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RUBBER GROWING IN BRAZIL IN VIEW OF THE DIFFICULTIES CAUSED BY SOUTH AMERICAN LEAF BLIGHT (DOTHIDELLA ULEI)[1])

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SUMMARY

Unless full consideration is given to South American leaf blight *Dothidella ulei*, rubber growing in Brazil is commercially a risky adventure. Climatic conditions in the Amazon area are so favourable for this disease, that when planted in monocrop plantations only the highest resistant selections survive. In the natural varzea forest the disease does not develop in such a perilous way because the rubbertrees are scattered and isolated, reducing the possibility of spreading and of epidemic intensifying.

In the zone of South Bahia disease conditions are not so favourable as they are in the Amazon area and there we can lay a little more weight on high yield than on full resistance to *Dothidella ulei.*

In the area of São Paulo *Dothidella* does not occur, but the larger the areas that become planted, the larger will be the chance that one day some spores are catched. As LANGFORD (1953) states: "windborne spores can be expected eventually to spread the disease over the whole continent". For that reason no susceptible material should be planted in the São Paulo area and the same choice should be made as recommended for South Bahia.

Planting of three component trees (a high yielding panel clone top-budded with a resistant crown) does not provide a practical solution, owing to the fact that such crown-buddings have a detrimental effect on yield. The highest producing resistant clones have in general a less depressing effect than the lowest yielding types. But it is preferable to use the first ones as single budgrafts because of simplicity and of better yields than to use them as crown-buddings on Eastern tapping panel clones.

To establish rubber plantations in Brazil at this moment, a choice must be made from the following material:

1 Highly resistant clones, but re the performance of which only very limited information is available (like FX25, FX3844, IAN710, IAN873);

2 High yielding Eastern clones which are tolerant (limited resistant, like PB86, AV1301);

3 Seedling plantations of selfed PB86 and AV1301, which as a whole also show a certain resistance.

Unless the problem of South American Leaf Blight (*Dothidella ulei*) can be solved in a practical way, rubber growing in Brazil will be a risky adventure. But notwithstanding all the work carried out in connection with the control of this disease, it remains difficult to put natural rubber production in Latin America on a safe footing.

This article describes the best ways to accomplish this, with the present knowledge and the author's experience in recent years.

1) Received for publication June 5, 1959.

I SYMPTOMS, SPREAD, CONDITIONS AND LIFE CYCLE OF *Dothidella ulei*

STAHEL (1915, 1916, 1917, 1919) in Dutch Guiana was the first one who gave a complete description of the fungus and its behaviour; in 1924 RANDS published a full account of the disease and its spread at that time, whereas in recent years especially LANGFORD (1945, 1953, 1955, 1956, 1957) has contributed much to a full understanding. *Dothidella ulei* only attacks species of *Hevea*. All very young growing tissues above the ground are subject to such attacks. Very common is the infection of young leaves. The length of the period that leaves are susceptible depends on the resistance of the clone and the conditions influencing "aging" of the leaves. With cool wet weather the leaves of a non-resistant clone may be subject to infection until they are 3–4 weeks old, but the leaves of a semi-resistant clone under the same conditions may become immune already within one week and those of a non-resistant clone may also reach immunity after one week when they develop and age rapidly in a hot dry climate.

Heavy attacks cause complete defoliation. Two to three successive defoliations kill a young rubbertree; a few more defoliations kill an old one. Infection of growing shoots and leaf petioles of susceptible clones causes die-back.

Conidial, pycnidial and ascigerous stages of the fungus are known; lesions may be incited by the first two stages. Conidia play the main role in the intensifying of the disease; ascospores are important for air-borne spreading over long distances. When a conidium germinates on a susceptible leaf and penetrates into the tissue, the lesion caused may produce millions of spores already after one week. When the leaf remains alive on the tree, sporulation will be extremely abundant for several weeks. This makes multiplication very rapid and heavy. Sporulation will become scarce after 2–3 months and at last it will cease completely.

Conidia and ascospores exposed to wind and sun remain partly viable for 7 days and more; when travelling on wind currents they will thus be able to infect rubbertrees hundreds of miles away. But the disease is not carried by the mature seed, because spores are not able to penetrate and develop lesions on the hard seed coat; this explains why in this way this disease was not carried from the Amazon to the Far East.

