Netherlands Journal of Agricultural Science

VOLUME 11 NO. 4 AUGUST 1963

Experiences with Hevea rubber in West New Guinea

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Summary

Various circumstances have retarded the development of rubber cultivation in West New Guinea until recent years. Mainly owing to a general prejudice against the country and to a lack of knowledge about its resources, the first serious attempts at establishing rubber plantations date only from shortly before World War II and these efforts have suffered frustration during the war and its aftermath. Investigations, commencing in 1959, however, have convincingly proved that an extensive potential rubber-producing area is present in the great plain of South New Guinea and since 1961 a very promising start has been made with native rubber cultivation in this region.

1. Introduction

While rubber planting in the Eastern part of the great Pacific island of New Guinea started as early as in South East Asia, *i.e.* at the turn of the century, the introduction of *Hevea brasiliensis* in West New Guinea took place at a much later date. In fact, the first serious attempts at establishing rubber plantations date from shortly before World War II.

There were some plausible reasons for this late introduction. The factual administration of the territory, which since 1828 had been merely a nominal part of the former Netherlands East Indies, began only in 1898. At that time the vast interior of the country was almost completely unexplored. Systematic exploration took place in the years 1907—1930 (ROUX, 1935). The general impression gained thereby was that the interior was a rugged, inaccessible country with high and steep mountain ranges alternating with extensive swampy areas. The population appeared to be sparse and very primitive. Except in the Northern mountain ranges, prodominently calcareous and quartzitic rocks were encountered, so that in connection with the humid equatorial climate, no high hopes could be fostered with regard to the fertility of the soils. In view of these unfavourable reports and of the eccentric geographical position of the territory with respect to the then existing main shipping routes it is quite understandable that private enterprise was disinclined to invest in estate agriculture in West New Guinea, the less so because Java and Sumatra with their good natural and marketing conditions, their basic facilities and their great reservoir of cheap labour offered much more attractive propositions in this respect.

Received for publication 4th February, 1963.

In the early thirties, when the oppressively rapid growth of the native population of Java needed an outlet, suitable areas for resettlement of Javanese farmers were sought, not only in Sumatra but also in Borneo, Celebes and West New Guinea. At the same time a group of Eurasians in Java and some Japanese interests were looking for suitable agricultural areas in West New Guinea.
It was then realised that the prevalent poor opinion of the quality of the West New Guinea soils was not based on proper soil research and therefore little more than a generalizing assumption. Up till then only a few casual and superficial observations on the appearance of the soil had been made (some of which, however, were interesting, *e.g.* the reported presence of red soil in the region of the upper Digul river). In the early thirties the Netherlands Indies Government decided that soil surveys should be undertaken in West New Guinea, in order to obtain more specific information on this subject. From 1932 onwards the soil conditions in several parts of the territory were studied, in the beginning mostly by WENTHOLT, who, rather surprisingly, discovered some quite fertile areas, in particular in the Ransiki plain (South of Manokwari) and in the Grimé plain (South-West of Hollandia). However, the prejudice against the territory persisted and moreover, the severe slump of the rubber prices in 1932—1933 offered little incentive for opening new rubber estates, while subsequently the International Rubber Restriction Agreement of May 1934, in which the Netherlands Indies participated, prohibited the new planting of rubber. In 1938, when the Rubber Restriction regulations were somewhat relaxed and a limited extension of the rubber area was allowed, the government decided to set an example by opening a Government rubber estate in the Ransiki plain. In 1941 the "Negumij", a private company, financed by a number of agricultural, shipping and commercial interests, somewhat reluctantly followed suit by establishing an experimental area with rubber and other crops in the Grimé plain.

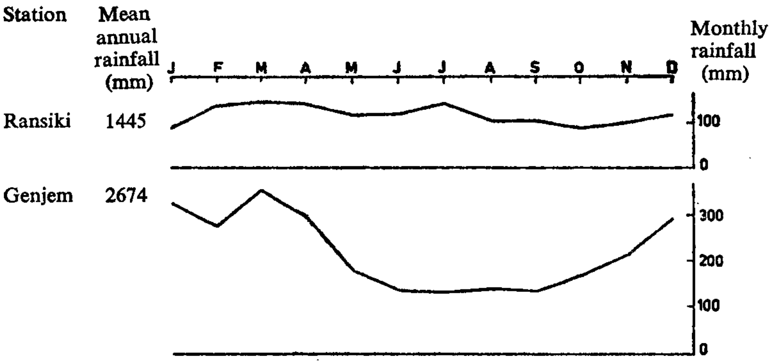
2. Pre-war rubber planting in West New Guinea

