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THE PATTERN OF LATEX FLOW IN RELATION TO CLONAL VARIATION, PLUGGING AND DROUGHT TOLERANCE.

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ABSTRACT

The kinetics of latex flow were examined at two soil moisture levels in four clones including RRII 105, a slow plugging clone with high initial flow. The rate of latex flow had two distinct phases: an initial "curvilinear" rapid expulsion and a later "exponential" slow phase. At low soil moisture the duration of latex flow was shortened, particulary the latter phase. The components of latex during flow in RRII 105 were studied in detail so as to understand the physiology. The high turgor pressure in latex vessels, up to 1.2 MPa, dropped down to a low 0.2 MPa within 4-5 min after tapping. The initiation of a rebuild-up of turgor by 10-15 min suggested an early plugging within the vessels. During flow, the bursting of lutoids increased contributing to the instability of latex. A steady dilution occured during flow. The levels of sugar or ions (P and K) in latex suggested that water had moved into laticifers first from xylem and later from phloem tissue. Two clones RRII 102 and RRII 105, which had high rubber yields even during summer months, maintained high osmotic concentration in C-serum. We suggest that the ability of osmotic adjustment in latex influences the sensitivity of clones to drought/summer period.

INTRODUCTION

The latex, contained in the laticiferous vessels of the bark, springs out when a tapping cut is made on the trunk of rubber tree (Gomez 1983). The initial flow is beleived to be due to the elastic contraction of walls when the fluid cytoplasm of latex vessels is expelled after a sudden release in their turgor (Boatman 1970; Buttery and Boatman 1976; Gomez 1983; Southorn 1969). After a while the flow is regulated by capillary forces until the flow ceases as the latex coagulates and plugs the vessels (Boatman 1966; Milford _et_ _al_. 1969). The latex flow is best described as 'die-away' expression ($y=be^{-at}$), but the rates in the first 1 or 2 min have always deviated away from such equation (Buttery and Boatman 1976; Paardekooper and Samosorn 1969). We have been examining in detail the kinetics and components of latex flow in different clones. Our data confirmed the existence of two distinct phases during latex flow which warranted development of two different equations. We coul also build distinct evidence on the dilution pattern.

The latex, being predominantly watery, its flow from tree forms one of the classical phenomena influenced by plant water relations (Buttery and Boatman 1976). Despite the clonal variation in the sensitivity to water stress, the latex yields are generally decreased at reduced soil moisture. Some of our previous studies indicated that lutoids became unstable resultin in a quick plugging (Sethuraj and George 1976). We have therefo studied the pattern of latex flow during depletion of soil moisture and evaluated a few components of water potential in relation to yield.

OBSERVATIONS AND DISCUSSION

Kinetics of latex flow

The course of latex flow followed two distinct phases in all the four clones studied (Figs. 1 and 2). In the first few min, the expulsion of latex was rapid and the rate decreased also very fast. During second phase latex flow settled down to a slow rate which continued until it finally ceased. Clonal variations in latex flow were reported mainly due to their plugging pattern (Milford *et al*. 1969). The duration of flow was less and rates of initial flow were more in clones Gl 1 or Tjir 1 (Fig. 1) than those in RRIM 501 (Fig. 2). The latex flow pattern in these three clones was already reported (cf. Gomez 1983) while we identified RRII 105 as a slow plugging clone with high initial flow rates (Fig. 2).

Statistical analysis of the data indicated that the two phases needed be expressed by different equations. The during the first four min was curvilinear while later phase fitted into an exponential curve. Several investigators attempted to derive a model for latex flow (Frey-Wyssling 1952; Riches and Gooding 1952; Paardekooper and Samosorn 1969; Gomez 1983) and the best

Fig. 1. Kinetics of latex flow at two levels of soil water potential in two fast plugging clones Tjir 1 and Gl 1. The rate of flow and cumulative volume are presented.