When *Dothidella ulei* is present, leaf blight severity is mainly determined by two factors: the climatic conditions and the situation of the host (immunity, density, age, etc.).

Climatic conditions. A moist period of at least 8 hours is required for the spores to germinate and to penetrate into a leaf; with 10 hours of 100% humidity the number of infections is highly increased. Dew, fog or drizzles offer much better conditions for infection than heavy rains. In practical all tropical areas suitable for rubber growing such humid periods occur frequently especially during the nights. In exceptional cases regular breezes shorten the period of dew formation. An example is "Non Pareil" Estate in Trinidad, exposed to constant sea breeze and the only plantation where rubber survived on that island. Susceptible clones on the river banks at "Belterra" (Amazon) probably survived for the same reason.

The influence of temperature on the virulency of the disease shows to be of little importance within the range where rubber grows well. Below the optimum temperature for the fungus (24°–28° for germination and growth) also the growth of rubber is retarded, with the consequence that the period during which the new leaves are susceptible becomes extended.

Condition of the host. The intensity of disease development depends also on the concentration of inoculum and the opportunity for its spread. Both are very limited in a dense tropical jungle, with here and there a scattered rubbertree. This explains why in the natural growing conditions of the Amazon varzeas susceptible rubbertrees survive, although climatic conditions are extremely favourable for the disease. But when planted as monocrop in the same area similar trees are destroyed.

The establishment of plantations in the Western Hemisphere during the past decades has been the cause of the extensive spread of this disease, which according to RANDS in 1924 only occurred in the Amazon valley and adjacent countries (Guianas and Trinidad). But with the establishment of plantations since then it spread to the whole continent from Mexico to Bahia (Brazil). And now that rubber plantations are developed in São Paulo, it is just a question of time to appear also there.

Very important is the density of susceptible young foliage. In a new plantation up till 1½ years old this density is rather low, but with the formation of the crown during the following 3–6 years the amount of young leaf flushes increases enormously (from one to several hundreds per tree) and moreover there is an abundancy of such leaves all the time. This creates optimum conditions for the disease to intensify; those years of intensive branch formation are the most critical period for the tree regarding *Dothidella ulei.* For the same reason conditions for the disease are very favourable on nurseries. After reaching maturity new flushes become mainly limited to one annual leaf change period ("wintering"); under those conditions the severity of the disease declines.

Immunity and a high grade of resistance to the disease also strongly limit the possibilities of spore production. Much work has been carried out by the Americans to select resistant rubber types. This work is not yet completed, as far as combining immunity with high yield is concerned. Although there is at this moment not sufficient experience with these new types to recommend them for planting on a large scale, regular progress is being made.

A standard of classification for resistance is based on two practical principles, viz. 1) resistance to leaf damage and defoliation and 2) partial or even complete inhibition of fungus sporulation.

Regarding this first principle a moderate spotting of the leaf has no serious consequences on growth and production; it is like a mild attack of mildew in the Far East. But it is of prime importance, that under favourable conditions for the disease *no defoliation and no destroying of the main growing point occurs.*

Regarding the second principle: inhibition of fungus sporulation as a consequence of resistance reduces the amount of inoculum and facilitates the control of the disease.

An important factor that must be taken into account is the variability of the fungus: there are different strains and sometimes the rise of a new and more virulent strain has been recorded. The ascigerous stage of the fungus may open possibilities of hybridization; mutation is another possibility.

Does this mean that even after developing highly resistant types rubber growing will remain a venture? I do not think so. The immune and highly resistant clones are as a rule all characterized by a type of thick shining leaf, resistant to leaf fungus diseases in general, *Phytophtora* included. And in no case a new strain proved to be more virulent to *a whole range* of components of a Hevea population (LANGFORD and TOWNSEND, 1954). The only advice has to be: do not plant one clone; and this advice also applies for several other reasons.

Breeding of resistant, high yielding clones offers the best possibilities for future successful rubber growing in Latin America; for that reason this is the main subject of this paper.

