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Light intensity affects axillary bud quality of rubber mini-seedling budding CATAS73397

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Abstract**—***Rubber mini-seedling budding have the characteristics of short nursery cycle, low labor intensity, large number of seedlings per unit area, easy transportation and planting, well-developed taproot and intact root system, high post-planting survival rate, fast growth, strong tolerance to drought, wind and cold, and early tapping. The quality of rubber tree axillary buds is a key factor affecting the budding of rubber mini-seedling buddings, and there are many environmental factors affecting the quality of rubber tree axillary bud. Production practice shows that moderate shading is beneficial to the quality of rubber bud stick. However, there is still a lack of systematic research on the effect of light on the quality of rubber tree axillary bud. This study set up two treatments with 75% and 100% light intensity based on production practice to observe and analyze the phenology and axillary bud morphological indicators of rubber tree leaf whorl. The results showed that axillary buds of the 3rd leaf whorl had the highest quality under 75% light intensity. Suitable light intensity promotes axillary buds to grow more robustly. Taken together, light has a significant impact on the quality of rubber tree axillary bud. Suitable lighting is more conducive to improving the quality of rubber tree axillary bud and laying a good foundation for the subsequent growth and development of rubber mini-seedling budding.*

Keywords**—*****Hevea brasiliensis, light intensity, leaf phenology, axillary bud, quality***

I. INTRODUCTION

Rubber tree (*Hevea brasiliensis* (Willd. ex A. Juss.) Muell. Arg), a plant of the genus Euphorbiaceae, native to the Amazon River Basin in Brazil, is a typical tropical rainforest tree species and is currently the largest rubber-producing plant [1]. The stem is upright, the leaf scars are horseshoe-shaped, the three leaflets are mostly separated, and the latex is white. Axillary buds are one type of lateral buds, specifically referring to the fixed buds that arise from the leaf axils. They play an important role in the growth, development and reproduction of plants, not only promoting plant growth, but also closely related to plant biomass and crop yield [2]. The axillary buds are the origin point of lateral branches and 2ndary flower buds in rubber trees, and their healthy development plays a decisive role in the yield and quality of rubber trees.

As an important economic crop, the quality of rubber tree axillary buds is crucial for its reproduction and growth. Light, as one of the important environmental factors, has a significant impact on the growth and development of plants [3-5]. In the process of rubber budding, the quality of axillary buds directly affects the success rate of budding and the subsequent growth status of rubber trees. Among them, light intensity is one of the important environmental factors affecting the quality of axillary buds. Appropriate light intensity can promote the normal growth and development of axillary buds, achieving a good state in morphology, physiology, and other aspects, providing high-quality bud patches for high-quality rubber mini-seedling budding.

At present, there have been many studies on the effect of light intensity on the growth and development of rubber trees [6,7]. Although we know that environmental factors such as light have an impact on rubber bud grafting, different light intensities will have a corresponding degree of influence on the anatomical structure and growth of rubber tree leaves [8]. There are also studies on different types of bud and initial growth of scions conducted by Liu Zhongliang and others in rubber tree Yunyan 77-4 [9], establishment of axillary bud cell embryo regeneration system and induction of tender leaf callus tissue by Wang Taihua and others in rubber tree CATAS73397 [10], and the effect of different concentrations of colchicine by Zhao Qi and others on axillary bud germination rate of rubber tree clones [11]. However, the detailed dynamic changes in the growth indicators of rubber axillary bud under different light intensities are not yet fully understood, which makes it difficult to achieve precise control operations in the actual rubber mini-seedling propagation process. In view of this, the aim of this study is to conduct in-depth research on various growth indicators of mini-seedling buddings under different light intensities, analyze their intrinsic relationship with axillary bud quality, and determine the most suitable light intensity for axillary bud growth of rubber trees under different light intensities. This will further deepen our understanding of the mechanism of rubber mini-seedling budding propagation, improve budding quality, and promote the sustainable development of the rubber industry.

II. MATERIAL AND METHODS

Experimental site Experimental site is located in the demonstration base of rubber tree seedling budding in Danzhou City, Hainan Province (109.50E, 19.50N, 148.6 m altitude). Shading treatment was carried out using a shading net, and one light intensity was controlled to be 75%. The other experimental treatment had no shading, the light intensity was 100%, the light was good, and the environment was stable. The test material is the excellent variety of rubber tree CATAS73397, which is a high-yield variety bred by the Rubber Research Institute of China Academy of Tropical Agricultural Sciences. It has fast growth, high yield, strong wind resistance and cold resistance. Each experimental treatment concluded ten plants, three replicates, through the observation of phenology in each period of experimental treatment and cultivation of rubber tree, and the determination of phenotypic traits of axillary buds.

Phenological observation From July to August 2024, plants with good growth and consistency were selected for manual observation, and the duration, leaf color change and leaf growth dynamics of each phenological period (S1, bud-break stage, S2, elongating stage, S3, leaf-unfolding stage, S4, bronze stage Ⅰ, S5, bronze stage Ⅱ, S6, coloring stage, S7, light green leaf stage, S8, stable leaf stage, S9 mature leaf stage) were recorded. The leaf length and leaf width were measured by a transparent ruler, and the leaf color change was measured by chlorophyll meter (Jinkelida TYS-4N).

Axillary bud morphology observation At least 4 leaf whorls with good and consistent growth were cut, and stem diameter of each leaf whorl close node bud (the starting growth point of new leaf whorl) was measured with a vernier caliper. The plant height of each leaf was measured with a tape measure, and the leaf buds and scale buds on the 2nd, 3rd and 4th leaf buds were cut from the top down respectively. The number of leaf buds and scale buds on each leaf whorl was recorded. The length, width and thickness of axillary bud scar and the length and width of axillary bud eye were measured with vernier caliper. After the measurement, the leaf buds and scale buds on each leaf whorl were weighed fresh weight, and then placed on a ceramic tray and dried in a blast oven (Shanghai Yiheng DHG-9620A) to constant weight to calculate the moisture content.

Data processing and analysis Word Processing System (WPS) Excel 2018 and GraphPad prism 8.3.0 were used for data processing and chart drawing. Statistical analyses were performed with data processing system (DPS) statistical software package version 20.05 using student's t-test, one-way ANOVA followed by the Duncan's Multiple Range Test (SSR) to evaluate significant difference among different treatments at $P<0.05$, and Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) for comprehensive analysis. All data were shown in the mean ± SD. Correlation heatmap analysis was evaluated on Tutools platform(http://www.cloudtutu.com), a free online data analysis website.