The very first rubber trees in West New Guinea were planted in and around Tanahmerah (upper Digul region) by the local civil service officers. The exact date of planting has not been recorded, but it is practically certain that the introduction has taken place in the period 1931—1932. Only a few scattered trees were planted, some of them in the middle of the village, so the introduction was obviously tentative so as to obtain an impression of the growth of Hevea under the local conditions of soil and climate. There was no follow up, probably owing to the slump and the subsequent plant stop. A number of rubber trees have survived the war and it is interesting to note that these now approx. 30 year old trees are healthy and well-grown, one of the larges having a circumference of over 200 cm at a height of 1 m in june, 1959 (FIG. 1).
As already mentioned above, the Government decided in 1938 to establish a rubber estate in the Ransiki plain, 80 km south of Manokwari. This low lying, permanently dry area is an alluvial fan of the Ransiki river and consequently has soils of varying texture. According to WENTHOLT (1938) the physically best soil types are grey-brown loams to sandy loams, which cover an area of approx. 1600 ha, and this area was chosen for the rubber plantation. Chemically these soil types are very well provided with mineral plant nutrients and of a neutral to alkaline reaction (pH 6,9—8,5). The climate of the Ransiki plain, which lies in the "rain shadow" of the Arfak mountains, is rather dry. The average yearly rainfall amounts to 1450 mm, somewhat

FIG. 1. Approx. 28 year old rubber tree at Tanahmerah; photo taken 2-6-1959

FIG. 3. Budwood nursery Ransiki, planted 1939; photo J. HAM, 1957

FIG. 2. Rainfall in the Ransiki plain and in Genjem



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irregularly, out in the average fairly well distributed over the year (FIG. 2). The work was tackled energetically and in 1939—1941 an area of 1000 ha was cleared of heavy forest and planted up with rubber. Only the best, then available planting material was used, *viz.* buddings of good clones and seedlings of good perentage, each on 50 % of the area.

It is evident that neither the soil nor the climate of the Ransiki area are particularly suitable for Hevea, the soil pH being above the optimum for (young) rubber and the rainfall being too low. It is therefore not surprising that FERWERDA (1941) reported in october 1941 that the planting programme was partly upset by a prolonged dry spell in the second half of 1940 and in the first months of 1941, and that the initial growth of the rubber was irregular. In some (alkaline) patches the young rubber even died off. However, in other parts of the plantation the growth was not less than that of rubber of the same age in Java and Sumatra and the author expected that — unless unforeseen setbacks occurred — the Ransiki rubber would reach the tappable stage in the sixth year of life. Apparently FERWERDA already sensed the imminent danger of a Japanese invasion, which indeed occurred in april 1942. The estate had to be abandoned and the Japanese authorities ordered the removal of the rubber and the planting of foodcrops instead.

After the war it indeed appeared that the plantation had been almost completely destroyed. Only a few remnants had survived, *viz.* a budwood nursery, a seedling nursery and two small seedling areas, altogether approx. 22 ha. It was interesting to note that these totally neglected rubber stands had maintained themselves comparatively well. They also showed some unusual features which are worth recording.

In the densely planted (1 by 1 m) budwood nursery the majority of the trees were heavily suppressed, but the dominant trees, numbering about 580 per ha, were quite well grown, with high set canopies and healthy foliage (FIG. 3). The seedling nursery which was even more densely planted, offered the same picture of dominance and suppression. Part of these seedlings had apparently been budded shortly before the war but the stocks had not been sawn off. Consequently the buds had remained dormant and the bud panels on the dominant trees had grown out to broad scars. The surviving seedling areas, which had been planted at a distance of 6 by 3 m, had suffered more from the neglect. Some trees were completely overgrown by the profusely growing leguminous cover-crops and by fast growing forest trees, *e.g. Octo-*

meles Sumatrana. Part of the trees had developed abnormally low-set crowns. However, on the whole these groves had also maintained themselves reasonably well.
Towards the end of 1941 the "Negumij" established an experimental station near Pobaim in the Grimé plain at an elevation of approx. 50 m above sea level. According to VAN LOENEN (1939) and WENTHOLT (1940) the soil type of the area is a grey-brown heavy loam of good depth and good water-holding capacity, but locally rather poorly draining. During the rainy season the lower parts of the area are more or less permanently inundated, so that an adequate drainage system was deemed necessary. Chemical analyses showed that the topsoil is well provided with mineral plant nutrients. The pH varies from 5,7 to 8,4, so that the soil reaction is partly unfavourable for (young) rubber.
The local climate is seasonal but not very pronounced, the average monthly rainfall in the dry season being well above 100 mm (FIG. 2). With a mean annual rainfall of 2674 mm the climate is therefore almost ideal for Hevea.
In March 1942, rubber seedling and budwood nurseries were planted, together with nurseries of other plantation crops and foodcrops. In August 1942 the Japanese invaders occupied the region. The manager, being a Swiss national, was allowed to continue his work, but he was instructed to grow exclusively foodcrops and forbidden to transplant rubber and other perennial crops into the field. In April 1944 he had to flee from demoralized and marauding Japanese soldiers, who destroyed all the buildings and records and ransacked the foodcrops. The manager was rescued by an American patrol and evacuated to Australia, from where he reported that the rubber nurseries had grown well. In the beginning of 1944 the then about two year old seedlings had an average height of 5—7 m and a mean diameter of 4—7 cm at one foot above ground level.
In 1950, when the area was inspected for the first time after the war, it appeared that the neglected rubber had maintained itself quite well. The nurseries showed the same picture as those at Ransiki: the majority of the seedlings were heavily suppressed, but the dominant trees were well grown. These 8 years old trees were about 10 m high and had a circumference at breast height of 65 to 75 cm.

