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Effect of leaf phenology on the growth of rubber buddings

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Abstract— *Rubber scion growth is the key step of rubber budding propagation. However, there is still a lack of systematic studies investigating leaf phenology effect on rubber scion growth. In this study, leaf phenology, stem diameter, plant height and the chlorophyll parameters were observed at six periods. The results showed that leaf-unfolding stage was the rapid growth and regulation stage of plant height and stem diameter, and light green leaf stage was the sensitive to environmental temperature. Taken together, leaf phenology affects the growth speed of rubber buddings, and distinguishing the differences in phenological effects helps to regulate the phenological process to raise rubber buddings.*

Keywords— ***Hevea brasiliensis, growth rate, leaf phenology, buddings.***

I. INTRODUCTION

The natural rubber self-sufficiency rate has gradually declined from about 50% in the 1990s to about 13.7% in 2020, and the self-sufficiency rate has been less than 20% for seven consecutive years, making China a major importer of natural rubber. Insufficient natural rubber self-sufficiency rate affects China strategic security to a certain extent. The implementation opinions of the Ministry of Agriculture and Rural Affairs of the Chinese Ministry of Agriculture and Rural Affairs on implementing the deployment of the Party Central Committee and the State Council in 2022 to comprehensively promote the key tasks of rural revitalization, namely Nongfa [2022] No. 1, pointed out that it is necessary to speed up the renovation of old rubber plantations and promote the standardized production of rubber plantations. As a result, the demand for rubber seedlings has risen sharply in the short term. Rubber propagation in China is mainly by the bud-grafting method and this technique requires an appropriately sized scion at the period of transferring budded plants out of the nursery. The speed of scion growth is related to the change of phenological process, which directly affects the speed of transferring budded plants out of the nursery. Leaf phenology is related to bud-grafting survival rate, disease control, and rubber tapping[1]. Ambient temperature[2], light[3-4], water and nutrients[5-6] affect the phenological process. At various developmental stages of leaf phenology, there are fluctuations in leaf color and shape, accompanied with the changes of leaf SPAD[7], leaf nutrients[8], leaf photosynthesis[9], the laticifer number[10] , leaf protein expression[11] and leaf gene expression[12]. However, the detailed changes of rubber budding growth index was still not clear, which make it difficult to precisely regulate the propagation process. Here we investigated growth index of buddings at different leaf phenology to further extend current knowledge of rubber budding propagation and to further regulate the growth of rubber buddings by the process of leaf phenology.

II. MATERIAL AND METHODS

The experiment was conducted from November 2018 to October 2020 at the nursery base of natural rubber of Rubber Research Institute of Chinese Academy of Tropical Agricultural Sciences, Danzhou City, Hainan Province, China. Clone GT1 seeds were sown in sand bed for germination and about 20-25 days later the GT1 seedlings were transplanted in polybags(8cm width*33cm length) for seedling nursery. Leaf phenology was investigated

from July 7 to September 30, which was best growth period for rubber seedling with 9mm average rainfall daily and good temperature(24.6℃-32.6℃). At different leaf phenology of new leaf whorl(Figure1), stem diameter was measured with vernier caliper (0.01 mm) and plant height were recorded with plastic ruler (0.1 mm). A Portable Chlorophyll Meter(CY-YL04, China) was used for detecting chlorophyll content(SPAD value), nitrogen content, leaf temperature and leaf humidity of plants during 9:30-10:30. Each leaf phenology of new leaf whorl 100 plants and 30 plants were investigated for the growth index(stem diameter and plant height) and for the chlorophyll parameters, respectively. Correlation heatmap analysis among the growth index and the chlorophyll parameters was evaluated on Tutools platform(http://www.cloudtutu.com), a free online data analysis website. Statistical analyses were performed with data processing system (DPS) statistical software package version 16.5 using student's t-test and one-way ANOVA followed by the Duncan's Multiple Range Test (SSR) to evaluate significant difference among different leaf phenology of seedlings at P<0.05. All data were shown in the mean ± SE.

