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An innovative tapping system, the double cut alternative, to improve the yield of *Hevea brasiliensis* in Thai rubber plantations

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ABSTRACT

In Thailand, the continuous decrease in the size of rubber plantations has led to the general adoption of intensive tapping systems which may lead to over harvesting, high rates of tapping panel dryness (TPD), short life-cycles of the plantations, and low labour productivity. In Thailand, farmers use a half-spiral downward tapping system (S/2) or a one third-spiral (S/3) with a tapping frequency of once two days (d2) or more. To increase productivity, it is difficult to reduce tapping frequencies, even with ethylene stimulation, as this would result in days without work for tappers. The purpose of this study was to characterize the behaviour of the Hevea latex yield under the double cut alternative tapping system (DCA). The aim was ensure the long-term sustainability of latex yield by increasing the time required for latex regeneration between two tappings through splitting this high tapping intensity (100% or above) into two different tapping cuts tapped alternately (S/2 d47d7(t,t). Over a period of 10 years, compared to a single cut tapping system (S/2 d2) of equivalent intensity, DCA increased cumulative rubber production by 9%. Ability of the trees to produce more latex under DCA was related to the sucrose and inorganic phosphorus contents of the latex cells in each tapping panel. DCA produced metabolic activity more favourable to yield during the first 10 years of tapping. But DCA also resulted in higher TPD rates, a sign of a metabolic dysfunction of the productive bark. DCA is a new tapping system. Further research is required to optimize the use of the DCA strategy. Such research will lead to new advances in our knowledge of the physiology of the rubber tree, mainly at the trunk scale.

1. Introduction

Worldwide natural rubber production in 2009 was around 9.9 million tons, of which Asia produced about 94% and Africa about 4%. The rest of the world produced about 2% (IRSG, 2009). Thailand represents 23% of the total area under *Hevea brasiliensis* in the world, and 32% of total natural rubber production, with 3.1 million tons produced in 2009. Rubber producers are mainly smallholders who represent more than 85% of the total rubber area in the country.

In Thailand, farmers harvest latex using a multi-annual tapping system comprising a half-spiral (S/2) or a one third-spiral (S/3) cut downward tapped at a frequency of two days (d2). In the last decade, the continuous decrease in the size of Thai rubber plantations has led to the general adoption of more intensive frequencies than d2, i.e. daily tapping (d1) for two days out of three (2d/3) or three days out of four (3d/4), with only one day of tapping rest. These very intensive tapping systems may result in overexploitation, high rates of tapping panel dryness (the dryness of the cut), short life-cycles of the plantations, and rather low labour productivity. The main physiological and practical causes of this low output per tapper are known. The insufficient time for latex regeneration between consecutive tappings because of too high tapping frequencies reduces output per tree per tapping (Jacob et al., 1988, 1995a; d'Auzac et al., 1997; Obouayeba et al., 2009a). A high rate of tapping panel dryness also occurs with such intensive tapping systems (Anekachai, 1989). The general use of a one third-spiral (S/3) often leads to a huge "bark island", with associated low yield potential of the third panel (BO-3) of the trunk (Anekachai, 1989), and early opening of small trees aggravates the situation (Anekachai, 1989).

Different strategies have already been experimented to improve rubber productivity. One of the main strategies combines reduced tapping frequency with ethylene stimulation. This strategy has been successfully used in rubber plantations worldwide with tapping systems like S/2 d3 or S/2 d4 (Abraham et al., 1971; Paardekooper et al., 1975; Eschbach and Banchi, 1985; Gohet, 1996; Gohet et al., 1996, 1997; Lacote et al., 2010; Rodrigo et al., 2009; Thanh et al., 1996; Vijayakumar et al., 2001, 2003). In Thailand, it is difficult to reduce tapping frequencies, as this would result in days

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without work for farmers and/or tappers. This is mainly due to the uneconomic size of the farms (less than 2 ha on average): one farm is usually made up of only one tapping task.

We propose another strategy: the double cut alternative (DCA) tapping system. The aim is to increase the time available for latex regeneration by splitting the tapping into two different tapping cuts, tapped alternately, avoiding competition between the two cuts as far as possible by leaving sufficient distance between their respective latex regeneration areas. The new tapping strategy may provide an alternative to currently used intensive tapping system. Its design was based on results of former experimental studies on alternate tapping in Thailand (Anekachai, 1989), as well as on physiological studies of the latex regeneration process and spatial extension (Silpi et al., 2006).

The physiological justification for DCA is based on optimization of the time available for latex regeneration, as complete regeneration generally requires 3–5 days depending on the latex metabolism of the clone concerned (Gohet and Chantuma, 2003). As a consequence, output per tapping of S/2 d2, the reference tapping system, is actually limited by the short regeneration period between consecutive tappings (Jacob et al., 1989, 1995a).