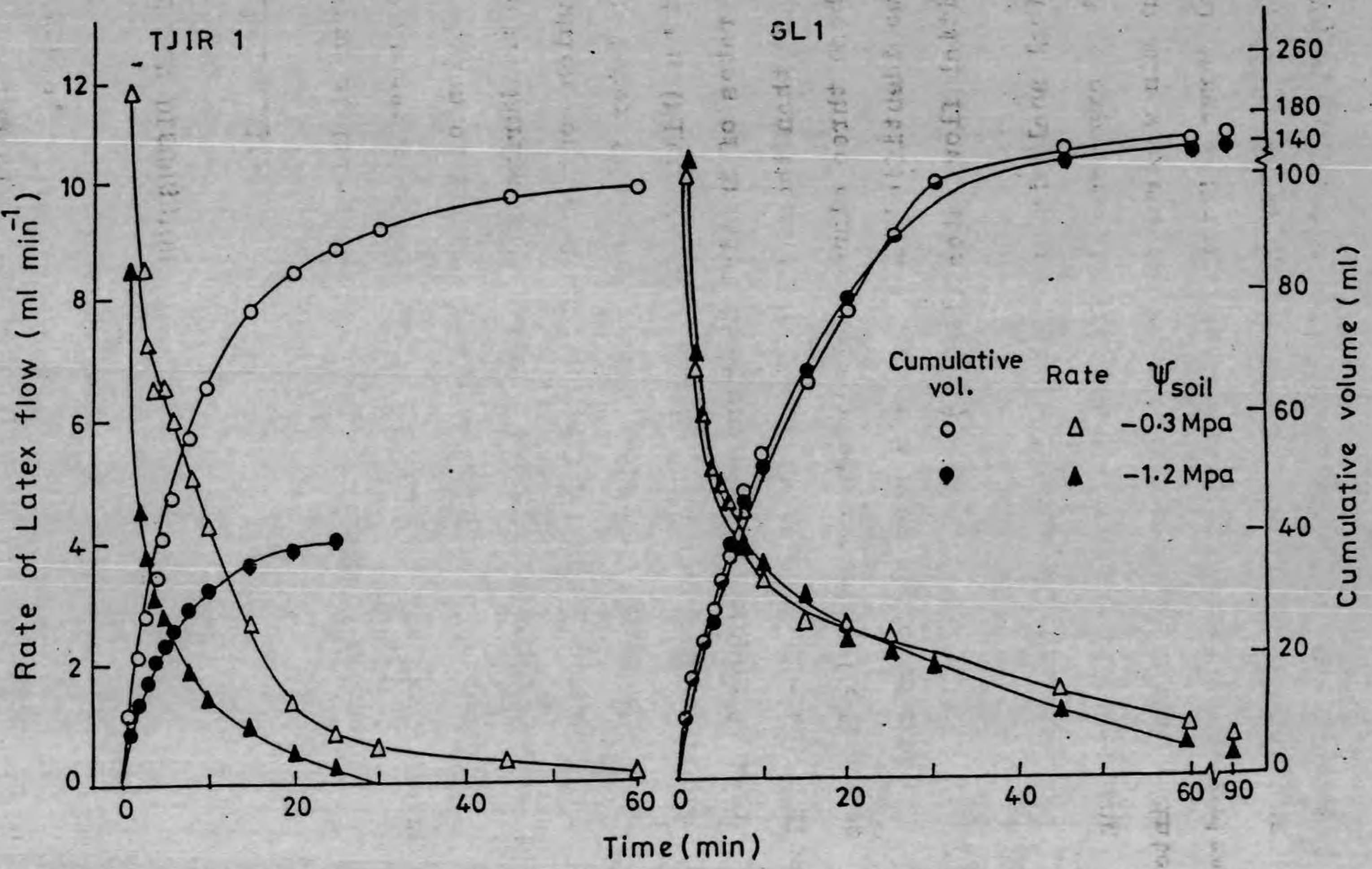
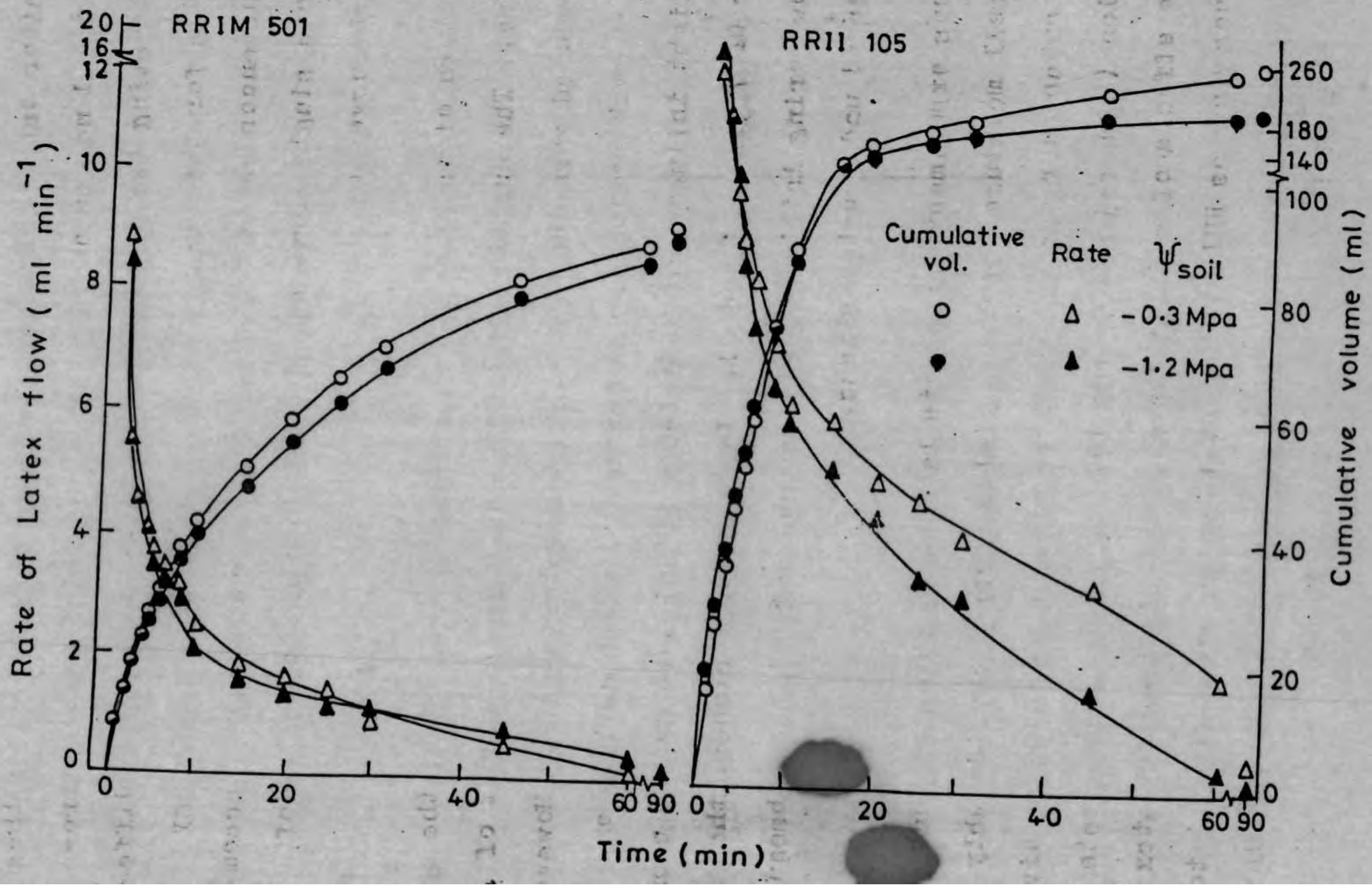


Fig. 2. Kinetics of latex flow at two levels of soil water potential in two slow plugging clones RRIM 501 and RRII 105. The rate of flow and cumulative volume are presented.



among them is the die-away expression derived by Paardekooper and Samosorn (1969). However the initial rates during first 1 or 2 min after tapping always deviated away from any of these models. We could now account for even the initial rates precisely, by treating two phases separately developing two different equations for the two phases of latex flow. In biology there are instances where the observed data would not be accommodated into a single curve but readily into a succession of two different curves (Hunt 1982).