3. Post-war developments

In the aftermath of the war the rubber-cultivation activities were not resumed, neither by the Government at Ransiki nor by the "Negumij" in the Grimé plain.
In the early fifties, when the territory had somewhat recovered from the ravages of the war, serious attention was given to economic development. In 1953 an Agrarian Commission of experts on tropical agriculture, hydrology, forestry, animal husbandry, etc., was installed by the Netherlands Government and instructed to study the agrarian possibilities of the territory and to compose a long-term development plan. The Commission visited New Guinea in 1953 and submitted a report to the Netherlands Government in 1954. In her letter of presentation of this report which was published in 1955 (Anon, 1955) the Commission again drew attention to the alleged generally low fertility of the West New Guinea soils and strongly emphasized the need for further research. Nevertheless the Commission gave a number of recommendations and an outline for a long-term development plan. With regard to perennial cash crops only the introduction of cocoa was considered economically justified. The introduction of Hevea was discouraged under the then prevailing circumstances, although it was admitted that rubber cultivation would certainly be tech-

nically possible in some areas, and might perhaps even become a paying proposition if the market situation should improve in the future.

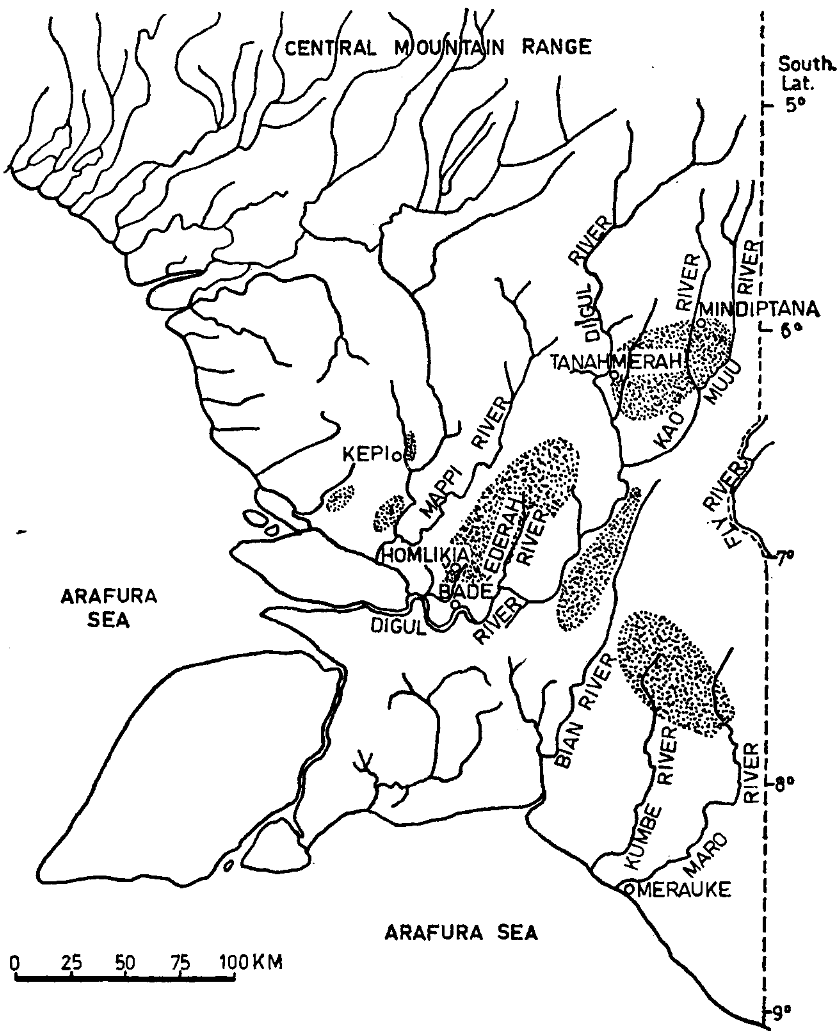
Obviously, the Commission's recommendations have been influenced by the trends on the world markets in 1953 and early 1954, which were extremely favourable for cocoa and unfavourable for rubber. However that may be, the fact remains that the introduction of rubber in West New Guinea was once more retarded, while the planting of cocoa was promoted with great energy by the Agricultural Extension Service in 1955 and following years and — incidentally — very successfully in several areas in the Northern part of the territory. The "Negumij" who transferred her activities in 1955 to Ransiki, also concentrated on experiments with cocoa cultivation and likewise with very good results.

