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The impact of ethylene gas application on young-tapping rubber trees

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The ethylene gaseous stimulation has been introduced by rubber smallholders in southern Thailand to increase latex production, land productivity and tapping labour efficiency. Some smallholders also apply ethylene gaseous stimulation even in young-tapping rubber trees. This may cause adverse impact on the rubber tree. Therefore, an experiment was established at the Thepa Research Station in Songkhla province to investigate the effect of ethylene gas stimulation on the young-tapping rubber tree. Nine-year-old RRIM 600 clones were used for study. The experiment was designed as one tree plot design with 6 treatments; T1: S/3 2d/3 6d/7, T2: S/6 3d 6d/7, T3: S/6 3d 6d/7. ET2.5% Pa 1(2) 12/y (m), T4: S/6 3d 6d/7. ETG99% RRIMFLOW -60- 36/y (9d), T5: S/6 3d 6d/7. ETG60% LET -40- 48/y (6d) and T6: S/6 3d 6d/7. ETG99% Double Tex -60- 36/y (9d). There were twenty replicates in each treatment. The result showed that the cup lump production of the T4 treatment provided the highest yield (3186.05 g tree^{-1} and 91.03 g tree^{-1} tapping^{-1}) and it was significantly different from the remaining treatments. Dry rubber content (DRC) of the T4, T5 and T6 treatments tended to decrease. However, there was no significant difference among the treatments. Bark consumption of T2, T3, T4, T5 and T6 was significantly less than that of the conventional tapping system (T1). There was no significant difference on radial trunk growth among ~~the~~ all treatments. Sucrose, inorganic phosphorus and thiol content of the ethylene stimulation treatments resulted to lower than the conventional tapping system. This indicated that latex production of young-tapping rubber tree was increased by ethylene stimulation, however, it affected latex physiology. This may lead to negative impact in long term. Hence, it needs to be investigated further for long term impact of using ethylene gaseous stimulation.

Key words: *Hevea brasiliensis*, latex yield, ethylene stimulation, latex biochemistry

Introduction

Tapping system efficiency is an important factor for the latex production of rubber tree (*Hevea brasiliensis*). As well as tapping system has been developed various to rubber smallholders' adoption. There were many reports

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of appropriate tapping systems to enhance latex production comprising low frequency tapping system (Obouayeba *et al*., 2009; Soumahin *et al*., 2009; Prasanna *et al*., 2010; Kudaligama *et al.,* 2010; Soumahin *et al*., 2010) and Double Cut Alternate (DCA) tapping system (Chantuma *et al*., 2011; Sdoodee *et al*., 2012). With the continuous increase of rubber price and decrease of each smallholder's rubber plantation size, high frequency tapping system have been implemented to enhance harvesting i.e. daily tapping (d1), two days out of three (2d/3) and three days out of four (3d/4) (Chantuma *et al.,* 2011). However, this affects latex regeneration time with an increase of tapping panel dryness (TPD) (Obouayeba *et al*., 2011) and growth in life cycles of rubber tree.

Researchers have been trying to improve tapping systems by using stimulants. The chemical stimulants of 2-chloroethylphosphonic acid (Ethephon or Ethrel) has been used to enhance latex yield by increasing the duration of latex flow after tapping, reduced tapping frequency and increased land or labor productivity (Sivakumaran and Chong, 1994; Sivakumaran, 2002; Jetro and Simon, 2007; Lacote *et al*., 2010; Njukeng *et al*., 2011; Traore *et al*., 2011). d' Auzac (1989) reported that ethylene reaction at the inner bark, increased pressure and elasticity of laticiferous cell, decreased the coagulate of latex. Njukeng *et al.* (2011) suggested that the frequency and concentration of stimulation should be adapted as an aspect of the clone, tree age and tapping system. Recently, the RRIMFLOW, LET and Double Tex equipments or more have been commercial adopted by rubber smallholders in Thailand.