The pattern of latex flow was remarkably altered by the soil moisture. The duration of flow as well as the amount of latex was reduced when the tree was under water stress. However the extent of such reduction was marked in Tjir 1 while there was only slight influence of depleted soil moisture on the clone RRII 105 or Gl 1 (Figs. 1 and 2). In the latter clones, the rate of flow during initial phase was enhanced but the subsequent rates decreased under water stress.

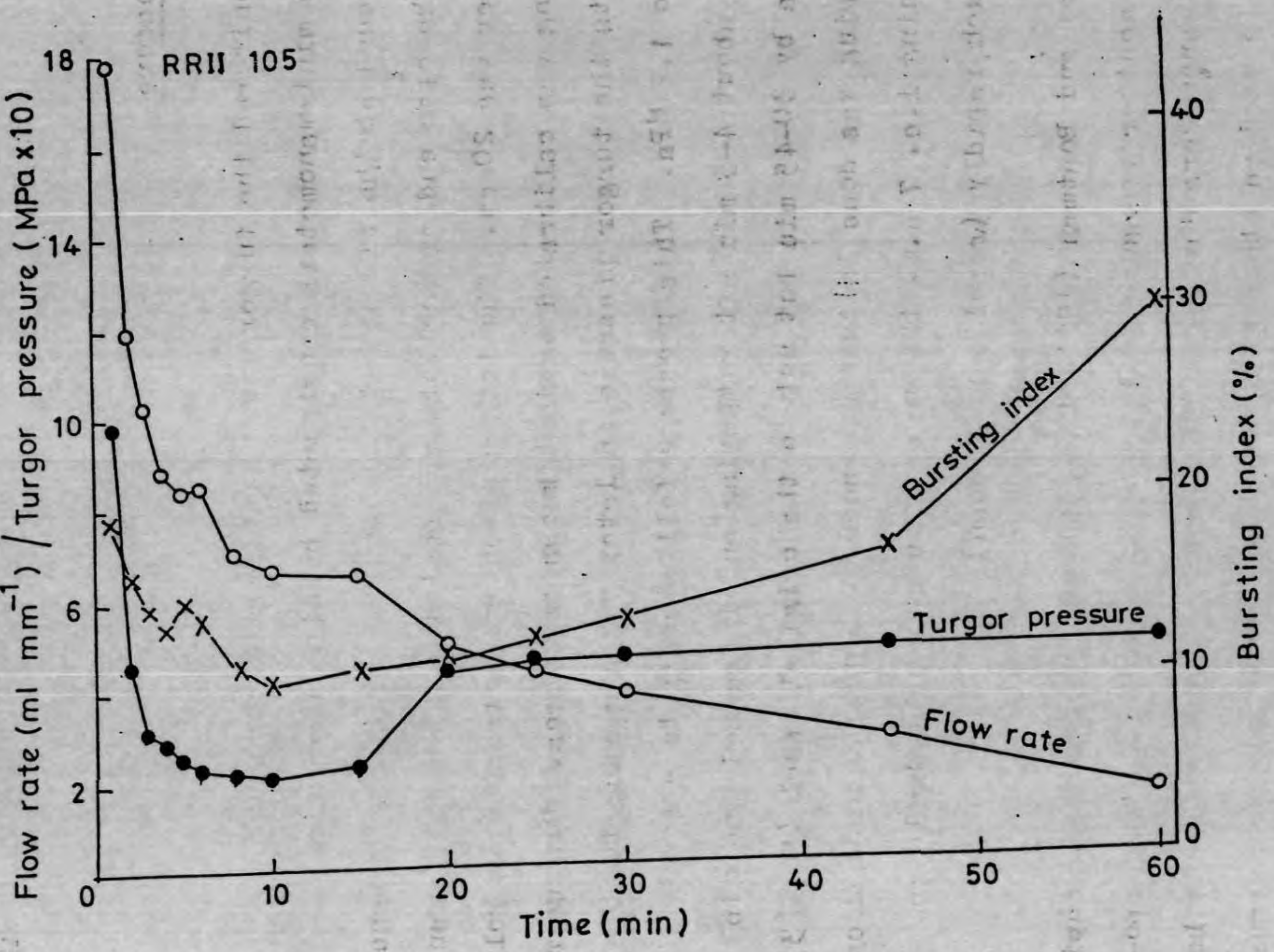
Previous experiments from this laboratory revealed that under low soil moisture the latex yields dropped considerably because of enhanced plugging and these effects could be releived by irrigation (Sethuraj and George 1976). We now demonstrate further the effects of soil moisture on the kinetics of latex flow. Clones such as RRII 105 or Gl 1, which were tolerant to water stress, could maintain high latex yields by enhanced initial flow. The increase in purgor pressure during low soil moisture might be one of the reasons for such elevated initial flow (Sethuraj et al. 1984). The lipid composition of lutoid membrane changes remarkably under water stress making them fairly unstable leading in an increase in plugging (Raghavendra et al. 1984).

Turgor pressure

We monitored the turgor pressure of latex vessels with disposable mini-manometers constructed by 21 gauge syringe needles ground at the tip attached to No.48 surgical polythene tubing. The open end of the tube was sealed and the total length of manometer was 20 cm. The length of airspace trapped in polythene tubing was calibrated against known pressures. During our measurements the turgor pressure in latex vessels ranged from 0.75 MPa to 1.2 MPa. This pressure fell steeply to a low 0.2 to 0.3 MPa by about 4-5 min after tapping and increased again to 0.6-0.7 MPa by 30-45 min but not to the original level (Fig. 3). If the tapping was done in the afternoon i.e. 1 p.m. instead of in the morning i.e. 7 a.m. the drop in turgor and rebuild-up occurred much rapidly (results not shown).