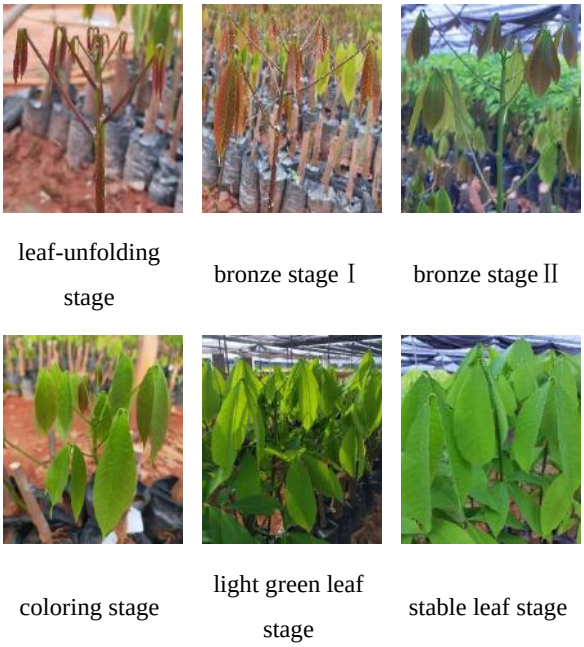

Fig.1: Leaf phenology of rubber buddings

Notes: Leaf-unfolding stage, bronze stageI, bronze stageII, coloring stage, light green leaf stage, stable leaf stage took 2 days, 2 days, 1 days, 2 days and 3 days, respectively.

III. RESULT AND DISCUSSION

Effect of leaf phenology on plant height

As shown in Figure2A, plant height of buddings new leaf whorl at bronze stageI, bronze stageII, coloring stage, light green leaf stage, and stable leaf stage were higher 40.36%($P < 0.01$), 53.38%($P < 0.01$), 60.56%($P < 0.01$),64.68%($P < 0.01$), and 66.47%($P < 0.01$) than that at leaf-unfolding stage, respectively. Plant height of buddings at bronze stageII, coloring stage, light green leaf stage, and stable leaf stage were higher 9.28%($P < 0.01$), 14.40%($P < 0.01$), 17.33%($P < 0.01$), 18.60%($P < 0.01$) than that at bronze stageI, respectively. Plant height of buddings at light green leaf stage and stable leaf stage were higher 7.37%($P < 0.05$) and 8.53%($P < 0.01$) than that at bronze stageII, respectively. There was no significant difference in plant height of buddings between bronze stageIIand coloring stage, among coloring stage, light green leaf stage, and stable leaf stage, respectively. These results indicate that leaf-unfolding stage is the rapid growth and regulation stage of plant height for buddings.

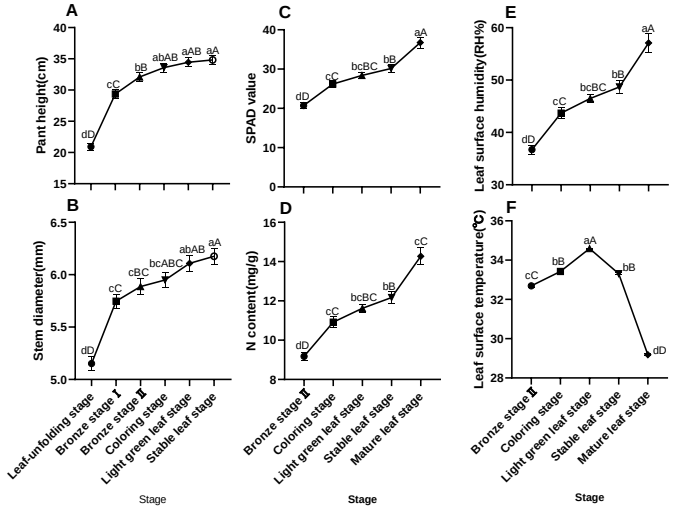

Fig.2 Comparison on plant height (A), scion stem diameter(B), SPAD value(C), N content(D) , leaf surface humidity(E) and leaf surface temperature(F) in rubber seedlings at different leaf phenology

