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Original Article

Effect of fertilizer and dolomite applications on growth and yield of tapping rubber trees

Issariyaporn Damrongrak[1], Jumpen Onthong[2]*, and Chairatna Nilnond[2]

[1] *Program in Tropical Agricultural Resource Management,*

[2] *Department of Earth Science,*
Faculty of Natural Resources, Prince of Songkla University, Hat Yai, Songkhla, 90110 Thailand.

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Abstract

Tropical acid soil used for rubber planting has usually low fertility due to continuous loss of plant nutrient elements by crop removal and leaching. Thus, proper soil improvement in tapping rubber is very essential. This study aimed to measure the growth and yield of 17-year-old rubber trees, chemical properties of soil, and plant nutrient status in the leaf and latex after two years of soil improvement. A randomized complete block of seven treatments: No fertilizer (Control treatment), Chemical fertilizer based on soil analysis according to the recommendation of the Rubber Research Institute (Ch.F), Ch.F+ Dolomite to raise pH up to 6.0 (D), 3 kg per plant of compost (C), Ch.F+C, ½ Ch.F+C and ½ Ch.F+C+D, with three replicates was designed. After two years of giving treatments, it was found that adding full rate of chemical fertilizer based on soil test together with compost or dolomite increased the tree girth increment from the first year to the second year. Rubber yield after soil improvements tended to increase from the beginning to the end of the year, especially with compost application. Increasing of soil fertility was found after soil improvement treatments. However, total N, available P and available K were still lower than optimum levels as well as leaf N and K. Nitrogen in rubber latex after soil improvement treatments was higher than those in the control treatment, which contrasted to those of Ca and Mg. However, fertilizer and dolomite effect on micronutrient elements in rubber leaf and latex were not clear. Thus, fertilizer should be continuously applied at least with the full rate of chemical fertilizer based on soil analysis, and organic fertilizer should be applied to gain some trace elements. Dolomite could also be applied in a very strong acid soil.

Keywords: fertilizer, dolomite, tapping rubber, rubber plantation

1. Introduction

Rubber tree (*Hevea brasiliensis* Muell.) is one of the prominent economic plants of Thailand, which has been the world's largest producer and exporter of natural rubber since 1991. In 2013, plantation area occupied around 3.55 million hectares (22.18 million rai). There were 2.42 million hectares (15.13 million rai) of production areas which produced 3.86 million tons of natural rubber (Office of Agricultural Economics, 2013).

To achieve high yield of rubber latex, good variety, high fertility of soil and appropriate cultural management both in immature and tapping stage are important. Most humid tropical soils are Ultisols and Oxisols which have inherently low fertility. Most of the clay minerals contained in the soil is 1:1 type clay which has low absorption capacity (Shamshuddin and Noordin, 2011).The characteristics of tropical soils are low pH, high exchangeable Al, low cation exchange capacity, low base saturation, and high phosphate-fixing capacity (Nanthi *et al*., 2003). Analysis of 27 soil series

* Corresponding author.
Email address: jumpen.o@psu.ac.th

samples at 0-30 cm depth from rubber plantation in southern Thailand found that they contained plant nutrient elements in the range of low to medium (Kangpisadarn, 2004). In addition, the soils were continuously used for 2 or 3 cycles of rubber re-plantation. Therefore, they should be needed to improve for plant growth.

The ideal soil pH for plant growth is 6.0-6.5 because most plant nutrients are in their most available states (Brady and Weil, 2002). However, most rubber growing soils have strong acid with low of Ca, Mg, K and P and too much Fe and Mn (Waizah *et al.*, 2011; Oku *et al.*, 2012; Suchartgul *et al.*, 2012). Soluble Al is almost certainly a problem when the soil pH is below 5.0 (Brady and Weil, 2002). The concentration likely to be troublesome to the plant is around 10-20 mg kg^{-1}. Liming is a common way to remedy that condition (Pabian *et al.*, 2012). It enhanced an increase in phosphate availability by stimulating mineralization of soil organic phosphorus, meanwhile, at high soil pH, the precipitation of insoluble calcium phosphate caused available phosphate to decrease (Haynes, 1982). Raising soil pH from 4.5-5.2 to 6.0 reduced the amounts of soluble Al, Mn and Zn, but increased NO_3-N markedly (Maclean *et al.*, 1972). Dolomite liming improved the nutrition of N and Ca but caused the imbalance of P, K, and Mg (Moore and Ouimet, 2006). The advantage of applying dolomite in acid soil can increase Ca and Mg, which normally contains low concentration of the elements and not enough for plant growth (Nanthi *et al.*, 2003).

