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Manuring in Rubber : Need for Re-Evaluation Based on Case Study

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The lack of significant response in latex yield to fertiliser treatments in a number of rubber trials has been attributed to high within trial variability arising from uncontrollable factors outside the experiment and inefficient trial conduct.

Positive responses were obtained in a fertiliser trial using field methodology aimed at minimising the variability. The improved field methodology included changing to a long rectangular plot to minimise the effect of time of tapping on yield, construction of bunds along boundaries of treatment plots to prevent cross contamination of treatments due to fertiliser wash and using trees of uniform girth for recording. The same tapper was employed to tap the treatment tasks in rotation to minimise differences due to tapping skill while yield recording was carried out three to four times a month confined to days tapped on third daily to improve accuracy of records.

Significant response in yield to nitrogen (N) ranging from 7.0 to 19.6 per cent was obtained from the second to fifth year of the trial and 14 and 15 per cent to potassium (K) in the fourth and fifth year respectively. The significant response in yield to N and K was obtained for both at the second level of application.

Leaf N levels were also significantly raised two years after application of N at both levels but the response disappeared thereafter. Leaf K levels were significantly raised from the third to fifth year at the second level of application of K and in the fifth year at both levels of application.

Whilst it is heartening to have obtained positive yield response to fertiliser application in the above trial, more of such trials may have to be conducted to ratify the results obtained.

Keywords : *Fertiliser response, rubber trees, improved field layout.*

Response in yield to fertiliser applications in mature rubber has been reported to be generally variable. In a review of 149 fertiliser experiments carried out by the Rubber Research Institute of Malaysia between 1920 and 1988, only 50 per cent were reported to show clear positive responses (Sivanadyan *et al.*, 1995). This led them to postulate that if nutrient build-up was provided to promote and sustain maximum growth during the immature phase of rubber through above normal levels of fertilisers with presence of full legumes, the stand would subsequently become a nutritionally self-sustaining ecosystem, at least during the early tapping phase. Subsequent application of fertilisers should be based on discriminatory fertiliser application as determined by soil and foliar analyses. More recently, Bah Lias Research Station (2001) also reported mostly lack of response to fertiliser application after eight years in three trials and five years in one trial, despite using extra wide guard-rows to prevent poaching effects in one trial.

The latex yield of rubber is influenced by several factors including genetic, environmental and also factors associated with commercial exploitation of the trees. Some of the latter include depth and frequency of tapping, time of tapping, slope of cut and phytohormonal stimulation practices (De Jonge,1968; Ismail Hashim, 1989). Latex yields are higher with early morning tapping and Paardekooper and Sookmark (1969) reported 15 to 20 per cent difference in yield between tappings at 8.00 and 11.00 a.m. If the effects of these factors are not controlled or evened out across the treatment plots, the response to treatments *e.g.* fertiliser application may be masked or biased.

In reviewing some fertiliser trials conducted in a large group of estates in the mid 1970s and early 1980s which did not show any significant response in yield to the fertilisers applied (Chan,1986), it was surmised that they might have been subjected to differences in time of tapping, cross contamination of treatment plots due to fertiliser wash during heavy rain and variable girth of measurement trees.

This paper reports on the positive responses to fertiliser treatments obtained in a trial conducted with improved trial methodology.

