



Effects of *Hevea nitida* interstock on the growth and physiology of *Hevea brasiliensis*

Xin-Long Wang^{1,2}, Han-Qi Tu¹, Jun Wang^{1,2}, Xing-Cheng Yao^{1,2*}

¹Rubber Research Institute, Chinese Academy of Tropical Agricultural Sciences (CATAS), Haikou 571101, China

²Haikou Key Laboratory of Innovation of Seedlings of Tropical Plants, Haikou

*: corresponding author

Received: 07 Sep 2026; Received in revised form: 05 Oct 2026; Accepted: 10 Oct 2026; Available online: 17 Oct 2026

©2026 The Author(s). Published by Infogain Publication. This is an open-access article under the CC BY license

(<https://creativecommons.org/licenses/by/4.0/>).

Abstract— This study aimed to evaluate the effects of *Hevea nitida* as an interstock on *Hevea brasiliensis*. The *H. nitida* interstock was set at 10 and 30 cm (*H. nitida*-10 and *H. nitida*-30). Growth indices, leaf stomatal traits, mineral element contents, carbohydrate contents, and rubber particle size were measured. The *H. nitida* interstock significantly reduced plant height and scion diameter, and the inhibitory effect increased with interstock length. *H. nitida*-10 showed larger scion and interstock diameters than *H. nitida*-30. The *H. nitida* interstock did not affect scion stomatal size or density. The interstock did not affect N or P contents, but reduced Ca and Mg contents. Soluble sugar and starch contents were significantly higher in *H. nitida*-10 and *H. nitida*-30 than in CK, but did not differ between the two interstock lengths. The average rubber particle size of *H. nitida* was smaller than that of *H. brasiliensis*, but *H. nitida* interstock did not affect rubber particle size in the scion. These results indicate that *H. nitida* interstock causes dwarfing and alters mineral and carbohydrate status in the scion, with effects dependent on interstock length, but does not affect leaf stomatal traits or rubber particle size.

Keywords— *Hevea brasiliensis*, *Hevea nitida*, interstock, stock-scion interaction



I. INTRODUCTION

The interstock is a segment of a tree trunk grafted between the rootstock and the scion. Interstocks were initially studied as a means to overcome interspecific incompatibility between rootstocks and scions (Rogers et al, 2003). For instance, ‘Hongmian miyou’ is incompatible with trifoliate orange rootstocks such as *Poncirus trifoliata*, therefore, an interstock of ‘Guanxi miyou’ (compatible with *Poncirus trifoliata*) was commonly used between the scion (‘Hongmian miyou’) and the rootstock (*Poncirus trifoliata*) (He et al, 2018). Heretofore, interstocks have been used in persimmon (Shen et al, 2019), lemon (Gil-Izquierdo et al,

2004), apple (Seleznova et al, 2008), and other fruit trees to regulate tree size (Calderón et al, 2021), improve fruit yield and quality, and delay tree aging (Gil-Izquierdo et al, 2004). The rational use of a combination of citrus rootstocks and interstocks can enhance disease resistance (Shokrollah et al, 2011, Elias-Roman et al 2019), promote tree dwarfing (Seleznova et al, 2008), and improve citrus fruit quality (Almqvist et al, 2013, Rebollo-Martínez et al, 2019).

Rubber trees (*Hevea brasiliensis*), which produce natural rubber, are important economic crops in tropical regions. Cultivated rubber trees are propagated by grafting high-yielding clones onto seedling rootstocks. Studies have

shown that both rootstocks and interstocks can affect the growth of rubber tree scions (Yao et al., 2017; Bastiah Ahmad et al., 1996). Leong and Yoon (1978) reported that interstocks with reduced growth potential, such as *H. spruceana*, could substantially reduce scion growth. Rubber trees planted in Hainan Province are frequently damaged by typhoons. Reducing tree height is an effective means of mitigating typhoon damage. *H. nitida*, which is small to medium in size, dwarfed the tree when used as a crown scion in a three-part tree (Lin et al., 1995). However, the effect of *H. nitida* as an interstock on rubber tree growth remains unknown. In the present study, *H. nitida* was used as an interstock, and its effect on tree growth and physiology was investigated.

