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Enhancing the latex productivity of *Hevea brasiliensis* clone RRIM 600 using ethylene stimulation

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Southern Thailand is defined as a traditional area of rubber production. With current increase of latex price, rubber smallholders try to increase the tapping productivity. Recently, ethylene stimulation has been introduced to increase rubber productivity in Songkhla province. Although it was commercial adoption, it needed to be tested before recommendation to rubber smallholders. Therefore, an experiment was established at Thepa Research Station in Songkhla province. Twenty one-year-old rubber trees clones RRIM 600 were used. The experiment was designed as one-tree plot design with 20 replicates. There were 6 treatments: 1) 1/3S↑ 2d/3(C), 2) 1/8S↑ d/3, 3)1/8S↑ d/3+RRIMFLOW (RF), 4) 1/8S↑ d/3+LET(LET), 5) 1/8S↑ d/3+Double Tex (DT) and 6) 1/8S↑ d/3+ Ethephon 5%(E). The investigation was done from June 2010 to February 2011. The result showed that RF treatment provided the highest yield (137.70 g/t/t and 5.9 kg/t/y) and it was significantly different from the other treatments. However, dry rubber content (DRC) of the treatment RF was significantly lower than the remaining treatments. It was found that sucrose in the RF treatment tended to decrease, whereas inorganic phosphate and thiol tended to increase. The RF treatment also caused a significant decrease of girth increment.

Key words: bark consumption, ethylene stimulation, latex physiology, RRIM 600

Introduction

Rubber *(Hevea brasiliensis)* is an important economic crop of Thailand, the majority of plantation is in southern Thailand (RRIT, 2011). Moreover, the trend of natural rubber production increases higher than synthetic rubber leading to high demand of natural rubber with the higher price. This inspires the rubber smallholder to increase income by using high tapping frequency, or using ethephon stimulation (Leconte *et al.*, 2006). According to the innovation of tapping system evolved from conventional tapping with using ethylene (2-chloroethylphosphonic acid) generator, it is applied to tapping panel to

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increase latex yield with reducing tapping frequency (Lacote *et al*., 2010). Ethylene has been reported that it is a major stimulating factor for natural rubber production in the rubber tree and it is applied in the both forms of ethephon and ethylene gas stimulations (Coup and Chrestin, 1989). d' Auzac (1989) reported that ethylene reaction at the inner bark, which increases latex flow while increasing pressure and elasticity of laticiferous cell, decreases the coagulate of latex. Sainoi and Sdoodee (2012) reported that ethylene gas application tended to cause an impact on latex physiology. Jetro and Simon (2007) found that the use of ethylene stimulation affected latex yield and latex physiology varied with seasons. Ethylene gas stimulation is recommended for the application over 15-year-old rubber trees. Sivakumaran *et al*. (2007) reported that RRIMFLOW tapped trees provides a practical avenue for maintaining high yield productivity over the long term by exploitation of different drainage through process of periodic panel changeover. Normally, there have been many products of ethylene gas stimulation in commercial such as RRIMFLOW, LET and Double Tex. Although it is commercial adoption, it needs to be tested before recommendation to rubber smallholders. The objective of this study was to investigate the effect of the application of RRIMFLOW, LET, Double Tex and Ethephon stimulation on latex yield and latex physiology of the rubber clone RRIM 600 with the purpose of enhancing latex productivity.

Materials and methods

The trial was conducted during June 2010 to March 2011 at Tepha Research Station (100°56' E 6°48' N) in Songkhla province. The trees were selected before opening for homogenous girth in clone RRIM 600 currently used in Thailand. The trial was planted in 1989 at 7×3 m spacing (476 trees/ha). The soil texture in the experimental plot was sandy loam with pH 5.5 (Coated, isohyperthermic, Typic Quartzipsamments). In this study, tapping implant was done on the panel with upward tapping cut at about 170 cm from the ground. The treatments of ethylene stimulations (RRIMFLOW, LET, Double-tex and Ethephon) with the short – tapping (S/8) was compared with the conventional tapping system (S/3 2d/3). Therefore, the experiment was designed as "one-tree-plot design". The stimulation treatments were stimulated with ethylene gas application and 5% ethephon. The 5% ethephon was applied on tapping panel. Ethylene gas applications were injected on RRIMFLOW, LET and Double Tex system. There were 6 treatments (20 trees per treatment) as follows:

T1 = S/3 2d/3
The trees were tapped with a third spiral upward cut, two days tapping by day rest, cut corners 30 degree.
T2 = S/8 d/3
The trees were tapped with an eighth spiral upward cut, every three days, cut corners 45 degree.
T3 = S/8 d/3+RRIMFLOW
The trees were tapped with an eighth spiral upward cut, every three days, stimulated with ethylene gas application of RRIMFLOW system ,cut corners 45 degree.
T4 = S/8 d/3+LET
The trees were tapped with an eighth spiral upward cut, every three days, stimulated with ethylene gas application of LET system ,cut corners 45 degree.
T5 = S/8 d/3+Double Tex
The trees were tapped with an eighth spiral upward cut, every three days, stimulated with ethylene gas application of Double Tex system, cut corners 45 degree.
T6 = S/8 d/3+Ethephon
The trees were tapped with an eighth spiral upward cut, every three days, cut corners 45 degree, stimulated with 5% ethephon, 12 applications per years.

Yield was collected from cup lumps. Studied parameters were dry rubber production (kg/tree/year, g/tree/tapping), girth measured at 1.70 m from ground and bark consumption. 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.

Results

Weather condition

In 2010, the drying period was during January – May (Figure 1). However, there was heavy rainfall at the end of year causing severe flooding in November with the highest monthly rainfall (627.2 mm.). Early period in 2011, the rainfall turned to reduce, but there was high rainfall in March (213.1 mm.). Average minimum and maximum temperatures were around 25 $^{\circ}$ C and 33 $^{\circ}$ C.

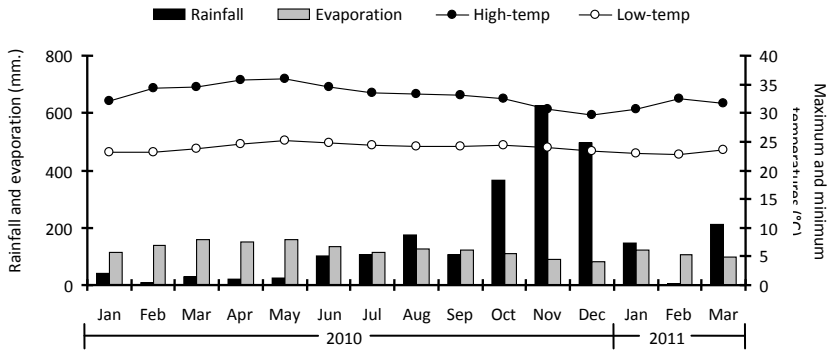
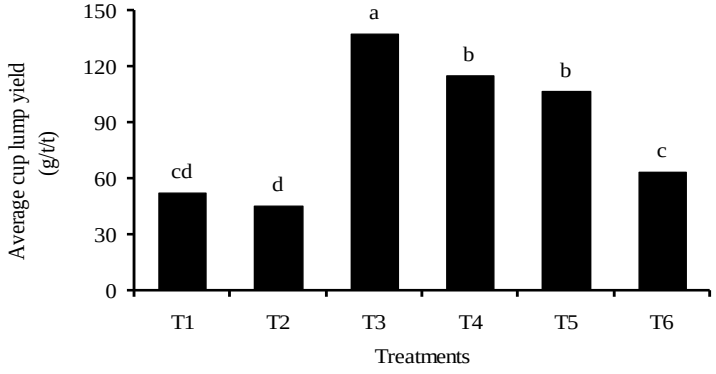


Fig. 1. Average monthly rainfall, evaporation and maximum and minimum temperatures during January 2010 – March 2011 at Thepa Research Station, in Songkhla province.

Latex yield

Rubber production per tapping

During the experimental period, there was a significant difference of average cup lump (gram/ tree/ tapping or g/t/t) among the treatments. The T3 treatment provided the highest cup lump yield (137.70 g/t/t) but the T2 treatment showed the lowest average cup lump (45.54 g/t/t). Particularly with the ethylene gas stimulation treatments (T3, T4 and T5), they expressed significantly higher yield than the remaining treatments (T6, T1 and T2) (Figure 2).