Buttery and Boatman (1964, 1966, 1967) employed glass capillaries to monitor pressure in latex vessel system. The disposable mini-manometers developed by us are very simple and we hope they would be used on other plants as well. The turgor pressures recorded by us are similar to the range observed in Hevea

Fig. 3. The course of turgor pressure in latex vessels, bursting index of lutoids in relation to the rate of flow in RRII 105.



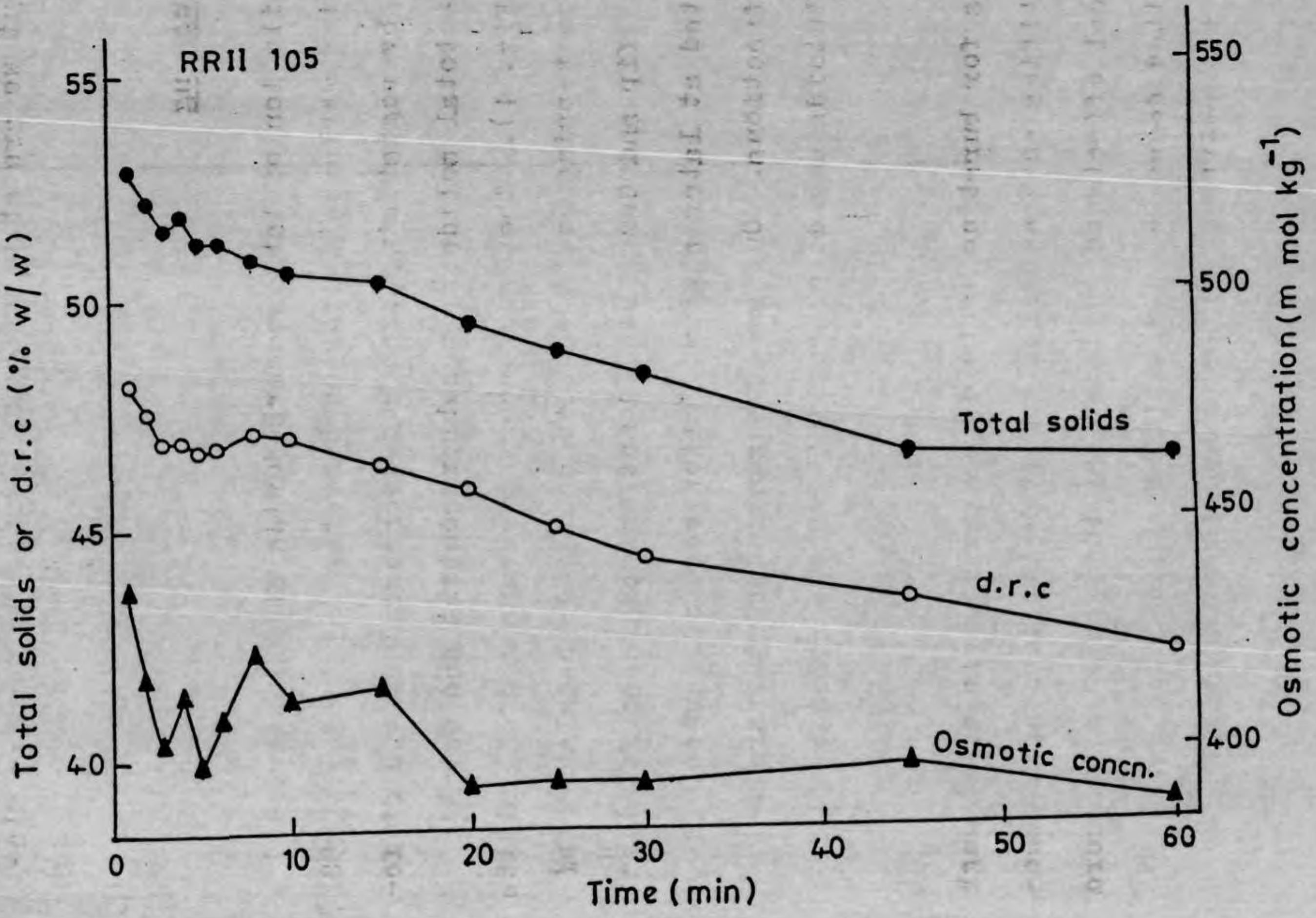
(Buttery and Boatman 1976). High turgor appears to be a characteristic of laticiferous tissues of several plants which facilitates an immediate expulsion of latex before even xylem or phloem sap (Downton 1981). We detected remarkable differences in the pattern of turgor pressure changes during tapping in morning or in afternoon, but we are at present unable to offer any explanation.

Dilution and plugging

That the dilution of latex occurs during flow is observed by several earlier workers in different contexts (cf. Gomez 1983). We confirmed it by registering a steady decrease in three different parameters- total solids, dry rubber content and osmotic concentration (Fig. 4). The increase in the bursting of lutoids after 30 min from tapping could lead to enhanced coagulation of latex (Fig. 3). Yip and Gomez (1976) noticed that the fractions of latex collected at later stages of flow were more unstable than the early fractions. Our results suggest that increased instability of lutoids could be one of the factors for such phenomenon.

The reasons for bursting of lutoids remain unclear although several possibilities such as osmolarity, shearing forces, electrical or chemical effects were thought of (Gomez 1983; Southorn 1969). The limited decrease in osmotic concentration of latex during flow was too small to result in enough hypotonicity.

Fig. 4. Dilution of latex during flow in RRII 105 as indicated by total solids, dry rubber content and osmotic concentration in latex.



Our results thus confirm the suggestion of Pujarniscle (1971) that osmotic shock might not account fully for lutoid damage. We therefore feel that other forces such as shearing at the cut end of vessels might lead to the breakage of lutoids (Yip and Southorn 1968).