Long-term cultivation with lack of appropriate soil management caused gradual soil degradation. Plant nutrient elements are generally lost by crop removal, soil erosion, and leaching. Some studies revealed decline of soil fertility in the early period of rubber growth (1-10 years), and an increase in the old age of plantation soils (Njar *et al.*, 2011; Yasin *et al.*, 2010; Zhang *et al.*, 2007). Observation from rubber plantation in Hinan Island, China during 1954-1995 found that soil organic matter, total N, available K and available P decreased by 48.2, 54.1, 56.7 and 64.1 %, respectively (Cheng *et al.*, 2007). Thus, appropriate nutrient management in rubber plantation should be well considered.

Fertilizer application based on soil analysis is one of the suitable fertilizer managements. It was found that girth and biomass of untapped rubber trees, with fertilizer based on soil test, were higher than those of general fertilizer (mixed fertilizer grade 20-8-20) recommendation by the Rubber Research Institute of Thailand (Boonyamanee *et al.*, 2013). Therefore, tapping period can start earlier. Latex yield after fertilizer application based on soil analysis was higher than those of traditional fertilizer which resulted in higher profit (Kangpisadarn, 2010). Organic fertilizer is an alternative fertilizer applicable, especially in soils with poor physical properties. It showed good efficiency in improving the physical, chemical, and nutritional properties of sandy soil and increasing crop yields (Ibrahim and Fadni, 2013). Improper characteristics of tropical soil such as rapid decomposition of organic matter, low cation exchangeable capacity, and low pH can be improved by adding organic residue or organic fertilizer (Ogundare *et al.*, 2012). Some planters applied organic fertilizer in rubber plantation and said that the rubber trees grew better and gave higher yield. Furthermore, the trees produced more concentrated latex. However, there are not any scientific evidences, but it is known that high concentration of latex means high dry rubber content which relates to low production due to rapid ceasing of latex flow (Jacob *et al.*, 2000).

The objectives of this experiment were to measure the growth and yield of tapping rubber, and to determine soil fertility, nutrient status in rubber leaf and rubber latex within two years of different fertilizer and dolomite applications.

2. Materials and Methods

The experiment was carried out in 17-year-old rubber plantation, located at the Agricultural Research and Development Center, Pattani Province, South Thailand (6° 41′ 33.25″ N, 101° 15′ 46.97″ E), in Klaeng soil series (very fine, kaolinitic, isohyperthermic typic plinthaqualts). The soil texture was sandy clay loam (48% sand, 12% silt and 40% clay). Chemical properties of the soil in the experimental site were as follows; pH 4.55 (1:2.5, soil:water) organic matter 23.82 g kg^{-1}, total N 1.08 g kg^{-1}, available P 3.73 mg kg^{-1}, available S 22.16 mg kg^{-1} and exchangeable K, Ca, Mg 20.23, 18.15, 15.28 mg kg^{-1}, extractable Fe, Mn, Zn and Cu 79.17, 4.67, 0.290, and 0.480 mg kg^{-1}, respectively.