T1 = 1/3S ↑2d/3 T2 = 1/8S ↑1d/3 T3 = 1/8S ↑1d/3 +RRIMFLOW
T4 = 1/8S ↑1d/3 + LET T5 = 1/8S ↑1d/3 + Double Tex T6 = 1/8S ↑1d/3 + Ethephon 5 %

Fig. 2. Average cup lump yields (g/t/t) of rubber trees in the all treatments during June 2010 – March 2011.

Rubber production per year

The result showed that cumulated cup lump in the six treatments during June 2010 – March 2011 period was significantly different. The T3 treatment provided the highest cumulated cup lump (5.92 kg/t), where as the lowest cumulated cup lump was found in the T2 treatment (1.95 kg/t). The ethylene gaseous stimulation treatments (T3 and T4) were higher cumulated cup lump than the conventional treatment (T1) and ethephon stimulation treatment (T6). The T1treatment provided higher cumulated cup lump than the T6 (Figure 3).

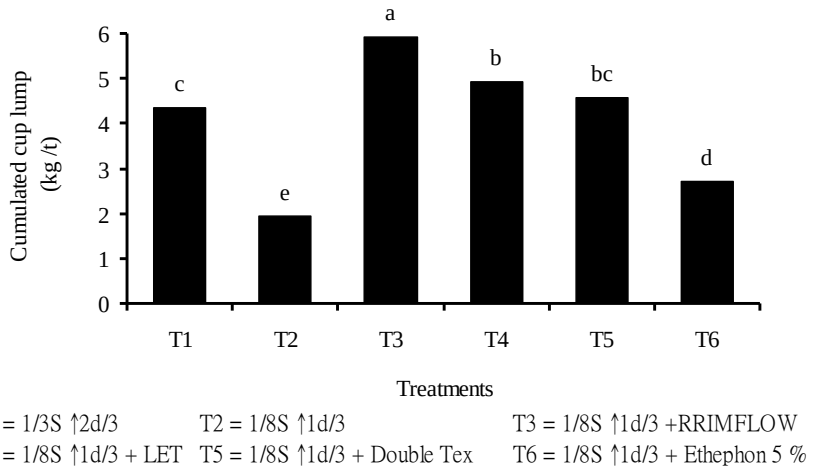
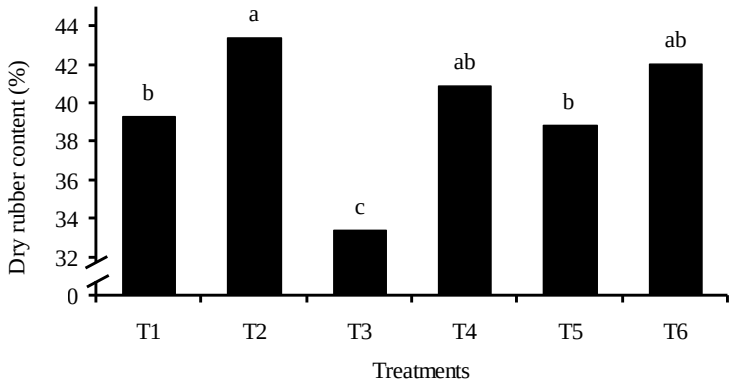


Fig. 3. Comparison of cumulated cup lump (kg/t) of rubber trees in the all treatments during June 2010 – March 2011.

Dry rubber content

Average dry rubber content (DRC) in the all treatments is shown in Figure 5, DRC in the T2 was the highest, but there was no significantly different from those of T4 and T6. It was remarkable that, DRC in the T3 was the lowest. There was significantly different in dry rubber content among the all treatments (Figure 4).