II. MATERIALS AND METHODS

Experimental materials

H. nitida was grafted onto *H. brasiliensis* seedlings, and then the *H. brasiliensis* clone CATAS 73397 was grafted onto *H. nitida* as the scion. The *H. nitida* interstock was set to lengths of 10 and 30 cm (plants designated as H. nitida-10 and H. nitida-30, respectively). For the control treatments, both the interstock and the scion were the clone CATAS 73397, and the interstock length was also set to 10 and 30 cm (designated as CK-10 and CK-30, respectively). In addition, *H. nitida* grafted onto *H. brasiliensis* rootstock was prepared and used as a control.

Measurement of plant growth index

The diameter of the scion stem was measured at 20 cm above the graft union between the scion and the interstock every two months after planting. The diameter of the interstock was also measured at its midpoint at 12 and 24 months after planting.

Leaf stomatal analysis

A thin layer of epidermis from the lower surface was peeled off and stained with I₂-KI on a slide. Stomatal images were captured using a light microscope equipped with a digital camera (Leica, DFC550). Stomatal length, width, and density were measured using the free software ImageJ 1.5.

Determination of physiological parameters

Leaves from H. nitida-10 and H. nitida-30 were collected separately, while leaves from CK-10 and CK-30 were mixed to form one treatment, designated CK. The collected

leaves were immediately oven-dried at 110 °C for 30 min and then dried at 60 °C for 24 h. The dried leaf samples were ground into powder and then used for the determination of mineral elements and carbohydrates. Total nitrogen content was determined by Nessler's colorimetric method, total phosphorus content by the molybdenum–antimony–ascorbic acid colorimetric method, and the contents of potassium (K) and calcium (Ca) by flame atomic absorption spectrometry (Bao, 2000). Soluble sugar content was determined by the anthrone–sulfuric acid method. Starch content was determined by polarimetry.

Rubber particle size analysis

Latex from the primary laticifers was collected from scion leaves of H. nitida-30, CATAS 73397 (CK), and *H. nitida*, and transferred into a tube containing ice-cold buffer (10 mM Tris-HCl, 100 mM sucrose, pH 7.5). The particle size of the rubber particles was determined using an LA-960 laser scattering particle size distribution analyzer according to the manufacturer's instructions.

III. RESULTS

Effect of *H. nitida* interstock on the plant growth

The effect of the *H. nitida* interstock on plant height is shown in Table 1. The *H. nitida* interstock resulted in shorter plants. The inhibitory effect of the *H. nitida* interstock on plant height became more evident with age, as illustrated in Figure 1. Scion diameter was also affected by the *H. nitida* interstock. The inhibitory effect on scion diameter was similar to that observed for plant height. The *H. nitida* interstock reduced scion diameter growth, and this reduction was more pronounced during the rainy seasons (July to December, 8 to 14 months after planting; Figure 1).

The effect of the *H. nitida* interstock on scion growth was associated with interstock length, as illustrated in Figures 1 and 2. Plant height and scion diameter in H. nitida-30 were lower and smaller, respectively, than those in H. nitida-10, indicating that the longer the *H. nitida* interstock, the stronger the inhibitory effect on plant growth.