Since 1955 an interesting development occurred in the region South of the Central Mountain Range. This immense plain, covering an area of roughly 100.000 square kilometers, is very low-lying, the elevation above sea level at 300 km from the south coast being no more than a few tens of meters. The plain is intersected by numerous rivers, several of which are navigable for seagoing ships over considerable distances. Apart from a comparatively narrow coastal belt with low dune formations and marine clay flats, the topography shows an intricate pattern of swamps and grassy marshes alternating with slightly more elevated and permanently dry knolls, ridges and flats, covered with primeval rain forests. In 1955 no detailed information was available about the relative occurrence of permanently dry land but reports from patrolling officers gave indications that the proportion of dry land is increasing from West to East. The best-known dry area was the relatively densely populated Muju district, situated between the Kao and Muju rivers (FIG. 4). According to RAZOUX SCHULTZ (1954) and SCHROO (1958, 1959) the main soil type in this area is a lateritic brown to yellow-brown silty clay to clay with good physical properties, but chemically extremely poor and acid (pH = 5). Therefore, only a certain "humus fertility" was attributed to this type of soil. In 1955, some experimental plots of cocoa were planted near Mindiptana. The growth of this cocoa, though inferior to most cocoa plantations in the North, exceeded expectations but there were doubts about the future yields on this poor soil. Moreover, a high incidence of fungoid diseases was to be feared in connection with the very humid climate of the district (4000 to 6000 mm average yearly rainfall). For these reasons the cultivation of cocoa by the population was discouraged and in 1957 the introduction of rubber was considered instead.

Meanwhile, the cultivation of cocoa was — rather optimistically — encouraged in the Mappi district, which lies nearer to the coast and has a drier climate. In the years 1957—1958 an area of 125 ha of cocoa was planted by the population of a number of villages. This introduction resulted in an almost complete failure. In general the growth of the cocoa was slow, many trees showed deficiency symptoms, suffered from root damage by larvae of a cockchafer (SCHREURS and SIMON THOMAS, 1961) and mortality was high. A soil survey by VAN SOELEN (1957) revealed that the predominant soil types of the dry land in the Mappi district are reddish brown, very porous sandy loams of varying depth. The subsoil, being more loamy or clayey, has a better water-holding capacity. Chemically, the Mappi soils are acid (pH = 5) and extremely poor, especially in phosphate, so they too were supposed to have only a certain humus fertility.

The climate of the Mappi region is distinctly monsoonal and the dry season can often be severe, as was actually the case in 1957 and 1959. The bad results of cocoa cultivation in the Mappi district are very probably due to an unfortunate combination of soil and climate. This hypothesis is sustained by the fact that the only village where the cocoa grew moderately well, had soil profiles which were loamy to clayey throughout and therefore possessed a better moisture-holding capacity. The disappointing results with cocoa in the Southern plain led in 1957 to the idea that rubber cultivation could possibly be a better proposition for the permanently dry areas in the broad zone between 6 and 8 degrees Southern latitude. In this zone the elevation and the climate seemed to be suitable to very suitable for Hevea. The

FIG. 4. Map of South New Guinea



Potential rubber areas

same applies to the physical properties of the soil, provided that only areas with sufficiently deep soils were selected. The main doubtful point was the alleged extreme poverty of the soil types concerned, because Hevea, though not exacting, certainly has minimum requirements with regard to soil fertility. Therefore a cautions approach was deemed advisable and it was decided to establish rubber-observation plots first in a number of places before definitely introducing the crop.

In March 1958 rubber nurseries were established at Mindiptana and Kepi. The seed was collected in the twenty year old budwood nursery at Ransiki, which was transformed in 1957 into an isolated polyclonal seed garden by prudent thinning out. In this area the following clones had meanwhile been identified by leaf and seed characteristics: *Tjirandji 1, Tjirandji 16, PR 107, LCB 53 and LCB 1320.* Since *Tjirandji 1, PR 107* and *LCB 1320* are excellent seed parents, the genetic quality of the collected seed could be expected to be good.

The rubber nurseries at Mindiptana and Kepi grew vigorously and in February-March, 1959, sufficient large stumps were available for the establishment of observation plots at Mindiptana, Kepi, Badé and Homlikia (see FIG. 4). The size of these plots varied from ½ to 5 ha. A rather high planting density was applied, *viz.* 3½ by 3½ m (816 trees per ha) for two reasons. Firstly with regard to the alleged infertility of the soils and seconddly because dense planting is an essential measure for successful native rubber cultivation, at least under primitive circumstances, as experience elsewhere has taught. In such a situation the obvious way to introduce rubber as a small holder's crop is its incorporation into the shifting-cultivation system by interplanting rubber stumps between the foodcrops in the forest clearings. Some upkeep is then only assured during the period in which the foodcrops are grown. After the harvesting of the foodcrops the rubber is usually left alone, because the people will then move to another clearing. Therefore, it is essential that the young rubber will close itself soon after the area is left, hence the necessity of dense planting.

In the observation plots the customary foodcrops (mainly tuberous crops and bananas) were planted between the rows of rubber stumps so as to imitate the small holder's system. In view of the low evaluation of the fertility of the soil types concerned, a simple fertilizing trial was included in each plot by applying 250 grams of basic slag in the planting holes of every second rubber row. In all plots the stumps struck well and the growth of the young rubber was remarkably fast, as is shown by the initial girth measurements, published by MOLL (1961) and by further figures given in the TABLE.

