Kasetsart J. (Nat. Sci.) 42 : 226 - 237 (2008)

The Effect of Fertilizer and Irrigation on Yield and Quality of Rubber (*Hevea brasiliensis*) Grown in Chanthaburi Province of Thailand

Sopheaveasna Mak[1*], Sali Chinsathit[2], Aphiphan Pookpakdi[3] and Poonpipope Kasemsap[4]

ABSTRACT

The experiment on effects of fertilizer and irrigation on yield and quality of rubber (*Hevea brasiliensis*) grown at Chanthaburi province is an on-farm research conducted at the Rubber Plantation of Sindane Thai Rubber Co, Ltd. The objective of the experiment was to investigate the effect of irrigation and fertilizer on yield and quality of rubber. Experimental design used was a split plot with three replications, having irrigation and non irrigation as main plots and three formulas of NPK fertilizer of 15-7-18, 30-5-18 and 23-5-18 as subplots factorially arranged within each main plot. The trial was conducted on the clay loam soil of Klongluk series having the pH of 5.0 with 1.6% organic matter, 80.9 and 134 ppm of P and K respectively. The result of the experiment revealed that irrigation treatment increased the yield per tree per tapping, monthly production and also total rubber production per year. Latex yield also increased as the result of irrigation treatment. Under non-irrigation, the percentage of dry rubber content (DRC) was higher than those of irrigation treatment. Percentage of DRC was negatively correlated with both rubber yield and latex yield only under non-irrigation treatments. Result of latex diagnosis analysis showed that sucrose and total solid content (TSC) of samples were not affected by irrigation and fertilizer treatments. Inorganic phosphate (Pi) increased in the irrigated plot than those of non-irrigation but was not significantly differed ($P>0.05$) among others. Thiol content in latex samples showed the significant different ($P<0.05$) between irrigated and non-irrigated plots. Girth of rubber increased as the result of irrigation application while the percentage of tapping panel dryness (%TPD) was higher in non-irrigation treatment. The result of this study did not showed the effect of fertilizer treatments in any of the parameters measured. It may be possible that it would take a longer time than the experimental period before the effect of fertilizer will be pronounced.

Key words: *Hevea brasiliensis,* dry rubber content, latex diagnosis

1 Present address: Rubber Research Institute, Ministry of Agriculture, Forestry and Fisheries, Cambodia

2 Office of Research and Development Region 6, Department of Agriculture, Chantaburi 22190, Thailand.

3 Department of Agronomy, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

4 Department of Horticulture, Faculty of Agriculture, Kasetsart University, Bangkok 10900, Thailand.

* Corresponding author, e-mail: shna_hevea@yahoo.com

Received date : 30/05/06 Accepted date : 31/03/08

INTRODUCTION

Hevea brasiliensis, a forest tree which is indigenous to the tropical rainforests of Central and South America and the only major commercial source of natural rubber, is one of the most recently domesticated crop species in the world (Markham, 1876; Petch, 1914). Since 1815, the rubber manufacturing industry began to expand and the imports of rubber into Britain and America increased considerably. Since the invention of pneumatic tyres, the prosperity of world rubber industry was to a large extent, dependent on the development in world automobile industry (Bauer, 1978).

Since *Hevea brasiliensis* is the only specie of tree grown commercially as the source of rubber and this particular industries crop species supplies more than 99 percent of the world natural rubber (Schultes, 1977; 1987; Wycherley, 1992). Therefore it is important to increase the yield and production of rubber tree.

Several technologies have been used in rubber production management in order to increase the yield. Growing suitable clonal varieties such as RRIM 600 and PB 235 increased the yield of rubber in India. Marattukalam *et al*. (1992 reported that the average yield of RRIM 600 for the first 16 years of tapping was 2,200 kg/ha/year. In Malaysia, the mean annual yield of clone PB 235 over first 15 years of tapping was 2,485 kg/ha/year (RRIM, 1992).