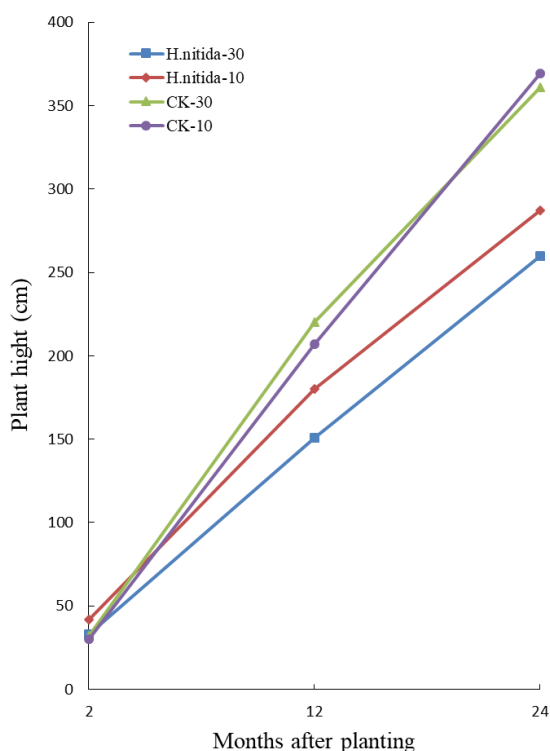


Fig.1 Effect of interstock on the plant height

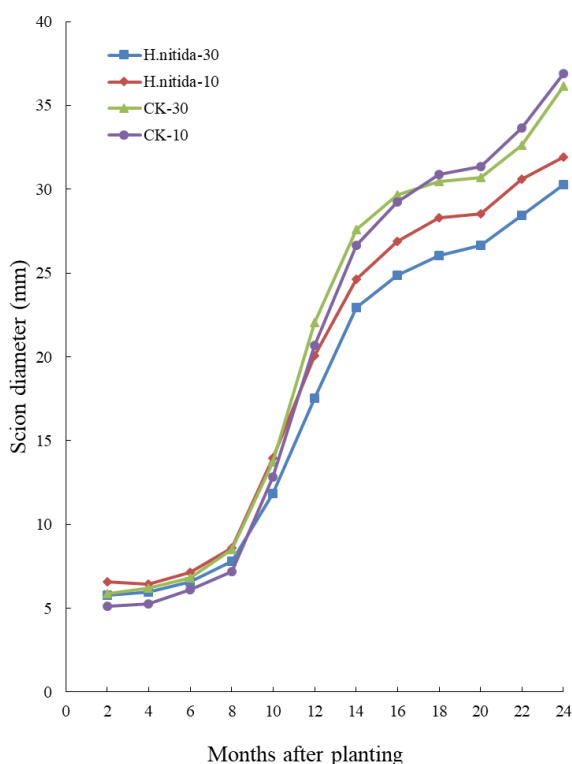


Fig.2 Effect of interstock on scion diameter

H. nitida exhibited a lower diameter growth rate than *H. brasiliensis* (0.68 vs. 1.05 mm/month; clone CATAS

73397). Therefore, when used as an interstock, *H. nitida* had a smaller diameter than CK-10 and CK-30 (Figure 3). The scion and interstock diameters of CK-10 were comparable to those of CK-30; however, the scion and interstock diameters of *H. nitida*-10 were larger than those of *H. nitida*-30. This indicated that the scion also affected interstock growth; the more vigorous scion growth in *H. nitida*-10 therefore resulted in a larger interstock diameter.

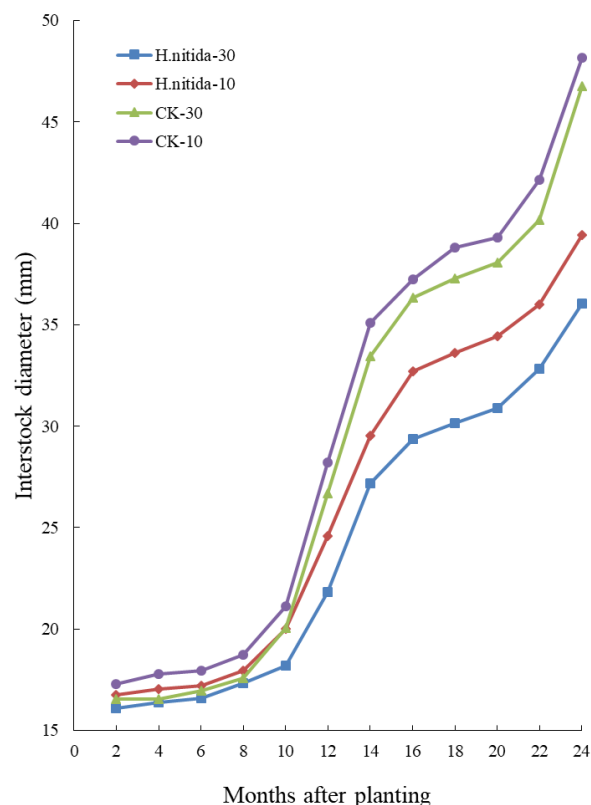


Fig.3 Effect of interstock on the interstock diameter

Effect of *H. nitida* interstock on leaf stomata

Leaf stomata are related to water utilization and further affect plant growth. The stomatal characteristics of *H. nitida* differ from those of *H. brasiliensis* (CK, viz. CATAS 73397). Stomatal density did not differ between *H. nitida* and *H. brasiliensis* (CK, viz. CATAS 73397) (514 vs. 499/mm²). Stomatal length and width of *H. nitida* were 16.42 and 11.52 μ m, respectively, significantly different from those of CK (24.51 and 15.58 μ m, respectively). Stomatal length and width of *H. nitida*-30 and *H. nitida*-10 were similar to those of CK-10 and CK-30.