2 TOP-BUDDING OF BLIGHT-RESISTANT CROWNS ON HIGH YIELDING EASTERN CLONES (THREE-COMPONENT TREES)

Hevea selection work carried out in tropical America has resulted in a number of resistant and a few immune types. Selection in *H. benthemiana, H. spruceuna* and in *H. brasiliensis* has provided us with clones showing resistance to *Dothidella ulei*. These *brasiliensis* clones are listed under letter F. A selection on resistance carried out in progenies of crosses of high yielding Eastern clones to highly resistant *benthemiana* and *brasiliensis* clones got the letter FX, when this work was carried out at Ford plantations and the letter IAN when it was executed at the Instituto Agronomo do Norte at Belem (Pará). Part of these selections were back-crossed to their high-yielding Eastern parent and these progenies also were numbered with FX.

The first attempt at establishing commercial plantations resistant to *Dothidella ulei* has been to top-bud resistant F and FX selections as crowns on high yielding Eastern panel clones. But it turned out that this system does not solve the practical problem because of the following facts:

1 The resistant crown buddings used have a highly depressing effect on the yield of the Eastern panel clone.

2 Because of the susceptibility of the Eastern clones it is impossible to grow up a regular planting in the field up till the moment that top-budding must be executed (at approx. 3 metres height) with a resistant clone.

3 Transplanting of three-component trees from a nursery, where the susceptible panel clones can be effectivily treated with fungicides until the moment of top-budding, results in a high percentage of failures, thus also leading to incomplete and irregular plantations.

Whether executed in one way or the other (the methods mentioned under 2 or 3), very irregular plantations are the result, which has a very depressive effect on yield per hectare. Although these facts are not yet fully realized by all the American rubber extension workers, BEERY (1957) came to the same conclusion: "The success of top-budding operations in small farm plantings has been extremely unsatisfactory. The overall result to date is that small farm plantings are very irregular."

Well managed large rubber enterprises might be able to organize the method, mentioned under point 3 in a better way, but as regular rainfall is needed after transplanting high three-component trees, it remains a risky system. But even if one would have luck, then the depressing effect of the top-budding on yield would remain, which would spoil the commercial success.

3 The depressing effect on yield of blight resistant crown buddings

In February 1952 I visited the Goodyear rubber plantations "Speedway" at Cairo (Costa Rica), approx. 1000 hectares planted with Eastern panel clones, top-budded with resistant clones. Although this was done in the early days of the three component tree, it had been carried out in the best possible way by Bangham, an experienced rubber expert from Sumatra. There was an uneasy feeling about the yield and I got the first shock when I learned that the average production was lower than that of an old unselected seedling plantation in the Far East. Since then production has remained disappointing and the estate is now being replanted.

In order to study the effect of resistant crown buddings on the yield I have gathered production figures of top-budded and of the same non top-budded Eastern clones, grown in Latin America. Yield figures of non top-budded non resistant Eastern clones are only available from a few places in Latin America before *Dothidella ulei* affected the area and at that time there were no three-component clones of the same panel clones in tapping in that area. So those yield figures had to be taken from other areas. This makes exact comparisons impossible, but as the differences are very large and always point in the same direction, it fully explains the disappointing experience at "Speedway" Estate.

In table 1 I brought together all the summarized yield figures; in table 2 and 3 the detailed figures are given for the clones Tjirandi 16 and AV49 as examples to show how I arrived at these summarized results.

Table 1 Comparing yields of Eastern clones, top-budded and non top-budded with resistant crowns.

Average yield per tree per tapping in grams dry rubber; tapping system S/2, d/2

Panel clone	Third tapping year		Fourth tapping year		Reference Langford published in
	top-budded	non top-budded	top-budded	non top-budded	
Tjir. I	17.6	31.0	–	33.5	1957
Tjir. 16	11.0	28.9	10.8	28.9	1956 I, 1957
AV49	10.1	19.6	13.4	21.0	1956 I, 1957
AV255	17.0	–	16.0	26.4	1957
AV264	17.0	19.2	–	23.8	1956 I, 1957
AV1279	15.4	22.6	16.3	32.6	1957
AV1301	16.2	20.5	17.0	21.1	1957
AV1350	19.0	28.6	–	25.5	1956 I, 1957
AV1518	17.3	25.5	20.4	–	1956 I, 1957
AV1581	17.1	31.9	17.4	40.9	1957
GT711 *)	10.5	23.5	–	36.5	1957

*) Goodyear clone.