Immediately after tapping there was a steep decrease in the level of sugars (Fig. 5) as well as the ionic concentrations of P or K (Fig. 6), which confirmed the dilution of latex. The level of P or K increased first, within 30 min while a steady increase in sugars was noted after 30-45 min. Since it is well established that sugars and ions move in xylem and phloem saps respectively, our results have indicated a flow of water occurs into laticifers first from xylem and subsequently from phloem tissue. This is in slight disagreement with the views of Zimmermann (1927) and Frey-Wyssling (1929) who suggested that the water of dilution was supplied first from phloem and ultimately by the xylem.

The main components of 'non-reducing' and 'other' sugars in latex were sucrose and isositols respectively. Glucose and fructose constituted the reducing sugars of latex. During our studies on the fluctuation in sugar content of latex, the relative changes in the levels of inositols and sucrose were much more than that in reducing sugars (glucose and fructose). Although sucrose is the major sugar in the translocatory

Fig. 5. The levels of reducing, non-reducing or total sugars of latex in relation to flow in RRII 105.

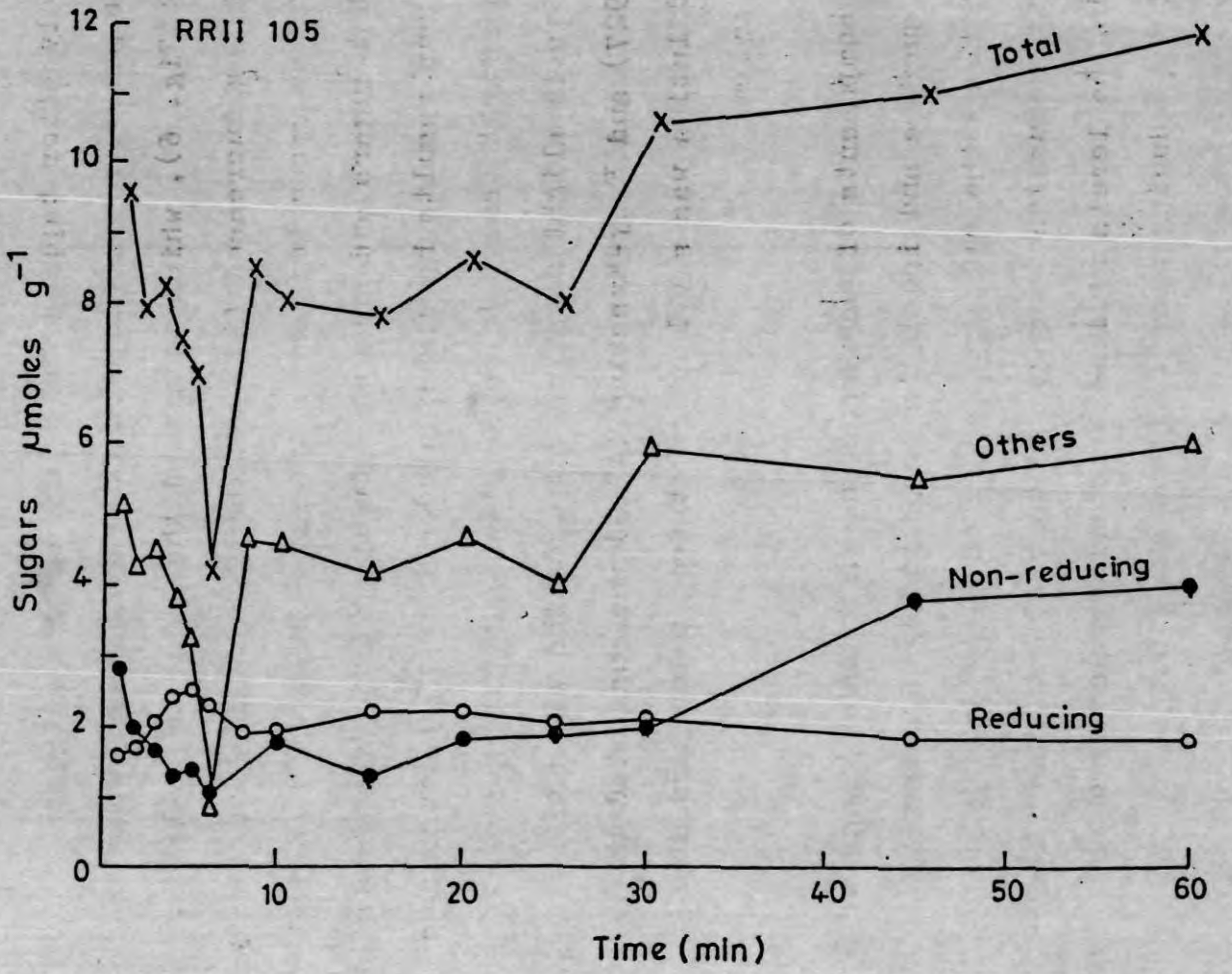
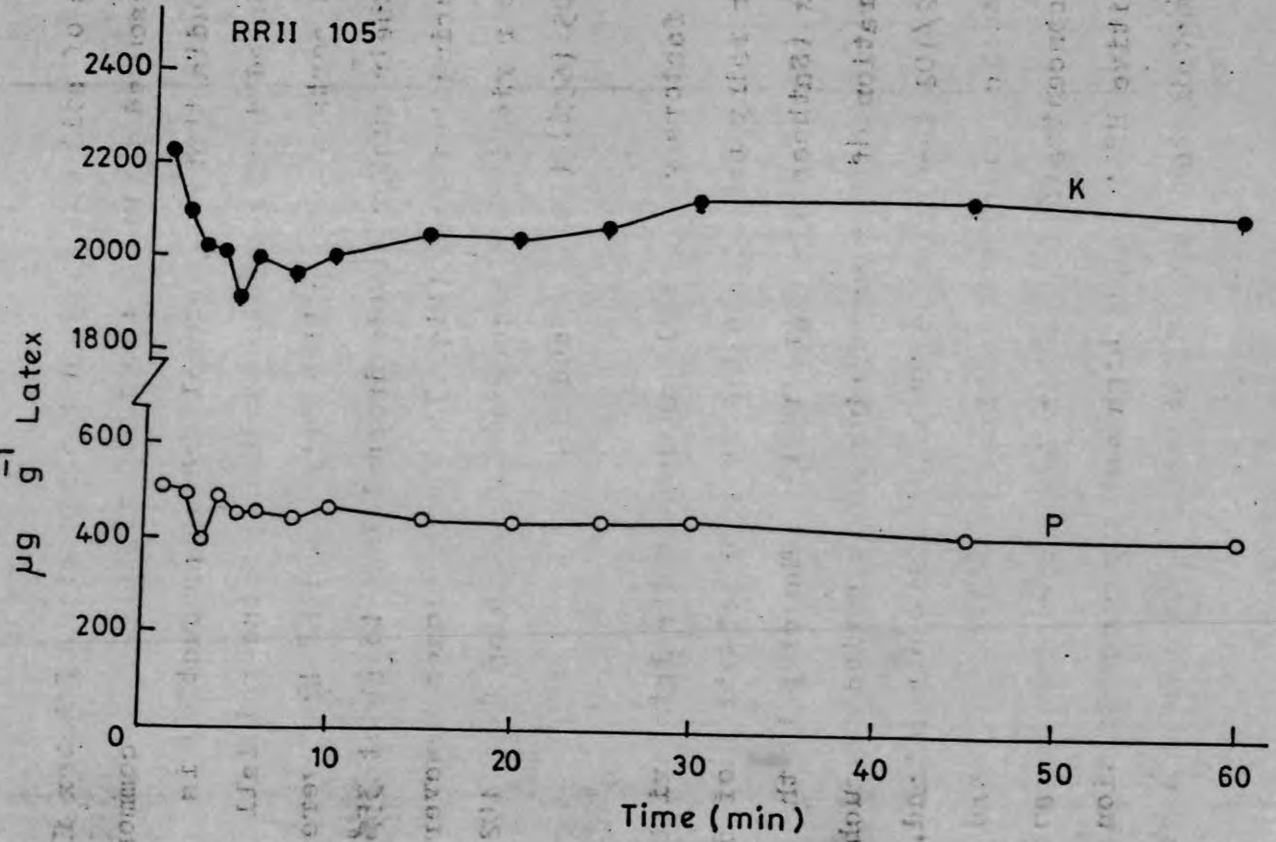