III. RESULT AND DISCUSSION

1 Plant growth

As shown in Fig.1A, leaf length of the 2nd, 3rd and 4th leaf whorl of CATAS73397 bud stick were significantly increased by 28.49% ($P<0.01$), 42.76% ($P<0.01$), and

47.32% (P<0.01), respectively, under 75% light compared with 100% light. As shown in Fig.1B, leaf width of the 3rd and 4th leaf whorl were significantly increased by 17.33% (P<0.01) and 26.66% (P<0.01), respectively, under 75% light compared with 100% light. The stem diameter of the 4th leaf whorl under 75% light was 9.85% smaller than that under 100% light (P< 0.05, Fig.1C). As shown in Fig.1D, leaf moisture of 2nd, 3rd and 4th leaf whorl under 75% light was significantly higher than that under 100% light by 6.00% (P < 0.01), 9.52% (P< 0.01) and 8.63% (P < 0.01), respectively, indicating that proper shading helps the growth of leaves. There was no significant difference in other parameters.

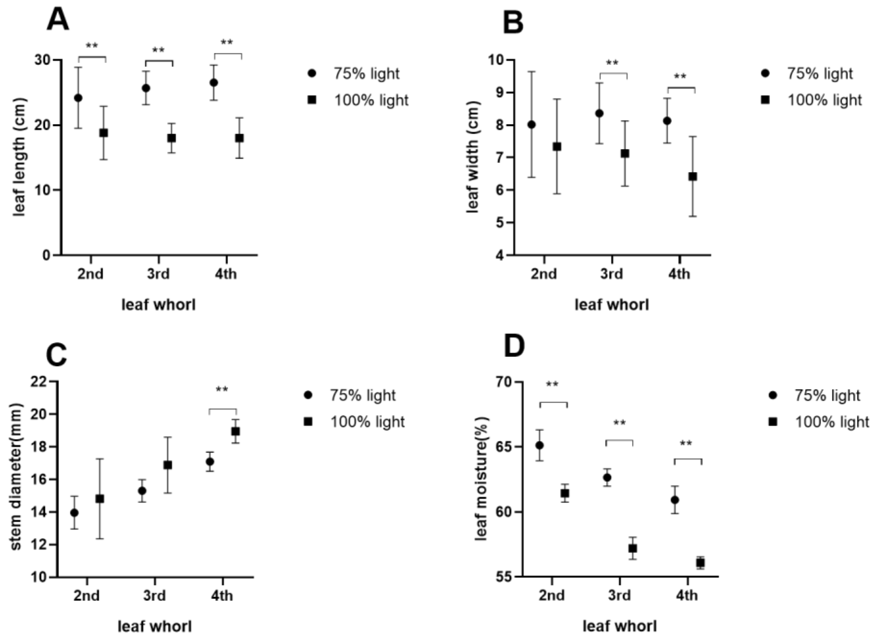

Fig.1 Plant growth performance at different leaf whorl under 75 % and 100 % light

2 Leaf phenology

As shown in Fig.2 and Fig.3A, compared with 100% light, the duration of leaf-unfolding stage and bronze stage I of CATAS73397 bud stick under 75% light was significantly shorter by 18.18% (P< 0.05) and 28.57% (P < 0.05), and the duration of coloring stage and mature leaf stage was significantly longer by 7.14% (P<0.01) and 57.14% (P<0.01), respectively. There was no significant difference in other leaf phenology periods.

2.1 Plant height

As shown in Fig.3B, plant height increase at leaf-unfolding stage and mature leaf stage of CATAS 73397 bud stick under 75% light was significantly 10.61% (P< 0.05) and 84.37% (P<0.05) higher than that under 100% light. There was no significant difference in other leaf phenology periods.

2.2 Leaf length As shown in Fig.3C, leaf length increase at bronze stage I and light green leaf stage of CATAS73397 bud stick under 75% light was significantly 43.53% (P<0.01) and 16.54% (P<0.01) shorter than that under 100% light, mature leaf stage was significantly 6.88% (P<0.05) higher than that under 100% light; There was no significant difference in other leaf phenology periods.

2.3 Leaf width As shown in Fig.3D, leaf width increase at bronze stage I, coloring stage and light green leaf stage of CATAS73397 bud stick under 75% light was significantly 51.23%, 10.98% and 20.45% shorter than that under 100% light (P<0.01), bronze stage II was significantly 9.49% shorter than that under 100% light (P <0.05), mature leaf stage was significantly 18.33% higher than that under 100% light (P < 0.01). There was no significant difference in other leaf phenology periods.

2.4 Leaf moisture As shown in Fig.3E, under 75% light, the leaf moisture of CATAS73397 was significantly 19.51% (P<0.05) lower than that under 100% light at coloring stage. There was no significant difference in other leaf phenology periods.

2.5 Leaf temperature As shown in Fig.3F, The leaf temperature of CATAS73397 under 75% light was significantly 2.01% (P<0.01) higher than that under 100% light at bronze stage II. Leaf temperature at mature leaf stage was significantly lower 2.42% (P<0.05) than that under 100% light; There was no significant difference in other leaf phenology periods.