Sivakumaran (2002) reported that the RRIMFLOW system could enhance latex yield and increase the income of tappers around two to three fold due to the increased tapper productivity. This RRIMFLOW system has not widely known due to limit data presented on this aspect in various publications on the RRIMFLOW system (Sivakumaran *et al*., 2007). Normally, ethylene gas stimulation is recommended for the application over 15-year-old rubber tree, but some smallholders apply in young-tapping rubber trees because of misunderstanding. Therefore, the objective of this study was to investigate the impact of ethylene gas application on young-tapping rubber trees as a guideline for the smallholders.

Materials and methods

The experiment was carried out during September 2010 to March 2012 at the Thepa Research Station, Thepa district (100^o 94' E 6^o 79' N) in Songkhla province, Thailand. The rubber tree var. RRIM 600 planted in 2001 with spacing of 7×3 m (476 trees ha^{-1}) was used in the experiment. The tapping was started in 2008 at 1.50 m from the ground (panel BO-1) and tapping in this experiment was implemented in 2010 at 0.90 m from the ground. At this stage, the trunk girth average was around 50.1 cm measured 1.70 m from the ground. The soil texture in the experimental plot was sandy loam with pH 5.5 (Coated, isohyperthermic, Typic Quartzipsamments). The experimental design was "one tree plot design" (OTPD) comprising 20 replicates per treatment. There were six treatments (T1-T6) which modified from Vijayakumar *et al*. (2009) and Sopchoke (2010) as follows: T1 = S/3 2d/3 6d/7 (Third spiral downward cut at two days tapped by one day rest, six days tapping follows one day rest), T2 = S/6 3d 6d/7 (Six spiral downward cut at every three days tapped, six days tapping follows one day rest), T3 = S/6 3d 6d/7. ET2.5% Pa 1(2) 12/y (m) (Six spiral downward cut at every three days tapped, six days tapping follows one day rest; stimulated with Ethephon of 2.5% active ingredient with 1 g of stimulant applied on panel on 2 cm band, 12 applications per year), T4 = S/6 3d 6d/7. ETG99% RRIMFLOW -60- 36/y (9d), (Six spiral downward cut at every three days tapped, six day tapping follows one day rest; stimulated with Ethylene gas of 99% RRIMFLOW system active quantity with 60 ml, 36 applications per year at 9-day interval), T5 = S/6 3d 6d/7. ETG60% LET -40- 48/y (6d) (Six spiral downward cut at every three days tapped, six day tapping follows one day rest; stimulated with Ethylene gas of 60% LET system active quantity with 40 ml, 48 applications per year at 6-day interval) and T6 = S/6 3d 6d/7. ETG99% Double Tex -60- 36/y (9d) (Six spiral downward cut at every three days tapped, six day tapping follows one day rest; stimulated with Ethylene gas of 99% Double Tex system active quantity with 60 ml, 36 applications per year at 9-day interval).

The installation positions of RRIMFLOW, LET and Double Tex equipments were followed the commercial recommendation (Figure 1). The schedule of panel management is shown in Figure 2.

The latex yield was collected from cup lumps which used to determine dry rubber production in gram per tree (g tree^{-1}), in gram per tree per tapping (g tree^{-1} tapping^{-1}). The other parameters of dry rubber content, girth increment (measured at 1.70 m height from the ground) and bark consumption were recorded. Latex diagnosis was carried out during September to November 2011 to determine sucrose, inorganic phosphorus and thiol content (Gohet and Chantuma, 1999).

