plant with accelerated growth from the vegetative to generative phase, it will be better able to compete with C. pubescens for nutrients while forming growth organs. Faster and more space-dominant vegetative growth will be better able to compete for water, nutrients, and light than slower vegetative growth, ultimately affecting production (Lestari et al., 2019).

The leaf area per plant is affected by the increase in the number of leaves, the maturity of the plant, and the increase in the number of leaves. Intercropping C. pubescens and sweet potato resulted in fewer C. pubescens leaves due to the presence of competitive growth factors. High light intensity that is not matched by the absorption of nutrients and water in the soil due to competition for nutrients can slow down the formation of leaves in plants (Tika and Sudarti, 2021). Still, these conditions have no effect on the growth of C. pubescens leaf area in monoculture and in intercropped systems with sweet potato (Table 1). The calculation of leaf area is depicted in Fig. 5 below.

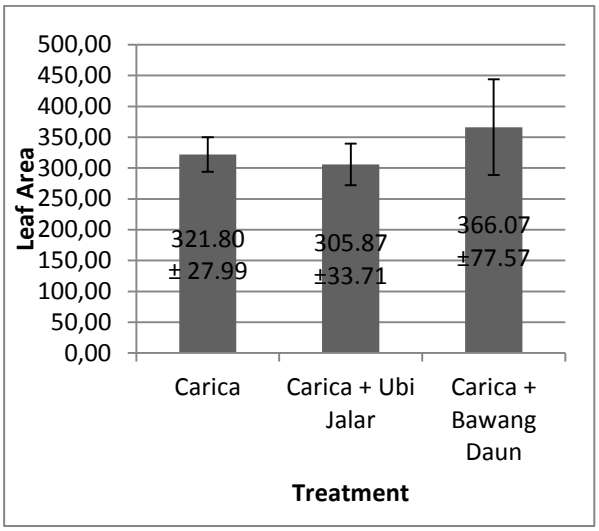

Figure 5. Graph of C. pubescens leaf area growth in monoculture and intercropping at 12 WAP (± Eror Bar)

Light and humidity influence the leaf area. C. pubescens can still utilise the environment to defend itself from rivals. C. pubescens can retain water in its stems for growth due to the humidity produced by the dense sweet potato plants, which lowers the ambient temperature. Low temperatures can be advantageous for the process of opening stomata so that CO2 absorption is optimized for photosynthesis. Low humidity under the plant canopy will provide water availability for roots to transport soil nutrients to plant parts, increasing leaf area growth and leaf area. Dini et al. (2018) found that despite competition in nutrient competition between corn and sweet potato plants, corn exhibited robust growth, the growth of DR 13 strain corn plants with a leaf area of 4.43 and DR 17 strain corn plants with a leaf area of 4.52.

***Competition Ratio* (CR) score**

Intercropping is a complex form of agriculture that involves interactions between similar and dissimilar plant species. When two or more varieties of plants coexist, there will be interaction, which can be both positive and negative. (Warman and Kristiana, 2018) The suitability of plants for the intercropping system is contingent on the compatibility of certain characteristics of the two plant species. The table below shows crop competition in the intercropping sowing system between C. pubescens, sweet potato, and scallion.

Table 2. Competition ratio (CR) value

Treatment	Value (CR) on Growth Parameter					
	Plant Height		Leaves Qty.		Leaf Area	
	a	b	a	b	a	b
Carica + Sweet Potato	0,86	1,27	0,83	1,72	0,94	1,10
Carica + Leeks	1	1	1	1	1,1	1,0

Information: if a>b then plant "a" is more competitive, b>a then plant "b" is more competitive. CR: competition ratio, a: C. pubescens, b: sweet potato and leek

The competition ratio (CR) value between C. pubescens (plant "a") and sweet potato and leek (plant "b") grown in intercropping (table 2) indicates that C. pubescens has a lower competition value than sweet potato. Competition ratio between C. pubescens and sweet potato for plant height a 0.86: b 1.27, number of leaves a 0.83: b 1.72, and leaf area a 0.94: b 1.01. As shown in Figures 6 and 7 below, this indicates that sweet potato is more competitive than C. pubescens.