2) All rubber clones from Java received in Latin America the letter CV.

The detailed yield figures for Tjir. 16 (GV31) [2]) are:

Table 2 [3])

	Third tapping year		Fourth tapping year	
	top-budded	non top-budded	top-budded	non top-budded
	(LD13) 11.8 (707) (LD10) 9.4 (77) (T8) 10.5 (27) (LD) 7.4 (186) (B) 10.4 (21)	(ER3) 23.5 (4) (ER4) 31.1 (19) (B) 25.0 (10) – –	– 9.8 – – 13.3	25.1 – 30.0 – –
Average	11.0(1018)	28.9 (33)	10.8 (98)	28.9 (14)

The detailed yield figures for AV49 (GA49) are:

Table 3 [4])

	Third tapping year		Fourth tapping year	
	top budded	non top-budded	top-budded	non top-budded
	(T) 13.3 (46) (LD9) 13.2 (97) (LD12) 7.4 (188)	(D) 18.2 (27) (ER4) 18.7 (31) (ER3) 22.2 (5)	– 13.4 –	20.5 – 23.9
Average	10.1 (331)	19.6 (63)	13.4 (97)	21.0 (32)

The depressive effect on yield amounts to 30–65% and this could be expected in view of the results obtained in the Far East when top-budding with low yielding rubber. Lasschuit and Vollema (1952) demonstrated this depressing effect on the yield of the tapping panel clone when it was top-budded with a mildew resistant but rather low yielding *brasiliensis* clone (LCB870).

4 Is there a close relation between the production of the top clone used and the effect on yield of the panel clone?

A basic experiment carried out in Java (Indonesia) indicates that the lower the production of the top clone, the more the yield of the panel clone becomes depressed. The summarized data of this experiment, published by Ostendorf (1948) are given in table 4.

We might perhaps prevent the depressing effect on production by using the highest yielding resistant top clones. In this connection I paid several visits

[3]) The numbers in parentheses behind the production figures refer to the numbers of trees tapped, on which the yield figure is based. The letters before the production figure refer to the trials, viz.:
LD = Los Diamantes, Costa Rica; LD 9, 10 or 13 are tests 9, 10, 13 at LD; Langford (1956 and 1957).
B = Belterra, Brazil; Langford (1956).
T = Turrialba, Costa Rica; Langford (1957).
ER3, ER4 = Exp. 3 and 4 at Entre Rios, Guatamala; Langford (1957).
D = Divisa, Panama; Langford (1957).

[4]) All rubber clones from Sumatra received in Latin America the letter GA.

Table 4 Effect of differently yielding top clones on the average production of three *brasiliensis* clones (AV36, CT88 and BR2) used as tapping panel. (Tapping system S/2, d/3)

The 3 *brasiliensis* clones were top-budded with	Average production in grams per tapping of panel clone	Production in grams per tapping of each of the top clones used
Brasiliensis (own top)	27.4	27.4
Confusa	20.4	10.7
Collina	11.1	2.7
Guianensis	8.7	0
Spruceana	7.0	0

to tests 12 and 13 at Los Diamantes, Costa Rica and I studied the detailed data, which were put at my disposal by the courtesy of the U.S. Department of Agriculuture in Washington D.C.

In field trial no. 13 Tjir. I, Tjir. 16, AV255 and Sabrang 24 are top-budded with 22 different clones resistant to *Dothidella ulei* and they are grown and tapped in comparison with one non-resistant clone F1619, see fig. 1.

Fig. 1 8 years old rubber; trial 13. Los Diamantes, Costa Rica.
At right: susceptible clone F 1619 (stunted). Same age as plantation at left.
At left : Tjirandji 1 as panel clone, top-budded with resistant crown (healthy, but too heavy crown, too dark plantation).

From the detailed figures at my disposal regarding the second tapping year it becomes evident that all these 4 tapping panel clones give better yields with IAN873, FX590 and FX614 than with FX475, FX664 and FX1042 as crown buddings; see table 5.

Table 5 Order — re effect on production — of 6 clones used for top-budding on Tjir. I, Tjir. 16, AV255, Sabrang 24.