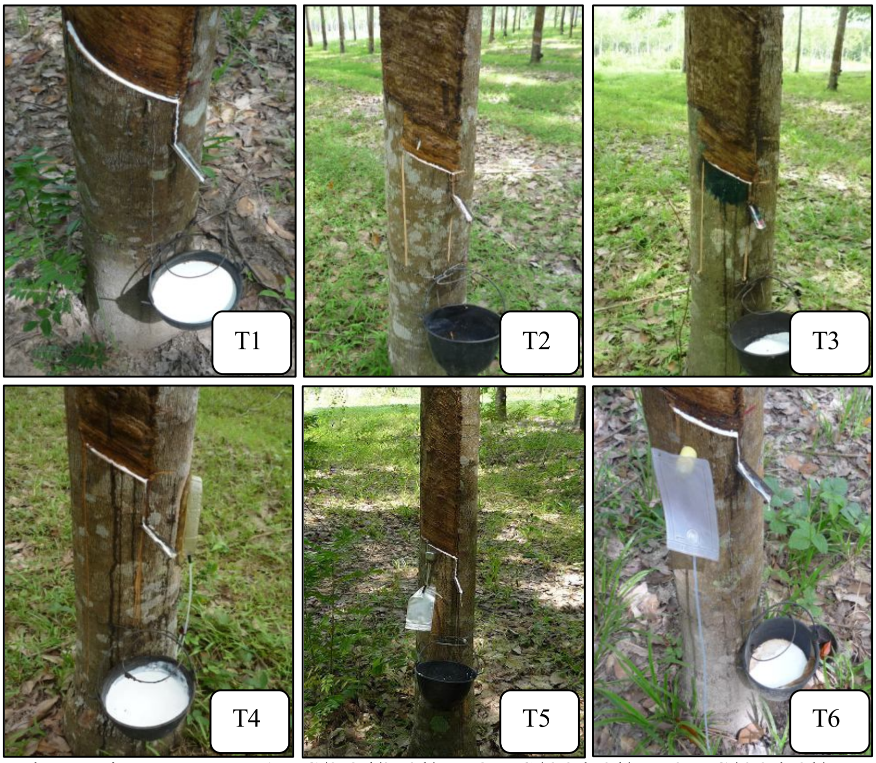


Fig. 1. The tapping systems: T1 = S/3 2d/3 6d/7, T2 = S/6 3d 6d/7, T3 = S/6 3d 6d/7. ET2.5% Pa 1(2) 12/y (m), T4 = S/6 3d 6d/7. ETG99% RRIMFLOW -60- 36/y (9d), T5 = S/6 3d 6d/7. ETG60% LET -40- 48/y (6d), T6 = S/6 3d 6d/7. ETG99% Double Tex -60- 36/y (9d)

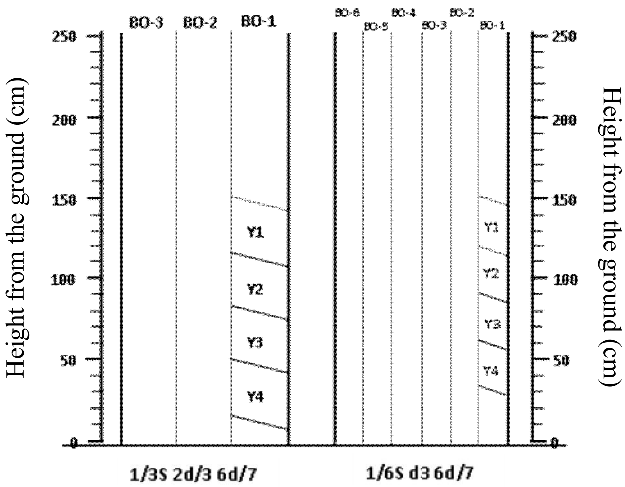


Fig. 2. Management of tapping panels (BO-1, BO-2, BO-3, BO-4, BO-5, BO-6) of tapping systems (1/3S 2d/3 6d/7 and 1/6S d3 6d/7) during experiment

Results and discussions

Rubber production per year

The cumulative cup lump (g tree^{-1}) was showed significantly different among the six treatments as shown in Figure 3A. The T4 provided the highest cumulative cup lump (3186.05 g tree^{-1}). In addition, the ethylene gaseous stimulation treatments in T4, T5 and T6 expressed significantly higher cumulative cup lump than the ethephon stimulation treatment (T3). Although the ethylene gaseous stimulation treatments increased cumulative cup lump, there was no significantly different from the conventional tapping system (T1). Similarly, Jetro and Simon (2007) reported that 2-chloroethylphosphonic acid caused an increase of rubber yield and varied with season. The increase in ~~of~~ yield per year was due to hormonal stimulation which prolonged period of latex flow per activation of laticiferous metabolism (Traore *et al*., 2011).

