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Trunk Contraction of *Hevea brasiliensis* Due to Tapping

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Abstract. Determination of bark contraction due to tapping made simultaneously at different positions on the trunk of *Hevea* trees (young PR 107, S/2 ↓) provided information about the flow area and the speed of contration spreading.

The relation between truck contraction at the given distance from the cut and the amount of latex tapped was experessed in mathematical terms. A quantitative relation was also established between the yields of latex and the linear dimension of flow areas in longitudinal direction below the middle of tapping cut.

From the contraction curves it is deduced that the lateral flow of latex becomes relatively more important with increasing yields.

Trunk contraction of *Hevea brasiliensis* due to tapping was investigated for the first time in Malaya by PYKE (1941), who constructed for this purpose a special dendrometer modified later by GOODING (1952a 1952b) and by BOATMAN (1956). Pyke found the contraction near the cut beginning a few seconds after opening of the cut and reaching its maximal value in three minutes. This value varied from tree to tree as a function of the weather and of the time of day — usually around 0·03 mm. No contraction was found to appear above the tapping cut. GOODING (1952a) confirmed Pyke's observation and in further experiments found that the contraction below the cut was immediate, that 30 cm below appeared 2—6 min. later and that 61 cm below some 8—10 min. after the cut was opened. With progressively increasing distance from the cut, the contraction was smaller and recovery slower.

During our visit to the Rubber Research Institute of Malaya, Kuala Lumpur 1965, Dr. Southorn kindly showed us a simple instrument utilised by him to detect local changes in bark thickness of hevea tree close to the tapping cut. This consisted of a Mercer dial gauge mounted on a duralumin head, and bolted to a robust cine camera tripod (SOUTHORN 1967). We fixed

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several Mercer dial gauges on metallic tubes so that the contractions of the bark at different distances from the cut could be detected simultaneously. This method we utilised to delimit the flow area (Luštinec, Chai Kim Chun and Resing 1966) and to differentiate it from the outflow area* (Luštinec, Resing and Simmer 1968). A similar method has been employed by Ninane (1967), who detected local changes of trunk dimensions of Hevea tree on four cardinal points during two months continuously and obtained data on the changes of the trunk diameter due to growth, weather and tapping.

The purpose of this work was to further investigate the contraction of the bark as a criterion of the latex flow at different places on the trunk and to establish a relation between the degree of contraction and the amount of latex tapped.

Material and Methods

Trees of clone PR 107 planted in 1957 and tapped from April 1965 on a half-spiral cut (S/2 ↓) were employed for the dendrometrical studies. Their circumference at the opening of the cut was about 52 cm at 1 m from the ground. During the experimental period (June—August 1966) the trees were tapped every three days (D/3) at 95 cm from the ground (the breadth of the consumed bark was about 12 cm). Mercer dial gauges (Southorn 1967) were bolted to duralumin holders which were fixed to metallic tubes (5 cm in diameter and 3 m long). The tube was inserted to the ground to a depth of 10 cm at its lower end and with the upper end fixed to the trunk so that it was standing parallel to the trunk at a distance of some 15 cm. By means of bolts the sensing probe of a dial gauge could be gently compressed against the trunk and the pointer brought easily to a starting position. The gauges were scaled in 2·5 micrometre divisions and could easily be read to 1 micrometre discrimination. This mode of fixation of dial gauges was very satisfactory provided that the tree was quite immobile. Swaying of the trunk due to wind was avoided by cutting the extremities of branches. Such a defoliation was useful also to prevent or at least greatly diminish changes in the trunk diameter caused by transpiration. Measurements were usually made in the early morning when the effect of disturbing climatic factors was the least. Dendrometrical readings were made at intervals of 30 seconds. The changes of bark thickness enregistered concern 2 mm^2 surface of the trunk where the sensing probe was contiguous with it.