	Clones used as tapping panel			
	Tjir. I	Tjir. 16	AV255	Sabrang 24
Used as crown : IAN873	nr. 5	nr. 1	nr. 2	nr. 3
,, ,, ,, : FX590	,, 3	,, 2	,, 6	,, 4
,, ,, ,, : FX614	,, 4	,, 7	,, 1	,, 5
,, ,, ,, : FX1042	,, 19	,, 21	,, 17	,, 20
,, ,, ,, : FX475	,, 17	,, 20	,, 18	,, 21
,, ,, ,, : FX664	,, 21	,, 10	,, 19	,, 18

From test 12 at Los Diamantes in which the yield of IAN873 and FX1042 can be compared, we learn that the first one is the highest producer; from the other 4 FX clones I could not find production figures with their own tops.

But a comparison in this respect is possible with two other FX clones, see table 6. (Data from test 12 and 13 at Los Diamantes; reference LANGFORD (1956).

Table 6 Yield in grams per tapping (S/2, d/2) in third tapping year

The following clones with their own top produce :		Average production of tapping panels of Tjir I, Tjir. 16, AV255, Sabrang 24 when the clones mentioned in the first column are used as crown buddings :
FX2261	22.1 (15)	18.7 (107)
IAN873	24.2 (12)	17.3 (112)
FX1012	9.1 (13)	14.7 (103)
FX1042	16.5 (15)	12.1 (110)

(The numbers in parentheses represent the number of trees, on which the average production is based).

There exists a tendency for crown buddings to depress the yield of a tapping panel clone more when they have a low than when they have a high production capacity. But the relationship between the two components is much more complicated and other interactions may also play a role.

This can also be observed in the field: Tjir. 16 for example stands top-budding worse than AV49; special combinations grow extremely well together; certain clones used as crowns cause much breakage, etc.

An important practical conclusion can be drawn, however, viz.: *if a clone is resistant and high yielding it is preferable to plant it as single budgraft and not to use it as crown on a non-resistant high yielding clone.* That will give higher yields (see table 6, production of IAN873) and it will avoid all the disadvantages of three component trees.

5 SINGLE BUDDED CLONES, TO BE RECOMMENDED FOR PLANTING ON A COMMERCIAL SCALE UNDER VIRULENT DISEASE CONDITIONS LIKE THOSE PREVAILING IN THE AMAZON VALLEY

At the moment there does not exist enough experience to enable to recommend a few universal and superior rubber clones, which are sufficiently resistant to *Dothidella ulei* and which at the same time have a production capacity comparable with modern planting material in the Far East and West Africa. In my opinion we must make our choice out of two groups, viz.:

a *Tolerant Eastern clones:* PB86, AV1301 (AV1279, AV1126), good producers, but with limited resistance to *Dothidella ulei.*

b *Resistant FX and IAN clones,* but most probably with limited production capacity.

They are safe as far as resistance is concerned, but there is unsufficient experience with these clones re production and secondary characteristics. As a whole their level of production will be lower than that of the clones mentioned under point a). They are selections from a progeny of which LANGFORD and TOWNSEND (1954) state, that "a very small percentage of the F. selections has indicated promising yields". They represent a progeny with a low production level and the best selections will for that reason not be able to compete with the yield of that group of superior Eastern clones so carefully selected and so widely tested in the course of the last 45 years. The risk with he FX and IAN groups is therefore: disappointing yield. Because of the extremely limited experience with these clones a rather wide choice should be made.

It is partly a question of gambling and partly a question of climate to which of the two groups one will give preference. As far as climatic conditions are concerned, it seems practical to distinguish between a climate where *Dothidella ulei* is very virulent and a climate, where the disease is rather mild. *In the virulent Dothidella climate* it is very wet the whole year, and no dry spell checks the development of *Dothidella ulei* for a while. Under those conditions also other rubber leaf diseases like *Phytophtora* leaf fall thrive. In the Far East this *Phytophtora* leaf fall is very rare; I saw it only on the Southern slopes of the high Smeru volcano at approx. 600 metres above sea level, where it is very foggy and where a dry season is lacking. But in Latin America *Phytophtora* leaf fall is common on the Atlantic Coast of Costa Rica and also in the Amazon valley (LANGFORD, 1953). Under such conditions it was necessary to select rubber not only resistant to *Dothidella ulei* but to *Phytophtora* leaf fall as well and then one is forced to give preference to resistance over yield. There is

Table 7 Yield figures of a number of cross-pollinated progeny clones (grams per tapping with S/2, d/2 tapping system).