TABLE. Some figures on post-war rubber plantings

Plot	Size (ha)	Number of trees measured	Mean girth (in cm) at 1 m at the age of				
			1½ years	2 years	2½ years	3 years	3½ years
Mindiptana	5	419—676	13,8	19,9	26,7	33,0	38,5
Badé	1	645—740	13,6	18,7	22,4	31,9	
Homlikia	0,5	305—317	12,0		22,8	29,9	
Kepi (fertilized)	1,5	215—219			22,7	29,7	33,9
Kepi (control)		221			19,7	28,6	32,8

The fertilizing with basic slag had little or no effect. In the Mindiptana, Badé and Homlikia plots no response whatsoever was found. In the Kepi plot the fertilized trees grew slightly but not significantly better than the control trees and the difference in mean girth between the two treatments tends to become smaller with increasing age. The growth curves are represented in FIG. 5, in which for comparison also the curve of a seedling plantation in one of the best rubber areas in West Java is included. FIG. 5 shows that the four observation plots in South New Guinea have even grown better than the Java plantation at the same age, certainly a surprising result. The seedling areas on the Java estate concerned reached the tappable stage at the age of 4½ years. As the densely planted observation plots are closing already at the age of 2½—3 years (see FIG. 6) allowance has to be made for a slowing down of the rate of growth after the third year. Even so, there is little doubt that the tappable stage will be reached at least as early as in the best grown seedling plantations in West Java. In fact, the best-grown Mindiptana plot had, at 3½ years, already 34 %, *i.e.* approx. 275 trees per ha with a circumference of 45 cm and over.

A well-known phenomenon in fast growing young rubber plantations, *viz.* the occurrence of trees that are bent by rain storms, was observed in some of the plots at the age of about 1½ years. This minor inconvenience was easily remedied by lopping the bent trees at a height of 3 m.

The Badé curve shows a temporary growth retardation in the period between 2 and 2½ years, *i.e.* March-October, 1961. As the dry season 1961 near the South coast was abnormally long and severe, this is very probably the cause of the comparatively small growth increment in the said period at Badé, which was, however, followed by a very strong growth in the next six months.

In 1960, when the outstandingly good growth of the young rubber in the observation plots became increasingly apparent, it was felt that the time had come for an energetic introduction of rubber as a small holder's crop in permanently dry areas with soil types similar to those of the observation plots. As still insufficient data on the occurrence and location of such areas were available for detailed planning, a soil survey of a large area (approx. 100.000 ha) between the Digul- and Bian rivers was carried out by HEKSTRA and VALETTE (1961) in March-April, 1961. This survey led to the discovery of an extensive permanently dry plateau between these two rivers, elevated approx. 30 meters above sea level, with an estimated area of 35.000 ha deep, red-brown loams of good physical properties. According to mineralogical and chemical analyses by MOUTHAAN and SCHROO (1962) the fertility of these soils was again considered to be as low as in the other investigated areas, *i.e.* extremely poor and acid.

As extensive dry areas of similar soils were known to be present between Tanahmerah and Mindiptana, in the Southern part of the Muju district, in the upper Maro-, upper Kumbe-, Ederah- and Mappi districts (see FIG. 4) a campaign was launched in 1961 to encourage the inhabitants of the villages in or near the said areas to interplant rubber as a future cashcrop in their foodcrop clearings. It was the intention to follow the pattern which had been successfully accomplished with cocoa as a cashcrop elsewhere in the territory, *viz.* the formation near each participating village of a centre of small family holdings, each ultimately comprising 2 ha of rubber, an adjoining area for growing foodcrops, some fruit trees in the farmyard and some livestock. This aim can be achieved smoothly by inducing each participant to interplant rubber stumps in the small area of foodcrops which he and his family are used to establish every year for their subsistance.