It was evident that the average cup lumps (g tree^{-1} tapping^{-1}) among the six treatments were significantly different (Figure 3B). The T4 treatment provided the highest average cup lump (91.03 g tree^{-1} tapping^{-1}). Sivakumaran (2002) also reported that the RRIMFLOW short cut tapping system increased in yield productivity, tapping efficiency. Besides, the ethylene gaseous stimulation treatments (T4, T5 and T6) expressed higher average cup lump than the remaining treatments. Jetro and Simon (2007) supported that the yield (g tree^{-1} tapping^{-1}) of stimulated tree was significantly higher than the non-stimulated trees.

Dry rubber content (%DRC)

All treatments of rubber tree were no significantly different, and the percentage dry rubber content varied from 41.33 to 44.62 percentages as shown in Figure 3C. However, the ethylene gaseous stimulation treatments in T4, T5 and T6 tended to lower percentage of dry rubber content than the other treatments. Hock and Sivakumaran (2003) and Leconte *et al*. (2006) reported that the dry rubber content of latex from ethylene application of rubber trees was lower than conventional tapping.

Bark consumption

The bark consumption among the six treatments was shown significantly different as seen in Table1. Especially, the conventional tapping system (T1) expressed significantly higher bark consumption than the other treatments because of higher frequencies. However, reduction in bark consumption is benefit to increase the life span and delays the replanting. Less bark consumption also provides increase time for bark renewal (Kudaligama *et al.*, 2010).

Growth

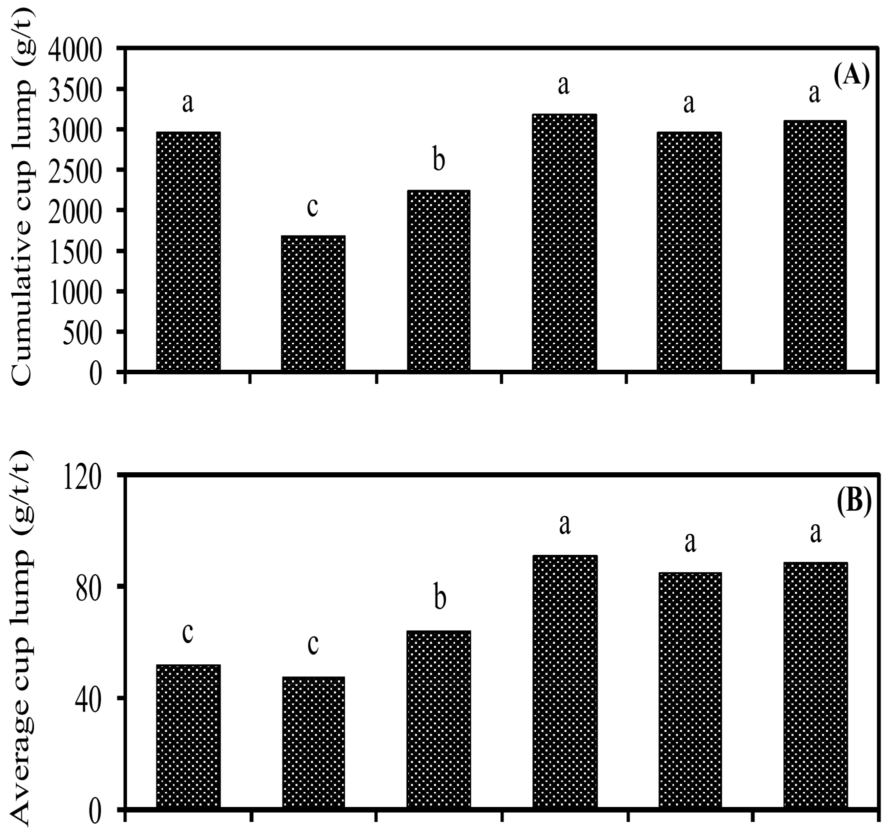
There was no significantly different of girth increased among the six treatments. Silpi *et al.* (2006) reported that ethylene had no effect on the growth rates of tapped trees and ethephon concentrations had no adverse effects on tree health (Prasanna *et al.*, 2010). However, the tree growth of the ethylene gaseous stimulation treatments of T4, T5 and T6 tended to be lower than T1, T2 and T3 treatments. Traore *et al.* (2011) found that the non-stimulated trees had girth increment which was superior to stimulated trees. Besides, girth increment the stimulated trees decreased because the trees were submitted to important stimulation, carry along the fatigue of trees due to overexploitation and overstimulation (Jacob *et al.*, 1995 refer to Traore *et al.*, 2011).

