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Full Length Research Paper

Effects of 2-chloroethylphosphonic acid formulations as yield stimulants on *Hevea brasiliensis*

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Stimulation of *Hevea brasiliensis* is a common practice in rubber estates. The chemicals commonly used are formulations of 2-chloroethylphosphonic acid (ethephon). Low frequency of tapping must be accompanied by use of yield stimulants in order to enjoy the economics of low tapping frequency. It is thus necessary to evaluate the effects of the available yield stimulants on *Hevea* in order to better formulate exploitation systems. Two formulations of 2-chloroethylphosphonic acid, under the trade name Hevetex 5% PA and Ehtrel® were used to stimulate two clones. Hevetex 5% PA was investigated using agronomic parameters, and latex diagnosis technique to determine its efficiency as a yield stimulant, its ability to induce tree dryness, activation of tree metabolism and ability to sustain rubber yields. Hevetex 5% PA is a good yield stimulant and has good sustaining properties demonstrated by the level of its physiological properties (such as sugar and thiols) which are comparable to those of Ethrel®. The use of these stimulants led to an increase in rubber yield. The physiological parameters and yield varied with season.

Key words: Stimulation, *Hevea brasiliensis*, rubber, 2-chloroethylphosphonic acid, physiological parameters.

INTRODUCTION

Rubber trees (*Hevea brasiliensis*) (Compagnon, 1986) are exploited for their latex obtained by incising the tree's bark. Several tapping systems have been used to improve production and maximise profits by adopting different tapping frequencies, cut lengths, stimulation frequencies and stimulant concentrations (Sivakumaran et al., 1982). Stimulation involves the application of ethylene gas or ethylene-generating substances on the tree's tapping cut which increase latex flow time by delaying plugging of latex vessels, (Wenxian et al., 1986) and hence increases production through the activation of metabolism. To maintain the physiological states of rubber trees, stimulation is usually accompanied by decreasing the tapping frequency.

Stimulation of rubber is today a routine practice in natural rubber production and the commonly used stimulant is Ethrel® (i.e. ethephon: 2-chloroethylphosphonic acid). Hevetex 5% PA is also a formulation of 2-chloroethylphosphonic acid which decomposes in plant tissues to generate ethylene which reacts on the metabo-lism of the plant.

$$ClCH_2\text{-}CH_2\text{-}PO_3H_2 + H_2O \xrightarrow{pH > 3.5} OCH_2CH_2PO_3H_2$$

$$OCH_2CH_2PO_3H_2 + HCl \longrightarrow CH_2{=}CH_2 + H_3PO_4$$

Over-stimulation could cause deleterious effects during the economic life of the trees and thus reduce yields. However, a good tapping system associated with suitable stimulation is necessary for good and sustained yields to be obtained, especially for slow metabolism clones which need activation to express their full yield potentials. Low tapping frequencies accompanied by adequate stimulation could permit the farmer have more time for other agricultural and non-agricultural revenue-generating activities (Gobina et al., 2005). To better understand the effect of stimulant on *Hevea* so as to formulate good stimulation systems, two (Ethrel® and Hevetex 5% PA) ethylene-releasing formulations were investigated at different concentrations on *Hevea* clones of different metabolic rates.

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Table 1. Effects of stimulation on yield and physiological parameters of *Hevea* (Mean annual values)

Clone	Treatment	Yield		RSH		Pi		SUC		TSC	
		g/t/t	% wrt control*	mM	% wrt control	mM	% wrt control	mM	% wrt control	(% w/w)	% wrt control
PB 217	Control	35.6b	---	0.54b	---	15.6b	---	16.1	---	43.7a	---
	2.5% Hevetex	63.6a	79	0.67a	24	19.9a	28	15.6	-3	40.0b	-8
	2.5% Ethrel	61.8a	74	0.67a	24	20.9a	34	16.5	2	41.2ab	-6
PB 260	Control	65.2b	---	0.70b	---	25.7b	---	7.4ab	---	48.0a	---
	1.25% Hevetex	84.3a	29	0.76ab	9	27.7ab	8	7.6ab	3	45.0b	-6
	1.25% Ethrel	80.9a	24	0.84a	20	29.3a	14	7.7ab	4	44.8b	-7
	2.5% Hevetex	78.0ab	20	0.81ab	16	29.5a	15	6.9b	-7	44.5b	-7
	2.5% Ethrel	84.3a	29	0.81	16	28.3ab	10	7.9ab	7	45.3b	-6