Fig. 6. The levels of potassium or phosphorus in latex of RRII 105 during flow.



pathway of plants, present observations suggest that inositols as well as sucrose are more important than the reducing sugars during the movement of sugars into and out of latex vessels.

Seasonal variation

The effects of soil moisture on the kinetics of latex flow were already presented in Figs. 1 and 2. It is also a common observation in India that the natural rubber production is considerably reduced during summer months when the rainfall is scanty. In fact certain clones like Tjir 1 and HP 14 were so sensitive that their rubber yields dropped down to about 35% of their maximum during the year (Fig. 7). Some clones however could retain their yield at a higher level, such as RRII 102 (75%) or RRII 105 (65%) (Figs. 8 and 9).

One of the factors which could influence the latex yields during summer or rainy periods is the osmotic potential of B or C-serum in latex (Satheesan _et al_. 1984). The drop in the osmotic concentration of C-serum during rainy period is much less in RRII 102/102 than that in HP 14. On the other hand, during summer months, the drought tolerant RRII 102/105 had much higher osmotic concentration in their C-serum of latex than that in drought sensitive HP 14. The high osmotic concentration of C-serum could sustain the flow of water into the latex so as to allow the flow.

Fig. 7. The osmotic concentration of c-serum, the difference in osmotic potentials of B/C sera at different times of an year in relation to the yield in clone HP 14.