Irrigation and fertilizer application were also important management factors gave rise to yield elevation. Omont (1982) reported that the yield of 1,904 kg/ha/year was obtained from irrigated rubber tree in the fifth year of tapping as compared to 1,614 kg/ha/year obtained from non-irrigated plant in the same year of tapping. Not only yielding which might be increased, it has been reported that growing rubber in the rainfed condition, the plant had an immature period up to seven year while irrigation during the summer season could enhance the growth and reduce an unproductive period (Pushparajah and Haridas, 1977; Omont, 1982; Jessy *et al*., 1994). While reports regarding the effect of fertilizer in increasing the rubber yield are scared, it was found in Malaysia that applying nitrogen fertilizer in the form of $(NH_4)_2SO_4$ increase N, K, Mg and Mg/P ratio in latex. Rock phosphate was found to influence the increase in P and Ca level, however lower the Mg/P ratio (RRIM, 1979). Potassium had the greatest influence on latex flow rate as well as producing the most stable latex concentration as it was found in Malaysia (Pushparajah and Guha, 1969; de Geus, 1973). Although the application of fertilizer did not directly reflected the increase in rubber yield, however, the increment of growth as affected by fertilizer such as the increase in girth and latex yield may be positively correlated with yield increase. Punnoose *et al*. (1976) reported the positively correlation between girth increment as responded to N and P fertilizer in rubber tree grown in poor soil.

Since latex yield indicates the growing condition and yield potential of rubber tree. The physiological parameter of latex in relation to yield potential may be of high interested to rubber grower (Jacob *et al*., 1989). Scientists have been using the method of latex diagnosis in determining the condition of growth and production potential of rubber tree. In analyzing latex samples, four important components, the total solid content (TSC), thiol (R-SH), sucrose and inorganic phosphate (Pi) are measured. TSC reflects the percentage of dry rubber content in the sample, while thiol neutralized various form of toxic oxygen which may be increasingly produced when trees are subjected to stress. High sucrose content might indicate the strong potential of growth and production and level of Pi also shows the metabolic condition of tree which is also related to growth. Theoretically, latex diagnosis is used to detect the effect of input factors such as irrigation and

fertilizer as it may affect to the growing condition of rubber tree (Jacob *et al.,* 1989).

Natural rubber production is not stable at any time. This is depending on many factors especially the weather factor. In dry season (February to April) productions are lower than in rainy and winter season. Fertilizer is one of the factors which may increase the yield and quality of rubber. Due to the high rubber prize influenced by the world market, farmers in the eastern provinces of Thailand such as those at Chanthaburi, Rayong or Trat would like to switch from fruit crop orchard into the rubber plantation due to the input cost and the prize fluctuation of fruit crops. If the method of increasing the yield of rubber through irrigation and fertilizer worked and the yield of rubber would increased up to the point when the economic return achieved, rubber cultivation might be an alternative crop for the farmers in those specific areas.

The objective of this study was to investigate the effects of irrigation and fertilizer application on the yield of rubber when grown under irrigation and rainfed condition.

In order to evaluate the real situation of rubber grown in the natural plantation, the experiment was conducted as on-farm research in the existed rubber plantation. It was anticipated of this experiment could be used as the practical recommendation especially in relation to the water and fertilizer management to those farmers growing rubber in the vicinity of the eastern provinces of Thailand which was the target area of this research investigation.

MATERIALS AND METHODS

The study on the effect of irrigation and fertilizer in rubber (*Hevea brasiliensis*) was conducted as an on-farm research in the rubber plantation of Sindane Thai Rubber Co, Ltd, at Kitechagood district of Chanthaburi province, Thailand, for the duration of 16 months which was between October 2004 to January 2006.

The experimental design used in this study was a split plot design with irrigation and non-irrigation as main plots and three formulas of fertilizer as sub plot. There were three replications in this study. Fertilizer treatments were composed of NPK of 15 – 7 – 18 (low N level as recommended by RRIT, 1982); 30 – 5 – 18 of NPK (high N level as recommended by RRIT, 1998); and 23 – 5 – 18 of NPK (the NPK formula largely used by farmer at Chanthaburi). Fertilizer was applied to each rubber tree at 500 g/tree at each time and it was given two times in a year. Fertilizers were given to the irrigated block and non irrigated block in October 2004, similar application was done in May 2005 and October 2005 during the period where soil moisture was ample.

Irrigation was given by sprinkler at every four days intervals. During irrigation, water was given at 40 minutes each time, approximately 92 liters/ 28.26 m^2 of raindrop. In non-irrigation plot, rainfall was the only source of water.

All the trees used in this experiment were planted in 1996. The variety of rubber used in the study was BPM 24. Spacing between rows and interrows of rubber tree were 6 m x 4 m.

The tapping area size was 720 m^2 composed of 30 tappable trees having 50 cm girth at the height of 170 cm.