For each clone, treatments with the same letter in a column are not significantly different (P = 5%) (students' t test). *wrt: with respect to. g/t/t: gram per tree per tapping. RSH: Thiols. Pi: Inorganic phosphorus. Suc: Sucrose. TSC: Total solid content.

MATERIALS AND METHODS

Experimental site

This study was carried out in the CDC industrial plantations of Likomba on clone (PB 217) and Missellelle on clone (PB 260) in the South West Province of Cameroon. Both areas are characterized a mono modal rainfall regime, that is a marked by a long wet season (April to November) and a short dry season (December to March). The total rainfall for both sites was highest in the month of September and lowest in the month of December and January.

Planting materials

Two widely planted clones, PB260 of high metabolism and PB217 of slow metabolism, were used. The trees had been planted in 1993 and opened at heights of about 150 cm (in 2000). Tapping was on panel B-O1 and the tapping system used was 1/2Sd/4. Clone PB217 was stimulated with 1.25% Hevetex and 1.25% Ethrel®, eleven rounds per year on the panel and the control was not stimulated. For PB 260, plants were stimulated with 1.25% Hevetex and 1.25% Ethrel®, eleven rounds per year, 2.5% Hevetex PA and 2.5% Ethrel®, six rounds per year on the tapped panel and the control was also not stimulated. Hevetex and Ethrel® are respectively 10% and 5% stocks of 2-chloroethylphosphonic acid.

Data collection and analysis

The experimental design was a randomized complete block. Monthly yields were measured in kilograms and the productivity (yields) in grams per tree per tapping (g/t/t) calculated. Latex diagnosis was carried out monthly to determine the latex's total solid content, sucrose, inorganic phosphorus and thiols contents (CIRAD, 1993). The length of the tapped cut was inspected during tapping for latex diagnosis and the percentage dry cut calculated.

Data collected was analysed using the JUMP statistical package version 5 and a one way analysis of variance was performed. Means for the various treatments and clones were compared using students' t-test at 5% alpha level and further ranked.

RESULTS AND DISCUSSION

Effects of stimulation on latex production

Production was generally low during the months of February, April and August. These are periods of low sunshine or beginning of defoliation or re foliation period when metabolism for latex synthesis is slow. A generally high trend was observed from October to December (Figure 1) for both clones. This coincides with the period of active metabolism for the tree as reported by Jacob et al. (1988).

Mean annual values of yields (shown in Table 1) evaluated in gram per tree per tapping (g/t/t) were signifycantly higher for the stimulated trees than the non-stimulated ones for both clones. However, there was no significant difference in yields between trees stimulated with Ethrel® and trees stimulated with Hevetex for the same clone (Table 1). Mean yields were increased by about 5% following both Hevetex and Ethrel applications compared to the control, similar to the report of Rajagopal et al. (2004) who used Ethrel. 2-chloroethylphosphonic acid decomposes with the help of the physiological medium when pH is higher than 3.5 and releases ethylene which is a phytochrome that facilitates hydrous transfer within the tissue of *H. brasiliensis* and thus latex flow. The volume of latex produced is increased as well as latex regeneration between tappings, enhance latex flow and is duration after tapping (Coupé and Chrestin, 1989). There was no significant difference between 1.25% eleven rounds application per year and 2.5% six rounds per year for both formulations in PB260 clone, probably due to the fact that it naturally has low sugars and so needs little stimulation for maximum yields. Although response rates to both stimulants are higher for clone PB217 (>70%), ob-