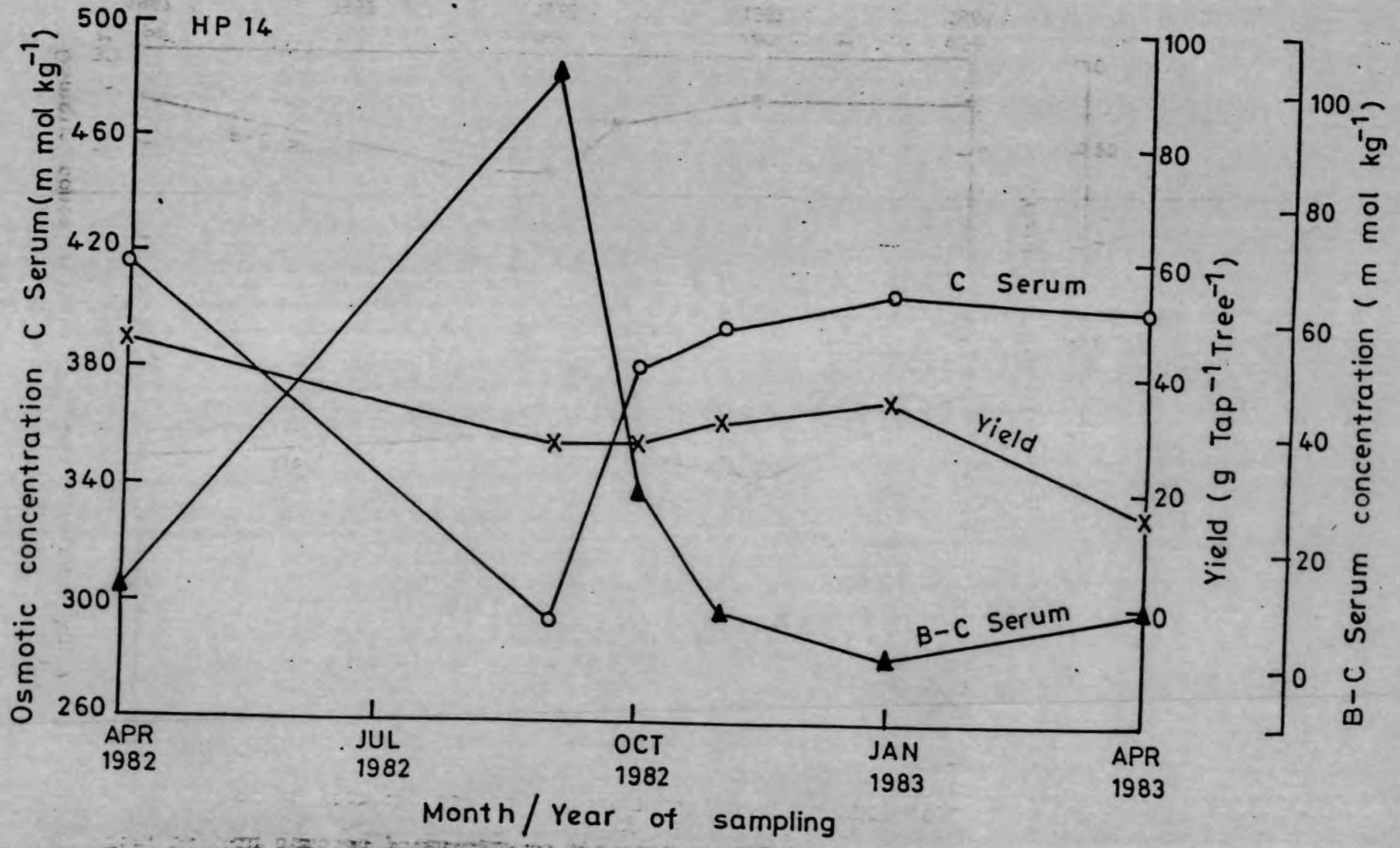


Fig. 8. The osmotic concentration of c-serum, the difference in osmotic potentials of B/C sera at different times of an year in relation to the yield in clone RRII 102.