MATERIALS AND METHOD

Trial site

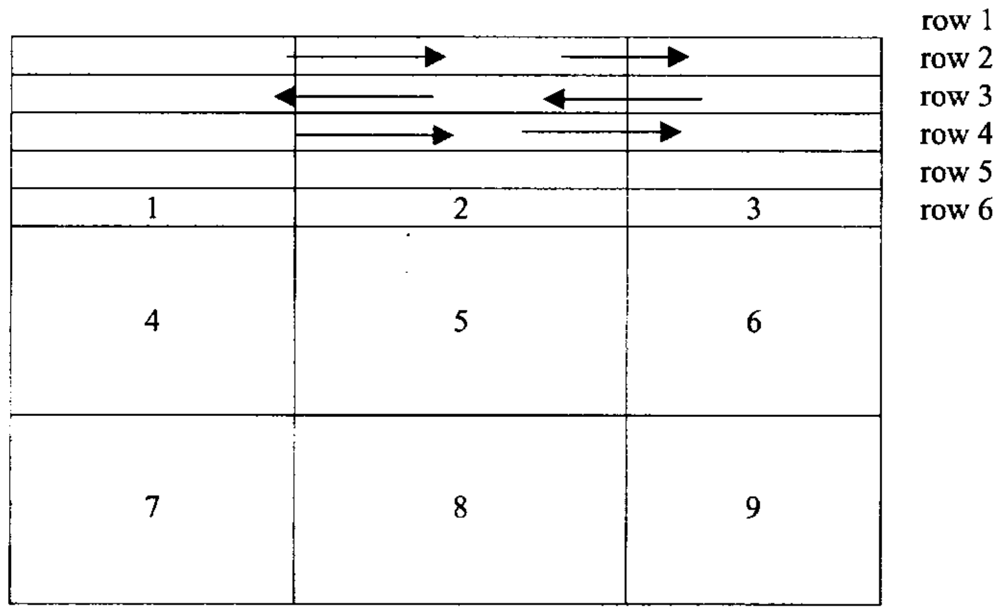
The trial was located in an estate in Segamat, Johore on undulating terrain (2-6^0 slope) on Bungor soil series (Typic kandiudult). The clone was PB 235 planted in 1981 and opened for tapping in 1987. The planting distance was 3.65 x 6.75 m. The trial commenced in 1990 when the cut was at 95 cm from the ground on the first basal virgin panel (BO1) and stand per hectare was 370 trees. Mean panel dryness was low at 3.5 per cent probably due to the trial area being sited on the deep profiled Bungor soil series. The panel was switched over to the second basal virgin panel (BO2) in 1993. Tapping system was half spiral tapped third daily (1/2Sd3) throughout the period of trial.

Legumes had been planted during the immature phase and trees received commercial fertilisers annually prior to laying down of the trial.

Experimental design and modified field layout

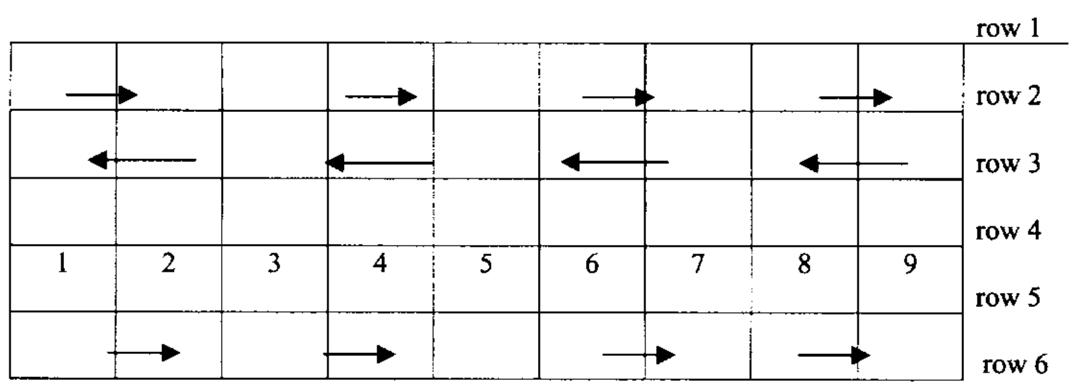
The trial was a 3^2 NK factorial with nine plots arranged in a randomised complete block design with three replicates. The conventional trial layout consists of treatment plots arranged in a rectangular block (*Figure 1*). Assuming the tapper commences tapping along the first row of trees in treatment plot 1, he would continue into the first row of trees in plots 2 and 3 before turning into the second row of plots 3, 2 and 1 and so on. Treatment plots 1 to 3 would have an inherent yield advantage over treatment plots 4 to 6 and also 7 to 9. Similarly treatment plots 4 to 6 would also have a yield advantage over plots 7 to 9. Moreover much time would be spent on tapping the border trees before the recording trees in each plot are tapped, thereby widening the time difference between tapping of recording trees between plots. Whilst the yield difference may be nullified by arranging for the tapper to commence tapping from two different corners of the task on alternate tapping days, in practice, the tapper by habit, always commences tapping from the same corner of the task.