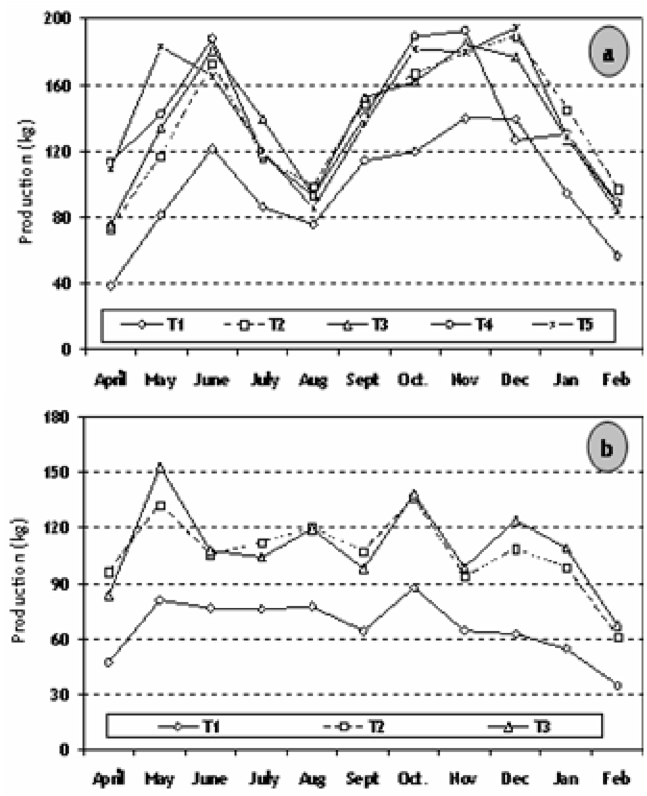

Figure 1. Effects of stimulation on monthly latex production. (a) PB 260; T1= control, T2 = 1.25% Hevetex, T3 = 1.25% Ethrel, T4 = 2.5% Hevetex and T5 = 2.5% Ethrel. (b) PB 217; T1 = control, T2 = 2.5% Hevetex and T3 = 2.5% Ethrel.

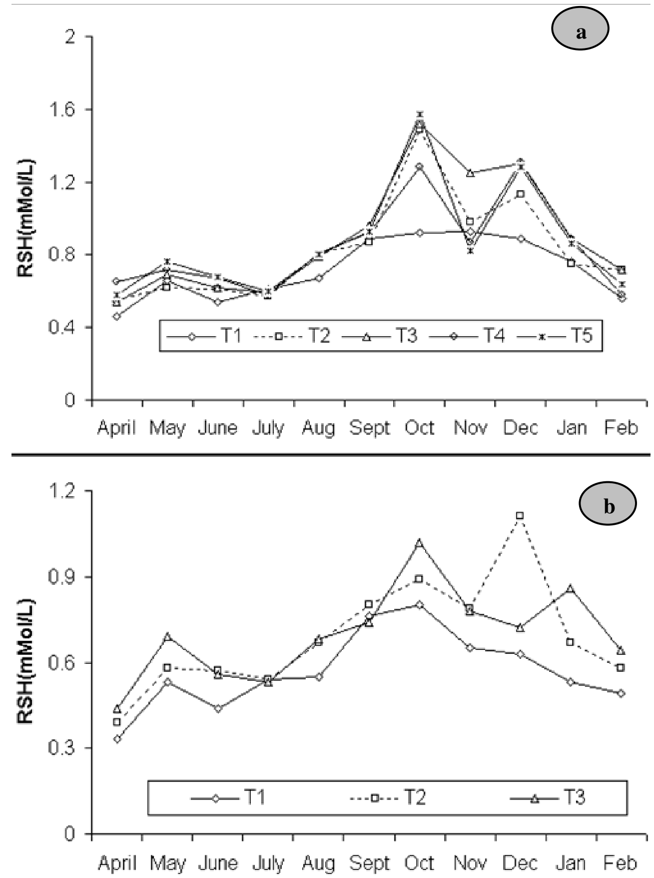

Figure 2. Effects of stimulation on monthly thiol levels. (a) PB 260; T1= control, T2 = 1.25% Hevetex, T3 = 1.25% Ethrel, T4 = 2.5% Hevetex and T5 = 2.5% Ethrel. (b) PB 217; T1 = control, T2 = 2.5% Hevetex and T3 = 2.5% Ethrel.