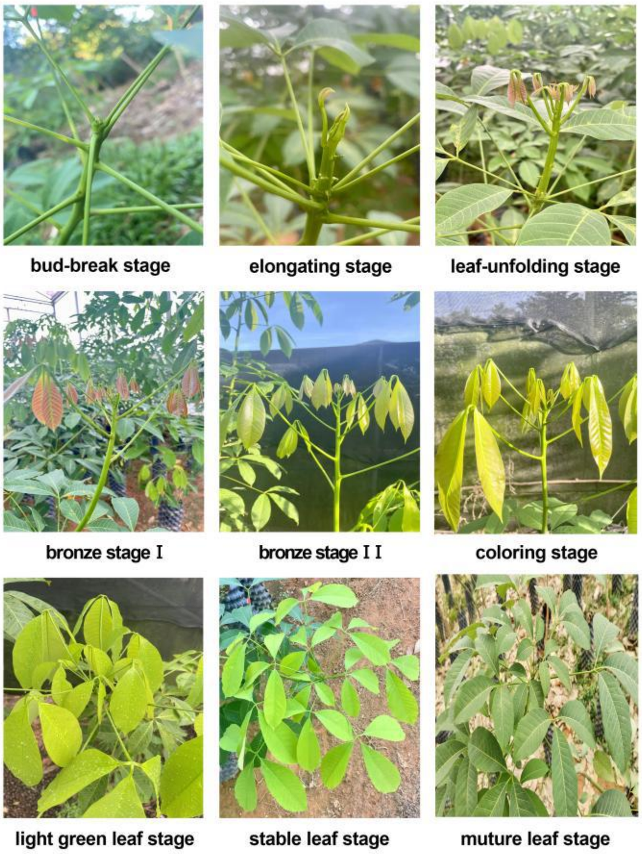

Fig.2 Leaf phenology of CATAS73397 rubber mini-seedling budding bud-stick

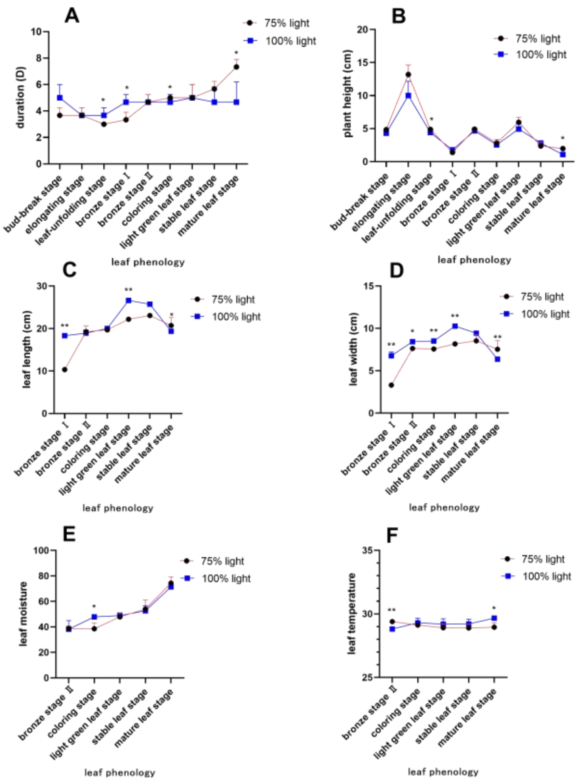

Fig.3 Change of phenology duration and leaf growth under 75 % and 100 % light

In general, although there was no significant difference in total phenological duration days and cumulative increase in plant height between 75% and 100% light, there were significant or extremely significant differences in duration days, increase in plant height, increase in leaf length, increase in leaf width, leaf moisture and leaf temperature among phenologically related leaves of CATAS 73397 bud stick.

3 Axillary bud quality

3.1 Different light intensities at the same leaf whorl

On the 2nd leaf whorl, the scale bud scar length (Fig. 4A), and leaf bud eye length (Fig.4G) were significantly increased by 41.30% ($P<0.01$), and 44.60% ($P<0.01$) respectively, under 75% light compared with 100% light. The leaf bud scar width was significantly 6.50% ($P<0.05$) higher than that under 100% light (Fig.4F). The scale bud eye width (Fig.4D) and leaf bud scar thickness (Fig. 4H) were significantly decreased by 14.58% ($P<0.05$) and 8.10% ($P<0.05$) compared with 100% light. There was no significant difference in other parameters.

On the 3rd leaf whorl, the leaf bud eye length (Fig. 4G, Fig. 5), were significantly increased by 33.09% ($P<0.01$), under 75% light compared with 100% light. The scale bud scar width (Fig.4B), leaf bud scar length (Fig.4E) and leaf bud scar width (Fig.4F) were significantly increased by 5.67% ($P<0.05$), 10.17% ($P<0.05$) and 0.66% ($P< 0.05$), respectively, under 75% light compared with 100% light. The scale bud scar length was significantly 19.34% ($P<0.01$) lower than that under 100% light. The leaf bud scar thickness (Fig.4H) and the scale bud moisture (Fig. 4I) were significantly lower than those under 100% light by 6.86% ($P<0.05$) and 4.09% ($P< 0.05$), respectively. There was no significant difference in other parameters.

On the 4th leaf whorl, under 75% light, the leaf bud scar thickness (Fig.4H) was significantly increased by 10.75% ($P < 0.01$). The leaf bud scar length (Fig.4E) and leaf bud eye length (Fig.4G) were significantly increased by 7.72% ($P < 0.05$) and 16.19% ($P < 0.05$) compared with 100% light. The scale bud scar length (Fig.4A), scale bud scar width (Fig. 4B), and scale bud eye length (Fig.4D) were significantly decreased by 22.54% ($P< 0.01$), 9.06% ($P<0.01$), and 39.45% ($P<0.01$) under 100% light, respectively. The scale bud moisture (Fig.4I) was 4.01% ($P<0.05$) lower than that under 100% light. There was no significant difference in other parameters.

In conclusion, the light intensity had significant effects on a number of morphologies and related indexes of CATAS73397 axillary buds. The indexes of different leaf buds increased or decreased to different degrees under the comparison of 75% light and 100% light, indicating that there were differences in the response of each leaf bud to light intensity. The CV difference of each index at the two light conditions reflects that the light intensity not only affects the value of the index, but also may affect its stability. It can be inferred that in the bud-stick cultivation process of this variety, the specific morphological index can be optimized by accurately regulating the light intensity for different leaf buds, so as to promote the overall growth and development. It can be seen that some indexes of leaf bud and scale bud have advantages under 75% light, which further indicates that reasonable light regulation is very important to balance the growth and development of different types of bud (such as leaf bud and scale bud).

3.2 Different leaf whorl on the same plant

3.2.1 75% light in the same plant

As shown in Fig. 6A, the scale bud scar length of the 2nd leaf whorl was significantly higher than that of the 3rd and 4th leaf whorls by 27.43% ($P<0.01$) and 40.88% ($P<0.01$), respectively.

As shown in Fig. 6B, the scale bud scar width of the 2nd leaf whorl was significantly smaller than the 3rd leaf whorl by 21.86% ($P<0.01$), and the 3rd leaf was significantly smaller than the 4th leaf whorl by 17.88% ($P < 0.01$).

As shown in Fig. 6C, the scale bud eye length of the 4th leaf whorl was significantly smaller than that of the2ndand 3rd leaf whorls by 48.12% ($P<0.01$) and 44.46% ($P<0.01$), respectively, and there was no significance between the 3rd leaf whorl and the 4th leaf whorl.