A randomized complete block design of seven treatments with three blocks was used. The treatments consisted of no fertilizer (control), chemical fertilizer based on soil analysis (Ch.F), Ch.F+Dolomite (D) to raise pH up to 6.0, 3 kg per plant of compost (C), Ch.F+C, ½Ch.F+C and ½ Ch.F +C+D. Experimental site contained RRIM 600 clone with 2.5x 8.0 m of growing space. Each sub-plot contained 36 trees including guard rows, and 10 of them at the middle row were selected for data collection. Bulk blending fertilizer consisting of urea (21-0-0), di-ammonium phosphate (18-46-0), and potassium chloride (0-0-60) were blended and applied. The rate of urea, di-ammonium phosphate and potassium chloride was followed according to the Rubber Research Institute of Thailand recommendation based on rapid soil analysis results which contained 304 g-N $plant^{-1}$, 105.14 g-P $plant^{-1}$ and 240 g-K $plant^{-1}$. This splitting was applied at the end of May and October in 2010 by banding along both sides of the planting row. The same rate was followed in the subsequent year. Three kilograms of compost, which contained 2.47 mS cm^{-1} of EC, 7.68 of pH, 6.0 , 2.6, 1.4, 2.1, 4.87, and 1.6 g kg^{-1} (based on dry weight) of N, P, K, Ca, Mg, and S were banded once a year. Dolomite was scattered only in the first year on the surface soil at the rate that is expected to elevate soil pH to 6.0 (772.8 kg rai-^{1}), according to lime requirement evaluation by lime incubation method (Maneepong, 1994).

Stem girths at 170 cm above ground of 10 rubber trees from each sub-plot were measured before and after one year and two years of giving treatments. Latex yield (g $plant^{-1}$) in

2012 was measured three times in June, September and November or after two years of soil improvement. Dry rubber content was measured at the same time, and then dry rubber yield per tree was calculated.

Soil samples were analyzed before and after one year and two years of giving treatments. Those were collected before treatments were given in May of each year. Soil samples from ten holes of 0-30 cm depth in each sub-plot were collected and mixed to make a composite sample. Then they were determined using standard method recommended by Onthong (2002) and Maneepong (1994). Soil pH was measured in 1:2.5 soil/water. Organic matter was determined by chromic acid oxidation method. Available P was extracted by using Bray II and phosphate solution assayed by molybdenum blue method. Available S was extracted with calcium tetrahydrogen di-orthophosphate, and then the concentration determined by turbidimetry method. Exchangeable K, Ca, and Mg were extracted with neutral 1 M ammonium acetate (NH_4OAc), and detected by atomic absorption spectrophotometer. Iron, Mn, Zn, and Cu were extracted with di-ethylene tri-amine penta acetic acid (DTPA), and detected by atomic absorption spectrophotometer (Maneepong, 1994).

Rubber leaves were analyzed after one year and two years of soil improvements. The leaf samples were collected in May 2011 and May 2012 when new leaves became mature. The second and third leaves of terminal cluster of low branches in the shade from ten stands of each sub-plot were collected (Kangpisadarn, 2008) and mixed to make the composite sample, then cleaned with de-ionized water, and immediately dried in hot air oven at 65°C. The dried leaves were ground and passed through a 0.5 mm-sieve, then digested with an acid mixture (3:1, nitric:perchloric). Phosphorus content of the digester was measured by vanadomolybdate method. Sulfur was determined by turbidimetric method. Potassium, Ca, Mg, Fe, Mn, Zn, and Cu were detected by atomic absorption spectrophotometer, and nitrogen was determined by Kjedalh method (Onthong, 2002).

Rubber latex from ten stands of each sub-plot were collected at the same time as the leaf sample collection, and mixed to composite samples, then digested with H_2SO_4/H_2O_2. Plant nutrients (N, P, K, Ca, Mg, Fe, Mn, Zn, and Cu) in the diluted samples were measured by the same methods as those of leaf analysis.

Data of girth increment, rubber yield, soil chemical properties, plant nutrients in leaves and latex were subjected to analysis of variance to test whether the treatment were effective or not, and the means were compared by Dunncan Multiple Range Test (DMRT) at p = 0.05.