Clones	Tapping years					Average based on how many trees	Location (for explanation see table 2)
	3rd	4th	5th	6th	7th		
[1] FX25	18.7	27.2	35.7	36.5	28.5	3	Belterra
[1] do.	14.6	–	–	–	–	4	ER
[2] FX3844	20.1	26.8	32.7	–	–	2	Belterra
[2] IAN710	23.7	35.7	–	–	–	4	ER
[2] do.	13.3	–	–	–	–	14	LD
[1] IAN873	24.2	–	–	–	–	12	LD
[1] do.	15.3	22.2	–	–	–	4	ER
[2] IAN713	15.3	–	–	–	–	13	LD
[2] do.	18.7	26.7	–	–	–	4	ER
[2] FX3846	18.2	24.6	22.1	–	–	4	Belterra
[1] FX3810	12.2	17.1	21.0	21.6	19.3	4	Belterra
[2] FX3925	11.1	12.7	18.6	18.7	–	4	Belterra

[1] Reference: BEERY (1957).
[2] „ : LANGFORD (1956 I).

only a very limited information available re these FX and IAN clones; re their secondary characteristics (breakage, conditions of tapping panel, bark renewal) even less is known. In table 7 yield figures are given of clones belonging to those very resistant ones, which may be taken into consideration for conditions like they are prevailing in the Amazon valley.

It will be clear, however, that this information is far too limited (only yield figures from 2–14 trees at only one or two locations) to allow a decision for planting on a large scale. Re secondary characteristics there are even less indications. *IAN873*, according to Beery (1957) is a vigorous grower in Guatamala as well as in Costa Rica, its tapping panel is clean and bark renewal is good.

Fig. 2 An example of a fully resistant cross-pollination progeny clone (FX3925), Oriboca, Belem; 3 years old. Tendency to build too dark crown is already perceptible.

I can fully confirm this; I consider it as a tree with very good properties: a not heavy crown, which allows a rather dense planting distance. Other clones of this group often possess too heavy and too dark crowns (disadvantages are too dark plantations for any covercrop to grow, with the consequence: erosion; only a limited number of trees per area; often breakage). Production of IAN873 seems reasonable (see tables 5, 6, 7).

With *IAN873* I should plant in the Amazon valley at this moment, with the information available, rather large areas.

FX25 is not making a bad impression. *FX3810* has good secondary characteristics (Beery, 1957).

FX2261 belongs to this group of resistant clones, yield indications are reasonable, but secondary characteristics make it an impossible tree for commercial plantings (very knotty bark, difficult to tap, trees incline).

I should also include for planting on a limited scale: *AV1301* and *PB86*, to be dealt with in the next paragraph.

At the time that one should have to make his choice in the Amazon area, it seems advisable to study the latest yield figures available, to judge the secondary characteristics of those clones which have the best yield figures in all the locations where they are planted. And then to divide the risks (as a consequence of present insufficient experience) over some 5–10 different clones. Then there remains the point from which clones reliable budwood is available; this will also influence the ultimate planting program.

6 SINGLE BUDDED CLONES TO BE RECOMMENDED FOR COMMERCIAL PLANTINGS UNDER MILD DISEASE CONDITIONS, LIKE OFTEN PREVAILING IN BAHIA ANR SAO PAULO

In the areas of South Bahia and in the coastal area (the "litoral") of São Paulo climatic conditions are less "wet" and the virulence of the disease will

a 1958, 2½ YEARS OLD : HEALTHY.

b 1959, 3 YEARS OLD : DOTHIDELLA ATTACK.

FIG. 3 CLONE AV 1301 AT ORIBOCA, BELEM (PARÁ).

be "milder' than in the Amazon valley. It is true, that at the moment *Dothidella ulei* is not present in the area of São Paulo, but conditions there are favourable enough for the development of the disease (see paragraph 1). With our recent experience of the spread of the disease through the whole continent of Latin America, after rubber plantations had been established, it seems just a question of time that São Paulo becomes infected and I want to repeat LANGFORD's warning (1945): that "large plantings of susceptible trees have eventually been ruined in all localities". For that reason in Bahia as well as in São Paulo only the planting of *resistant* rubber clones is acceptable. But under those climatic conditions it is acceptable lay a little more weight on production than on highest resistance.