Thus after a number of years an industrious participant can become the owner of

FIG. 5. Growth curves of post-war rubber plantings

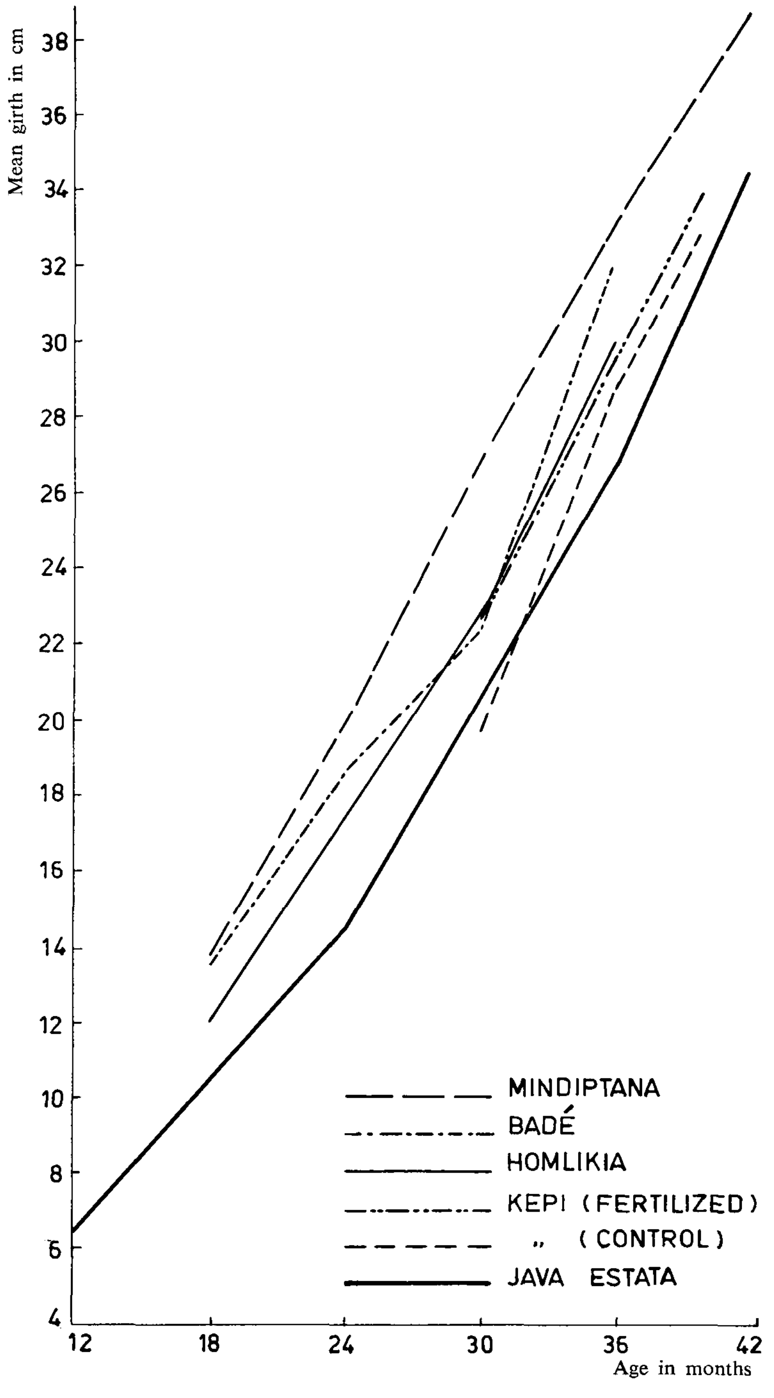


FIG. 6. Observation plot Mindiptana, planted February, 1959

Note rubber stand is closing at the age of 2 years and 7 months; banana trees are already completely overgrown
Photo BLOM, September, 1961

a small property that provides him and his family with their subsistance and a reasonable income in cash. In this way the people are gradually persuaded to give up their semi-nomadic way of life and to become permanently settled, which is an essential precondition for better economic and cultural development. However, experience in the past with the introduction of cocoa had shown that the extension of the cash-crop area progresses rather slowly when the assistance offered to the participants consisted merely of proper guidance and the supplying of planting materials and tools.

The reason for this slow progress was that the participants who were badly in need of cash money to satisfy their recently acquired want of Western goods, had to wait four years and more before their perennial cash crop was bringing in money. This relatively long time of waiting held many people back from planting these crops, especially when other — perhaps easier — possibilities to satisfy their need for immediate cash income, are present. Therefore, the Government introduced a new element, resulting in a considerable acceleration of the planting of perennial cash crops, by offering payment for the labour involved in the clearing of the forest, the planting of rubber and the construction of simple roads which were meant to connect the rubber areas with the nearest navigable river. It was stipulated that the payment for clearing and planting their own holdings was a provision of credit, to be refunded on easy terms out of the future revenues of the rubber plantation. The response of the population on these proposals was rather overwhelming. So many were the applications for participation that the available planting material became the limiting factor. As the importation of Hevea seed of appropriate quality from abroad proved to be impossible, it was decided to use not only the seeds from the clonal seed garden at Ransiki, but also from the pre-war seedling areas in the Ransiki plain. These isolated areas were known to consist exclusively of the best pre-war selected seedlings, *e.g. AV 163* ill., *LCB 1320* ill., etc. and the progenies of these areas could therefore be expected to be of sufficient genetic quality for general use. All the available planting material was transported in the first months of 1961 by charter plane to Tanahmerah, where extensive rubber nurseries were established, which developed well and in the rainy season 1961/1962 yielded sufficient stumps for over 2000 participants of many villages throughout the Southern plain. The work progressed well and in this first season a total rubber area of 697 ha was planted, whilst in addition an area of approx. 1000 ha was in clearing.

The first planted rubber is reported to grow on the whole satisfactorily and in the beginning of 1962 new rubber nurseries, now covering 7 ha, have been established, so that the increasing number of participants (now almost 3000) can be provided with rubber stumps for the extension of the rubber area in the season 1962/1963. Last but not least, an isolated area of 20 ha is being budded in the field with the best available parent clones (*Tjir 1, PR 107* and *LCB 1320*) in order to provide the smallholders with monoclonal and biclonal planting material of still higher yield-potential in the future.

4. Discussion

The seeming discrepancy between the excellent performance of the young rubber in the observation plots and the very unfavourable reports on the fertility of the soil types concerned presents an interesting point of discussion which requires elucidation.