3. Results and Discussion

3.1 Growth and yield of rubber

Average girth at 170 cm above ground of rubber trees before giving treatment was 70.5 cm, which showed non-significant difference among the treatments. After one year of soil improvement, chemical fertilizer together with dolomite treatment showed the lowest girth increment, whereas in the second year of soil improvement, it showed the highest value. Compost application showed the highest girth increment in the first year of soil improvement, but decreased in the second year (Table 1). Increasing soil pH might have caused the imbalance of plant nutrient elements, especially Cu, that showed lower concentration in rubber leaf of Ch.F+Dolomite treatment (4.54 mg kg^{-1}) when compared to the Ch.F treatment (7.11 mg kg^{-1}) after one year of soil improvement. Also found was high a Ca/Cu content in rubber leafs from liming soil with $Ca(OH)_2$ in pot experiment (Damrongrak *et al.*, 2014). However, after the soil pH decreased because dolomite liming was stopped, Ca and Mg residue and N, P, and K from full rate of chemical fertilizer enhanced distinctly the growth

Table 1. Girth and girth increment at 170 cm above ground after soil improvement.

Treatments	Girth (cm)		Girth increment (cm)		
	Before soil improvement	After 2 years of soil improvement	1st year	2nd year	1st year +2nd year
Control	66.14	69.41	2.17	1.10	3.27
Ch.F	69.50	73.31	2.60	1.21	3.81
Ch.F+D	72.18	75.49	0.79	2.51	3.30
C	72.07	76.26	2.46	1.73	4.19
Ch+C	68.41	71.98	1.53	2.04	3.57
1/2Ch.F+C	71.72	75.68	2.28	1.68	3.96
1/2Ch.F+C+D	73.64	77.27	1.94	1.69	3.63
F-test	ns	ns	ns	ns	ns
C.V. (%)	6.28	5.41	79.8	72.86	63.93

ns = Non-significant difference of average value among treatments (p≥0.05).

of rubber trees. Two years of soil improvement showed higher girth increment (3.80 cm in average) than in the control treatment (3.10 cm), and compost application gave the highest value (4.19 cm). The average girth increments were only 1.9 and 1.8 cm/year in the first and second year of soil improvement, respectively (Table 1). That was nearly the girth increment of tapping rubber (1.78 cm $year^{-1}$) revealed by the former researcher in Thailand (Bangjan and Yingjajaval, 2006). However, they were lower than the reference value (2.00-2.05 cm $year^{-1}$) proposed by the Rubber Research Institute of Thailand (Kangpisadarn *et al*., 1999). The girth of late tapping rubber (older than 15 years) increases were lower than early tapping plant. The girth increment of RRIM 600 clone grown in loamy sand and low fertility soil in Sao Paulo, Brazil, that calculated from the 6^{th} and 10^{th} year, increased 2.87 cm $year^{-1}$ (Goncalves *et al*., 2011). It should be noted that full rate of chemical fertilizer application based on soil test together with compost or dolomite had increased the girth increments from the first year to the second year, whereas, other treatments had decreased girth increments. This indicated that rubber trees need enough continuously applied plant nutrient elements, especially macronutrients (N,P,K from full rate of chemical fertilizer, including Ca and Mg from dolomite or compost).

After two years of soil improvement, all treatments did not show significant difference in dry rubber yield, as well as dry rubber content (Table 2). Response to fertilizer of long perennial crops like rubber trees take time (Sopheaveasna *et al*., 2008). However, dry rubber yield after soil improvements tended to increase from the beginning to the end of the year, especially in solely compost application in contrast to the yield of the control treatment (Table 2). It might be that high increase of trunk girth and high P, Ca, and Mg in the compost enhanced the rubber synthetic process. For instance, P constituent in adenosine triphosphate is necessary to all plant metabolisms and magnesium activates ATPase, and transferase (Jacob *et al*., 1989). Higher Mg and Ca in rubber latex of the control treatment (1.40 g kg^{-1} and 48.38 mg kg^{-1}) might accelerate latex coagulation and enhance rapid cease of latex flow, and they are inhibitors of various enzymes in laticiferous cytosol (d'Auzac and Jacob, 1989).

The former research results also revealed the trend of girth and rubber yield increasing after applying chemical fertilizer together with dolomite or compost. (Purkwiwat *et al.*, 2003; Pothiwatthutham *et al.,* 2003). Manure application together with weed straw and 75% of the full rate of chemical fertilizer (12-5-14) in 8 years old and untapped trees gave significant higher girth increment than in control trees. Whereas four years of the application in tapping tree could not find significant differences in girth increment and yield (Noulsri *et al.,* 1991). The use of organic fertilizer increased chemical fertilizer efficiency or even partial substitution of chemical fertilizer, however, economic return should be considered.