AV1301 seems a very attractive clone under these conditions. There are plantations of 14 years old trees near Uruçuca (Bahia) that produce well (at least 1000 kg/ha with S/2, d/2) and suffer little from *Dothidella ulei*. The tree has a light crown and it will be possible to plant 450–550 trees per hectare (e.g. in 4½ metre triangle system). This clone also reacts favourably to the use of

14 months old : Una, Bahia.

3 years old : Oriboca, Belem (Pará).

Tappable plantation ; Mucambo (Bahia).

Fig. 4 Clone PB86. Good resistance to Dothidella ; not too heavy crowns.

yield stimulants (experience at Mucambo, Bahia) and it will be possible to reach a production of 1200–1600 kg per hectare. From what I have been in successive years, under different conditions, I have come to the conclusion that at present *AV1301 can be recommended for planting on a large scale in areas like South Bahia.*

Hoedt (1953) published a photograph taken in the garden of the Instituto Agronomico do Norte at Belem (Pará), of the "highly resistant Hevea-buddings of clone AV1301, 8 years old". Since then I have seen these AV1301 trees in that garden in 4 successive years and under severe *Dothidella* conditions, but they always showed a good leaf canopy. On "Oriboca"-estate near Belem I have also observed this clone several times the last 3 years. Only recently it suffered from a severe attack (fig. 3b), which is a warning that under very virulent conditions of climate and in a susceptible stage of development (crown formation) this clone is not 100% safe under Amazon conditions and there it should only be tried out on a limited scale.

PB86. This seems to be a very attractive clone for mild *Dothidella* conditions like in Bahia and São Paulo. Plantings of PB86 of different ages up till 14 years old in the Bahia area make a resistant impression (see fig. 4a, c). Young plantings at Oriboca show at present reasonable resistance but whether this clone will show to be safe at all ages and when planted in large blocks under the virulent Amazon conditions remains to be seen.

In the Bahia area I have observed this clone in several locations at different ages and in several years and like AV1301 at the moment this clone can be recommended for planting on a large scale in Bahia and São Paulo. It belongs to the top producers in the Far East and it is planted on large areas in Malaya and Sumatra. It is a clone with good secondary characteristics; also in Bahia production is satisfactory (over 1000 kg/ha).

AV1279 and AV1126. These Eastern clones, especially AV1279 with a high production (see table 1), show some resistance to *Dothidella ulei,* but less than AV1301 and PB86. These clones should therefore not be used in the Amazon valley and in Bahia and São Paulo they should only be tried out on a limited scale.

In the last two areas planting on a limited scale of the best producing

Fig. 5 Mist-blowing Cobre-Sandoz, which controls Dothidella effectively. Nursery, Oriboca, Belem (Pará).

5 months old progeny of AV 1301 ; little affected by Dothidella.

20 months old. In front ; tall seedlings AV 1301 ; behind and one in front of man's trousers : stunted, susceptible seedlings of same age.

Fig. 6 Legitimate seedlings of AV 1301 ; they show resistance to Dothidella ; at Mucombo, Bahia.

highly resistant IAN and FX selections might be considered, and in the first place *IAN873*.

7 The planting material to be used as rootstock. Plantations of clonal seedlings

As the author (1941) demonstrated in Indonesia, high yielding clones need high yielding rootstock, otherwise production is depressed.

Where *Dothidella* is present it will be an advantage when the rootstock also shows resistance to *Dothidella*. Otherwise intensive disease control is necessary up till the moment of base budding. On nurseries, as a consequence of close planting distance and constant formation of new leaves, it is quite a problem to control *Dothidella ulei* when using susceptible seedlings. Alternately daily mist-blowing with 2% Cobre-Sandoz proved to keep the disease even in the Amazon Valley under reasonable control (see fig. 5), but this means much work and expenses.