As shown in Fig. 6D, the scale bud eye width of the 2nd leaf whorl was significantly smaller than that of the 3rd leaf whorl by 41.25% ($P<0.01$) and significantly smaller than that of the 4th leaf whorl by 15.19% ($P < 0.05$), and the 3rd leaf whorl was significantly larger than that of the 4th leaf whorl by 18.45% ($P<0.01$).

As shown in Fig. 6E, the leaf bud scar length of the 2nd leaf whorl was significantly smaller than that of the 3rd leaf whorl by 12.96% ($P<0.01$), the 2nd leaf whorl was significantly larger than that of the 4th leaf whorl by 21.52% ($P<0.01$), and the 3rd leaf whorl was significantly larger than that of the 4th leaf whorl by 30.52% ($P<0.01$).

As shown in Fig. 6F, the leaf bud scar width of the 2nd leaf whorl was significantly smaller than that of the 3rd leaf whorl by 8.45% ($P<0.01$), and the 3rd leaf whorl was significantly larger than the 4th leaf whorl by 6.99% ($P< 0.01$).

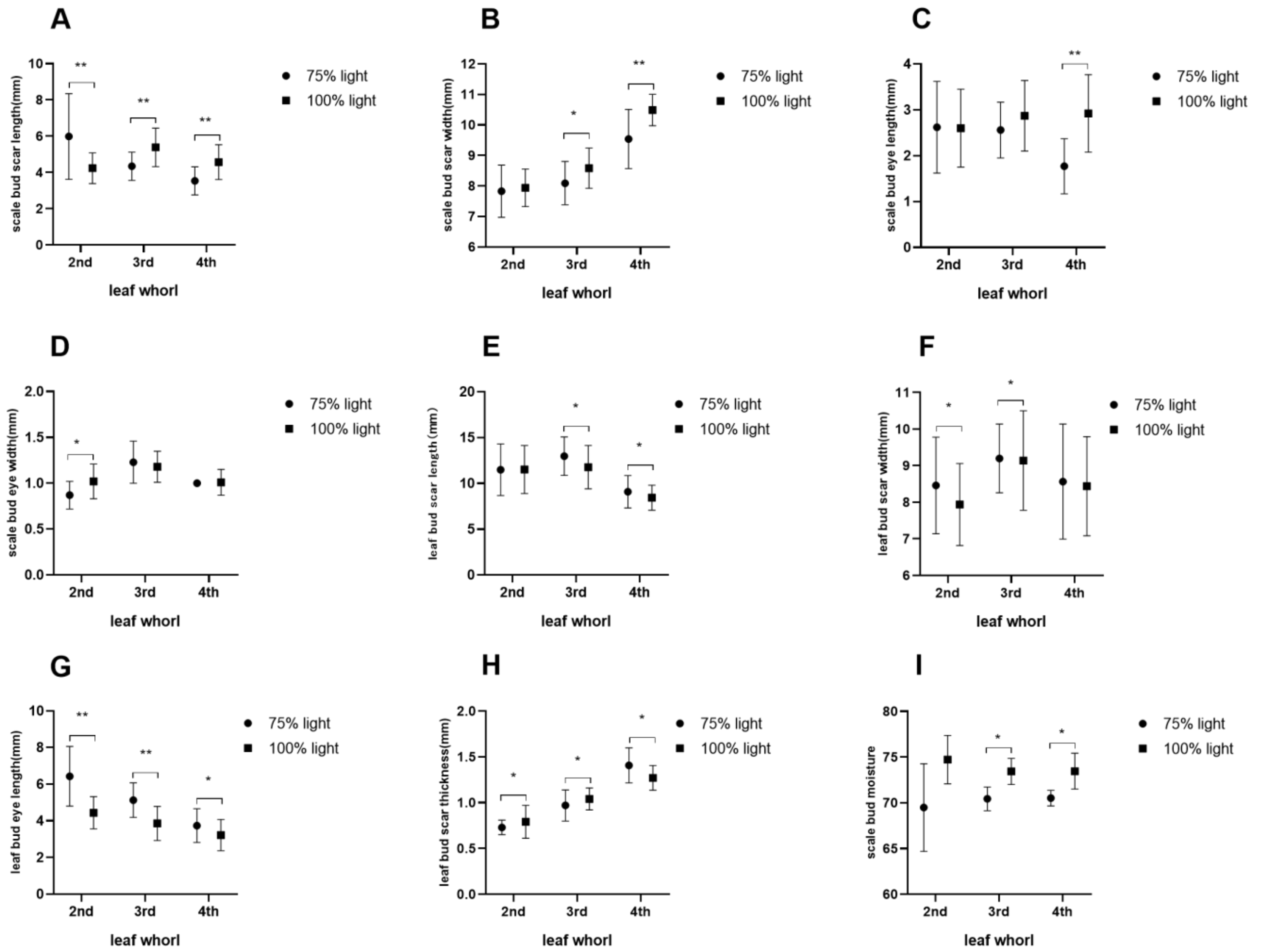

Fig.4 The axillary bud growth of the 2nd, 3rd and 4th leaf whorl under 75 % and 100 % light

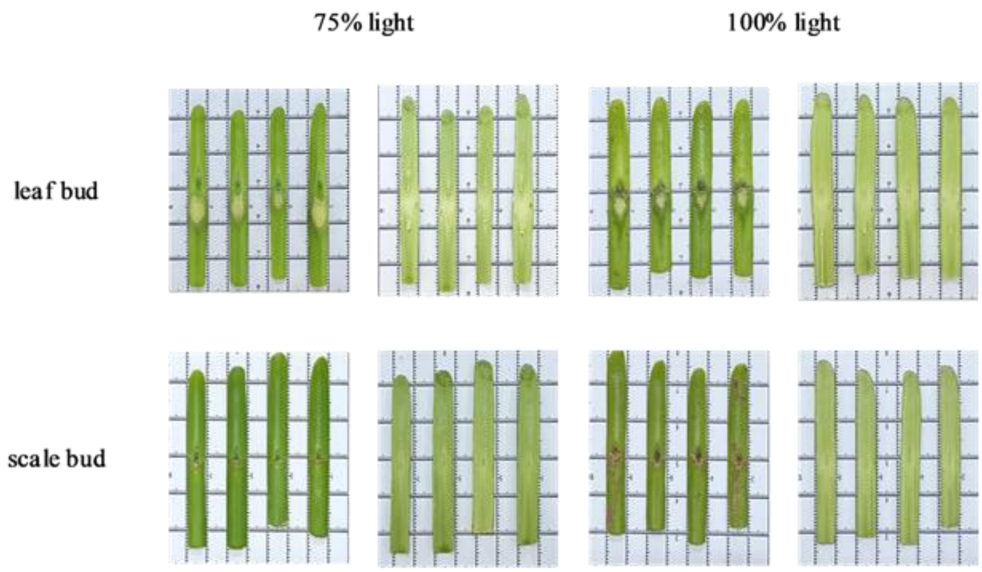

Fig.5 Positive and negative side view of leaf bud patch and scale bud patch on 3rd leaf whorl