tained yields are higher on clone PB 260 (Table 1). Differences in yield response of both clones is attributable to their inherent rates of metabolism - clone PB 217's activity is low so reacts more, whereas the activity is higher for PB 260 which reacts less to stimulation (Jacob et al., 1989).

Effects of stimulation on physiological parameters

A number of parameters were evaluated to characterize the physiological status of *H. brasiliensis* trees notably; total solid content, sucrose, in organic phosphorus and thiols contents. Thiols, which are protective elements in the laticiferous system, showed a general increase from April to December for both stimulated tree and non-stimulated trees (Figure 2). However, there was a drop in November probably due to the high rains the previous month as thiols are negatively correlated with cumulative rainfall during the previous month (Le Roux et al., 2000). Mean annual cell membrane protection was higher for the stimulated trees than the non-stimulated trees (control) for both clones (Table 1). The low level of thiols for the control could be due to the low level of activity in the laticiferous cells as the turnover of these molecules slow down with low activity (Jacob et al., 1988). The higher value of thiols for the stimulated trees could be due to a good level of metabolic activation that was not accompanied by stress. High stress leads to degradative reactions which reduce thiol levels.

The rate of energetic metabolism measured by the inorganic phosphorus content increased from April to September/October and increased again in December (Figure 3). The high inorganic phosphorus content in December could be due to decrease in rain and higher sunshine which increases metabolism. Changes in inorganic phosphorus content due to stimulation effect were not very significant for the PB260 clone probably due to its naturally low sugar content which limits stimulation effects. However for PB217 clone, the inorganic phosphorus content was higher for the stimulated trees than the non-stimulated trees (control) (Table 1) similar to the observation of Jacob and Prévot (1989). This confirms that stimulation activates laticiferous vessel metabolism and increases inorganic phosphorus content in latex.

The sucrose content is an indication of the capacity of

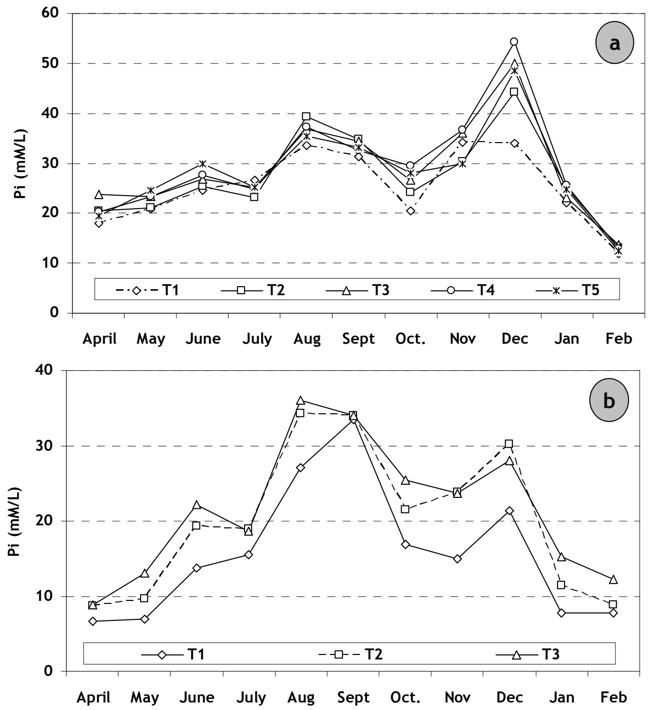

Figure 3. Effects of stimulation on monthly inorganic phosphorus levels. (a) PB 260; T1= control, T2 = 1.25% Hevetex, T3 = 1.25% Ethrel, T4 = 2.5% Hevetex and T5 = 2.5% Ethrel. (b) PB 217; T1 = control, T2 = 2.5% Hevetex and T3 = 2.5% Ethrel.