Some years ago I was struck by the fact that in a monoclonal plantation of AV1301 at Mucambo, Bahia, seedlings germinating under the trees developed in such way that annually a cleaning of grown up seedlings was necessary. After that observation seed of AV1301 from a monoclone block was laid out on a seed bed in comparison with seed from a mixture of susceptible *brasiliensis* trees. The AV1301 seedlings showed for the greater part a good resistance, they developed faster and did not need fungicidal treatment under the conditions prevailing at Mucambo, Bahia. Without fungicidal treatment the *brasiliensis* seedlings never reached the transplanting stage (see fig. 6).

Also the progeny of PB86 grows faster and shows resistance. *It is advisable to use AV1301 and PB86 seedlings as rootstock,* whereever this clonal seed is available in Latin America.

We may even go one step further and pose that it will be worth while to try out the progenies of legitimate AV1301 and PB86 families, non-budded. They might show a reasonable production. Especially for small farmers seedling plantations would be much easier to establish than single-budded plantings. They also become earlier tappable. By dense planting and thinning out on yield, production might not be less than of the best clonal plantations. Besides that in such progenies selection on resistance and yield might result in attractive new clones for commercial plantings.

8 Plantation technique

A few words should be said about plantation technique in connection with the planting material described in this article. As a matter of cause only planting as *monoclonal* blocks can be advised. Different clones mixed together always hamper each other.

The number of plants to be set out per hectare for clonal plantings should be 450–550; a somewhat larger number on less good soils. Seedling plantations should be started with more plants than clonal plantations, because more selective thinning out will be advisable there (larger variation in production).

The important point of the *planting system* needs more discussion.

Generally speaking the more regularly the rubbertrees are distributed over the area, the better and the more efficient the root and leaf system will be albe to make use of the total space. The more regularly distributed the faster they will grow, the earlier the plantation will close, the cheaper will become the weeding, the earlier the plantation will become tappable and the higher will be its yield. In Belgian Congo, EVERS (1954) studied the subject also in connection with expenses and revenues and his conclusion is, that the more irregular the planting system, the lower the production and the less the nett profit: "Les dispositifs de plantations de heveas en ligne équidistances donnent les meilleurs rendements à l'hectare et offrent les prix de revient les plus bas".

TAN HONG TONG (1956) found the same in Indonesia, he rejects the hedge-system and concludes: ".... 200 trees per acre in a quadrangular system is far from equal to planting the same number of trees in a hedge system".

Theoretically the triangular system is better than the quadrangular, which is superior to the rectangular system, but the hedge system is least efficient of all.

It is true that there are sometimes circumstances which make it impossible to use the most efficient planting system, e.g. because the triangular system is too difficult for the local labour, or because the terrain is too hilly and because of erosion it is preferable to plant in a contour system. In certain cases after felling the forest there is too much timber to allow a triangular or rectangular planting system. Hedge systems are necessary when we want to make mixed plantings. But we should realize that this is not the ideal pattern for a pure rubber plantation, and it was strange enough to find that in Brazil hedge systems with 7 metres distance between the rows have been recommended. I have tried to find out from where this idea was introduced. Not from experience in Brazil, because there is none. It ultimately came back to DYKMAN (1951). But the hedge system he describes was a system in use for mixed plantings with coffee. The 7 metres distance between the rows came from the pre-war "Rubber Restriction Regulations" in the Far East! [5]) DYKMAN states that: "For mixed plantings it was permissible to plant the rubber "rows" (hedges) on a hectare 7 metres wide" (Decree Rubber Restriction Regulation).

When one wants to aim at maximum production and maximum nett revenues, however, hedge systems are not the right approach.

A covercrop like Kudezu (*Pueraria*) takes all weeds excellently under control (fig. 3a). The following should however be kept in mind. I clearly demonstrated in Indonesia, that up to the moment a rubber plantation closes in *all* plants between the rubber cause heavy root competition and retard growth of rubber considerably. As soon as the rubber has closed in, the transpiration of the covercrops is reduced so much (no direct insolation) that there is no further root competition of any importance. In a closed rubber plantation a covercrop is a definite advantage (preventing erosion); in an open young plantation reduction of the covercrop as far as allowable will speed up growth, closing in and tappability of the young plantation.

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[5]) Rubber hedge systems up till 7 metre distances got the full licence; they were from the point of view of the "Rubber Regulations" considered as 100% rubberplantings.

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