Yield and production were evaluated from each tapping which was done at the tappable months period. Percentage of dry rubber content and rubber yield were determined from latex yield. During four months towards the termination of experimentation (October 2005, November 2005, December 2005 and January 2006), latex samples were collected and analyzed using the colorimetric analysis of sugars, microcolorimetric analysis of inorganic phosphorous, methodology for analysis of tissue sulfhydril components and TSC calculation (Ashwell, 1957; Taussky and Shorr, 1953; Boyne and Ellman, 1972). Soil and leaf

analysis were conducted twice, prior and at the termination of the trial. Girth measurement and tapping panel dryness were done at appropriate interval.

RESULTS AND DISCUSSION

1. Climatic and edaphic growing condition

Figure 1 showed the rainfall pattern at Chanthaburi province between October 2004 to December 2005 during most of the period when the experiment was conducted. Rainfall at Chanthaburi increased considerably from April and decreased heavily from October to December. Total amount of rainfall was 3,637.8 mm for the whole period shown. In this figure, it can be seen that tapping were not done in every month, tapping were not done in October 2004 during the initial period of the trial, it was not done in January 2005 to March 2005 due to the dryness and also it was not done in June 2005 and August 2005 due to high rainfall and the wetness of the plantation.

Table 1 showed some components of soil analysis such as pH, organic matter (OM), P and K taken during the initial period (October 2004) and final period (January 2006). Analysis of variance was not conducted for these data, while the result obtained revealed that the pH at the final stage of the experiment had been increased as compared to the initial sample and irrigation treatment tended to increase the pH value to be higher than in the non irrigated plot. Organic matter was slightly decreased in irrigation, perhaps due to leaching and higher rate of decomposition as hasten by irrigation water when compared to non irrigated plot. The value of P was high during the termination period in irrigated plot as compared to the initial phase; however, P value was slightly lower at the final stages than the initial stage in non irrigated plot. The K value were both lower in the irrigated and non-irrigated plots at the final stage than at the beginning. Result of the soil analysis shown in Table1 did not reflected any effect derived from fertilizer treatment.

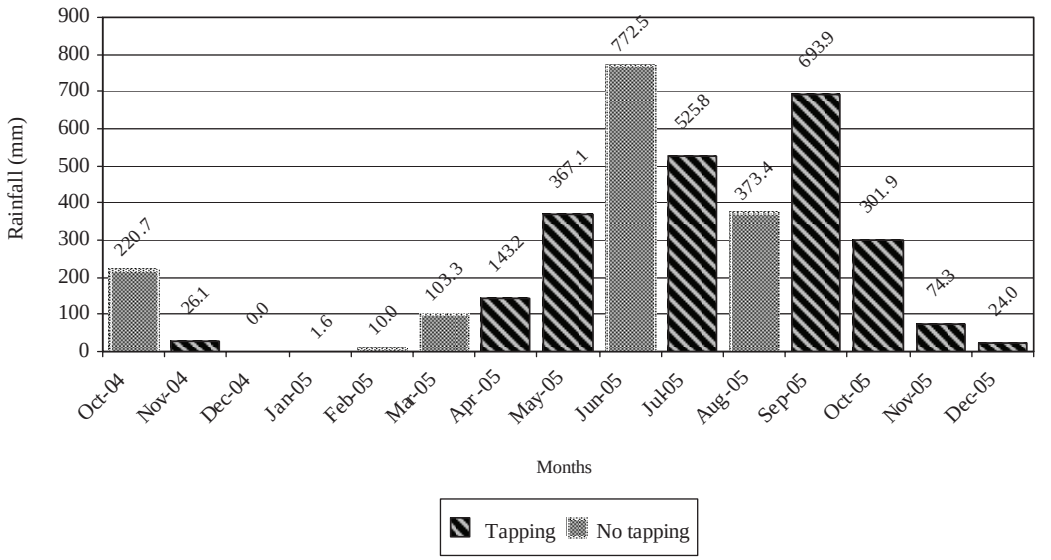

Figure 1 Rainfall amount (mm) and pattern at Chathaburi province between October 2004 to December 2005 during most of the period when the experiment on irrigation and fertilizer on rubber tree was conducted.

Table 1 Soil analysis of the experiment on irrigation and fertilizer on rubber production showing the initial and final values of pH, organic matter, P and K in which the data were taken on October 2004 and January 2006.