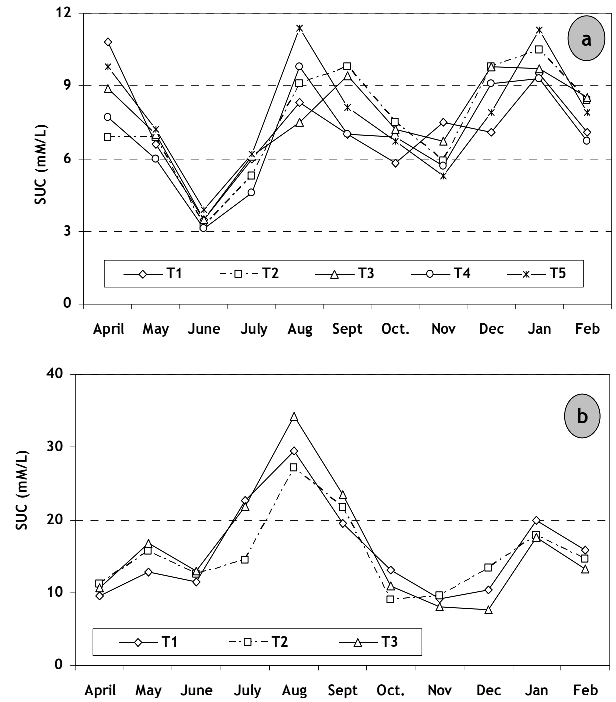

Figure 4. Effects of stimulation on monthly sucrose levels. (a) PB 260; T1= control, T2 = 1.25% Hevetex, T3 = 1.25% Ethrel, T4 = 2.5% Hevetex and T5 = 2.5% Ethrel. (b) PB 217; T1 = control, T2 = 2.5% Hevetex and T3 = 2.5% Ethrel.

the tree to synthesise rubber or cis-polyisoprene. It showed a similar trend for both clones and for stimulated and non-stimulated trees. Lowest values were obtained in June and October to December (Figure 4) which corresponds to periods of great synthesis as demonstrated by high inorganic phosphorus levels. Highest values recorded in August show low metabolic activity as demonstrated by low yields for that month. The stimulants did not cause excessive use up or inhibit the use up of sucrose, as there was no significant difference between the stimulated trees and the control trees for PB217 clone. This may be due to the fact that the stimulation frequencies adopted for this experiment are well suited to the clones as has been established in previous stimulation experiments (Le Roux and Gobina, 1997) with Ethrel. However for PB260, the sucrose level for trees stimulated six times a year with 2.5% Hevetex was significantly less than that for trees stimulated at the same frequency with 2.5% Ethrel suggesting that Hevetex may induce higher solicitation of sugars in this clone at 2.5% concentration.

The total solid content (TSC) which is an indication of the viscosity of the latex and flow characteristics showed highest values in April and February (Figure 5) corresponding to periods of lowest rainfall. The latex is very viscous and thus flow is inhibited hence the low level of production during this period. The mean TSC (%) was higher for the control than for the stimulated trees (Table 1). This confirms the fact that the stimulant leads to the dilution of latex, hence reduction in total solid content causing easier flow and thus higher yields in the presence of adequate sugar (Lacrotte et al., 1988).

The level of dry cuts is an indication of the level of stress in the laticiferous system. It varied with season with the highest values obtained in July and October for both clones (Figure 6) corresponding to period of high rains. This observation is similar to that of De Faÿ (1988) who reported that total dry zones in *Hevea* bark were more extensive during periods of heavy rains.