3.2 Chemical properties of soil

After six months of dolomite application, soil pH was distinctly increased (data not shown). However, soil pH decreased after liming was stopped. Gradual pH decrease of tropical acid soil generally occurred after liming was stopped (Dharmakeerthi, 2012), especially in the low rate of liming (Edwards *et al*., 2009). Two years of compost application made soil pH significantly higher than the full rate of chemical fertilizer and control treatment, because of the high pH (7.68) of compost used in this experiment and it seems likely that carboxyl and phenolic hydroxyl groups from compost had important role in buffering soil acidity and increasing the soil pH (Whalen *et al*, 2000). Soil pH in solely chemical fertilizer treatment tended to decrease because of H^+ generation from nitrification as urea was incorporated in to mixed fertilizer.

Table 2. Dry rubber and dry rubber content after 2 years of soil improvement.

Treatment	June 2012		September 2012		November 2012	
	Dry rubber yield (g/t/t)	DRC (%)	Dry rubber yield (g/t/t)	DRC (%)	Dry rubber yield (g/t/t)	DRC (%)
Control	50.79	38.81	47.86	35.43	42.89	41.63
Ch.F	43.04	39.45	54.23	41.32	54.94	40.90
Ch.F+D	49.28	38.09	66.24	38.58	52.66	40.02
C	50.63	37.43	57.63	41.06	59.02	42.81
Ch+C	44.86	37.69	47.88	41.84	55.47	43.35
1/2Ch.F+C	44.54	38.23	43.56	42.50	43.59	41.48
1/2Ch.F+C+D	41.17	38.77	50.34	40.59	50.03	44.41
F-test	ns	ns	ns	ns	ns	ns
C.V. (%)	20.83	4.70	23.42	6.39	18.05	7.56

ns = Non-significant difference of average value among treatments ($p \geq 0.05$); g/t/t = gram/tree/tapping.

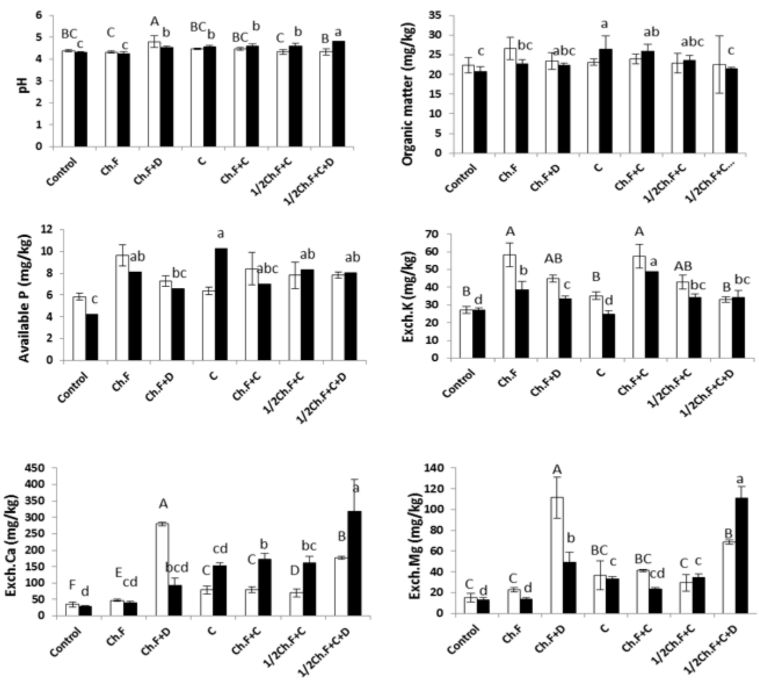

Figure 1. Chemical properties of soil after 1 year and 2 years of soil improvement. ☐ 1 year after soil improvement, ■ 2 years after soil improvement.