Soil component	Initial soil sample	Irrigation			Mean Irrigation	Non irrigation			Mean Non irrigation
		Trt 1	Trt 2	Trt 3		Trt 1	Trt 2	Trt 3	
pH (1:1)	5.0	5.9	5.9	5.7	5.9	4.8	5.5	5.4	5.2
OM (%)	1.6	1.1	1.2	1.2	1.2	1.9	1.7	1.6	1.7
P (ppm)	80.9	164.4	112.5	136.6	137.8	29.0	113.5	51.8	64.8
K (ppm)	134.0	115.1	94.2	77.0	95.4	84.9	128.4	78.3	97.2

Table 2 Leaf analysis of the experiment on irrigation and fertilizer on rubber production showing the initial and final values of N, P and K in which data were taken on October 2004 and January 2006.

Leaf component	Initial leaf sample	Irrigation			Mean Irrigation	Non irrigation			Mean Non irrigation
		Trt 1	Trt 2	Trt 3		Trt 1	Trt 2	Trt 3	
N (%)	2.5	3.1	3.2	3.0	3.1	3.0	2.7	2.6	2.8
P (%)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
K (%)	1.2	1.5	1.6	1.4	1.5	1.2	1.0	1.1	1.1

Data shown in Table 2 revealed that the percentage of N, P and K taken at the initial phase and at the final phase of the experiment (October 2004 vs January 2006) were not differed with regarded to the effect of fertilizer or irrigation. Only the percentage of N at the irrigated plot during the final phase was slightly higher than the value at the initial phase. Percentage of P and K were similar when compared between the initial phase and the final phase when the plot received or not receiving irrigation. Again, data in Table 2 did not reflected any effect of fertilizer treatment upon the percentage of N, P and K in the leaf analysis component.

2. Component of yield and production

2.1 Yield and production of rubber tree

Table 3 and 4 showed the average yield of rubber as expressed by yield per tree per tapping (g/tree/tapping) and production of rubber per month of tapping and also total production during the entire experimental period, respectively. The data from both Tables showed similar results as reflected to the effect of irrigation and fertilizer. Both yield per tree per tapping and the production per month of tapping were significantly higher in irrigated plot as compared to the non-irrigation ($P<0.05$) in most of the tapping months except in October and November 2005.

The yield per tree was between 87.4 – 47.5 g in the irrigated block while in the non-irrigated treatment, the yield per tree were between 89.3 – 26.8 g. The average production of rubber tree per month was between 354.3 – 61.9 kg/ha regardless of irrigated or non-irrigated treatments. Total production in irrigation block was 2,469.4 kg/ha which was significantly higher than in non-irrigated block ($P<0.05$). There is no effect of fertilizer shown in the data on yield and production of rubber. Also, it was shown that seasonal variation such as the rainy and dry season put

Table 3 Averaged yield of rubber as expressed by yield per tree per tapping (g/t/t) in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between October 2004 to January 2006.

Months	Nov	Dec	Apr	May	Jul	Sep	Oct	Nov	Dec	Jan
Irrigation treatment	2004	2004	2005	2005	2005	2005	2005	2005	2005	2006
Irrigation	55.4	67.1	47.5	72.0	87.4	76.9	87.2	85.6	71.5	56.8
Non irrigation	50.6	53.0	26.8	42.3	66.7	89.3	87.8	84.5	63.2	65.7
Mean	53.0	60.1	37.2	57.1	77.0	83.1	87.5	85.0	67.4	61.3
cv(%)	0.20%	0.40%	0.80%	0.70%	4.70%	1.30%	0.10%	0.50%	0.30%	0.90%
F test	*	**	**	**	*	*	ns	ns	*	*
$LSD_{0.05}$	3.4	5.2	2.3	8.5	14.5	8.9	-	-	5.3	7.6

Table 4 Production of rubber per month of tapping and total production collected for the entire experimentation (kg/ha) in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between October 2004 to January 2006.

Months	Nov	Dec	Apr	May	Jul	Sep	Oct	Nov	Dec	Jan	Total
Irrigation trt	2004	2004	2005	2005	2005	2005	2005	2005	2005	2006	yield
Irrogation	323.2	335.7	79.2	300.1	72.8	128.1	290.7	356.5	417.4	165.7	2469.4
Non irrigation	295.3	264.8	44.7	176.1	55.6	148.9	292.6	352.2	368.6	191.7	2190.5
Mean	309.2	300.3	62.0	238.1	64.2	138.5	291.6	354.4	393.0	178.7	2329.9
cv(%)	3.20%	4.30%	3.10%	7.50%	9.40%	5.30%	0.80%	4.60%	3.90%	6.20%	2.10%
F test	*	**	**	**	*	*	ns	ns	*	*	**
$LSD_{0.05}$	19.5	25.8	3.8	35.5	12.1	14.8	-	-	31.0	22.2	95.6

certain impact to the yield and production of rubber tree. Both yield and production of rubber were obviously high during the rainy season as compared to the dry season.