Effect of leaf phenology on stem diameter

As shown in Figure2B, stem diameter of buddings new leaf whorl at bronze stageI, bronze stageII, coloring stage, light green leaf stage, and stable leaf stage were more 11.53%($P < 0.05$), 14.27%($P < 0.01$),15.46%($P < 0.01$), 18.54%($P < 0.01$), and 19.86%($P < 0.01$)than that at leaf-unfolding stage, respectively. Stem diameter of buddings new leaf whorl at light green leaf stage and stable leaf stage were more 6.29%($P < 0.01$) and 7.47%($P < 0.01$) than that at bronze stageI, respectively. Stem diameter of buddings new leaf whorl at light green leaf stage and stable leaf stage were more 3.74%($P < 0.05$) and 4.89%(P

< 0.01) than that at bronze stageII. Stem diameter of buddings s new leaf whorl at stable leaf stage were more 3.81%(P < 0.05) than that at coloring stage. These results indicate that leaf-unfolding stage is the rapid growth and regulation stage of stem diameter for seedlings.

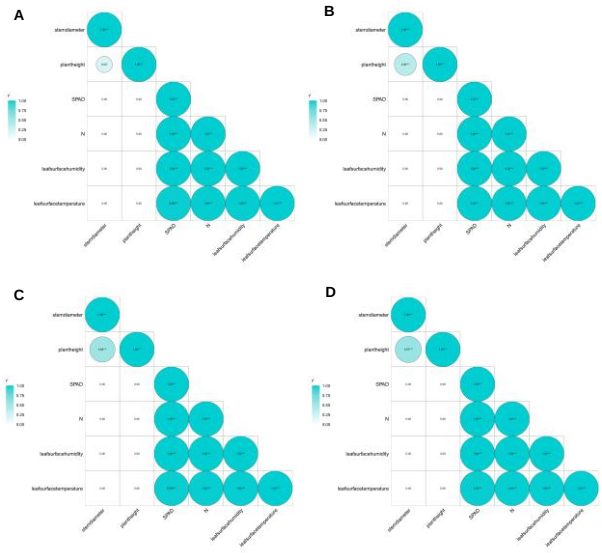

Fig.3 Correlation analysis among stem diameter, plant height, SPAD value, N content, leaf surface humidity and leaf surface temperature at bronze stageII(A), coloring stage(B), light green leaf stage(C), and stable leaf stage(D).

Effect of leaf phenology on the chlorophyll parameters

As shown in Figure2C, SPAD value, N content and leaf surface humidity of buddings new leaf whorl showed a same and upward trend with leaf phenology. SPAD value of seedlings new leaf whorl at coloring stage, light green leaf stage, stable leaf stage and mature leaf stage were more 26.46%(P < 0.01), 36.99%(P < 0.01),45.58%(P < 0.01), and 77.40%(P < 0.01) than that at bronze stageII, respectively. SPAD value of buddings new leaf whorl at stable leaf stage and mature leaf stage were more 15.12%(P < 0.01) and 40.28%(P < 0.01) than that at coloring stage, respectively. SPAD value of buddings new leaf whorl at mature leaf stage was more 29.50%(P < 0.01) and 21.86%(P < 0.01) than that at light green leaf stage and at stable leaf stage, respectively. There was no significant difference in SPAD value of buddings between coloring stage and light green leaf stage, between light green leaf stage and stable leaf stage, respectively.

As shown in Figure2D, N content of buddings new leaf whorl at coloring stage, light green leaf stage, stable leaf stage and mature leaf stage were more 18.95%(P < 0.01), 26.58%(P < 0.01), 32.57%(P < 0.01), and 55.45%(P < 0.01) than that at bronze stageII, respectively. N content of buddings new leaf whorl at stable leaf stage and mature leaf stage were more 11.45%(P < 0.01) and 30.68%(P < 0.01) than that at coloring stage, respectively. N content of buddings new leaf whorl at mature leaf stage was more 22.81%(P < 0.01) and 17.26%(P < 0.01) than that at light green leaf stage and at stable leaf stage, respectively. There was no significant difference in N content of buddings between coloring stage and light green leaf stage, between light green leaf stage and stable leaf stage, respectively.