As shown in Fig. 6G, the leaf bud eye length of the 2nd leaf whorl was 18.26% (P<0.01) and 41.10% (P<0.01) higher than that of the 3rd and 4th leaf whorls respectively, and the 3rd leaf whorl was 27.94% (P<0.01) higher than that of the 4th leaf whorl. There was no significant difference in other parameters.

As shown in Fig. 6H, the scale bud scar thickness in the 2nd leaf whorl was 17.47% (P<0.05) higher than that in the 3rd leaf whorl, and the 3rd leaf whorl was 20.77% (P< 0.05) lower than that in the 4th leaf whorl.

As shown in Fig. 6I, the leaf bud scar thickness of the 2nd leaf whorl was significantly smaller than that of the 3rd and 4th leaf whorls by 33.16% (P<0.01) and 94.73% (P< 0.01), respectively. The 3rd leaf whorl was significantly smaller than that of the 4th leaf whorl by 43.42% (P< 0.01).

As shown in Fig. 6J, the number of scale buds in the 2nd leaf whorl was significantly lower than that in the 3rd leaf whorl by 40% (P<0.05), and the 3rd leaf whorl was significantly higher than that in the 4th leaf whorl by 28.57% (P< 0.05).

As shown in Fig. 6K, the leaf length of the 2nd leaf whorl was significantly smaller than that of the 4th whorl by 9.6 % (P<0.01), and that of the 3rd whorl was significantly smaller than that of the 4th whorl by 3.2 % (P< 0.05).

As shown in Fig. 6L, the leaf width of the 2nd leaf whorl was significantly higher than that of the 3rd and 4th leaf whorl by 2.96 % and 12.96 %, respectively, and the 3rd leaf whorl was significantly higher than that of the 4th leaf whorl by 9.89 %.

As shown in Fig. 6M, the leaf moisture of the 2nd leaf whorl was significantly higher than that of the 3rd and 4th leaf whorls by 4.67% (P<0.01) and 6.77% (P<0.01), respectively.

As shown in Fig. 6N, the stem diameter of the 2nd leaf whorl was 31.95% (P< 0.05) higher than that of the 3rd leaf whorl, and 41.89% (P<0.01) higher than that of the 4th leaf whorl from the top, the 3rd leaf whorl from top was significantly smaller than the 4th leaf whorl from top by 46.96% (P< 0.05).

3.2.2 100% light on the same plant

As shown in Fig. 6A, the scale bud scar length of the 2nd leaf whorl was significantly smaller than that of the 3rd leaf whorl by 27.13% (P<0.05), and was significantly larger than that of the 4th leaf whorl by 16.46% (P<0.01). The 3rd leaf whorl was significantly larger than the 4th leaf whorl by 34.29% (P<0.01).

As shown in Fig. 6B, the scale bud scar width of the 2nd leaf whorl was significantly smaller than that of the 3rd and 4th leaf whorls by 8.06% (P<0.01) and 32.12% (P< 0.01), respectively, and the 3rd leaf whorl was significantly smaller than that of the 4th leaf whorl by 32.12% (P<0.01).

As shown in Fig. 6C, there was no significance among the 2nd, 3rd and the 4th leaf whorl in the scale bud eye length.

As shown in Fig. 6D, the scale bud eye width of the 2nd leaf whorl was significantly smaller than that of the 3rd leaf whorl by 16.16% (P<0.01), and the 3rd leaf whorl was significantly larger than that of the 4th leaf whorl by 14.51% (P<0.01).

As shown in Fig. 6E, the leaf bud scar length of the 2nd leaf whorl was 28.08% (P<0.01) higher than that of the 4th leaf whorl, and the 3rd leaf whorl was 29.23% (P<0.01) higher than that of the 4th leaf whorl.

As shown in Fig. 6F, the leaf bud scar width of the 2nd leaf whorl was significantly smaller than that of the 3rd leaf whorl by 14.52% (P<0.01), and the 3rd leaf whorl was significantly larger than that of the 4th leaf whorl by 8.45% (P< 0.01).

As shown in Fig. 6G, the leaf bud eye length of the 2nd leaf whorl was 15.51% (P<0.01) and 30.00% (P< 0.01) higher than that of the 3rd and 4th leaf whorls, respectively, and the 3rd leaf whorl was 17.15% (P<0.01) higher than that of the 4th leaf whorl. There was no significant difference in other parameters.

As shown in Fig. 6H, the scale bud scar thickness in the 2nd leaf whorl was significantly lower than that in the 4th leaf whorls by 20.16% (P<0.01) and 20.52% (P<0.01), respectively.

As shown in Fig. 6I, the leaf bud scar thickness of the 2nd leaf whorl was significantly smaller than that of the 3rd and 4th leaf whorls by 30.96% (P<0.01) and 60.66% (P< 0.01), respectively. The leaf bud scar thickness of the 3rd leaf whorl was significantly smaller than that of the 4th leaf whorl by 22.68% (P<0.01).

As shown in Fig. 6J, the scale buds in the 3rd leaf whorl were 52% (P<0.05) higher than that in the 4th leaf whorl.

As shown in Fig.6M, the leaf moisture of the 2nd whorl was significantly higher than that of the 3rd and 4th whorls by 6.96% (P<0.01) and 8.83% (P<0.01), respectively.

As shown in Fig. 6N, the stem diameter of the 2nd and 3rd leave whorls was significantly larger than that of the 4th leave whorl by 19.61% (P<0.05) and 20.11% (P<0.05), respectively.

To sum up, it shows that even under the same light conditions, different leaf whorls have different responses to light, and their growth and development characteristics are not the same, and each leaf position has its own unique growth characteristics.