2.2. Dry rubber content (DRC) and latex yield

Table 5 and 6 showed the average percentage of dry rubber content and latex yield per month of tapping and also the total amount of latex collected during 16 months of experimentation. It was shown that the percentage of DRC values were high in non-irrigated plot than in the irrigated plot and significant different were obtained ($P<0.05$) in most of the month except December 2004, July and December 2005. Fertilizer treatment did not have any significant effect on the percentage of DRC at all.

For latex yield in which data were shown in Table 6, it can be seen that production of latex was higher in irrigated plot than those of non irrigation. Since latex yield was mainly composed of water, analysis of variance has not been done. Obviously, latex yield was plenty in the rainy season such as May and October to December 2005 (it was still raining in December in the year of 2005). However, data did not reflected any effect of fertilizer application at all.

As the percentage of DRC is nearly 90% of total solid content (TSC) in the latex (Jacob *et al.*, 1989), high percentage of DRC result in viscosity increase in latex and limit the flow of latex. In this study, it was found for the non-irrigation trial that %DRC was negatively correlated with latex yield (Figure 2) and also negatively correlated with the dry rubber yield

Table 5 Average dry rubber content (%DRC) per month of tapping in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between October 2004 to January 2006.

Irrigation trt	Nov 04	Dec 04	Apr 05	May 05	Jul 05	Sep 05	Oct 05	Nov 05	Dec 05	Jan 06
Irrigation	32.2	31.7	43.9	37.6	32.1	33.6	32.7	32.7	29.9	31.8
Non irrigation	34.2	32.5	45.2	41.5	33.7	36.2	33.4	34.3	30.4	33.3
Mean	33.2	32.1	44.6	39.5	32.9	34.9	33.1	33.5	30.1	32.6
cv(%)	1.60%	3.30%	0.40%	0.10%	3.90%	2.40%	1.00%	0.20%	1.20%	2.20%
F test	*	ns	**	**	ns	*	*	**	ns	*
$LSD_{0.05}$	1.0	-	0.3	0.9	-	1.7	0.7	0.2	-	1.4

Table 6 Average latex yield per month of tapping and total latex collected for the entire experimentation (kg/ha) in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between October 2004 to January 2006.

Irrigation treatment	Fertilizer treatment	Nov 2004	Dec 2004	Apr 2005	May 2005	Jul 2005	Sep 2005	Oct 2005	Nov 2005	Dec 2005	Jan 2006	Total latex
	15-7-18	961.6	1022.2	163.0	776.9	222.2	381.9	872.7	1089.8	1386.1	504.2	7380.6
Irrigated	23-5-18	1083.8	1126.4	196.3	802.8	226.9	384.3	912.0	1138.4	1441.2	551.4	7863.5
	30-5-18	961.6	1020.8	182.4	813.0	231.5	377.3	884.3	1047.2	1356.9	511.6	7386.6
Mean		1002.3	1056.5	180.6	797.5	226.9	381.2	889.7	1091.8	1394.8	522.4	7543.5
	15-7-18	950.0	905.6	100.9	428.7	170.8	421.3	893.5	1063.0	1261.1	594.9	6789.8
Non irrigated	23-5-18	795.4	742.6	94.4	408.8	166.2	388.9	838.0	976.9	1142.1	556.9	6110.2
	30-5-18	848.6	800.9	100.9	436.6	157.9	425.9	893.5	1041.7	1235.2	574.5	6515.8
Mean		864.7	816.4	98.8	424.7	165.0	412.0	875.0	1027.2	1212.8	575.5	6471.9

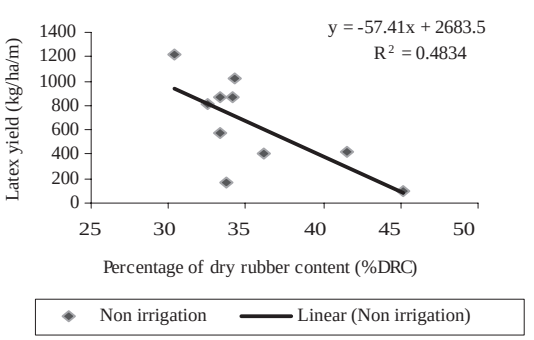

Figure 2 Correlation between latex and %DRC in non irrigation block.