Results and Discussion

Dendrometrical measurements made simultaneously at different places in the trunk supplied information about latex movements in the bark above and below the tapping cut (Fig. 1, 2), around the trunk circumference (Fig. 3), and about the speed of contraction spreading (Fig. 1). In most cases the greatest shrinkage occurs immediately below the cut (Fig. 2-A). With increasing

* Outflow area (l'aire d'écoulement) was defined as an area of bark from which latex runs out during one tapping. Flow area (l'aire de déplacement) is an area of bark in which latex flows towards the cut during tapping or even after it.

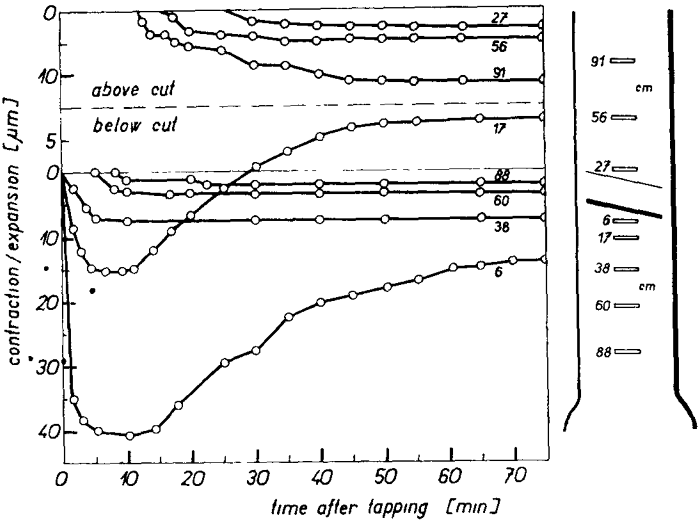


Fig. 1. Contraction and expansion of the bark in micrometres at different distances above and below tapping cut plotted against time in min since opening the cut. Yield of latex: 57 ml.

distance from the cut the contraction is smaller, disappearing at the end of the flow area. Curve A, representing the most frequent case of trunk contraction below the cut, may be expressed by an equation given later. The shrinkage of the bark is less above the cut and its scarcely defined maximum is at about 30—40 cm distance away. But the lengths of the contraction

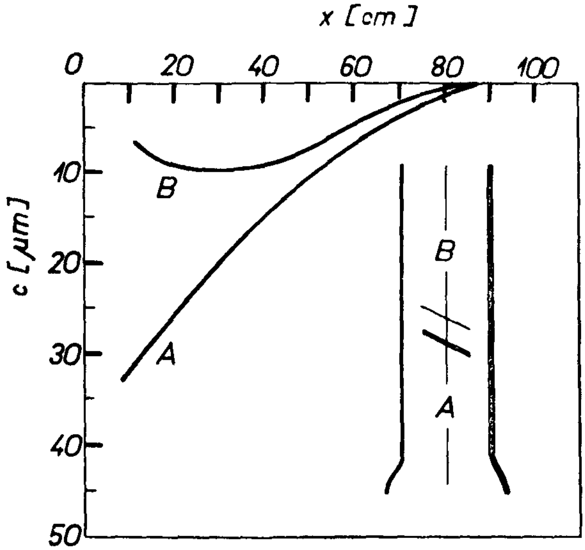


Fig. 2. Two most frequent types of maximal contraction curves: A — below, B — above the cut. Average of 5 trees and 5 tappings. Average yield of latex: 45 ml.

(or flow) areas on both sides of the cut are nearly the same. The mode of bark contraction above the cut may perhaps be explained by the lateral movement of the latex in that region of the trunk. Most of the latex, however, flows from this point directly to the cut as observed in our previous experiments (LUŠTINEC, CHAI KIM CHUN and RESING 1966).