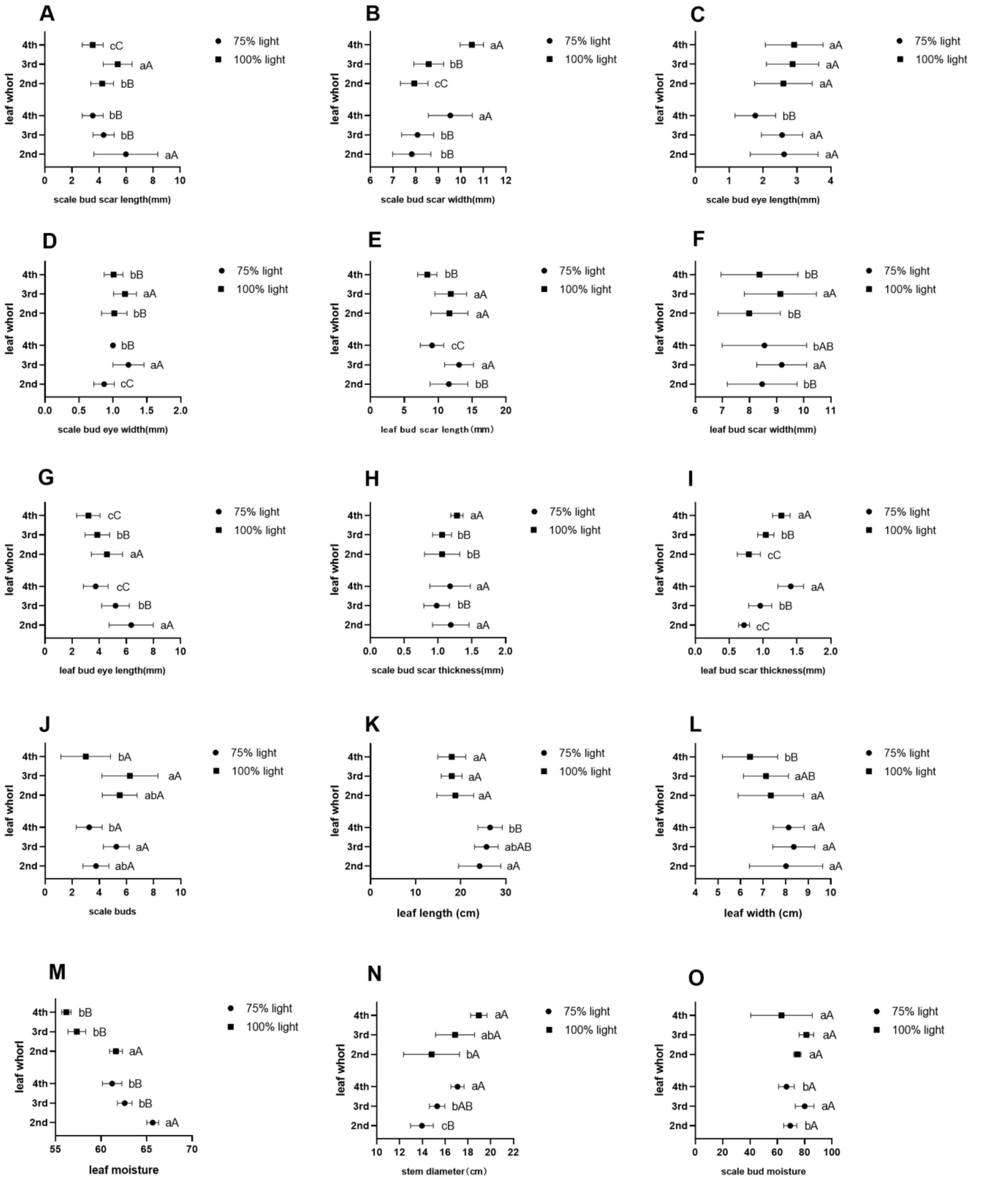

Fig.6 The quality of axillary buds at different leaf whorl on the same plant under 75 % and 100 % light

4 Coefficient of variation analysis

As shown in Tab.1, the coefficient of variation (CV) of leaf moisture of the 2nd, 3rd and 4th leaf whorl under 75% light were 32.87%, 24. 60% and 13.54%, while that under 100% light were 32.53%, 23.86% and 13.40%, respectively. The CV of scale bud moisture of the 3rd and 4th leaf whorl under 75% light, were 8.6% and 8.61%, while that under 100% light were 6.55% and 35.7%, respectively.

The CV of scale bud scar length of the 2^{nd}, 3^{rd} and 4^{th} leaf whorl under 75% light were 39.49%, 17.9%, 21.94%, while that under 100% light were 19.96%, 19.75% and 21.94%, respectively. The CV of leaf bud scar length of the 3^{rd} and 4^{th} leaf whorl under 75% light were 16.26% and 19.17%, while that under 100% light were 19.78% and 16.78%, respectively.

The CV of scale bud eye length of 4^{th} leaf whorl under 75% light were 33.86% and under100% light was 28.93%. The CV of leaf bud eye length of the 2^{nd}, 3^{rd} and 4^{th} leaf whorl under 75% light were 25.66%, 19.58%, 24.28%, while that under 100% light were 25.12%, 23.67% and 26.78%, respectively. The CV of scale bud scar width of 3^{rd} and 4^{th} leaf whorl under 75% light were 8.79%, 10.14%, while that under 100% light were 7.75% and 4.92%, respectively. The CV of leaf bud scar width of 2^{nd}, and 3^{rd} leaf whorl under 75% light were 15.23%, 10.14%, while that under 100% light were 14.35% and 14.58%, respectively.

The CV of scale bud eye width was 17.14% under 75% light and 18.50% under 75% light. The CV of leaf bud scar thickness of the 2^{nd}, 3^{rd} and 4^{th} leaf whorl under 75% light was 11.75%, 17.49%, 13.53%, while that under 100% light were 21.97%, 11.57% and 10.56%, respectively.

The CV of leaf length of the 2^{nd}, 3^{rd} and 4^{th} leaf whorl under 75% light was 19.28%, 9.95% and 10.21%, while that under 100% light were 21.62%, 12.55% and 17.26%, respectively. The CV of leaf width of the 3^{rd} and 4^{th} leaf whorl under 75% light was 11.13% and 8.42%, while that under 100% light were 14.01% and 19.06%, respectively. It shows that sufficient light contributes to the growth of leaf width.