Figure 6. Monoculture of *C*. pubescens

Figure 7. Overlapping of *C.* pubescens with sweet potato

Figure 8. Monoculture of Sweet Potatoes

The root system of C. pubescens and sweet potato is a mount that causes competition in the soil, but the sweet potato has not provided substantial competition because it has not yet impacted the growth of C. pubescens on growth parameters other than leaf number. C. pubescens grew well in both monoculture and intercropped conditions. This is because competition for illumination on the ground can still be avoided. C. pubescens had a taller corona than the sweet potato. C. pubescens can take advantage of humidity and low temperatures under the canopy (figure 6), despite sweet potato having long tendrils and a significant number of leaves. In accordance with research from (Paulus, 2016), sweet potato does not compete with maize for growth factor acquisition.

Based on the data in Table 2, C. pubescens grown in monoculture and intercropped with long pods exhibited no evidence of competition and was neutral. The growth parameters are plant height a 1: b 1, number of leaves a 1: b 1, leaf area a 1.1: b 1.0, and the coefficient of relative growth (CR). As shown in Figure 9 and Figure 10 below, the ratio value does not contribute to competition for nutrient availability

Figure 9. Intercropping of C. pubescens with leeks

Figure 10. Leeks Monoculture

The root system of C. pubescens differs from the root system of cassava. C. pubescens has a taproot, whereas it has fibrous roots in cassava plants. The modest root distribution of Loncang allows it to utilize the nutrients in the topsoil. This will reduce competition due to differences in plant physiology, providing producers with agronomic benefits. (Setyowati et al., 2013) Suggests that intercropped plant pairs must be chosen so that both can utilize space and time efficiently and can suppress competitive influence to a minimum so that constituent plants in intercropping can develop well in combination.

***Land equivalent ratio* (LER) Value**

Land productivity in intercropping cropping systems can be determined using the land equivalent ratio (LER) to demonstrate profitability when the LER value exceeds 1. In table 3 below are the results of land productivity calculations.

Table 3. Land Equivalent Ratio (LER) values for the combination of C. pubescens with sweet potatoes and leeks

Treatment	*Land Equivalent Ratio* (LER) value		
	Plant Height	Leaves Qty	Leaf Area
Carica + Sweet Potato	1,84	1,89	1,99
Carica + Leeks	2	2	2,25

Note: LER > 1 there are advantages in the intercropping system

Based on the calculation of the LER value, it can be concluded that land efficiency can be improved by employing an intercropping cropping pattern. The LER value > 1 (table 3) indicates that intercropping between C. pubescens and sweet potato results in plant height of 1.84, number of leaves of 1.89, and leaf area of 1.99, whereas intercropping between C. pubescens and leeks results in plant height of 2, number of leaves of 2, and leaf area of 2.25. The LER value indicates that C. pubescens with sweet potato and leek plants can still provide an agronomic advantage; therefore, intercropping is still recommended over monoculture, in accordance with Ceunfin et al.'s (2017) assertion that increased land productivity is due to the selection of the optimal combination of plants and cropping systems and the existence of a mutualistic relationship or symbiosis between plants planted in intercropping.

This symbiosis is closely related to the main plant's need for nitrogen, which is fulfilled by the insertion plant's capacity to fix nitrogen from the air. In contrast, the insertion plant has a shade tolerance and can survive in dense vegetation. As per previous research, the combination of C. pubescens as an annual plant with sweet potato and leek plants as inlay plants. These results are consistent with Rochmah and Muliasari's (2020) findings that the intercropping cropping system is applicable under oil palm stands, with an intercropping treatment of 1 corn + 1 peanut yielding 1.40 NKL and intercropping 1 corn + 2 peanuts yielding 1.46 NKL.

4. Conclusion

1. The number of leaves considerably differed between C. pubescens grown in monoculture and C. pubescens planted in intercropping with sweet potato, with a total of 7 strands.
2. 2. The intercropping system demonstrates that C. pubescens is less competitive than sweet potato plants, as indicated by the CR values of plant height a 0.86: b 1.27, leaf number a 0.83: b 1.72, and leaf area a 0.94:b 1.10.
3. Intercropping between C. pubescens and sweet potato and C. pubescens and leeks increases land productivity. Intercropping is more economically profitable than monoculture planting, as indicated by the LER value at plant height of 1.84, number of leaves of 1.89, and leaf area of 1.99, and plant height of 2, number of leaves of 2, leaf area of 2.25..

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