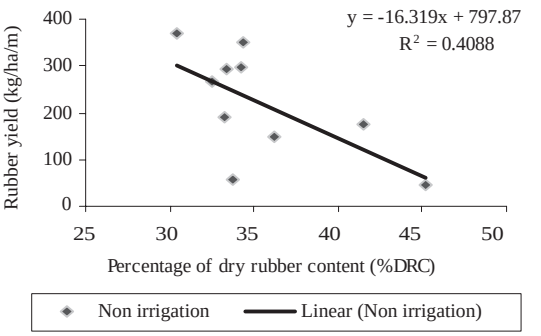

Figure 3 Correlation between rubber yield and %DRC in non irrigation block.

(Figure 3). Jacob *et al*. (1989) also found the same results on the relationship between %DRC, latex yield and rubber yield. However, there were no correlation between these characters in irrigation trial. In this experiment, it was found that positive correlation was obtained between rubber yield and latex yield in which R^2 value was 0.979 which was highly significant (data not shown).

3. Latex diagnosis component

As discussed previously, the important latex diagnosis component compose of sucrose, inorganic phosphate (Pi), thiol (R-SH) and total solid content (TSC). Latex samples were collected for diagnosis between October 2005 to January 2006 towards the termination of the trial. Data on sucrose, inorganic phosphate, thiol and total solid content of rubber trees in the experiment on the effect of irrigation and fertilizer were shown in Table 7, 8, 9 and 10, respectively.

Both sucrose (Table 7) and total solid content (TSC) (Table 10) of latex samples neither showed any different between irrigation nor fertilizer application. However, in the inorganic phosphate component (Table 8) value of Pi in the irrigation treatment were higher than in the non-irrigation in every samples collected although significant different were not obtained. Furthermore, fertilizer application did not increase the level of Pi.

In Table 9 where the average of thiol [R-SH]mM of latex samples were demonstrated, it was found that the level of thiol was higher in the irrigated plot as compared to the non-irrigation in the October, November and December 2005 samples. Still the thiol value of irrigation treatment in January 2006 sample was higher than in the non-irrigated plot although the significant different was not obtained.

Since latex thiol consist of cysteine, methionine and above all glutathione (Müllen (Me), 1960) and thiol is used to neutralize various form of toxic oxygen which is normally exist when metabolism is normal. Jacob *et al.*, (1989) also stated that there are positively significant correlation between the thiol content and production. Since irrigation give beneficial effect to the growth and production of rubber, therefore rubber tree growing under favorable irrigated condition may produce higher value of thiol as compared to the non irrigated condition.

4. Other parameters of growth

4.1 Girth increase

Table 11 showed the increase in rubber girth (cm) from the beginning of the trial (October 2004) until the termination of experimentation. During 16 months period girth was measured 4 times starting from the initial girth measurement of 50 cm. It was found that girth increased significantly in the irrigated plot as compared to the non-irrigation ($P<0.05$). Increment of girth in the irrigation plot was 7.6 cm in 16 months period as compared to non-irrigation where girth

Table 7 Average of sucrose per month of latex analysis for the entire experimentation [Suc]mM in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between October 2005 to January 2006.

Irrigation trt[(a)]	Fertilizer trt[(b)]	Oct-05	Nov-05	Dec-05	Jan-06
	15-7-18	4.9	8.1	4.6	4.7
Irrigated	23-5-18	5.0	6.8	4.8	4.9
	30-5-18	5.3	8.3	5.1	4.1
Mean		5.1	7.8	4.8	4.6
	15-7-18	4.5	8.4	4.5	3.9
Non irrigated	23-5-18	4.8	8.0	4.4	5.6
	30-5-18	5.3	7.9	4.6	3.4
Mean		4.9	8.1	4.5	4.3
$cv_{(a)}$%		10.20%	15.00%	12.40%	29.10%
$cv_{(b)}$%		15.30%	17.50%	8.10%	24.00%

Table 8 Average of inorganic phosphorus [Pi]mM per month of latex analysis for the entire experimentation in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between October 2005 to January 2006.

Irrigation trt[(a)]	Fertilizer trt[(b)]	Oct-05	Nov-05	Dec-05	Jan-06
	15-7-18	26.0	24.8	26.8	22.4
Irrigated	23-5-18	26.0	24.0	24.4	22.2
	30-5-18	24.0	23.5	24.5	21.9
Mean		25.3	24.1	25.2	22.2
	15-7-18	19.8	19.5	23.4	18.7
Non irrigated	23-5-18	19.6	20.0	23.8	20.3
	30-5-18	21.5	20.2	23.8	18.1
Mean		20.3	19.9	23.7	19.0
$cv_{(a)}$%		17.90%	16.70%	13.00%	20.30%
$cv_{(b)}$%		26.00%	20.80%	26.00%	22.60%

Table 9 Average of thiol [R-SH]mM per month of latex analysis for the entire experimentation in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between October 2005 to January 2006.