A modified field layout with contiguous long rectangular plots (*Figure 2*) was devised to minimise the effect of time of tapping on yield. By tapping along the first row of trees of all treatment plots before turning into the second row and so on, the effect of difference in time of tapping on yield could be minimised. The



Number in box denotes treatment plot

Figure 1 Conventional field layout of plots within block (replicate)



Number in box denotes treatment plot

Figure 2 Modified field layout of plots within block (replicate)

layout of the trial replicate was rearranged from the normal shape and size of the commercial task to comprise approximately eight long rows of approximately 99 trees per row. These were demarcated into nine treatment plots comprising eight rows of 11 trees per treatment plot arranged adjacent to one another. Within each treatment plot, trees with girth sizes between plus (+) or minus (–) one standard deviation from the mean only were selected from rows 2 to 7 for recording in order to minimise the effect of variable girth sizes on yield. The balance of trees formed the guard rows, comprising a single border between rows

(rows 1 and 8) and double borders along the tree rows between treatment plots.

Soil along the boundary between the treatment plots were pushed up to a level of 50 cm to form bunds separating the different plots, to minimise fertiliser wash along terraces during heavy rain.

The layout of two treatment plots is shown in *Figure 3*. Whilst the total number of trees in the basic trial block was around 792 trees, the trial tapper only tapped around 594 trees comprising trees in rows 2 to 7 only so as not to spend time tapping the border trees in rows 1 and 8. Border trees in rows 1 and 8 were tapped by other tappers.

Treatments

Fertiliser treatments were carried out according to rates given in *Table 1*. Ammonium sulphate (N fertiliser) and muriate of potash (K fertiliser) were applied mainly around February/March each year, broadcasting along the tree rows and generally coinciding with time of budburst after primary wintering. Basal applications of rock phosphate (P fertiliser) at 0.5 kg per tree and kieserite (Mg fertiliser) at 0.3 kg per tree to all plots were carried out one year and four years after initiation of the trial. All fertilisers were applied in one application .

Measurements and yield recording

Pretreatment

Yield

After demarcation of treatment plots, pretreatment yield recordings were carried out for six months. Treatment plots were randomised based on pre-treatment yields.

Soil analysis

Soil samples were collected from depths 0-15 cm and 15-45 cm from both the tree-row and interrow from each of the three replicates. Thirty-six points were collected from each