Conclusion

Yield stimulants have been used to increase yields of rubber trees. The performance of Hevetex 5% PA as a yield stimulant and its sustaining properties as demonstrated by levels of sugar and thiols was shown in this study to be comparable with Ethrel. Consequently, the number of stimulants that could be available to rubber growers in Cameroon can now be increased without fear of any degradative properties with the use of Hevetex. The results obtained with Hevetex, either agronomic or physiologic are comparable to those obtained with Ethrel

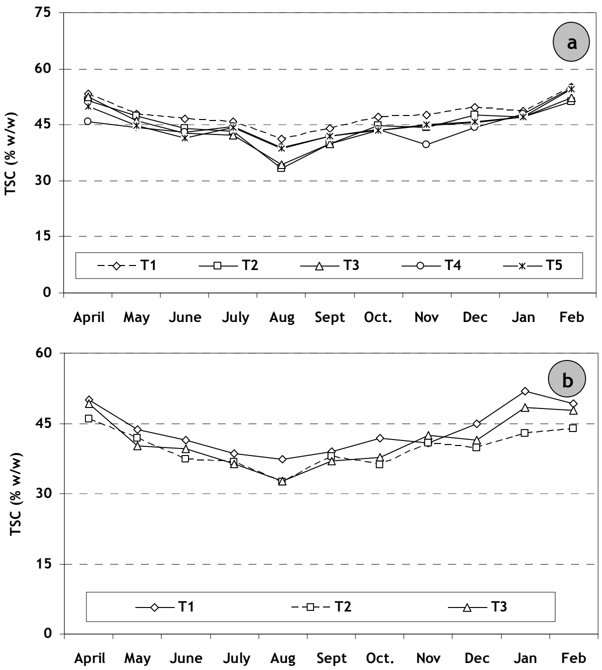

Figure 5. Effects of stimulation on monthly total solids levels. (a) PB 260; T1= control, T2 = 1.25% Hevetex, T3 = 1.25% Ethrel, T4 = 2.5% Hevetex and T5 = 2.5% Ethrel. (b) PB 217; T1 = control, T2 = 2.5% Hevetex and T3 = 2.5% Ethrel.

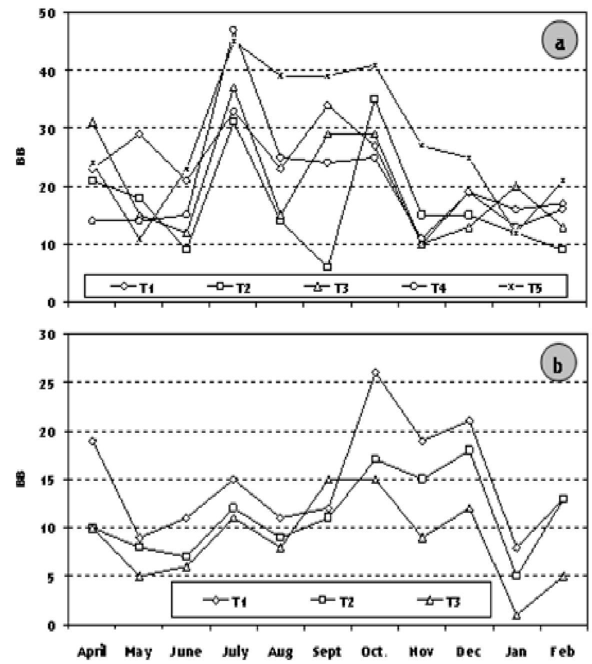

Figure 6. Variation of Brown Bast (BB) percentage with season. (a) PB 260; T1= control, T2 = 1.25% Hevetex, T3 = 1.25% Ethrel, T4 = 2.5% Hevetex and T5 = 2.5% Ethrel. (b) PB 217; T1 = control, T2 = 2.5% Hevetex and T3 = 2.5% Ethrel.

suggesting that the exploitation policy developed for Ethrel could easily be adapted to Hevetex at similar concentrations. The effects of both stimulants on yield and physiological parameters of *Hevea* have been shown to vary with season. An understanding of the effects of these stimulants will lead to the formulation of good exploitation systems in order to obtain high sustainable tree productivity with little deleterious effect (tree dryness) on trees through out their economic life.

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