Effect of *H. nitida* interstock on leaf mineral element content

The leaves were analyzed for mineral element content. The *H. nitida* interstock did not affect the macronutrients N and P (Figure 4). The macronutrient K content of *H. nitida*-30 was comparable to that of *H. nitida*-10 but significantly lower than that of CK. The *H. nitida* interstock significantly reduced Ca and Mg contents in *H. nitida*-30 and *H. nitida*-10. The length of the *H. nitida* interstock did not affect Ca and Mg contents.

Effect of *H. nitida* interstock on carbohydrate content

Soluble sugar content in *H. nitida*-30 and *H. nitida*-10 was significantly higher than that in CK (Figure 5). Starch content in *H. nitida*-30 and *H. nitida*-10 was also significantly higher than that in CK. However, the length of the *H. nitida* interstock did not affect the contents of soluble sugar and starch, as both were comparable between *H. nitida*-30 and *H. nitida*-10.

Effect of *H. nitida* interstock on rubber particle size

The average rubber particle size of *H. nitida* from primary laticifers was smaller than that of *H. brasiliensis* (clone CATAS 73397; 0.32 vs. 0.35 μm). The average rubber particle size of *H. nitida*-30 was similar to that of CK (0.35 μm). The particle size frequency curves of *H. nitida*, CK, and *H. nitida*-30 illustrated in Figure 6 showed the difference between *H. nitida* and *H. brasiliensis* (CK), and the similarity between CK and *H. nitida*-30. Therefore, the *H. nitida* interstock did not affect rubber particle size in the scion.