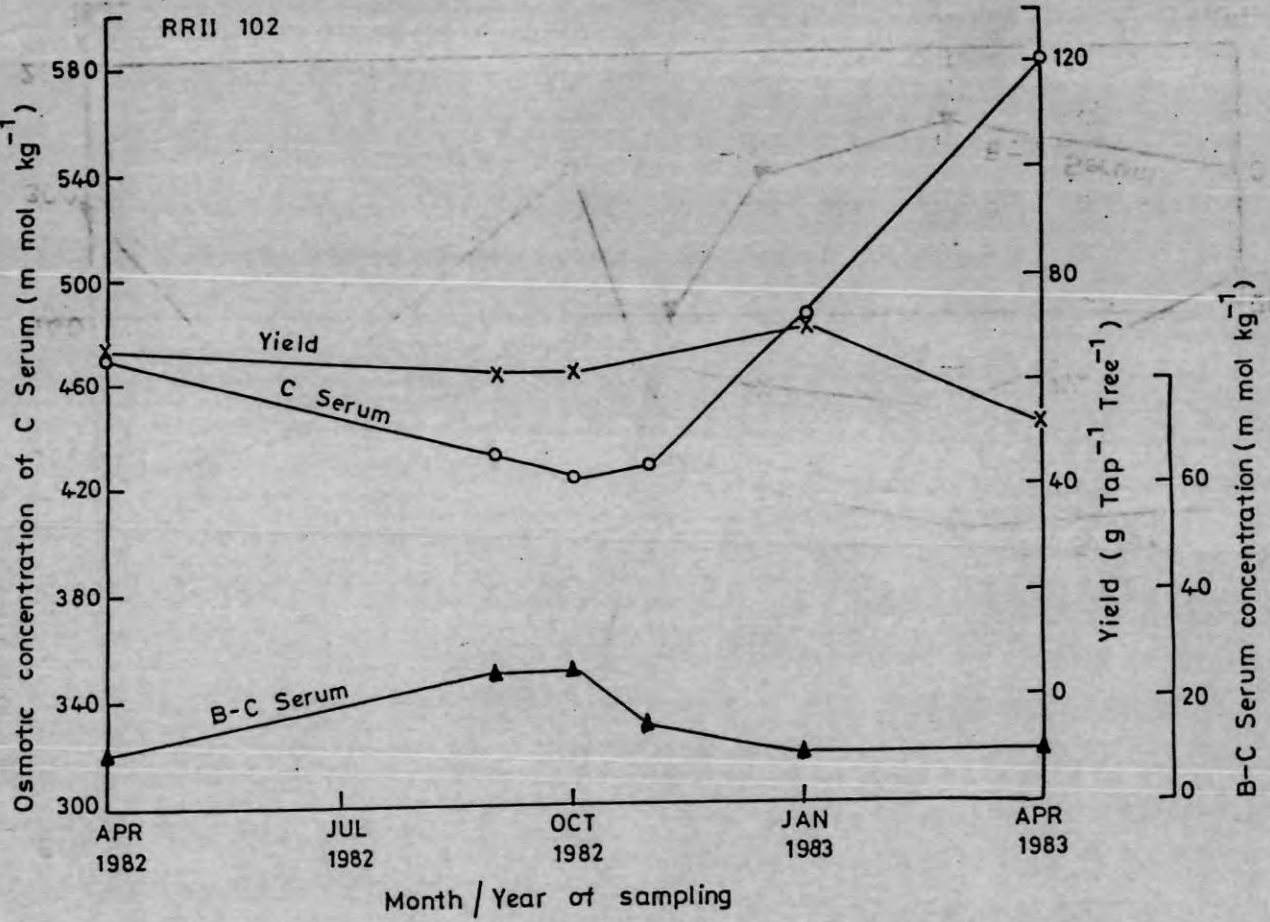
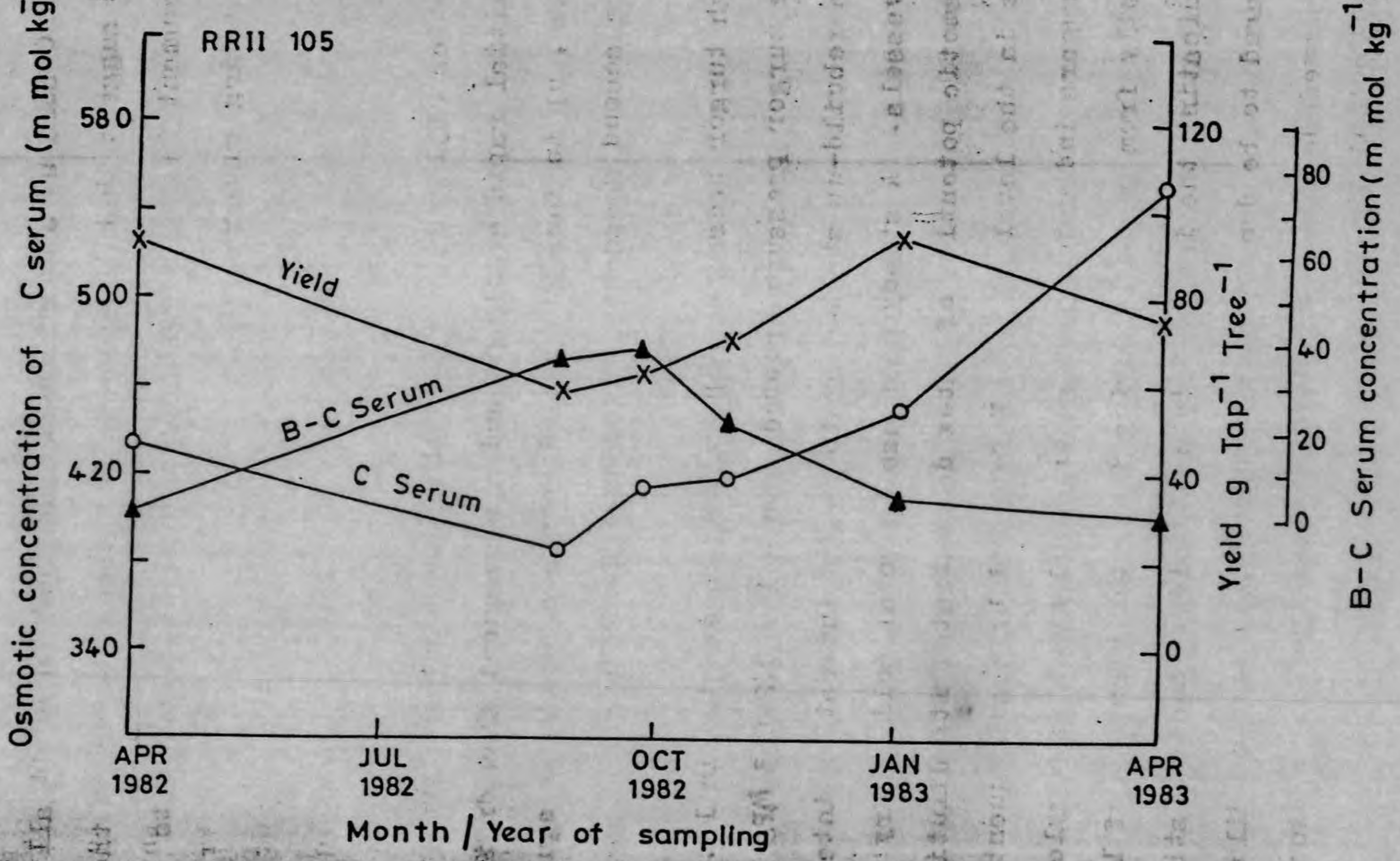


Fig. 9. The osmotic concentration of c-serum, the difference in osmotic potentials of B/C sera at different times of an year in relation to the yield in clone RRII 105.



The possible importance of osmotic gradient between B & C-sera was brought by our observations. Clones RRII 102 or RRII 105 kept the fluctuation in the difference in osmotic concentration of B & C-sera at a lower level than that in HP 14 all the year. We suggest that the capacity of trees to adjust the osmotic environment in latex may influence their response to water stress during summer periods.

CONCLUSIONS

The kinetics of latex flow from the tapped cut followed two phases; an initial rapid expulsion and a subsequent slow drainage. The first phase, up to four min fitted into a curirlinear equation while the second phase was an exponential curve.

Very high turgor pressures, up to 1.2 MPa existed in latex vessels. The turgor pressure dropped down a low 0.2-0.3 MPa after tapping but a rebuild-up started by 10-15 min indicating internal plugging of vessels. A steady decrease in total solids, dry rubber content or osmotic potential of latex demonstrated its dilution. An early rise in the level of P or K followed by a subsequent increase in sugars indicated that water moved first from xylem and subsequently from phloem. During flow, the bursting of lutoids increased indicating the instability of lutoids. Such bursting of lutoids appeared to be due to reasons other than osmotic dilution since the observed decrease in osmotic concentration was too small to result in hypotonicity.

A decrease in soil moisture restricted the duration of latex flow and this effect was pronounced in clone Tjir 1. However in clones Gl 1 and RRII 105 the enhanced rates of latex flow in the first few min, helped to minimise the reduction caused by the water stress. The rubber yields were maximum during rainy months and minimum in summer of an year. The reduction in summer months was prominent in clone HP 14 while the yield of clone RRII 102 was only marginally affected. One of the factors which could influence such drought tolerance was the ability to modulate the osmotic potential of C-serum. In alone RRII 102, the osmotic potential of C-serum was maintained at a higher level in summer months than those in HP 14.

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