The duration CV under 75% light of leaf-unfolding stage, bronze stage Ⅰ, coloring stage and mature leaf stage were 0, 17.32%, 0 and 7.87%, while that under 100% light was 15.75%, 12.37%, 12.37% and 32.73%, respectively. It shows that proper shading is helpful for the rapid initiation of new leaf whorl, but it is not conducive to the completion of new leaf whorl phenology, suggesting that more light is needed in the later stage with the gradual increase of leaf area.

The CV of plant height increase at mature leaf stage was15.53% under 75% light and 14.32% under 100% light. CV of leaf length increase under 75% light was 2.44% at bronze stage Ⅰ, 0.45% at light green leaf stage and 1.10% at mature leaf stage, respectively, and that under 100% light was 2.19%, 1.64% and 0.81% respectively. The CV of leaf width increase under 75% light was 3.03% t bronze stage Ⅰ, 3.78% at bronze stage Ⅱ, 0.76% at coloring stage, 0.71% at light green leaf stage respectively, and that under 100% light was 6.66%, 1.37% , 1.18%, and 1.49%, respectively.

The CV of leaf temperature under 75% light was 0.53% at bronze stage II, 1.23% at mature leaf stage, and that under 100% light was 0.50%, 0.27%, respectively. The CV of leaf moisture at coloring stage was 11.67% under 75% and 2.09% under 100% light, respectively.

Table 1 Coefficient of variation (%) between significantly different parameters under two light intensities

parameter		75%light			100%light			parameter	leaf phenology	75%light	100%light
		2nd	3rd	4th	2nd	3rd	4th	duration	leaf-unfolding stage	0	15.75
moisture	leaf	32.87	24.6	13.54	32.53	23.86	13.4		bronze stage Ⅰ	17.32	12.37
	scale bud	-	8.6	8.61	-	6.55	35.7		coloring stage	0	12.37
bud scar length	scale bud	39.49	17.9	21.94	19.96	19.75	21.94		mature leaf stage	7.87	32.73
	leaf bud	-	16.26	19.17	-	19.78	16.78	plant height increase	mature leaf stage	15.53	14.32
bud eye length	scale bud	-		33.86	-	-	28.93	leaf length increase	bronze stage Ⅰ	2.44	2.19
	leaf bud	25.66	19.58	24.28	25.12	23.67	26.78		light green leaf stage	0.45	1.64
bud scar width	scale bud	-	8.79	10.14	-	7.75	4.92		stable leaf stage	1.10	0.81
	leaf	15.23	10.04	-	14.35	14.58	-	leaf width	bronze stage I	3.03	6.66

	bud							increase			
bud eye width	scale bud	17.14	-	-	18.5	-	-		bronze stage II	3.78	1.37
bud scar thickness	leaf bud	11.75	17.49	13.53	21.97	11.57	10.56		coloring stage	0.76	1.18
leaf length		19.28	9.95	10.21	21.62	12.55	17.26		light green leaf stage	0.71	1.49
leaf width		-	11.13	8.42	-	14.01	19.06	leaf temperature	bronze stage II	0.53	0.50
									mature leaf stage	1.23	0.27
								leaf moisture	coloring stage	11.67	2.09

5 Correlation analysis

5.1 Under 75% light, the 2nd, 3rd and 4th leaf whorl of scale bud

As shown in Fig.8A, leaves were significantly negatively correlated with leaf moisture ($p<0.01$). The scale bud moisture was significantly negatively correlated with the scale bud scar width and scale bud scar thickness, and the leaf moisture was significantly negatively correlated with plant height ($p<0.05$). There was a significant positive correlation between leaves and plant height ($p<0.01$). There was a significant positive correlation between scale bud eye length and scale buds ($p<0.05$). Fertilization and reasonable pruning measures can be taken to increase the scale buds, thereby promoting the growth of scale bud eye length, so as to have a positive impact on the scale bud eye width.

5.2 Under 75% light, the 2nd, 3rd and 4th leaf whorl of leaf bud

As shown in Fig.8a, leaves were significantly negatively correlated with leaf moisture ($p<0.01$). There was a significant negative correlation between the stem moisture and the of leaf bud scale eye length, the leaf bud scale thickness and the leaf buds, the leaf moisture and the plant height ($p<0.05$). There was a significant positive correlation between leaves and plant height ($p<0.01$). There was a significant positive correlation between the leaf bud eye width and the leaf bud eye length ($p<0.05$). It can be seen that when the stem moisture increases, the leaf bud eye length becomes smaller. Therefore, in the early management of the rubber bud grafting bud, reasonable irrigation and appropriate reduction of the stem moisture are beneficial to increase the leaf bud eye length.

5.3 Under 100% light, the 2nd, 3rd and 4th leaf whorl of scale bud

As shown in Fig.8B, there was a significant positive correlation between leaf moisture and stem diameter, plant height and scale bud moisture, scale bud eye length and scale bud eye width ($p<0.01$). There was a significant positive correlation between leaf width and scale bud scar thickness, scale bud scar length and scale bud scar width ($p<0.05$). There was a significant negative correlation between the stem moisture and the scale bud eye length and the scale bud eye width ($p<0.05$). Therefore, in the early management of rubber bud grafting, reducing the stem moisture is helpful to increase the scale bud eye length and width. However, the stem moisture should not be excessively reduced, so as not to have a serious negative impact on the overall growth of the plant.

5.4 Under 100% light, the 2nd, 3rd and 4th leaf whorl of leaf bud

As shown in Fig.8b, leaves were significantly positively correlated with plant height ($p<0.01$). There was a significant positive correlation between leaves and leaf bud eye length, plant height and leaf bud eye length ($p < 0.05$). There was a significant negative correlation between the leaf bud scar width and the leaf buds ($p < 0.01$). Under 100% light, the leaves are an important factor in their growth and development. The increase in the leaves will increase the plant height and the leaf bud eye length. However, the increase in the leaf bud will reduce the leaf bud eye width. In rubber mini-seedling budding operation, leaf bud size can be roughly judged by the naked eye.

It can be concluded from the correlation analysis results that scale buds and leaves increase, controlling the stem moisture content and the number of leaf bud is beneficial to increasing the length and width of the bud eyes. In the process of plant growth and development, various parts of the plant affect and restrict each other through a variety of physiological and morphological mechanisms to achieve overall growth and development, in order to provide better quality buds for rubber mini-budding.