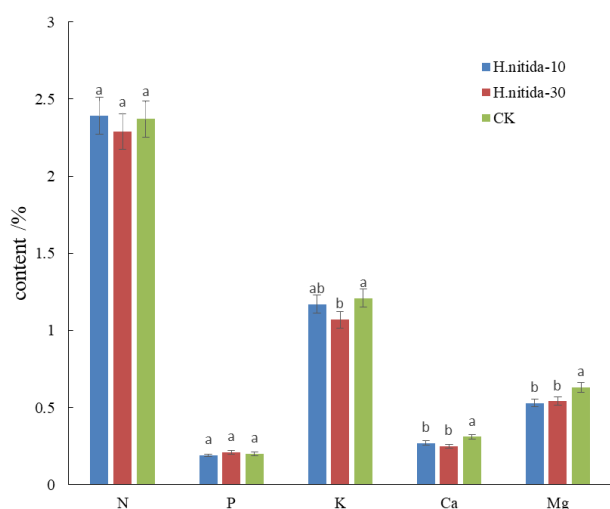


Fig.4 Effect of interstock on mineral element content

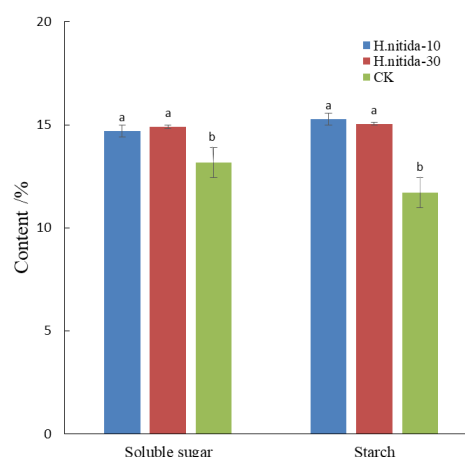


Fig.5 Effect of interstock on soluble sugar and starch contents

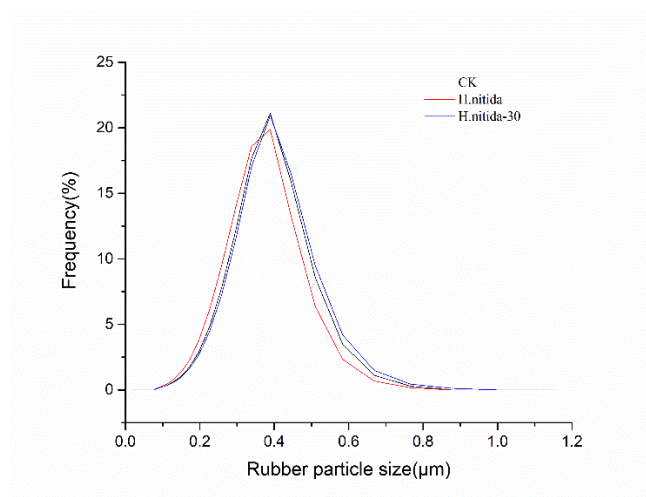


Fig.6 Comparison of the size of rubber particles

IV. DISCUSSION

Using low-vigor species as interstocks can suppress scion growth. Low-vigor *Hevea* species, such as *H. spruceana* and dwarf *H. brasiliensis* varieties, have also been shown to inhibit growth when used as interstocks (Leong and Yoon, 1978; Bastiah Ahmad et al., 1996). In this study, *H. nitida* exhibited low growth vigor and consequently reduced scion growth. *H. nitida* not only shortened the height of the composite plant but also retarded scion stem growth. Together with earlier findings (Leong and Yoon, 1978; Bastiah Ahmad et al., 1996), these results suggest that low-vigor *Hevea* species share similar characteristics when used as interstocks. By reducing plant height, *H. nitida* interstock has the potential to enhance typhoon resistance.

The dwarfing effect of interstock length is commonly

observed across different tree species: the longer the interstock, the shorter the plant height (Jiang et al., 2010). In this study, a longer *H. nitida* interstock produced a stronger dwarfing effect, which is consistent with the findings of Leong and Yoon (1978) for *H. spruceana* interstock. For *H. nitida* interstock, the stem growth rate was expected to be similar between *H. nitida*-30 and *H. nitida*-10. However, the *H. nitida* interstock in *H. nitida*-10 was larger than that in *H. nitida*-30. This was probably due to the scion effect: *H. nitida*-10 grew faster than *H. nitida*-30 and therefore produced more dry matter, resulting in more dry matter being allocated to the *H. nitida* interstock in *H. nitida*-10.

Although the leaf stomata of *H. nitida* were smaller than those of *H. brasiliensis* (CK), the stomatal size and density in *H. nitida*-30 and *H. nitida*-10 were similar to those in the CK, indicating that *H. nitida* interstock did not affect the leaf stomata of the scion. This result differs from the findings of Bastiah Ahmad (1990), which showed that *Hevea* interstock affected stomatal density and size. *H. nitida* interstock also did not affect the size of rubber particles in the primary laticifers of the leaf, suggesting that it would not affect rubber synthesis and, consequently, rubber production in the scion. Bastiah Ahmad's study demonstrated that rubber production in scions depended largely on the genotype of the scion clone and rarely on that of the interstock clone. However, this conclusion was based on *H. brasiliensis* species; the effect of other species used as interstock on rubber production has not yet been reported.

The effect of interstock on leaf mineral element contents in fruit trees has been widely reported (Jiang et al., 2010; He et al., 2018; Li et al., 2023). In this study, the *H. nitida* interstock did not affect N or P contents, but it reduced Ca and Mg contents. In addition, K content was found to be affected by interstock length. These results suggest that *H. nitida* interstock may influence the distribution and/or transport of K, Ca, and Mg.

Plant growth is closely associated with carbohydrate status. Soluble sugar and starch are the main carbohydrate components, and their contents are closely related to plant growth. The contents of soluble sugar and starch in *H. nitida*-30 and *H. nitida*-10 were significantly higher than those in the CK. This suggests that the *H. nitida* interstock may reduce sink strength, restrict carbohydrate export from

the leaves, and decrease carbohydrate consumption, thereby leading to greater carbohydrate accumulation in the leaves.

ACKNOWLEDGEMENT

This study was financially supported by Hainan Provincial Natural Science Foundation of China (No.325MS134).

