

Production Figures for Hybrid Cocoa Progenies Tested at
L.A.E.S. Keravat (Kg dry beans/ha)

Seedlings were planted in the field ex nursery in November 1973.

Cross	1975/76	1976/77	1977/78	1978/79	1979/80	TOTAL
K21 x KEE 40	1977 ¹⁷⁷	962	1607	2029	1674	6449
x KEE 51	219	584	734	1421	1470	4428
x KEE 2	310	1258	1699	2507	2619	8393
K24-103xKEE 40	153	744	871	1452	1814	5034
x KEE 34	135	720	985	1428	1497	4765
x KEE 52	320	1197	1169	1723	1607	6016
K20 x KEE 40	375	1282	1354	2047	1783	6841
x KEE 5	511	1417	1683	2937	2326	8874
x KEE 19	162	768	497	755	1207	3389
KA2-105xKEE 51	311	877	1221	1565	1440	5414
x KEE 34	173	800	1382	1629	1356	5340
x KEE 5	466	1576	2269	2940	2369	9620
KA2-101xKEE 51	516	1192	1298	2002	1951	6959
x KEE 51	475	1423	1589	2501	1910	7898
x KEE 19	300	1386	1607	2537	2087	7917
KA5-104 xKEE 2	101	801	850	1564	1836	5152
x KEE 34	263	781	538	1126	1441	4149
x KEE 19	190	738	349	948	1287	3512
KA5-201 x KEE 2	540	1198	1678	2911	3027	9354
x KEE 52	335	902	1339	2046	2006	6628
x KEE 5	928	1683	1766	2852	1691	8920
MEAN	331	1061	1192	1949	1828	

(1962)

production. First the 4.57 m spacing, then the 5.23 m spacing ⁽¹⁹⁶³⁾ produced about as much as the 3.66 m spacing in one year. To the end of seven years' production the ~~closest~~ ^{densest} spacing produced the most cocoa. Whether the extra production would be economic is debatable as the 3.66 m spacing would involve greater inputs in marking out, nursery, planting out, weeding, dieback control, early fertilizing, etc. It would require less early maintenance of ground growth because of the quicker canopy cover, there would be no real need for replacing misses & the canopy would be less likely to be broken by tree deaths. These factors weigh heavily in its favour.

B. KTC 4-2. Hedge Spacing Trial

An addendum to KTC 4 was a hedge spacing trial of two spacings, 7.32 m x 1.83 m and 5.49 m x 2.44 m. This was planted about 12 months after KTC 4. In the first 5 years of bearing the ~~best~~ ^{best} of these densities produced a total of about 3900 kg of dry beans/hectare, compared with 5200 kg/ha for the 3.66 m triangle spacing in KTC 4. As well as this yield disadvantage the hedges took longer than the closest triangular plantings to form a complete canopy. Thus, there is no reason to think that

there is no obvious advantage of hedge planting over triangular plantings but two disadvantages, namely lower production & higher maintenance costs resulting from slower canopy closure.

* C. KTC 4-3. Close Spacing Trial. (SEE NEXT PAGE)

RD KTC 6 Spacing x bearing trial with cuttings.

Five three triangular spacings (2.74 m, 3.51 m & 4.27 m) and two hedge spacings (5.49 m x 1.83 m and 5.49 m x 1.22 m) were tested on a single cultivar ~~selection~~, KAS-104, grown from cuttings. The highest yielding treatment produced 11% more

Wasa over the first seven years of bearing than did the worst treatment but, as variability was high, there were no significant differences. Absolute yields were low because of low soil fertility. It is felt that differences may have been detected ^{had} ~~with~~ other selections, ^{been used,} KAS-104 is a high-yielding selection of medium vigour. It is thought that vigorous selections which eventually grow into very large trees would produce more, over a period of several years, at a wide spacing than at a close spacing.

REVISION PAGE

* C. KAC-3 Closer Spacing Trial.

As the closest spacing in KAC-1 had been the highest productivity it was decided to test even closer spacings. KAC-3 comprised ~~two hedge~~ six treatments, detailed in Table #.

Table . KAC-3 treatment details.

Actual	Metric equivalents	Trees/hectare
		1940
8 feet triangle	2.44 m	1940
10 feet triangle	3.05 m	1240
10 feet triangle, ^{two} trees	3.05 m	1240
two trees		860
12 feet triangle	3.66 m	860
→ 18 ft. x 8 ft. hedge	5.49 m x 2.44 m	1104
↘ 15 ft. x 7.5 ft. hedge	4.57 m x 2.29 m	946

The portions in this trial were planted at state ^{illegitimate} ~~with~~ seed in March 1962. Production commenced in February 1965 but, even at that stage, damage from vascular streak ~~debil~~ dieback had been significant. This damage increased & the trial was

abandoned in ~~1966/67~~ 1966. The ~~17~~ 17 months production to June 1966 indicated increasing yields with increasing ^{tree density} up to the 3.05 m triangle (1240/hectare) and then a decline at the 2.44 m triangle spacing. These results did not quite attain statistical significance at the 5% level.