Irrigation trt[(a)]	Fertilizer trt[(b)]	Oct-05	Nov-05	Dec-05	Jan-06
	15-7-18	0.4	0.3	0.5	0.5
Irrigated	23-5-18	0.4	0.3	0.5	0.6
	30-5-18	0.4	0.3	0.5	0.6
Mean		0.4	0.3	0.5	0.6
	15-7-18	0.3	0.2	0.4	0.4
Non irrigated	23-5-18	0.3	0.3	0.4	0.4
	30-5-18	0.4	0.2	0.4	0.4
Mean		0.3	0.2	0.4	0.4
$cv_{(a)}$%		4.00%	10.40%	2.30%	17.90%
$cv_{(b)}$%		11.70%	3.70%	5.20%	17.30%
$LSD_{0.05}$(a)		0.027	0.056	0.023	-

Table 10 Average of total solid content (TSC) per month of latex analysis in the irrigation and fertilizer experiment conducted at Chantaburi, Thailand between November 2004 to January 2006.

Months	Oct-05	Nov-05	Dec-05	Jan-06
Irrigation treatment				
Irrogation	43.6	30.9	38.5	46.2
Non irrigation	45.2	28.3	36.7	47.7
Mean	44.4	29.6	37.6	46.9
cv(%)	2.10%	3.10%	0.70%	1.30%

Table 11 Girth measurement of rubber (cm) during the entire experimentation in the irrigation and fertilizer experiment conducted at Chanthaburi, Thailand between November 2004 to January 2006.

Months	11-Jan-05	19-Oct-05	11-Jan-06	Increment during
Irrigation trt	2nd measurement	3rd measurement	Final measurement	16 months of growth
Irrigation	54.3	55.7	58.0	7.6
Non irrigation	50.3	51.6	53.4	3.5
Mean	52.3	53.7	55.7	5.5
cv (%)	2.30	2.40	0.4	13.60
F test	*	*	**	**
LSD $_{0.05}$	2.443	2.567	0.498	1.509

Table 12 Percentage of tapping panel dryness measured at finish of experimentation in the irrigation and fertilizer experiment conducted at Chantaburi, Thailand on January 2006.

Irrigation treatment	Fertilizer treatment	Percentage of tapping panel dryness (%TPD)
	15-7-18	0.80
Irrigated	23-5-18	3.24
	30-5-18	4.00
Mean		2.68
	15-7-18	6.73
Non irrigated	23-5-18	3.65
	30-5-18	3.26
Mean		4.55

increased during 16 months was only 3.4 cm ($P<0.05$) while irrigation application inserted positive effect to girth development, fertilizer treatment did not showed any effect on girth increase at all.

4.2 Tapping panel dryness

Percentage of tapping panel dryness (TPD) when measured at the termination of the trial was shown in Table 12. Data obtained revealed that the percentage of TPD was more in the non irrigated plot as compared to irrigation application. Again, fertilizer did not showed any effect on the percentage TPD. Significant different were not obtained between irrigation and fertilizer treatment for the percentage of tapping panel dryness.

CONCLUSIONS

Data obtained from 16-month trial on the effect of irrigation and fertilizer on growth and production of rubber tree variety BPM 24 grown at Chantaburi province of Thailand revealed that irrigation treatment increased the yield per tree per tapping, monthly production and also total production of rubber yield. Latex yield also increased as the result of irrigation treatment. Seasonal variation excerted certain effect on rubber yield and latex production in which both rubber yield and latex were more in the rainy season.

For the percentage of dry rubber content, it was found that under non-irrigation, the percentage of DRC was higher than those of

irrigation treatment. Percentage of DRC was negatively correlated with both rubber yield and latex yield only under non-irrigation trial.

By performing latex diagnosis in order to determine the effect of irrigation and fertilizer, it was found that sucrose and total solid content of samples were not related to either irrigation or fertilizer treatment. Inorganic phosphate increased in the irrigation plot than those of non-irrigation but was not significantly differed. Thiols (R-SH) content in latex samples taken from the irrigated plot were significantly higher than non irrigated plot as thiol was produced in higher amount in the tree growing under favorable condition and high thiol content indicated better potential for production.