REFERENCES

- [1] Almqvist, C. (2013). Interstock effects on topgraft vitality and strobili production after topgrafting in *Pinus sylvestris*. *Can J For Res*, 43: 584–588.
- [2] Bao, S.D. (2000). Soil and agricultural chemistry analysis (3rd Edition) [M]. Beijing: China Agriculture Press.
- [3] Bastiah B. Ahmad, Wan, C.K., Mohd Ahib Mohd Yusoff. (1996). Effect of interstock on dry matter production and growth analysis of *Hevea brasiliensis* (Muell. Arg.) *J Nat Rubb Res*, 11(4): 265–296.
- [4] Bastiah B. Ahmad. (1990). Effect of interstock on growth and yield of *Hevea brasiliensis* (Muell. Arg.) [D] Universiti Putra Malaysia.
- [5] Calderón, F., Weibel, A.M., Trentacoste, E.R. (2021). Effects of different interstock length on vegetative growth and flowering in peach cv. Pavie Catherine. *Sci Hortic*, 285: 110174.
- [6] Elias-Roman, R.D., Calderon-Zavala, G., Guzman-Mendoza, R., et al. (2019). 'Mondragon': a clonal plum rootstock to enhance management of Armillaria root disease in peach orchards of Mexico. *Crop Prot*, 121: 89–95.
- [7] Gil-Izquierdo, A., Riquelme, M.T., Porras, I., et al. (2004). Effect of the rootstock and Interstock grafted in lemon tree (*Citruslimon* (L.) *Burm.*) on the flavonoid content of lemon juice. *J Agric Food Chem*, 52: 324–331.
- [8] He, P., Li, L.G., Wang, H.B., et al. (2018). Effects of five dwarfing interstocks on shoot growth, fruiting and accumulation of mineral elements in leaves of Yishui red Fuji apple. *Scientia Agricultura Sinica*, 51(4):750–757.
- [9] He, W., Wang, Y., Chen, Q., et al. (2018). Dissection of the mechanism for compatible and incompatible graft combinations of *Citrus grandis* (L.) Osbeck ('Hongmian Miyou'). *Int J Mol Sci*, 19: 505.
- [10] Jiang, S.L., Jia, J.X., Wang, F., et al. (2010). The dwarfing effect of three pear dwarfing intermediate stocks on grafting trees. *Scientia Agricultura Sinica*, 43(23): 4886–4892.
- [11] Leong, W., Yoon, P.K. (1978). Effect of interstock on growth of *Hevea*. *J Rubb Res Inst Malaysia*, 26(3): 99–104.
- [12] Li, S., Chen, H.W., Zhang, Y.H., et al. (2023). Effects of Jizhen 1 interstock on mineral nutrition and endogenous hormone contents in

- leaves of 'Tianhong 2'. J Hebei Agric University, 46(2): 28–34.
- [13] Lin, W.F., Huang, S. F. (1995). Dwarf three-part trees of *Hevea brasiliensis*. Chinese J Tropical Crops, 16(1): 1–9.
- [14] Luo, J., Wang, F., Han., M.Y., et al. (2013) Anatomical mechanism of two apple dwarf interstocks. J Northwest Agri Forest University, 41(6): 124–132.
- [15] Rebolledo-Martínez, A., Peralta-Antonio, N., Rebolledo-Martínez, L., et al. (2019). Effect of rootstock in tree growth, dry matter, flowering, yield and quality of 'Manila' mango. Sci. Hortic, 251: 155–161.
- [16] Rogers, W.S., Beakbane, A.B. (2003). Stock and scion relations. Annu. Rev. Plant Physiol, 8: 217–236.
- [17] Seleznyova, A.N., Tustin, D.S., Thorp, T.G. (2008). Apple dwarfing rootstocks and interstocks affect the type of growth units produced during the annual growth cycle: Precocious transition to flowering affects the composition and vigour of annual shoots. Ann Bot, 101: 679–687.
- [18] Shen, Y., Zhuang, W., Tu, X., et al. (2019). Transcriptomic analysis of interstock-induced dwarfism in sweet persimmon (*Diospyros kaki* Thunb.). Hortic Res, 6: 1086–1102.
- [19] Shokrollah, H., Abdullah, T.L., Sijam, K., et al. (2011). Potential use of selected citrus rootstocks and interstocks against HLB disease in Malaysia. Crop Prot, 30: 521–525.
- [20] Yao, X., Chen, X., Wang, J., et al. (2017). Effect of clonal rootstocks on the growth and yield of hevea rubber. Journal of Rubber Research, 20(3): 203–212.