D → (SEE PAGE 2).

E. Koc 11. Shade x Spacing x Fertilizer Trial

Three triangular spacings were compared at under two shade regimes & three fertilizer treatments. The spacings were 2.76 m, 3.43 m & 4.42 m. Seed was planted at stake in July-August 1962. Vascular-streak dieback was a problem from the early years & one section of the trial was abandoned by age 3 years. The whole trial was abandoned in 1967 because of continuing dieback damage.

The only conclusion from the trial was that the 2.76 m triangle was too close as inter-tree competition began before the trees commenced bearing. (Quote figures)

F → (See over page).

G. Koc 46 Vigour x Spacings Trial (Cuttings)

A number of selections which on the resistant end of the scale in Koc 3 (Cuttings Resistance Trial) were of low vigour. It was thought desirable to compare their performance at higher than normal densities with vigorous selections at normal densities and lower than normal densities.

Five clones were selected to represent each of the two vigour classes. The weak clones were planted at 3m x 4m triangles while

the vigorous clones were planted at 4m x 5m triangles. Planting took place in March 1973.

F. Krc 50 Seeding Spacing Trial No. 4.

This was a repeat of Krc 4-3 with two treatment changes. The treatments are listed in Table

Table. Krc 50 treatment details.

Imperial units	Metric units	Trees per hectare
5 feet triangle	1.52 m	4972
8 feet triangle	2.44 m	1940
10 feet -	3.05 m	1240
12 - -	3.66 m	860
15 ft x 7.5 ft hedge	5.49 m x 2.44 m	1105
18 ft x 8 ft hedge	6.57 m x 2.29 m	746

Seed was planted at stake in December 1969 & production commenced in March 1972. In January 1974 when it was obvious that the trees of the 1.52 m spacing were competing strongly with each other, the stand was thinned to the equivalent of the 2.44 m spacing (ie. 1940 trees per hectare).

Production to the end of 1976 is given in Table

Table. KTC 50 ~~total production~~ ^{production} (kg dry beans/ha)

Spacing	1972	1973	1974	1975	1976	TOTAL
1.52 m	72	216	835	745 845	756	2724
2.44 m	143	400	1107	953	954	3557
3.05 m	183	583	1417	1135	1112	4430
3.66 m	123	478	1143	975	964	3683
4.57 x 2.29 m	177	451	1140	957	748	3473
5.49 x 2.44 m	155	599	1270	1140	1074	4238

The 3.05 m triangle ^{was} ~~had~~ consistently ~~been~~ the best producer. The 5.49 x 2.44 m hedge was as good in some years and almost in the others. This apparent ~~even~~ result was largely produced by the exceptional performance of one plot of this particular spacing. This plot was on one corner of the trial & may have derived some advantage from this. Also, the variation in tree performance in this plot was much lower than average & the plot production was thus the result of ~~being~~ all trees pulling their weight.

As this result ~~seemed~~ ^{was} clear-cut ~~the~~ ~~3.05~~ 3m triangle became the recommended spacing for seedling cocoa. The opportunity was then taken to desense

the effect of the removal of "passenger" trees on plot production. All ~~the~~ these trees were those which had been out-competed by their neighbours & were growing beneath their canopies. In March 1977 all such trees were removed from all plots of replicates II & III, the lowest producing of the four in the trial. The selection of these trees was done only on appearance as growers would not have access to individual tree production data and would be able to select passengers on appearance only. On checking the records it was found that the great majority of trees selected for removal were poor producers. Guard trees were included in the removal exercise. The percentage of ~~total~~ ^{total} trees removed varied from 26% for the widest spacing to 48% for the densest, which at the time of thinning was about equivalent to the second densest.

Production by replicates & years is given in Table.

Table . KTC 50 production by replicates and years (~~plots~~ pods/hectare).

Reps	1972	1973	1974	1975	1976	TOTAL	1977	1978	1979	TOTAL
I	751	1271 3559	10659							
IV	370	1716	9177							
II	923	4433	12492							
III	837	3942	11297							

As a follow up to the rates x frequency trial KTC 8 a larger rates x frequency trial KTC 59 was commenced in ~~1971~~ 1973 on a private property adjacent to LAES. Five rates of urea application were included, namely 0, 240, 480, 720 + 960 kg/ha/year. There were 3 frequencies, namely 4, 8 and 12 applications per year.