For girth increase and tapping panel dryness of rubber, data also showed that irrigation inserted beneficial effect on these parameters. As girth increase indicated the increase in growth and development, therefore, potential production will be increased. However, irrigation resulted in less percentage of panel dryness and may decrease the plugs at the cut of latex vessels.

The overall result of this experiment indicated the beneficial effect of irrigation on growth and yield of rubber. However, results did not show the effect of fertilizer treatment in any of the parameter measured. It may be possible that it would take a longer time than the experimentation period before the effect of fertilizer will be pronounced.

LITERATURE CITED

Ashwell. 1957. Colorimetric analysis of sucrose. **Methods in Enzymology.** 3: 73 – 105.

Bauer, P.T. 1978. **The Natural Rubber Industry:** A study in competition and monopoly. Green and Co., Longmans, 404 P.

Boyne, A.F. and G.L. Ellman. 1972, A methodology for analysis of tissue sulfhydril components. **Analytical Biochem**. 46: 639 – 653.

de Geus, J. G. 1973 **Fertilizer Guide for the Tropics and Subtropics, 2nd edn.** Centre d' Etude de l'Azote, Zurich, 541p.

Jacob, J.L., J. C. PrâvÙt, D. Roussel, R. Lacrotte, E. Serres, J. d'Auzac, J. L. Jacob and H. Chrestin 1989. **Physiology of Rubber Tree Latex: the laticiferous Cell and Latex–A Model of Cytoplasm**. CRC Press, Inc., Boca Raton, Florida, U.S.A.

Jessy, M.D., M. Mathew., S. Jacob and K.I. Punnoose. 1994. Comparative evaluation of basin and drip systems of irrigation in rubber**. Indian journal of Natural Rubber Research**. 7(1): 51-56.

Marattukalam, J. G., A. O. N. Panikkar and C. K. Saraswathyamma. 1992. Long term performance of a clones of *Hevea brasiliensis* in large scale trial**. Journal of Plantation Crops**. 20(Supplement):170-174.

Markham, C. R. 1876. The cultivation of caoutchouc yielding trees in British Indian**. Journal of the Society of Arts**. 475-482.

Müllen (Me), A. I. 1960. Thiols of low molecular weight in *Hevea brasiliensis* latex**. Biochem Biophys. Acta**. 41–341.

Omont, H. 1982. Plantations d'*hevea* en zone climatique marginale**. Revue generale des caoutchoucs et du plastiques.** 625: 75-79.

Petch, T. 1914. Notes on the history of the plantation rubber industry in the east**. Annals of the Botanic Gardens, Peradeniya**, **S**: 440-487.

Punnoose, K. I., S.N. Potty., M. Mathew and C.M. George. 1976. Response of *Hevea brasiliensis* fertilizers in south India**. Proceedings, International Natural Rubber Conference**, 1975, Kuala Lumpur, Malaysia, PP. 84-107.

Pushparajah, E. and M.M. Guha. 1969. Fertilizer response in *Hevea brasiliensis* in relation to soil type and leaf nutrition studies. **Transactions of the Ninth International Congress on Soil Science Adelaide** 1968 pp.

85-92.

Pushparajah, E. and G. Haridas. 1977. Developments in reduction in immaturity period of *Hevea* in Penninsular Malaysia**. Journal of Rubber Research Institute of Sri Lanka** 54: 93-105.

RRIM. 1979. **Influence of nutrients on latex flow and properties.** Annual Report 1978. 125 p.

RRIM. 1992. **Planting recommendation 1992-1994.** Planters' Bulletin, 211: 31-50.

Schultes, R. E. 1977. Wild *Hevea:* An untapped source of germ plasm. **Journal of the Rubber Research Institute of Sri lanka.** 54: 227-257.

Schultes, R. E. 1987. Studies in the genus *Hevea*: 8. Notes on infraspecific variants of *Hevea brasiliensis* (Euphorbiaceae). **Economic Botany**. 41(2): 125-147.

Taussky, H.H. and E. Shorr. 1953. A microcolorimetric method for the determination of inorganic phosphorous. **J. Biol. Chem.** 202: 675 – 685.

Wycherley, P. R. 1992. The genus *Hevea*: Botanical aspects, pp. 50-66. *In* M. R. Sethuraj and N. M. Mathew (eds.). **Natural Rubber**: **Biology, Cultivation and Technology.** Elsevier, Amsterdam.