It is a well-known fact that *Hevea brasiliensis* thrives best in dry tropical lowlands with an evenly distributed annual rainfall between 2000 and 4000 mm. Furthermore, Hevea requires a uniform physically good topsoil to a depth of at least 75 cm and a subsoil without hard impenetrable layers or a high water table. The topsoil must be of good structure, well draining and at the same time sufficiently moisture-retaining. The optimum soil reaction for young rubber is about pH = 5, while mature rubber is more tolerant and can stand up to pH = 8 (VOLLEMA, 1949). Hevea can grow very satisfactorily on less fertile soils but certain minimum amounts of plant nutrients are, of course, required for a good development. An approximation of these minimum requirements has been given by DYCK (1939) who analyzed a complete well-grown mature rubber tree (wood and bark of stem, roots and branches, twigs and leaves). He found that this tree contained 15,5 kg N; 4,9 kg P_2O_5; 17,5 kg K_2O; 26,2 kg CaO; 0,5 kg Na_2O and 6,7 kg MgO. Thus a well-grown mature stand of 250 trees per ha would contain approx. 3800 kg N, 1200 kg P_2O_5, 4300 kg K_2O, 6500 kg CaO, 130 kg Na_2O and 1600 kg MgO. DYCK pointed out that evidence obtained from the analysis of a single rubber tree naturally contributes but little towards a knowledge of the absorption and translocation processes in the plant. He drew attention to the fact that the relative amounts of the elements in the rubber tree can vary considerably on different soils and he mentioned an instance that a rubber tree on another type of soil contained less potash and much more soda. So it would seem that the rubber tree is capable to adapt itself, to a certain extent, to the chemical composition of the soil and is able to substitute related elements.

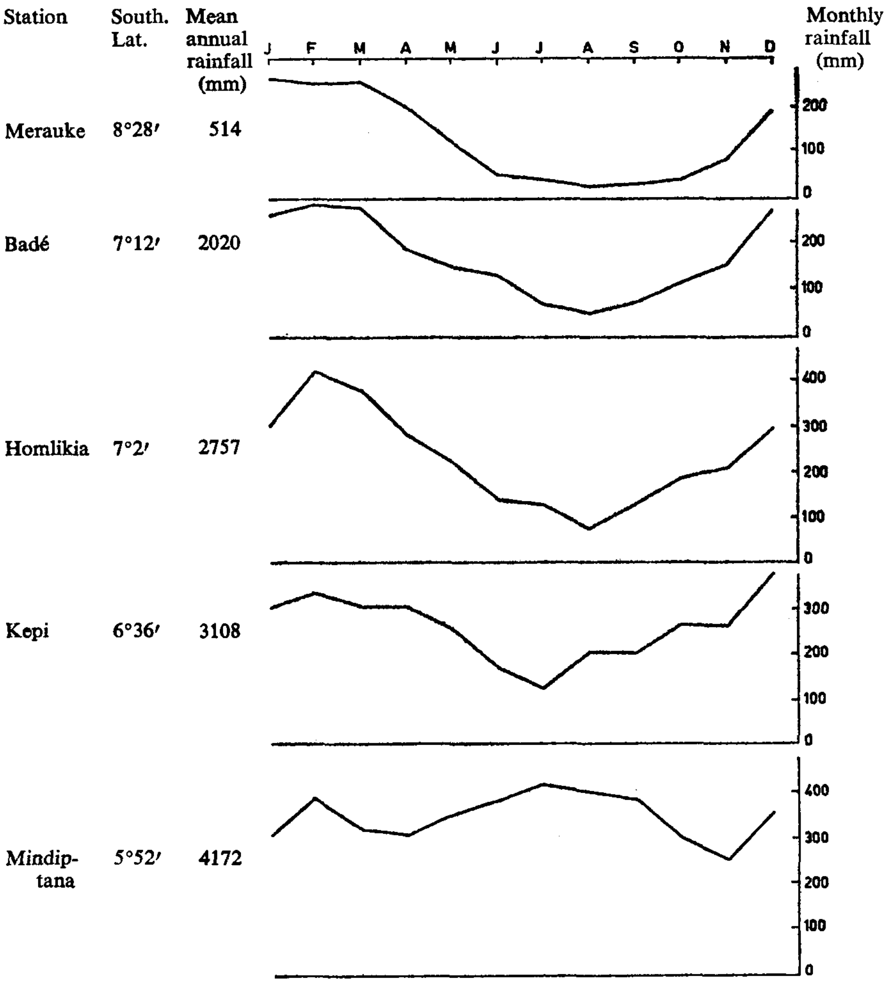
Nevertheless, it is evident that quite considerable quantities of plant nutrients are needed for the building up of a hectare mature rubber. The amounts of plant nutrients removed with the latex, on the other hand, are very small. According to TROMP DE HAAS (1910), BEADLE and STEVENS (1912), normal latex contains 0,23 % N; 0,09 % P_2O_5; 0,17 % K_2O; 0,01 % CaO and 0,016 % MgO. Thus a yield of 3000 kg latex per ha (the estimated potential yield at maturity of the planting material used in South New Guinea) would withdraw only approx. 7 kg N; 2,7 kg P_2O_5; 5 kg K_2O; 0,3 kg CaO and 0,5 kg MgO per ha per year from the soil.