Latex physiology

The average sucrose content, inorganic phosphorus content and thiol content of rubber trees in the six treatments during September to November 2011 were shown in Table1. The sucrose content among the six treatments was shown significantly different from the data gathered in September and October, except in November 2011. Although the ethylene gaseous stimulation treatments of T4, T5 and T6 were higher sucrose content than T1, T2 and T3 treatments in September but they tended to decrease in October to November. However, sucrose content of the ethephon stimulation treatment (T3) expressed which similarly compared to the conventional tapping system (T1).

There was significantly different of inorganic phosphorus content in September among the six treatments except October and November. In addition, the ethylene gaseous stimulations of T4, T5 and T6 caused higher inorganic phosphorus content in September, but lower in October and November than the conventional tapping system (T1). However, inorganic phosphorus content of the ethephon and ethylene gaseous stimulation treatments of T3, T4, T5 and T6 tended to decrease in October and increased in November. Lacote *et al.* (2010) reported that the effect of ethylene stimulation on PB 217 clone was high sucrose content and low inorganic phosphorus content.

There was significant difference of thiol content among the six treatments in October, except in September and November. Thiol content seemed to increase continuously in the all treatments. However, the ethephon and ethylene gaseous stimulation treatments of T3, T4, T5 and T6 tended to–lower thiol content than the conventional treatment (T1). Jetro and Simon (2007) reported that the higher thiol of the stimulated trees could be due to a good level of metabolic activition that was not accompanied by stress. High stress leads to degradation reactions which reduce thiol level.



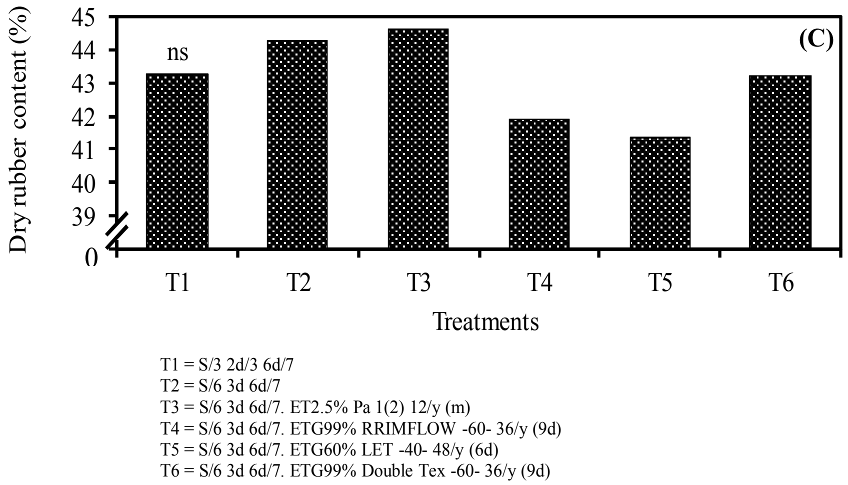


Fig. 3. Comparison of cumulated cup lump (g $tree^{-1}$) (A), average cup lumps (g $tree^{-1}$ $tapping^{-1}$) (B) and average dry rubber content (DRC) (C) of rubber trees in the six treatments during September 2010 to March 2012

Table 1. Bark consumption of rubber trees in the six treatments during September 2010 to March 2012

Treatments	Bark consumption (cm)
T1 = S/3 2d/3 6d/7	20.21a
T2 = S/6 3d 6d/7	18.46b
T3 = S/6 3d 6d/7. ET2.5% Pa 1(2) 12/y (m)	18.24b
T4 = S/6 3d 6d/7. ETG99% RRIMFLOW -60- 36/y (9d)	18.59b
T5 = S/6 3d 6d/7. ETG60% LET -40- 48/y (6d)	19.06b
T6 = S/6 3d 6d/7. ETG99% Double Tex -60- 36/y (9d)	18.54b
F-test	*
C.V.	8.66

Means with different letters in the same column indicate significant difference at $P \leq 0.05$, DMRT.