Organic matter markedly increased after two years of compost application (Figure 1), whereas it tended to decrease with full rate chemical fertilizer treatments. That might be because plant nutrients increased due to chemical fertilizer application, especially N, which enhanced high micro-organism activity including organic carbon mineralization (Chantigny *et al.*, 1999). Total N of one year and two years of soil improvement were in the range of 1.03-1.07 and 0.97-1.07 g kg^{-1}, whereas 1.0 and 0.87 g kg^{-1} were found in the control treatment. Available P increased from the first year to the second year after compost application in contrast to full rate of chemical fertilizer and the control treatments. That might be because compost used in this experiment contained a little bit high total phosphorus (2.6 g kg^{-1}) and it gradually released the available P into the soil. However, after 2 years of solely compost application, exchangeable K was significantly lower than that in the full rate chemical fertilizer treatments.

Both compost and dolomite application increased exchangeable Ca and Mg (Figure 1). After soil improvement, exchangeable Ca and Mg reached the optimum level that proposed by Kangpisadarn (2004) (>60 and >36 mg kg^{-1}, respectively) but total N, available P and exchangeable K were still in the low level. The optimum ranges were 1.10-2.50 g kg^{-1} for total N, 11.0-30.0 mg kg^{-1} for available P and >40.0 mg kg^{-1} for exchangeable K.

After one year of soil improvement, extractable Fe, Mn, Zn, and Cu were in the range of 62.49-82.63, 3.92-8.40, 0.145-0.391, and 0.941-1.496 mg kg^{-1}, respectively. After two years of soil improvement, their concentrations were 59.22-65.71.80, 5.78-10.46, 0.193-0.479, and 0.375-0.556 mg kg^{-1}, respectively. Significant differences in the values were not found among the treatments.

3.3 Nutrient concentration in rubber leaf and latex

Two years of soil improvement by fertilizer or dolomite tended to increase N and showed significantly higher P and Mg in rubber leaf than in the control treatment. Phosphorus and Mg reached the optimum level after two years. However, N was still lower than the reference value (33.1 g kg^{-1}) (Kangpisadarn, 2004). Fertilizer and dolomite application elevated P concentration in rubber leaf after two years of soil improvement, whereas, it decreased in the control treatment. Although the lowest exchangeable K occurred in compost application soil, its concentration in rubber leaf did not decrease. Thus, solely compost application after two years of the experiment maintained high rubber yield. However, leaf K still got lower than reference value (13.6-16.5 g kg^{-1}) (Kangpisadarn, 2004).

Soil pH increase due to dolomite or compost application tended to decrease extractable Fe, Mn, Zn and Cu in the soil, whereby leaf Mn decreased in contrast to Fe. Soil improvement made concentration of Cu in the leaf higher than non-improve treatment, especially in compost application, and all treatments showed sufficient amounts of Cu except solely chemical fertilizer application (Table 3).

Nitrogen, K and Ca in rubber latex among treatments were not significantly different. The trend of higher N in rubber latex after soil improvements compared to the control

Table 3. Plant nutrient in rubber leaf after 2 years of soil improvement.

Treatment	N (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})	Ca (g kg^{-1})	Mg (g kg^{-1})	S (g kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})
Control	25.98	2.43^{b}	12.15^{bc}	8.26	2.76^{d}	2.49	49.2	269.9^{ab}	39.5^{c}	11.7^{d}
Ch.F	27.17	3.08^{a}	2.25^{bc}	7.23	3.15^{c}	2.44	43.7	252.6^{ab}	48.5^{ab}	13.3^{cd}
Ch.F+D	27.17	3.01^{a}	112.18^{bc}	7.74	3.62^{a}	2.53	49.1	151.7^{c}	51.7^{a}	15.0^{bc}
C	27.95	3.12^{a}	12.08^{c}	8.62	3.22b^{c}	2.70	48.5	319.3^{a}	41.7^{bc}	16.8^{ab}
Ch.F+C	29.80	3.00^{a}	11.98^{c}	8.48	3.48a^{b}	2.56	50.3	210.9^{bc}	54.0^{a}	15.5^{bc}
1/2Ch.F+C	28.23	3.24^{a}	12.52^{ab}	8.20	2.84^{d}	2.41	45.8	197.7^{bc}	51.7^{a}	18.9^{a}
1/2Ch.F+C+D	28.97	3.05^{a}	12.92^{a}	8.68	3.43^{abc}	2.30	49.8	228.2^{abc}	30.7^{d}	16.4^{b}
F-test	ns	*	**	**	**	ns	ns	*	**	**
C.V. (%)	7.75	8.56	9.88	12.46	4.86	12.74	6.41	21.23	9.57	8.30