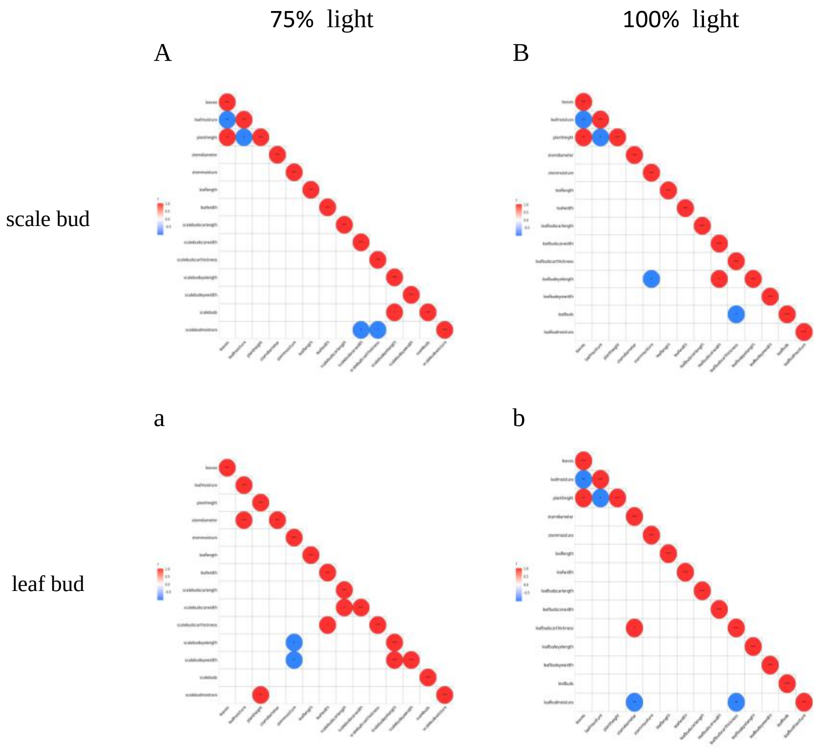

Fig. 8 Correlation analysis of leaf, stem, axillary bud and other indicators

6 Comprehensive analysis

As shown in Tab.2, taking stem diameter and plant height as low-optimal indexes, the TOPSIS method was used to analyze the leaves, leaf moisture, plant height, stem diameter, stem moisture, leaf length, leaf width, scale bud scar length, scale bud scar width, scale bud scar thickness, scale bud eye length, scale bud eye width, scale buds, scale bud moisture, leaf bud scar length, leaf bud scar width, leaf bud scar thickness, leaf bud eye length, leaf bud eye width, leaf buds, leaf bud moisture. The results are shown in Table 1. When considering the light intensity, the quality of axillary buds under 75% light was better than that under 100% light. When considering the bud leaf whorl, the best quality of axillary buds is the 3^{rd} leaf whorl, followed by the 2^{nd} leaf whorl, and finally the 4^{th} leaf whorl; without considering the light intensity and leaf whorl position, axillary bud quality: 3^{rd}-75% light > 3^{rd}-100% light > 2^{nd}-75% light > 2^{nd}-100% light > 4^{th}-75% light > 4^{th}-100% light.

Table 2 Comprehensive analysis of TOPSIS method based on leaves, stems and axillary buds

The sorting index value of each sample				
Leaf whorl -light intensity	D+	D-	Statistic CI	Rank
3^{rd}-75% light	0.3282	0.4364	0.5708	1
3^{rd} -100% light	0.3697	0.4451	0.5463	2
2^{nd}- 75% light	0.4075	0.4623	0.5315	3
2^{nd}- 100% light	0.4209	0.353	0.4561	4
4^{th}- 75% light	0.5045	0.3557	0.4135	5
4^{th}- 100% light	0.5317	0.3429	03921	6

D+, distance to optimal vector. D-, distance to inferior vector. CI, approximation to the Optimal Vectors.

In the growth process of rubber bud-stick, first of all, in terms of light management, priority should be given to controlling the light intensity at about 75%, under this light condition, the leaf length, leaf width, leaf bud scar width, scale bud eye length, scale bud scar length and scale bud scar width were better than those under 100% light condition, thus effectively improving the quality of axillary buds and providing better bud resources for subsequent rubber bud grafting production. For example, when building a greenhouse or shading facility, precise regulation can be carried out according to this light ratio to promote the good development of axillary buds. This is different from Chen Qing 's study on the effects of five shading intensities (0, 50%, 70%, 80% and 90%) on the growth of rubber tree tissue culture seedlings in Hainan Province by artificial shading [12]. It is concluded that the nursery rate of rubber tree tissue culture seedlings under 90% shading is significantly higher than that of other groups. In the process of seed selection and seedling raising, the axillary buds from the 3rd and 75% light conditions can be preferentially selected as the budding materials according to the results of axillary bud quality without considering the light intensity and leaf position, so as to improve the overall quality and growth potential of the seedlings, and lay a solid foundation for the later high-yield and high-quality production. It is consistent with the conclusion that the seedling growth of the seed seedlings obtained from the scale buds and axillary buds of the 3rd canopy leaves in the bud grafting experiment of rubber tree seed seedlings with different leaves and different buds of different canopy leaves such as Xiaolong Sun is significantly higher than that of other treatments and controls [13].

IV. CONCLUSION

This study analyzed multiple quality evaluation indicators of rubber tree axillary buds. The results showed that different light intensities have a significant impact on the quality of rubber tree axillary buds, covering many aspects such as axillary bud phenotypic traits, moisture content, and photosynthetic physiological indicators. Appropriate light intensity is the key factor to ensure the high quality of rubber tree axillary buds. Based on the above indicators and the actual performance of the plant, it was determined that under 75% light intensity conditions, the axillary buds in the 3rd-leaf whorl have the best quality. Therefore, during the growth process of rubber bud-stick seedlings, it is recommended to set the light intensity to 75%. For the propagation of rubber mini-seedling buddings through bud grafting, it is optimal to select bud-stick with three leaf whorls for bud grafting, and recommended for bud grafting according to leaf whorl position, which will optimize grafting technology and further improve the quality of rubber mini-seedling buddings. This can ensure that the mini-seedling buddings have high uniformity and neat forest appearance, and further solve the problem of labor consumption after transplanting in the field.

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