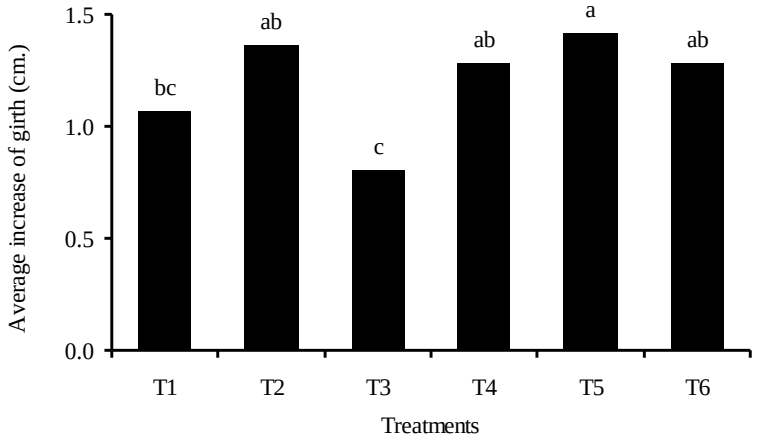


T1 = 1/3S↑ 2d/3 T2 = 1/8S↑ 1d/3 T3 = 1/8S↑ 1d/3 +RRIMFLOW
T4 = 1/8S↑ 1d/3 + LET T5 = 1/8S↑ 1d/3 + Double Tex T6 = 1/8S↑ 1d/3 + Ethephon 5 %

Fig. 4. Average dry rubber content (DRC) of rubber trees in the all treatments during June 2010 – March 2011.

Girth increment

During experimental period, the result showed that radial trunk girth in the T3 was the lowest. At the same time, the T3 was significantly lower in the girth increment than the remaining treatments (Figure 5). There was no significantly different of trunk girth among the T5, T2, T4 and T6.



T1 = 1/3S ↑2d/3 T2 = 1/8S ↑1d/3 T3 = 1/8S ↑1d/3 +RRIMFLOW
T4 = 1/8S ↑1d/3 + LET T5 = 1/8S ↑1d/3 + Double Tex T6 = 1/8S ↑1d/3 + Ethephon 5 %

Fig. 5. Average girth increment of rubber trees in the all treatments during June 2010 – March 2011.

Bark consumption

Compare of bark consumption among the treatments. Table 3 showed that bark consumption in T1 treatment was significantly higher than the other treatments (Table 1).

Table 1. Bark consumption of rubber trees in the six treatments during June 2010 – March 2011

Treatments	Bark consumption (cm.)
T1 : 1/3S↑ 2d/3	24.18[a]
T2 : 1/8S↑ 1d/3	12.96[b]
T3 : 1/8S↑ 1d/3 + RRIMFLOW	12.40[b]
T4 : 1/8S↑ 1d/3 + LET	12.79[b]
T5 : 1/8S↑ 1d/3 + Double Tex	12.83[b]
T6 : 1/8S↑ 1d/3 + Ethephon 5%	12.08[b]

Mean with different letters in the same column indicate a significant difference at $P \leq 0.05$ by DMRT.

Latex physiology

During the July – October 2010, Table 4 showed the average sucrose, inorganic phosphorus and thiol content. Sucrose in the treatment T3 tended to be the lowest compared with the other treatments. There was no significant difference of inorganic phosphorus content among the treatments. However, the ethylene stimulation with RRIMFLOW treatment (T3) tended to express higher inorganic phosphorus content than the remaining treatments. The moment of thiol expressed that there was no significant difference among the treatments except in July and October. Chantuma *et al*. (2003) also reported that ethylene application in clone RRIM 600 caused a decrease of sucrose, but increase of inorganic phosphorus and thiol.

Table 4. Sucrose, inorganic phosphorus and thiol (mmol/L) of latex in the six treatments during July – October 2010