This potentially valuable trial was terminated in September 1977 when it became obvious that no useful results were to be got from it. The reasons for this included over-fertilizing through the whole trial area at least twice by the plantation labourers; unauthorized collection of pods by the plantation labourers on an unknown number of occasions and poor tree maintenance leading to a rapid decline in their condition.

In late ~~1971~~ 1971 a nitrogen x sulphur fertilizer trial ^{KTC 58} was commenced in Block 506 on LAES. This trial was prompted by leaf analysis data which indicated sulphur contents as low as ~~200~~ ²⁹⁵ ppm in this block, against a tentative critical level of 300 p.p.m. It was suggested that continuous urea applications since 1958 had contributed to ~~the~~ ^{the} low leaf sulphur figures.

The treatments applied were:-

- | | |
|-------------------------------|---|
| N ₁ | 450 g 450 g urea/tree/3 months |
| N ₂ | 110 g 110 g urea/tree/3 months |
| S ₁ | 110 g 110 g sulphur/tree/3 months |
| S ₂ | 28 g sulphur/tree/3 months |
| N ₁ S ₁ | N ₁ + S ₁ |
| N ₂ S ₂ | 3 applications of urea at 110g/tree and one of ammonium Sulphate at 220 g/tree, all at 3-monthly intervals. |

The cocoa in this block was planted in 1949 as a shade x spacing observation and a progeny trial. These treatments plus the age of the trees led to very variable conditions over the block.

In spite of replication the results indicated extreme variability and no conclusions were possible. The trial was therefore terminated in 1973 at the end of 1973.

At first glance it appears that the cultivation treatment has brought about an increase in girth greater than that which occurred in the control plots. However, while 12% of the control plot trees have died over the last three years, 20% have died in the cultivation/no fertilizer treatment and 16% in the cultivation/KCL treatment. This substantial reduction in tree numbers per plot would certainly have produced an increase in girth through reduced competition, and it seems that on balance cultivation had a deleterious effect.

Two treatments which resulted in greater girth increases and lower mortalities than the controls were KC 1 fertilizing and NPK fertilizing plus cultivation. It is unfortunate that there is no nitrogen treatment without cultivation, as on the surface it appears that the nitrogen has had a marked effect on growth despite the setback brought about by cultivation. However, this conclusion is not really valid in the absence of the nitrogen/no cultivation treatment, although it is supported by conclusions drawn by Trinidad workers. Potash has had a beneficial effect leading to lower mortality and greater girth than for the controls. Mortality in the KCL treatment was 8% compared to 16% for KCL plus cultivation and this is also supported by the Trinidad conclusion that fertilizers tend to offset the deleterious effects of cultivation.

Early in 1965, three shade x fertilizer x insecticide trials were laid down on cacao in the Popondetta area. The main aim of the trials was control of caterpillars but fertilizer treatments were included as it was felt that a need for fertilizers may have been created by the removal of shade.

Unfortunately, these trials had to be commenced before yield levels prior to treatment could be established and the interpretation of results is therefore very difficult. There has been no marked response to any fertilizer treatment. It is possible that once yields begin to decline in the no shade/no fertilizer plots trends will emerge from the different fertilizer treatments.

That concludes the account of past and present cacao fertilizer trials. The results of these trials lead to a number of conclusions and recommendations.

1. On the Gazelle Peninsula at least, fertilizers are not required where cacao is grown under Leucaena shade.
2. If cacao is grown under mature coconuts or without shade nitrogen fertilizer will be necessary to maintain yields. Overseas experience and observations in other parts of the Territory indicate that this conclusion would be true of all cacao areas of the Territory.
3. There have been spectacular responses in coconuts on the yellow-brown clay-loams of New Ireland to applications

- of potash, and strong indications also of a response from cacao under the same conditions.
4. Fertilizer should not be forked or ploughed in as any form of cultivation is deleterious to the tree.
 5. Not enough is yet known about frequencies of application to make firm recommendations. However, if the maximum response to fertilizers occurs if they are applied 5-7 months before a flush crop is expected then twice-yearly applications would probably be as effective as applications made more frequently. In this respect it is important to be able to predict flush crop periods. This is best done by reference to the pattern of previous years, taking due notice of the stage of flowering and setting of the trees and of weather conditions. Where a prolonged dry spell occurs a harvest peak cannot be expected until at least six months after good rains fall. The question of frequency of application will be clarified by results from the frequency trial on interplanted cacao-coconuts which was started this year.
 6. The results of the various nitrogen trials so far conducted indicate that, while an application rate of four lbs. of urea per tree per year leads to higher production than does two lbs./tree/year, the extra crop from the higher rate is not sufficient to cover the extra costs involved. The recommended rate of application is two lbs. of urea per tree per year.
 7. It is doubtful whether clearing the leaf litter away from the base of a tree prior to applying fertilizer is a worthwhile practice. Under the high rainfall conditions of most of our cacao-growing areas fertilizers would be washed into the soil relatively quickly even when applied to the top of the leaf litter. Any grass or weeds growing under the trees should be cut prior to application, and, if young seedlings are to be fertilized, e.g. replants through a mature block, they should be ring-weeded.
 8. Fertilizer applications are made on a per tree basis and it is the usual practice to supply labourers with a bucket or similar container and a tin of a size to hold the required amount of fertilizer. Fertilizer densities vary and a tin which holds, say, 1/2 lb. of ammonium sulphate will not hold 1/2 lb. of urea, for example. Where different types of fertilizer are used different containers will be necessary to apply the same weight per tree.
 9. Good placement of the fertilizer is necessary to ensure maximum uptake by the tree and to prevent damage to the trunk or root system. The dressing should be spread as evenly as possible in a band which extends from below the edge of the leaf canopy inwards to a distance from