As shown in Figure2E, leaf surface humidity of buddings new leaf whorl at coloring stage, light green leaf stage, stable leaf stage and mature leaf stage were more 18.95%(P < 0.01), 26.58%(P < 0.01), 32.57%(P < 0.01), and 55.45%(P < 0.01) than that at bronze stageII, respectively. Leaf surface humidity of buddings new leaf whorl at stable leaf stage and mature leaf stage were more 11.45%(P < 0.01) and 30.68%(P < 0.01) than that at coloring stage, respectively. Leaf surface humidity of buddings new leaf whorl at mature leaf stage was more 22.81%(P < 0.01) and 17.26%(P < 0.01) than that at light green leaf stage and at stable leaf stage, respectively. There was no significant difference in Leaf surface humidity of buddings between coloring stage and light green leaf stage, between light green leaf stage and stable leaf stage, respectively.

As shown in Figure2F, leaf surface temperature of buddings new leaf whorl at coloring stage, light green leaf stage, stable leaf stage and mature leaf stage were more 2.24%(P < 0.01), more 5.82%(P < 0.01), more 1.89%(P < 0.01) and less 10.73%(P < 0.01) than that at bronze stageII, respectively. Leaf surface temperature of buddings new leaf whorl at light green leaf stage and mature leaf stage were more 3.50% (P < 0.01) and 12.68% (P < 0.01) than that at coloring stage, respectively. Leaf surface temperature of buddings new leaf whorl at stable leaf stage and mature leaf stage were less 3.71% (P < 0.01) and 15.63% (P < 0.01) than that at light green leaf stage, respectively. Leaf surface temperature of buddings new leaf whorl at mature leaf stage were less 12.38% (P < 0.01) than that at stable leaf stage. Leaf surface temperature of buddings new leaf whorl at light green leaf stage showed a rapidly increase in comparison with other leaf stages. These results indicate that light green leaf is the sensitive stage to environmental temperature for seedlings, and as well stable leaf stage and mature leaf stage are the start of proper time and the best time to transplant the buddings out of the nursery to the field.

Correlation analysis between the growth index and the chlorophyll parameters at different leaf stage

As shown in Figure3A-D, there was a significant positive correlation between plant height and stem diameter at bronze stageII($r=0.22$, $p<0.05$), coloring stage($r=0.40$, $p<0.01$), light green leaf stage($r=0.54$, $p<0.01$), stable leaf stage($r=0.57$, $p<0.01$), respectively. There was a significant positive correlation($r=1$, $p<0.01$) among SPAD value, N content, leaf surface humidity and leaf surface temperature at different leaf stages. Plant height had no significant correlation with chlorophyll parameters(SPAD value, N content, leaf surface humidity and leaf surface temperature) . Stem diameter had no significant correlation with chlorophyll parameters(SPAD value, N content, leaf surface humidity and leaf surface temperature) . These results indicate that there is no significant correlation between growth index(plant height and stem diameter) and chlorophyll parameters(SPAD value, N content, leaf surface humidity and leaf surface temperature) for rubber buddings at different leaf stages, which might be related with the different methods of rubber buddings propagation[13-14].

IV. CONCLUSION

For rubber buddings propagation, leaf-unfolding stage was the rapid growth and regulation stage of plant height and stem diameter, light green leaf stage was the sensitive to environmental temperature, and mature leaf stage with high nutrient accumulation and low metabolism was the best time to transplant the buddings to the field.

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AUTHORS' CONTRIBUTION

X.H. Chen conceived the experiments, R. Wang and X.H. Chen conducted the experiments, R. Wang and X.H. Chen analyzed the data and drafted the manuscript, R. Wang , X.H. Chen, and J. Wang discussed the results and finalized the manuscript.

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