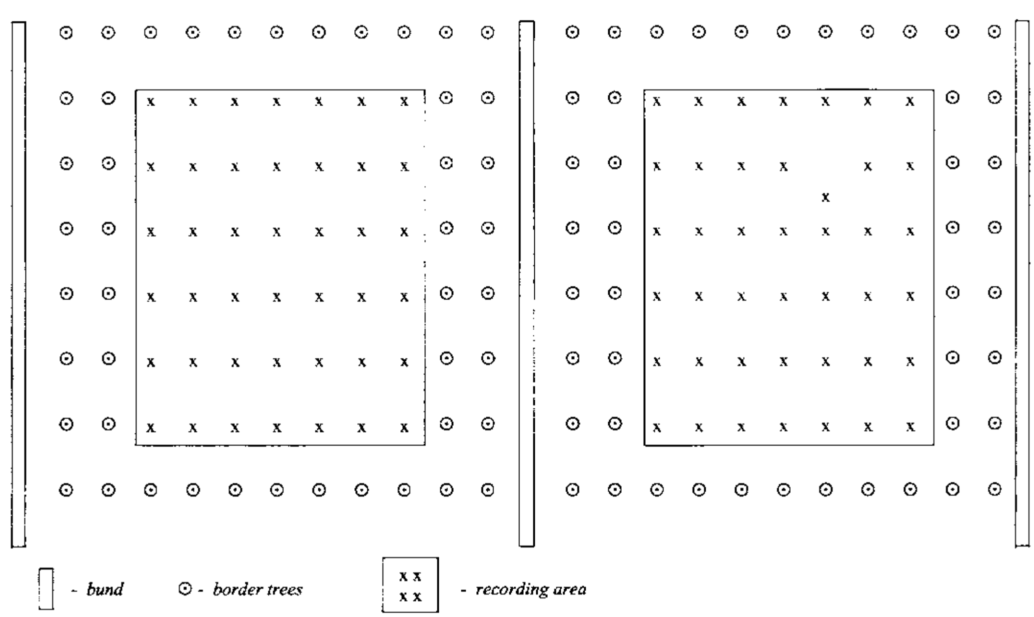


Figure 3 Diagram of two treatment plots

TABLE 1
RATES OF FERTILISERS APPLIED PER TREE PER YEAR

Fertiliser	*Level*		
	0	*1*	*2*
Ammonium sulphate (kg per tree per year)	0	0.75	1.50
Muriate of potash (kg per tree per year)	0	0.35	0.70

replicate and were bulked prior to analysis.

Girth

Girth was measured at a height of 160 cm from the ground at six-monthly intervals.

Post treatment

Girth

Girth was measured at a height of 160 cm from the ground at six-monthly intervals.

Foliar analysis

Leaf sampling was carried out around September/October annually. Leaves were collected from alternate recording trees and bulked to form one sample for each treatment plot prior to chemical analysis.

Soil analysis

Soil sampling was carried out four years after commencement of the trial. Samples were collected from depths 0-15 cm and 15-45 cm from both the tree-row and interrow from treatment plots N0K0, N1K1 and N2K2 for observation. Six points within the recording area were sampled per plot. Samples collected in the three replicates were bulked prior to analysis.

Yield

The three experimental tasks (replicates) were tapped by the same tapper in rotation.

Yield recording was carried out three to four times a month. Care was taken to record yields only on days where the tapping cycle was on third daily as frequency of tapping could change due to interference by rain and also to recovery tapping. Yield was weighed separately for latex and cuplump. Dry rubber content (drc) of latex was determined with a metrolac at every recording. Drc of cuplump was calculated assuming water content to be 50 per cent.

RESULTS

Girth increment

The effect of fertiliser treatments on girth increment is given in *Table 2*.

Application of nitrogen(N) and/or potassium (K) did not result in any significant girth increment of trees over the period reviewed.

Leaf analysis

The effect of fertiliser treatments on leaf N and K is shown in *Table 3*.

Leaf N was significantly raised in the second year after application of N at both the first and second levels. The significant response however disappeared in the next three years.

Significant response in leaf K was obtained in the third year after application of K at the

TABLE 2
EFFECT OF TREATMENTS ON GIRTH INCREMENT (CM)

Treatment	1990 Initial girth	Year 1 Increment	Year 2 Increment	Year 3 Increment	Year 4 Increment	Year 5 Increment	1995 Girth
Control N0	62.4	2.7	1.2	0.9	0.8	0.8	68.8
N1	62.1	2.7	1.1	1.0	0.9	0.9	68.7
N2	62.3	3.1	1.1	0.9	0.9	0.8	69.1
Control K0	62.2	3.0	1.2	0.9	0.7	0.9	68.9
K1	62.4	2.8	1.0	0.8	0.8	1.0	68.8
K2	62.3	2.8	1.2	1.0	0.9	1.0	69.2
LSD 0.05	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.	n.s.