Treatments	Sucrose				Inorganic phosphorus				Thiol			
	Jul	Aug	Sep	Oct	Jul	Aug	Sep	Oct	Jul	Aug	Sep	Oct
T1 : 1/3S↑ 2d/3	10.14^{d}	11.46^{bc}	10.71^{b}	12.61^{a}	8.95^{ns}	9.76^{ns}	8.55^{ns}	10.36^{ns}	0.37^{b}	0.40^{ns}	0.38^{ns}	0.37^{b}
T2 : 1/8S↑ 1d/3	17.51^{a}	13.03^{ab}	16.63^{a}	13.93^{a}	7.80	10.56	8.04	10.56	0.48^{ab}	0.45	0.44	0.48^{ab}
T3 : 1/8S↑ 1d/3 + RRIMFLOW	10.60^{cd}	8.91^{c}	10.28^{b}	9.00^{b}	12.31	12.07	12.06	12.07	0.48^{ab}	0.50	0.41	0.53^{a}
T4 : 1/8S↑ 1d/3 + LET	13.05^{bcd}	14.24^{ab}	14.36^{a}	13.96^{a}	7.55	10.26	8.31	10.26	0.47^{ab}	0.24	0.42	0.52^{a}
T5 : 1/8S↑ 1d/3 + Double Tex	13.74^{bc}	12.01^{abc}	14.42^{a}	11.77^{ab}	8.84	12.54	9.28	12.54	0.40^{b}	0.23	0.53	0.40^{b}
T6 : 1/8S↑ 1d/3 + Ethephon 5%	14.35^{b}	14.84^{a}	14.06^{a}	15.06^{a}	8.98	12.79	9.87	12.79	0.53^{a}	0.28	0.49	0.52^{a}

Different letters in the same column indicate a significant difference ($P \leq 0.05$) by DMRT
ns = non-significant difference

Discussion

It was evident that RRIMFLOW, LET and Double Tex techniques could increase rubber yield with significantly higher yield than the ethephon smearing, the short–tapping (no ethylene gas) and the conventional tapping system. This supports that ethylene gas stimulation is effective in clone RRIM 600, particularly with RRIMFLOW provided the significant highest latex yield. The RRIMFLOW treatment could enhance cup lump yield per tapping around three fold comparing with the conventional tapping system. Similarly, Sivakumaran (2002) also reported that the RRIMFLOW system could increase latex yield and income of tappers around two to three fold due to the increased tapper productivity. The advantage of the RRIMFLOW stimulation was both reduce tapping frequency and increase tapping labor efficiency (Sivakumaran and Chong, 1994). However, this study was only short period, Traore *et al.* (2011) suggested that the effect of ethylene stimulation has to be investigated in long term.

According to the positive response on yield of the rubber trees to the RRIMFLOW treatment, negative impact should be considered because of sucrose decrease. This implied that there was over exploitation of sucrose in latex regeneration particularly under the RRIMFLOW treatment or T3. This may lead to tapping panel dryness in long term. Besides, there was a significant decrease of dry rubber content in the T3 treatment, this is adversely impact of the RRIMFLOW treatment with higher amount of ethylene gas application and longer surface of gas absorption. During the experimental period, the girth increment of T3 treatment was the lowest, this might be due to high assimilation and sucrose converted to latex. In the case of the T1 treatment the girth increment was low because of high tapping frequency with significant

high bark consumption. Hence, rubber smallholders should aware of negative impact in the methodology of ethylene stimulation. Although LET and Double Tex provided lower yield than that of the RRIMFLOW treatment, it did not cause adversely impact on dry rubber content and girth increment. This implied that amount and concentration of gas ethylene application should be optimized to increase latex yield without an adverse impact on growth and latex physiology of the rubber tree. Njukeng *et al.* (2011) also suggested that the frequency and concentration of stimulation should be adapted with the clone, tree age and tapping system. Besides, LET and Double Tex also caused the damage of bark because of equipment installation. Therefore, it needs to be investigated further to improve the equipment for ethylene gas stimulation.

Conclusion

Ethylene gas stimulation in the 21-year-old rubber tree clone RRIM 600 using RRIMFLOW provided the highest latex productivity, comparing with the other stimulation treatment of LET, Double Tex and Ethephon. Average yield per tapping (g/t/t) in the RRIMFLOW treatment was around three fold of the conventional tapping. However, it caused a significant decrease of dry rubber content. Latex diagnosis in the RRIMFLOW treatment showed that sucrose tended to decrease, whereas inorganic phosphate and thiol tended to increase. Besides, the impact of RRIMFLOW on a significant decrease of girth increment was found.

Acknowledgement

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