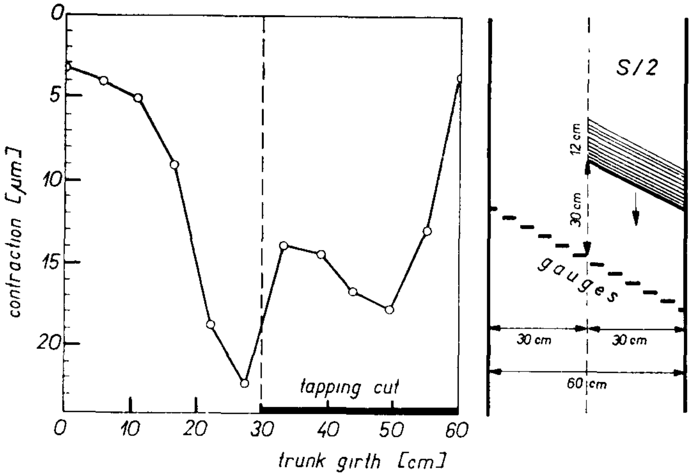


Fig. 3. Maximal contraction of the bark on the circumference of the trunk. Average of 2 trees and 4 tappings. Average yield of latex: 28 ml. The tapping cut and the bark contractions are represented in vertical projection on the horizontal circumference of the trunk.

Fig. 3 shows how the bark contracted on the circumference of the trunk. Two maxima of shrinkage seem to be in relation with the streams coming from the sides.

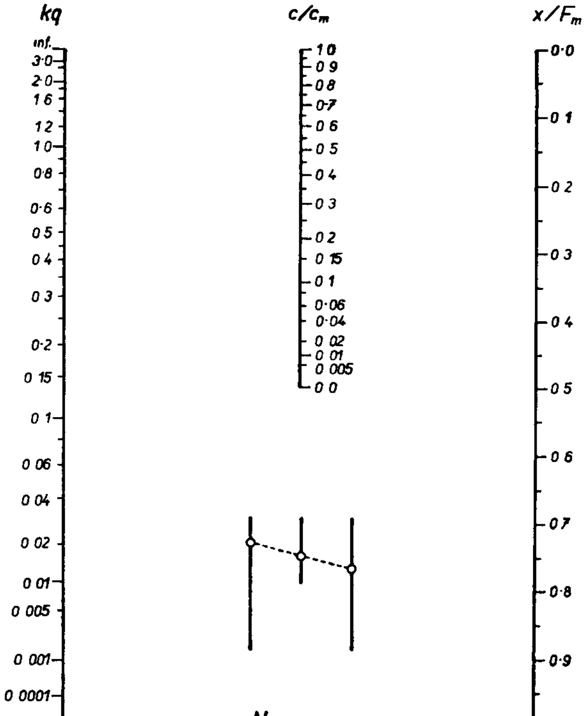
The contraction of the bark spreads away from the cut progressively (Fig. 1). In most cases the contraction 0—20 cm below the cut was immediate, that at 20—40 cm during 1 min., at 40—60 cm during 3 min. and at 60—80 cm during 60 min. after the cut was opened. On the opposite side of the trunk the contraction usually began 90—120 min. after the tapping was started. In a few cases, however, a contraction at 100 cm below the cut was noticed 4 min. after opening the cut and on the opposite side even during some seconds. Knowledge of the beginning of contraction is essential when the speed of latex flow in the bark is determined by means of radioisotopes (Rubb. Res. Inst. Camb., unpublished results).

In several trees the contraction was determined systematically at ten positions below the cut during ten to fifteen tappings yielding 20 to 80 ml of latex. The measurements made on one selected tree having a convenient normal yield variation were utilised to establish the relation between contraction of the trunk at the given distance from the tapping cut and the amount of latex tapped. The contraction values corresponding to different amounts of latex collected permitted one to draw parabolic contraction curves which are expressed by the following equation:

$$c = c_p \left[\sqrt[3]{1 - e^{-kq}} - x/F_p \right]^2 \qquad (1)$$

where c = maximal contraction of the bark in micrometres at distance x below the middle of tapping cut,
c_p = greatest possible contraction of the bark in micrometres below the middle of tapping cut,
x = distance from the tapping cut in cm,
F_p = greatest possible linear dimension of flow area in longitudinal direction below the middle of tapping cut to which the actual flow area can approach asymptotically as a function of the increasing flow,
k = specific constant,
q = amount of latex tapped in ml

Construction of the equation was inspired by the theory of elasticity. Standard deviation of experimental values from calculated curves is $\pm 0{\cdot}8$ to $\pm 2{\cdot}3$ μm.