TABLE 3
EFFECT OF TREATMENTS ON LEAF N AND K

Treatment	Year 1 N%	Year 1 K%	Year 2 N%	Year 2 K%	Year 3 N%	Year 3 K%	Year 4 N%	Year 4 K%	Year 5 N%	Year 5 K%
Control N0	3.51a	1.74a	3.17a	1.55a	3.39a	1.66a	3.52a	1.64a	3.73a	1.79b
N1	3.64a	1.64b	3.47b	1.55a	3.43a	1.57ab	3.59a	1.55ab	3.78a	1.71ab
N2	3.61a	1.58b	3.38b	1.45a	3.33a	1.54b	3.54a	1.49b	3.79a	1.58b
LSD 0.05	n.s.	0.1	0.18	n.s.	n.s.	0.12	n.s.	0.11	n.s.	0.12
Control K0	3.62a	1.63a	3.36a	1.46a	3.39a	1.50a	3.58a	1.51a	3.73a	1.60a
K1	3.56a	1.68a	3.33a	1.51a	3.38a	1.59ab	3.54a	1.55ab	3.79a	1.73b
K2	3.58a	1.66a	3.33a	1.58a	3.36a	1.67b	3.53a	1.62b	3.78a	1.76b
LSD 0.05	n.s.	0.1	0.18	n.s.	n.s.	0.12	n.s.	0.11	n.s.	0.12

In a column, means followed by a common letter are not significantly different at 5% level

second level. This response continued into the fourth and fifth year. Leaf K was also significantly higher than the control at the first level of application of K in the fifth year.

Application of N significantly reduced leaf K every year except in the second year. Application of K however did not suppress uptake of N.

Soil analysis

Pretreatment of total N and exchangeable K levels were generally similar in the tree-rows and also interrows for similar depths in all three replicates (*Table 4*).

Four years after application of treatments, total N was only marginally higher for treatments N1K1 and N2K2 than the control at both depths of sampling in both the tree-row and inter-row (*Table 4a*).

Exchangeable K was however markedly increased in the tree-row for both N1K1 and N2K2 over the control. The increase in exchangeable K was higher for N2K2.

TABLE 4
PRETREATMENT STATUS OF SOIL TOTAL NITROGEN AND EXCHANGEABLE POTASSIUM

Soil	*Sampling area*	*Depth (cm)*	*Replication* 1	2	3
Total nitrogen (%)	Interrow	0-15	0.07	0.08	0.07
		15-45	0.05	0.06	0.05
	Tree row	0-15	0.07	0.07	0.06
		15-45	0.06	0.05	0.04
Exchangeable K (m.e. %)	Interrow	0-15	0.08	0.07	0.07
		15-45	0.06	0.06	0.05
	Tree row	0-15	0.09	0.11	0.11
		15-45	0.08	0.09	0.08

TABLE 4A
EFFECT OF TREATMENTS ON SOIL TOTAL NITROGEN AND EXCHANGEABLE POTASSIUM

Soil	*Sampling area*	*Depth (cm)*	*Treatments* N0K0	N1K1	N2K2
Total nitrogen (%)	Interrow	0-15	0.07	0.10	0.11
		15-45	0.06	0.08	0.08
	Tree row	0-15	0.09	0.09	0.11
		15-45	0.07	0.07	0.09
Exchangeable K (m.e. %)	Interrow	0-15	0.07	0.08	0.09
		15-45	0.06	0.07	0.07
	Tree row	0-15	0.10	0.36	0.63
		15-45	0.10	0.39	0.59

Yield

The response in yield to the fertiliser treatments is given in *Table 5* and illustrated in *Figures 4* and *5*.

A significant increase in yield of 7.0 per cent over the control was obtained in the second year at the second level of N application. The significant response continued into the fifth year with increases in yield ranging from 13.0 to 19.6 per cent. Application of N at the first level did not result in any significant response in yield although a widening yield gap from the control was apparent from the third to fifth year.

Application of K at the second level gave a significant response in yield of 14 and 15 per cent over the control in the fourth and fifth year respectively. Application of K at the first level did not show any significant response in yield although yields were higher than the control for all years.

Interaction effect of N and K on yield was not detected.