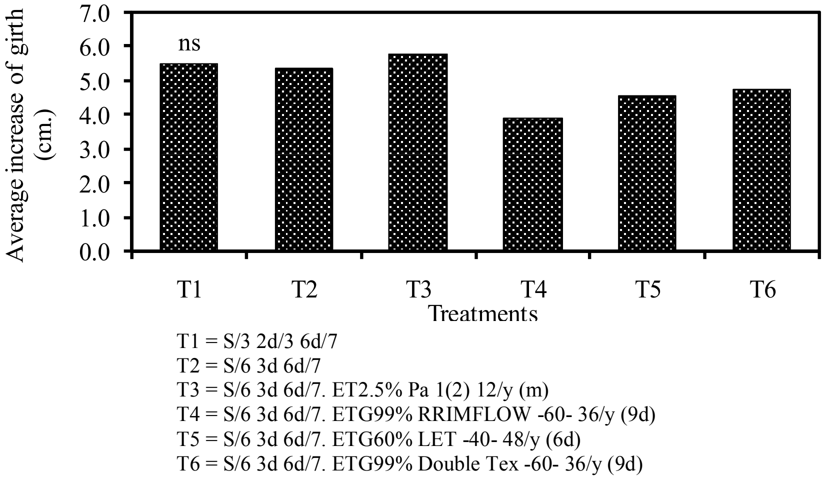


Fig. 4. Average girth increment of rubber trees in the six treatments during September 2010 to March 2012

Table 2. Average of sucrose content, inorganic phosphorus content and thiol content of rubber trees in the six treatments during September to November 2011

Treatments	Sucrose ($mM\ L^{-1}$)			Inorganic phosphorus ($mM\ L^{-1}$)			Thiol ($mM\ L^{-1}$)		
	Sep	Oct	Nov	Sep	Oct	Nov	Sep	Oct	Nov
T1 = S/3 2d/3 6d/7	7.35b	6.10ab	5.69	8.32bc	9.79	18.15	0.24	0.48a	0.77
T2 = S/6 3d 6d/7	9.38b	7.83a	6.17	5.11c	7.30	11.43	0.27	0.34bc	0.76
T3 = S/6 3d 6d/7. ET2.5% Pa 1(2) 12/y (m)	9.07b	6.72ab	4.90	8.14bc	4.75	13.87	0.20	0.51a	0.59
T4 = S/6 3d 6d/7. ETG99% RRIMFLOW -60- 36/y (9d)	18.58a	5.02ab	4.81	17.14a	6.37	17.05	0.10	0.44ab	0.70
T5 = S/6 3d 6d/7. ETG60% LET -40- 48/y (6d)	15.06a	5.08ab	4.79	9.48bc	6.00	16.49	0.21	0.45ab	0.62
T6 = S/6 3d 6d/7. ETG99% Double Tex -60- 36/y (9d)	16.42a	4.30b	3.68	13.12ab	5.60	14.50	0.14	0.26c	0.61
F-test	*	*	ns	*	ns	ns	ns	*	ns
C.V.	27.16	24.89	36.74	25.93	38.55	23.63	32.44	16.71	23.31

Means with different letters in the same column indicate significant difference at $P \leq 0.05$, DMRT
ns = no significant difference

Conclusion

Ethylene stimulant tapping system enhanced latex production in gram per tapping of young-tapping of rubber trees. However, there was no significantly different of cumulative latex production compared with the conventional tapping system. In addition, dry rubber content (% DRC) and girth increment of ethylene stimulation tapping system tended to decrease from regular. Bark consumption was significantly reduced under the stimulant application treatments. However, latex physiology tended to be affected under the stimulate treatments; this may lead to negative impact in the long term.

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