the trunk which depends on the size of the tree. For a young seedling fertilizer could be placed to within a few inches of the base. For a mature tree no fertilizer should be placed closer than about two feet from the trunk, as a greater concentration of feeding roots would be found some distance from the trunk.

10. Mature cacao lends itself to mechanical distribution of fertilizers as the root-systems of adjacent trees would be interwoven and would exploit the whole of the soil area. However, the largest single cost in a fertilizer programme at present is the cost of the fertilizer and it will be some time before the cost of hand application exceeds that of mechanical application.

DISCUSSION

Mr. J. Dunbar-Reid (Kabanga Plantation, Kokopo)

commented that while he is quite certain that fertilizing is worthwhile economically, he has heard people express doubts about this.

Mr. O'Donohue

Certainly fertilizing would not be economical especially if we have a season like we had last year. You cannot predict seasons. You can take as much notice as you like of the weather conditions, and say that the trees will be slower in fruiting. You can on occasions be sure that you are not going to get a crop but you cannot always be sure you are going to get a crop. Under these conditions in the long term I think it's better if you have a fertilizer programme underway to keep it up. Once again we have a period as we had last year where the price dropped and certainly it doesn't appear economic to fertilize a crop when you only get \$360 a ton for it. In the long term I feel it is better to maintain your programme and consider this fertilizer programme as a long term thing. Rather than a set of yields in any individual year consider the totals over a number of years and I'm pretty sure you'll find that overall fertilizing economic.

Question

Is the peak production decided seven months beforehand in relation to the fertilizer application?

Mr. O'Donohue

You won't get any peak production due to fertilizing unless you're going to have a flush five to seven months later. The effect of fertilizer is on flower production and often a reduction in cherville wilt, but if you apply fertilizer five to seven months beforehand and the flush does not occur (this you can't predict accurately) under these conditions you won't get a big crop. You get a crop but not a good one.

Question

If you get a peak in production and, as you say, fertilizer must be applied five to seven months before hand there must be some relationship between flowering and fruit set with peak in production. Wouldn't it be better to relate fertilizer application to flowering?

Mr. O'Donohue

The fertilizer will have an effect on the tree with flowering pod setting and subsequent wilting. Even under conditions of no fertilizing you get the peak in production about the same time as treatment with fertilizer which actually has no effect on the inducing a flush. You can't say that by applying fertilizer now that you can bring about a fruit flush which is going to be maintained.

Question

How long does it take for a pod to develop from pollination to picking?

Mr. O'Donohue

The time it takes to develop from pollination of the flower to the formation of the pod varies from tree to tree roughly about 170 days with a range of five and a half to six months.

~~Mr. P. Coote (Rabaul)~~ *Question*

Do you recommend only nitrogenous fertilizers for the Gazelle Peninsula or a compound fertilizer?

Mr. O'Donohue

Under normal conditions we would probably recommend only nitrogenous fertilizers except in cases where the other elements are required. As Mr. Southern pointed out there are areas of sulphur deficiency. However, under the present circumstances where a lot of pruning of trees is being done it is probably preferable for that reason and other reasons to change your fertilizer programme and put on instead of urea occasionally ammonium sulphate or NPK.

Question

Has there been any natural effect to dieback on fertilized trees to unfertilized trees?

Mr. O'Donohue

No, we haven't been able to relate the incidence of dieback to fertilizer applications or to shade level. Block 405 I mentioned was a shade level trial of Normal, $\frac{1}{2}$ Normal, $\frac{1}{4}$ Normal to Nil. In none of the shade level blocks is there any indication of dieback being more adverse to one than the other but as a slight indication, and only an indication, trees under fertilizer treatment recover better than those unfertilized.

Question

Do you consider the poor response to fertilizer in the last year is due to another deficiency occurring as a result of fertilizing?

Mr. Byrne

No. This poor response has occurred on all fertilizer trials at the same time. These fertilizer trials have been going for different periods. It is probably a seasonal effect.