DISCUSSION

Positive yield responses to application of N and K were obtained in the current trial, in contrast

TABLE 5
EFFECT OF TREATMENTS ON YIELD (KG/HA)

Treatment		*Year*				
		1	*2*	*3*	*4*	*5*
	N0	1733a	1436a	1297a	2231a	1650a
Control	N1	1786a	1451a	1349a	2382ab	1783a
	N2	1787a	1613b	1524b	2526b	1974b
	LSD 0.05	102	63	148	261	182
	K0	1741a	1463a	1322a	2246a	1683a
Control	K1	1791a	1511a	1419a	2331ab	1785ab
	K2	1774a	1525a	1429a	2562b	1938b
	LSD 0.05	102	63	148	261	182

In a column, means followed by a common letter are not significantly different at 5% level

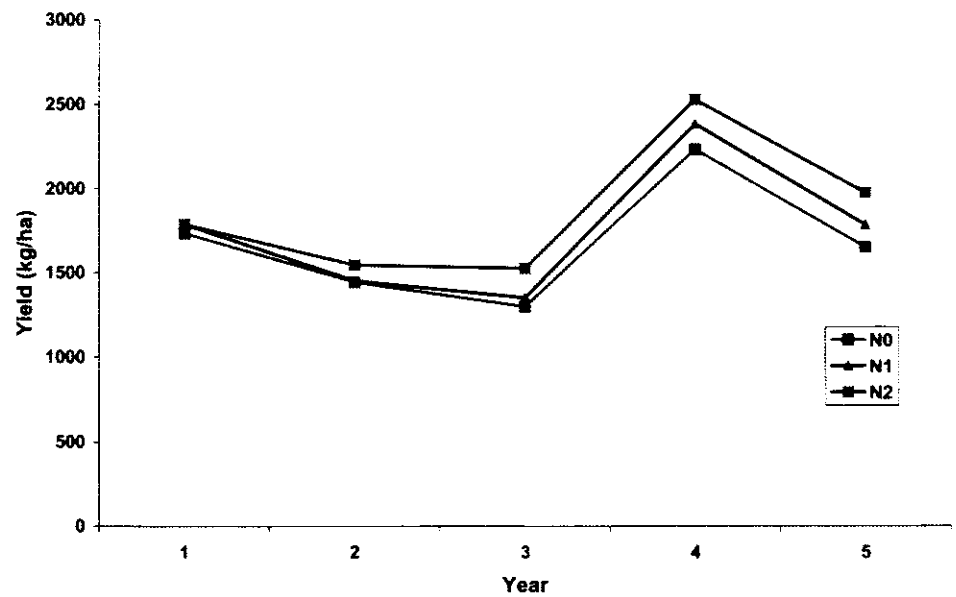


Figure 4 Yield response to N application (kg/ha)

to past results of fertiliser trials conducted in the Group (Chan, 1986). Whilst treatments were basically similar, the field conduct or methodology in the current trial was modified to minimise influence of extraneous factors other than fertiliser treatments on yield. The main modifications in the field trial methodology included using a field-layout with contiguous long rectangular plots to minimise the effect of time on yield, construction of bunds to minimise cross contamination of treatment plots due to fertiliser wash during heavy rain and using trees of uniform girth for recording. Narayanan (1968) showed that girth could be used as a calibrating variate to improve precision in manuring trials.