In the light of these facts it can be stated that:

a. The areas in South New Guinea which are selected for rubber curtivation are tropical lowlands with a particularly favourable elevation for Hevea.

b. The climate in the broad zone in which the suitable areas occur varies from monsoonal with a mean annual rainfall of approx. 2000 mm in the South to one with an evenly distributed yearly rainfall of over 4000 mm in the North (FIG. 7). Between these two extremes the climate is favourable to almost optimal for Hevea. In the Southernmost fringe (Badé and Homlikia) the dry season can occasionally be severe. In such years some temporary growth retardation has been found to occur and in future some yield depression may be expected in pronounced dry seasons. In the North (Tanahmerah and Mindiptana) the climate is on the humid side for rubber, although the rains come as a rule in the afternoon and/or during the night and an average of 4,6 to 5,6 hours of sunshine per day has been recorded for these two stations (Duration of sunshine, 1959). However, this type of climate may give rise to a high incidence of fungoid diseases. Up till now only some Pink Disease (*Corticium salmonicolor*) has been observed, but in future, panel disease may become trouble some. In order to get an idea how the chances are in this respect, some of the old trees at Tanahmerah have been tapped daily since 1959 (see FIG. 1).

FIG. 7. Rainfall in the potential rubber areas and at Merauke



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Curiously enough, no panel diseases have occurred so far, but as these old trees are free-standing and quickly drying up after rain, a close observation in the young stands will be necessary as soon as tapping is commenced.

c. The physical properties of the soils in the areas concerned are in general very favourable for rubber. In the Mappi district the topsoil is locally very permeable to varying depth and in severe dry seasons, which are not rare in this region, shallow-rooted crops can consequently suffer from lack of moisture. In fact the failure of cocoa cultivation in most villages of the Mappi district is very probably mainly due to an unfavourable combination of soil and climate: the mortality of the cocoa was greatest after the severe droughts of 1957 and 1959. In January 1961 the depth of rooting was investigated in the Homlikia area where the permeable sandy loam topsoil is about 1 m deep. Here the well-grown rubber observation plot adjoins a then 4 years old cocoa area which had almost completely died off. One of the largest surviving cocoa trees and a rubber tree of average size were carefully dug out. It appeared that the roots of the cocoa tree had in four years time only reached a depth of 65 cm while the rubber taproot was already over 1½ m long and therefore had penetrated — within two years — into the moisture-retaining loamy subsoil. This observation elucidates why the rubber, which is moreover less exacting as to the fertility of the soil, had grown so well where the cocoa had completely failed. In the other districts the soils have physical properties that are perfectly suitable for Hevea while, as stated before, only areas with soils of sufficient depth have been chosen for rubber cultivation.

d. The soil reaction of about pH = 5 throughout the areas concerned is optimal for rubber.

e. The only controversial point is the alleged low fertility of the soil types in the chosen areas. Contrary to expectations, based on the derogatory results of chemical analyses, the rubber has made an exceptionally good start and phosphate fertilizing had little or no effect. It has been argued that the good initial growth of the rubber might be due to humus fertility, so that, after a few years, serious growth retardation might set in and deficiency symptoms might manifest themselves. However, up to 3½ years of age nothing of the kind occurred: the growth rate continued to be vigourous and no deficiency symptoms whatsoever have been forthcoming so far. Moreover, the large and healthy 30 years old trees at Tanahmerah are there to prove that the rubber is capable to derive from the soil the not inconsiderable quantities of plant nutrients that are needed for building up such big trees. The explanation is presumably that in deep soils the rubber tree is able to develop such an extensive root system that it can utilize a much greater volume of soil than most other perennial crops. In addition, densely planted rubber is virtually a re-afforestation that restores and maintains humus fertility.

5. Conclusion

Summing up, it appears justified to conclude that there are extensive areas in the great plain of South New Guinea, where natural conditions are very suitable for rubber cultivation. At first sight it is remarkable that the first attempts at large-scale rubber planting, shortly before the war, have been undertaken in other areas where climatic and/or soil conditions were not particularly favourable for Hevea. It should be remembered, however, that at the time little was known about the topography and the soils in the southern plain, although the good growth of the then 7 years old rubber trees at Tanahmerah should have given a strong indication in favour of rubber cultivation, but this was probably overlooked. Presumably also the biased general underestimation of the suitability for agricultural purposes of the West New Guinea soils has played a part and led to a preference for the most fertile areas that were discovered at that time.

However that may be, recent investigations have convincingly proved that an extensive potential rubber-producing area, probably exceeding a hundred thousand ha, is present in the South New Guinea plain. Another advantage of great economic importance is the presence of several navigable rivers in the region. The main limiting factor for a rapid realization of the potential is the still sparse population. However, there is every reason to expect that an important new source of revenue for the population and for the territory will come to the fore in the near future.

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