Nomogram

If x equals F (linear dimension of flow area in longitudinal direction below the middle of tapping cut), then the expression in the brackets equals zero, so that:

$$F = F_p \sqrt[3]{1 - e^{-kq}} \tag{2}$$

Equation (2) expresses the relation between the length of flow area and the amount of the latex tapped (Fig. 6).

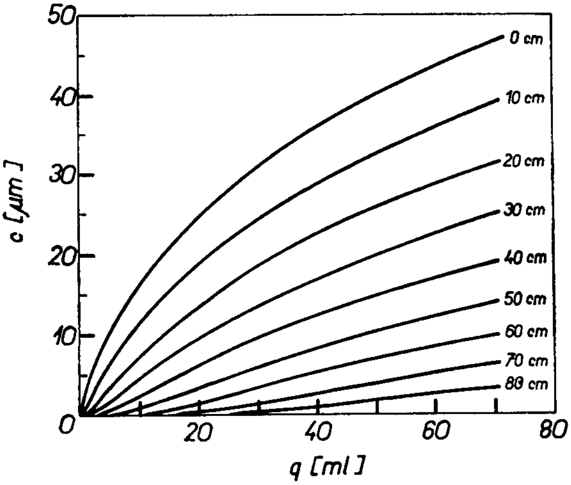


Fig. 4. Maximal contraction of the bark (c) at different distances from the tapping cut as a function of different amounts of latex tapped (q).

The values of the constants were derived from the experimental results. In the given case $c_p = 68$ μm, k = 0·012 ml, $F_p = 132$ cm.

On the basis of equations (1) and (2) — see nomogram — graphically represented by Fig. 4 and 5, it was possible to get an idea about area contraction of the bark in a longitudinal direction below the middle of the tapping cut (c_a):

$$c = \int_0^F c\,dx = \frac{1}{3} c_p F_p (1 - e^{-kq}) \qquad (3)$$

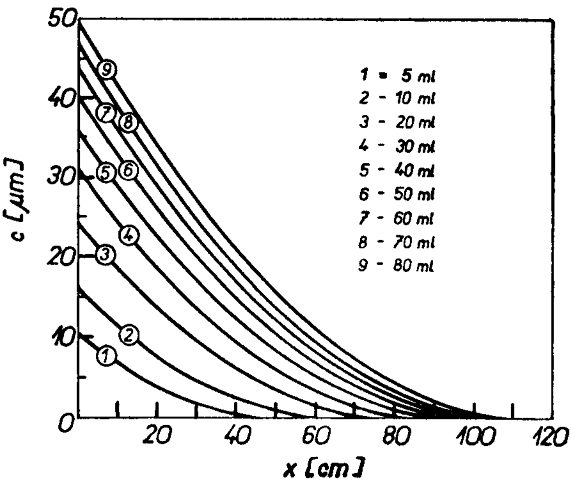


Fig. 5. Maximal contraction of the bark (c) for different amounts of latex tapped as a function of distance from the tapping cut (x).

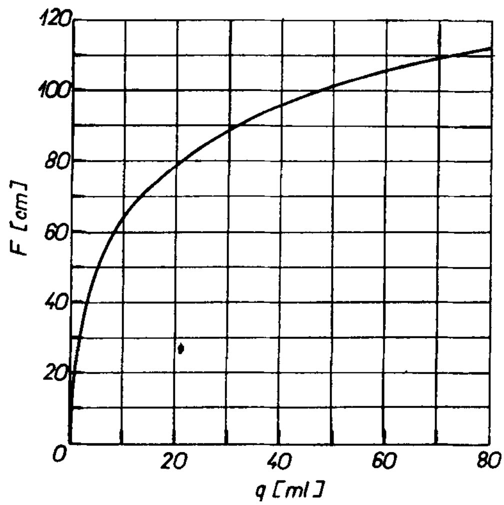


Fig. 6. Graphic expression of the relation between the linear dimension of flow area in longitudinal direction below the middle of tapping cut (F) and the amount of the latex tapped (q).