Splitting of S/2 d2 into two different cuts tapped alternately once in every 4 days (S/2 d/4 (t,t)) instead of once in every 2 days, although maintaining a d/2 frequency of tapping of tree, would therefore theoretically result in improved latex regeneration and increased output per tree and per tapping. It may be possible to optimize exploitation of each d/4 cut by using appropriate ethylene stimulation on each cut with the DCA system, as it has already been shown that d/4 tapping frequency can be optimized in this way (Eschbach and Banchi, 1985; Eschbach et al., 1986; Gohet et al., 1996, 1997; Lacrotte et al., 1985; Lacote et al., 2010).

The purpose of this study was to analyze the results and find future prospects of the DCA system to improve the productivity of Thai rubber plantations. The results will help managers choose tapping systems according to the policy of each plantation and at the same time to optimize latex productivity.

2. Materials and methods

2.1. Location of the trials

The trials were conducted between 2000 and 2010 at the Chachoengsao Rubber Research Station in east Thailand (13°36′N, 101°27′E, altitude 27 M msl). The climate is subtropical, characterized by temperature amplitudes of 25–35 °C, high humidity (80–90%) and mean annual rainfall of up to 1200 mm.

2.2. Plant material

Clone RRIM 600, the most widely planted clone in Thailand, was used for the experiment.

2.3. Experimental design

During the 10-year experimental period, trees were compared under three tapping systems. The experimental plot used for each treatment was 0.0438 ha. Trees were spaced at 7 m × 2.5 m (571 trees ha^{-1}). The experimental design was a "randomized complete block" comprising three treatments (A–C) and four replications per treatment with 25 trees per treatment and total randomization of all the plots in a given block. The rubber trees were 8 year old at the beginning of the trial. Trees of equal size were selected. The first opening was made in May 2000. The incision in the bark (a single tapping cut) was located 1.50 m from the ground, at a standard trunk girth of 50 cm measured 1 m from the ground. Every two days, the trees were tapped with a half spiral downward cut (treatment A: S/2 d2 7d/7) or with a third spiral downward cut (treatment B: S/3 d2 7d/7). With treatment C, the double cut alternate system (DCA: 2 × S/2 d4), a cut was made simultaneously on panel BO-1, 0.75 m from the ground and on panel BO-2, 1.50 m from the ground (Table 1). All treatments were continued for 9 months (9 month/year), as refoliation and the dry season, associated with very high temperatures, prevent economic tapping in February, March and April in the Chachoengsao area.

Table 2
Experimental treatments.

Treatments	Opening
(A) S/2 d2 7d/7 9 m(May–Jan)/12	B0-1, 1.50 m
(B) S/3 d2 7d/7 9 m(May–Jan)/12 ET2.5% Pa0.7(1) 4/Y	B0-1, 1.50 m
(C) DCA S/2 d4 7d/7 9 m(May–Jan)/12 Et 2.5% Pa0.7(1) 4/Y(t,t)	B0-1, 0.75 m, B0-2, 1.50 m

Ethylene stimulant was applied four times per year (4/year). Trees wee stimulated by applying 0.7 gram of a mixture of water containing ethephon (2.5% active ingredient) on the single cut tapping system S/3 d2 and on each cut in the DCA system. Stimulant was applied to 1 cm of the regenerating bark just above the tapping cut (Pa 0.7 (1) according to Vijayakumar et al. (2009). The stimulant was evenly distributed from May to December. Treatments are listed in Table 2.

The panel management schedule for the 10 first years of tapping is shown in Fig. 1.

2.4. Measurements and data processing

The latex yield per tree was measured by weighing the cumulative coagulated rubber from each tree every four weeks. Total solid content was measured from a bulk sample taken in each treatment in order to convert fresh weights into grams of dry rubber per tree. Latex yield was expressed in grams per tree (g/tree). The girth and radial growth the trees were measured every year 1.70 cm above the ground.

The main latex biochemical parameters, i.e. sucrose (Suc) content and inorganic phosphorus (Pi) content, were measured in a bulk sample from 10 trees taken from each replication, each year in October, when latex metabolic activity is the highest, using methods developed by CIRAD (Jacob et al., 1989, 1995b) adapted in 1995 by IRRDB (1995). Sucrose and inorganic phosphorus contents were expressed in millimoles per litre of latex (mmol l^{-1}). Sucrose content was measured using Ashwell's anthrone method (1957). Inorganic phosphorus content was measured using the Taussky and Shorr method (1953).

Table 1
Tapping sequences of d2 7d/7 tapping frequency and its DCA equivalent 2 × d/4 7d/7 (t,t).

Days	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun
d2 7d/7	T		T		T		T		T		T		T	
DCA: 2 × d/4 7d/7 (t,t)	T_{low}		T_{high}		T_{low}		T_{high}		T_{low}		T_{high}		T_{low}	

T_{low} indicates tapping on the lower panel BO-01, T_{high} indicates tapping on the upper panel BO-2.