The same tapper was employed to tap the treatment tasks in rotation to minimise

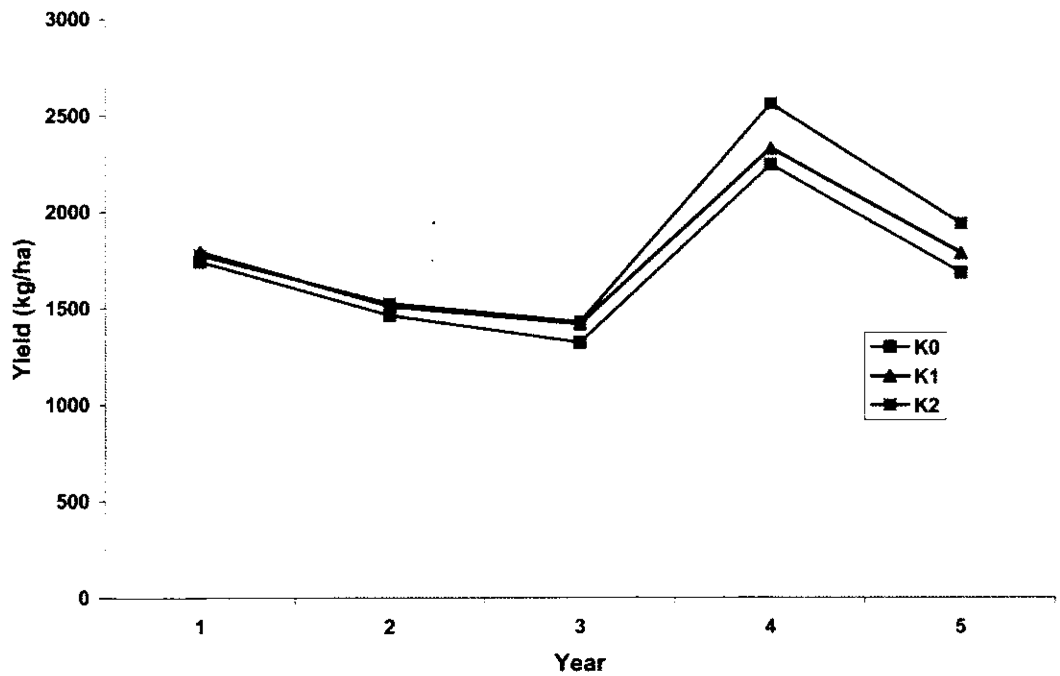


Figure 5 Yield response to K application (kg/ha)

differences due to tapping skill while yield recording was carried out three to four times a month confined to days tapped on third daily to improve accuracy of results.

Significant response in yield to N ranging from 7.0 to 19.6 per cent was detected from the second to fifth year and 14 and 15 per cent to K in the fourth and fifth year respectively, both at the second level of application. Although response to the first level of application of N was not significant, there was a widening yield gap from the control from the third to the fifth year. Similarly, application of K at the first level showed higher yields than the control, albeit not significant.

Response in yield to both N and K was mainly preceded by the response in leaf levels of these nutrients. Significant response in leaf N was detected in the second year at the same time that response in yield to N was obtained. Leaf K was significantly raised in the third year prior to the initial significant response in yield to K in the fourth year. Bolton and Shorrocks (1962) had also reported increase in leaf Mg prior to obtaining yield response to application of magnesium. The disappearance in significant response in leaf N after the second year remains inexplicable apart from observing an increasing trend in leaf N in the control. Bah Lias Research Station (2001) also reported differential responses in yield and leaf nutrient levels to fertiliser applications. In their only trial which showed positive response in yield to N application on clone PB 217, leaf N was not significantly raised. On PB 260, application of N significantly increased leaf N but not yield. In another trial which did not show any positive response in yield, leaf N, P and K were raised by application of N, P and K on PB 217 but only leaf N from N application on PB 260.

Application of K significantly increased soil exchangeable K in the tree rows along the terraces. The magnitude of accumulation of exchangeable K in the tree rows corresponded with the rate of application of K fertiliser. There was however little to no accumulation of exchangeable K in the interrows indicating little movement of applied potassium into the interrows. This could be due to the inward sloping nature of the terraces whereby most of the movement of water/wash probably took place along the terrace or infiltrated into the ground in the event of rain. In light of this the bunds constructed across the terraces between the treatment plots probably prevented/ minimised lateral movement of fertiliser wash between treatment plots, thereby minimising potential error due to fertiliser wash.

The positive yield responses obtained in the current trial underline the importance of continuous fertiliser application to sustain yield of mature rubber and also support the visual observation of deterioration in canopies where fertilisation had been withdrawn for more than two years. The latter is particularly conspicuous in old areas due for replanting where canopies turn sparse and yellowish due to cessation of manuring, often three to five years prior to felling of the rubber trees (Chan Weng Hoong, 2004, pers comm). It may therefore still be worthwhile to apply nitrogen to rubber trees up to two years prior to felling, and potassium up to four years from felling. The latter appears to differ from Sivanadyan, *et al.* (1995), contention that if immature trees are well nurtured nutritionally, then in their mature phase they can be expected to sustain themselves nutritionally without any yield depression for at least five years.

The findings reported are probably broadly indicative only, being based on a single trial. However they may justify the need for more of such trials to be laid down to ratify the results obtained.

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