ns = Non-significant difference of average value among treatments ($p \geq 0.05$); * = Significant difference of average value among treatments ($p \leq 0.05$); ** = Significant difference of average value among treatments ($p \leq 0.01$); Different letters within the column showed the significant difference of average values among the treatments by DMRT ($p \leq 0.05$).

treatment was found but not Ca and Mg. Dolomite application showed low Ca and Mg in rubber latex. Phosphorus in the rubber latex after soil improvement was significantly higher than those in the control treatment. Other researchers found higher N and P in the latex by increasing the application amount as well as higher Mg and Ca values (Kangpisadarn *et al.*, 1999). Iron concentration in full rate of chemical fertilizer application was lower than in other treatments. No trend effect of the treatments to other trace elements in rubber latex was found (Table 4).

4. Conclusions

Two years of acid soil improvement on growing rubber tree by application of different fertilizers and dolomite increased soil fertility. However, total N, available P and available K in soil were still lower than optimum levels as well as N and K in rubber leaf. Adding full rate chemical fertilizer based on soil analysis together with compost or dolomite gave higher girth increment at the second year than those at the first year. Compost application tended to support tree growth and latex yield. Thus, to increase the growth and yield of lately tapping rubber should be continuously applied at least the full rate of chemical fertilizer based on soil analysis. Organic fertilizers like compost should be considered for application to gain some trace elements. Dolomite application to very strong acid soil could be practiced to raise soil pH and elevate Ca and Mg. However, imbalance of plant nutrients might occur, especially when it is not incorporated to the soil as applied by scattering.

Table 4. Plant nutrient in dry rubber latex after 2 years of soil improvement.

Treatment	N (g kg^{-1})	P (g kg^{-1})	K (g kg^{-1})	Mg (g kg^{-1})	Ca (mg kg^{-1})	Fe (mg kg^{-1})	Mn (mg kg^{-1})	Zn (mg kg^{-1})	Cu (mg kg^{-1})
Control	5.06	1.94b	4.65	1.40	48.38^{b}	58.96^{abc}	20.85^{a}	22.14^{bc}	18.77^{a}
Ch.F	5.18	2.21a	4.71	1.34	36.88^{c}	52.55^{c}	17.95^{a}	17.51^{c}	16.16^{b}
Ch.F+D	5.54	2.26a	4.67	1.18	26.29^{d}	54.86b^{c}	18.17^{a}	29.33^{a}	16.45^{b}
C	5.09	2.47a	4.92	1.32	46.51^{b}	62.54a^{b}	20.69^{a}	24.17^{b}	18.62^{a}
Ch.F+C	5.09	2.33a	4.45	1.35	32.08^{cd}	57.66ab^{c}	17.61^{ab}	17.60^{c}	15.85^{b}
1/2Ch.F+C	5.21	2.35a	4.53	1.26	56.58^{a}	63.60^{a}	14.41^{bc}	23.26^{b}	10.90^{c}
1/2Ch.F+C+D	5.21	2.29a	4.56	1.03	31.38^{cd}	60.28^{ab}	13.35^{c}	22.61^{b}	8.42^{d}
F-test	ns	*	ns	ns	**	*	**	**	**
C.V. (%)	7.71	6.54	4.81	19.46	11.12	6.50	10.63	11.38	5.91

ns = Non-significant difference of average value among treatments ($p \geq 0.05$); * = Significant difference of average value among treatments ($p \leq 0.05$); ** = Significant difference of average value among treatments ($p \leq 0.01$); Different letters within the column showed the significant difference of average values among the treatments by DMRT ($p \leq 0.05$).

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