In Fig. 7 the area contraction values were plotted against the corresponding amounts of latex. The nonlinearity of the resulting curve (a) may be explained by two factors:

a) by progressive expansion of the flow area in a lateral direction,
b) by the dilution reaction (FREY-WYSSLING 1932), the importance of which may increase with greater amounts of latex tapped due to longer time of latex flow.

To evaluate the possible effect of the dilution reaction, the values of latex concentration (TSC) were compared with specific area contractions (c_a/q)

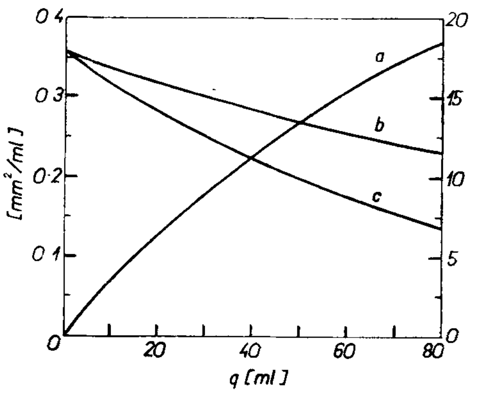


Fig. 7. Area contraction of the bark (a) in mm², specific area contraction (b) and derivation of area contraction of bark (c) in mm²/ml, below the middle of tapping cut at different quantities of latex tapped.

and with derivations of area contractions (dc_a/dq) represented in Fig. 7 by curves b and c.

$$\left[\frac{dc_a}{dq} = \frac{1}{3} c_p F_p ke^{-kq}\right]$$

The dc_a/dq values are more suitable for the comparison than the c_a/q ones, because they are not affected by the preceding course of the process. Curve c showes that the dc_a/dq decreases from the original 0·36 to 0·14 mm^2/ml. The percentual difference between these values is more than ten times greater than the difference between the corresponding TSC values and cannot be explained by the dilution reaction. It can be therefore concluded that with increasing yields the lateral flow of latex becomes relatively more important.

Acknowledgement
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Stanovení kontrakce kůry na kmeni kaučukovníků (mladé PR-107, S/2), ↓ provedené během „krvácení" (výtoku latexu) v různých vzdálenostech od zářezu současně, poskytlo informace o vlastnostech tzv. pohybové oblasti a o rychlosti šíření kontrakce.

Vztah mezi smrštěním kmene v dané vzdálenosti od zářezu a mezi množstvím vyteklého latexu byl vyjádřen matematicky. Kvantitativně byl formulován také vztah mezi výnosy latexu a lineárním rozměrem pohybové oblasti v longitudinálním směru pod středem zářezu.

Z kontrakčních křivek bylo vyvozeno, že podíl laterálního toku latexu v celkovém výnosu relativně (i absolutně) vzrůstá v závislosti na zvětšujících se množstvích latexu vyteklého ze zářezu.

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Détermination de la contraction de l'écorce des jeunes hévéas (PR-107, S/2 ↓), effectuée pendant la saignée, aux differentes distances de l'encoche simultanément, a fournie des informations de l'aire de déplacement et de la vitesse de déplacement du latex dans l'écorce.

La rélation entre la contraction du tronc à la distance donnée de l'encoche et la quantité du latex écoulé a été exprimée par une formule mathématique. La rélation quantitative a été établie aussi entre les rendements de latex et le dimension linéaire de l'aire de déplacement dans le sens longitudinal au dessous de milieu de l'encoche.

Des courbes de la contraction a été déduit que la participation de l'afflux latéral dans le rendement total augmente relativement (aussi bien qu'absolument) en fonction des quantités croissantes du latex écoulé de l'encoche.